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PPL Electric Utilities Annual Report to the Pennsylvania Public Utility Commission

PHASE III OF ACT 129 PY9 ANNUAL REPORT
(JUNE 1, 2017 – MAY 31, 2018)
FOR PENNSYLVANIA ACT 129 OF 2008
ENERGY EFFICIENCY AND CONSERVATION PLAN

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Prepared for:
PPL Electric Utilities

November 15, 2018

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Acronyms

BDR	Behavioral Demand Response
C&I	Commercial and Industrial
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
CSP	Conservation Service Provider or Curtailment Service Provider
CV	Coefficient of Variation
DLC	Direct Load Control
DR	Demand Response
EDC	Electric Distribution Company
EDT	Eastern Daylight Time
EE&C	Energy Efficiency and Conservation
EM&V	Evaluation, Measurement, and Verification
EISA	Energy Independence and Security Act
EUL	Effective Useful Life
GNE	Government, Nonprofit, Educational
HER	Home Energy Report
HIM	High Impact Measure
HOU	Hours of Use
HVAC	Heating, Ventilating, and Air Conditioning
ICSP	Implementation Conservation Service Provider
IPMVP	International Performance Measurement and Verification Protocol
kW	Kilowatt
kWh	Kilowatt-hour
KPI	Key Performance Indicator
LED	Light-Emitting Diode
LIURP	Low-Income Usage Reduction Program
M&V	Measurement and Verification
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NTG	Net-to-Gross
O&M	Operations and Maintenance
P3TD	Phase III to Date
PA PUC	Pennsylvania Public Utility Commission
PSA	Phase III to Date Preliminary Savings Achieved; equal to VTD + PYRTD
PSA+CO	PSA savings plus Carryover from Phase II

PY	Program Year: for example, PY8, from June 1, 2016, to May 31, 2017
PYRTD	Program Year Reported to Date
PYVTD	Program Year Verified to Date
PYTD	Program Year to Date
QA/QC	Quality Assurance/Quality Control
RTD	Phase III to Date Reported Gross Savings
SEER	Seasonal Energy Efficiency Rating
SWE	Statewide Evaluator
T&D	Transmission and Distribution
TRC	Total Resource Cost
TRM	Technical Reference Manual
VTD	Phase III to Date Verified Gross Savings
WRAP	Weatherization Relief Assistance Program

Types of Savings

Gross Savings: The change in energy consumption and/or peak demand that results directly from program-related actions taken by participants in an EE&C program, regardless of why they participated.

Net Savings: The total change in energy consumption and/or peak demand that is attributable to an EE&C program. Depending on the program delivery model and evaluation methodology, the net savings estimates may differ from the gross savings estimate due to adjustments for the effects of free riders, changes in codes and standards, market effects, participant and nonparticipant spillover, and other causes of changes in energy consumption or demand not directly attributable to the EE&C program.

Reported Gross: Also referred to as *ex ante* (Latin for "beforehand") savings. The energy and peak demand savings values calculated by the EDC or its program Implementation Conservation Service Providers (ICSP), and stored in the program tracking system.

Unverified Reported Gross: The Phase III Evaluation Framework allows EDCs and the evaluation contractors the flexibility to not evaluate each program every year. If an EE&C program is being evaluated over a multi-year cycle, the reported savings for a program year where evaluated results are not available are characterized as unverified reported gross until the impact evaluation is completed and verified savings can be calculated and reported.

Verified Gross: Also referred to as *ex post* (Latin for "from something done afterward") gross savings. The energy and peak demand savings estimates reported by the independent evaluation contractor after the gross impact evaluation and associated M&V efforts have been completed.

Verified Net: Also referred to as *ex post* net savings. The energy and peak demand savings estimates reported by the independent evaluation contractor after application of the results of the net impact evaluation. Typically calculated by multiplying the verified gross savings by a net-to-gross (NTG) ratio.

Annual Savings: Energy and demand savings expressed on an annual basis, or the amount of energy and/or peak demand an EE&C measure or program can be expected to save over the course of a typical year. Annualized savings are noted as MWh/year or MW/year. The Pennsylvania (PA) Phase III technical reference manual (TRM), hereafter referenced as the PA TRM, provides algorithms and assumptions to calculate annual savings, and Act 129 compliance targets for consumption reduction are based on the sum of the annual savings estimates of installed measures or behavior change.

Lifetime Savings: Energy and demand savings expressed in terms of the total expected savings over the useful life of the measure. Typically calculated by multiplying the annual savings of a measure by its effective useful life. The TRC Test uses savings from the full lifetime of a measure to calculate the cost-effectiveness of EE&C programs.

Program Year Reported to Date (PYRTD): The reported gross energy and peak demand savings achieved by an EE&C program or portfolio within the current program year. PYTD values for energy efficiency will always be reported gross savings in a semi-annual or preliminary annual report.

Program Year Verified to Date (PYVTD): The verified gross energy and peak demand savings achieved by an EE&C program or portfolio within the current program year as determined by the impact evaluation findings of the independent evaluation contractor.

Phase III to Date (P3TD): The energy and peak demand savings achieved by an EE&C program or portfolio within Phase III of Act 129. Reported in several permutations described below.

- **Phase III to Date Reported (RTD):** The sum of the reported gross savings recorded to date in Phase III of Act 129 for an EE&C program or portfolio.
- **Phase III to Date Verified (VTD):** The sum of the verified gross savings recorded to date in Phase III of Act 129 for an EE&C program or portfolio, as determined by the impact evaluation finding of the independent evaluation contractor.
- **Phase III to Date Preliminary Savings Achieved (PSA):** The sum of the verified gross savings (VTD) from previous program years in Phase III where the impact evaluation is complete plus the reported gross savings from the current program year (PYTD).
- **Phase III to Date Preliminary Savings Achieved + Carryover (PSA+CO):** The sum of the verified gross savings from previous program years in Phase III plus the reported gross savings from the current program year plus any verified gross carryover savings from Phase II of Act 129. This is the best estimate of an EDC’s progress toward the Phase III compliance targets.
- **Phase III to Date Verified + Carryover (VTD + CO):** The sum of the verified gross savings recorded to date in Phase III plus any verified gross carryover savings from Phase II of Act 129.

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PORTFOLIO

PPL Electric Utilities offers nine energy-efficiency programs to non-residential, residential and income-verified customers.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **740,525 MWh/yr**

47% of projected

121% of projected

PY9 saved **382,882 MWh/yr**

PROGRAM SATISFACTION

88% Satisfied with overall programs

95% satisfied with **Non-Residential programs**

94% satisfied with **Low-Income programs**

80% satisfied with **Demand Response program**

84% satisfied with **Residential programs**

PY9 PARTICIPATION

A total of **550,680** participants:

93 Demand Response

25,648 Low-Income

5,926 Non-Residential

519,013 Residential

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$105,298**

39% of projected

108% of projected

PY9 expenditures **$54,698**

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NON-RESIDENTIAL ENERGY EFFICIENCY PROGRAM

Four non-residential programs offer financial incentives to customers in a non-residential rate class.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **305,950 MWh/yr**

38% of projected

119% of projected

PY9 saved **162,377 MWh/yr**

PROGRAM SATISFACTION

95% Satisfied with overall programs

100% satisfied with **Continuous Energy Improvement program**

96% satisfied with **Custom program**

95% satisfied with **Efficient Equipment program**

92% satisfied with **Midstream Lighting program**

PY9 PARTICIPATION

A total of **5,926** participants:

16 Continuous Energy Improvement

100 Custom

1,125 Efficient Equipment

4,685 Midstream Lighting

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$28,480**

27% of projected

78% of projected

PY9 expenditures **$13,849**

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RESIDENTIAL PROGRAMS

Residential customers participate in five programs to recycle inefficient appliances, purchase rebated efficient equipment and discounted lighting, receive home energy reports with tips to save energy, and to educate students about energy efficiency.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **406,784 MWh/yr**

59% of projected

125% of projected

PY9 saved **200,203 MWh/yr**

PROGRAM SATISFACTION

84% Satisfied with overall programs

98% satisfied with the **Appliance Recycling Program**

90% satisfied with **Energy Efficient Home Program**

85% satisfied with the **Student Energy Efficient Education Program**

65% satisfied with the **Home Energy Education Program**

PY9 PARTICIPATION

A total of **519,013** participants:

12,852	Appliance Recycling
287,024	Efficient Lighting
33,334	Energy Efficient Home
161,589	Home Energy Education
24,214	Student Energy Efficient Education

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$40,852**

41% of projected

94% of projected

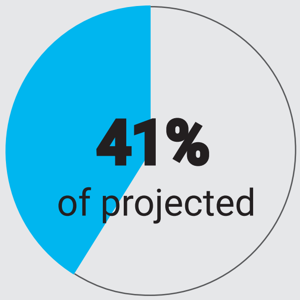
PY9 expenditures **$19,059**

LOW-INCOME PROGRAMS

Two dedicated programs offer weatherization, energy education, and energy conservation kits to income-qualified customers.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **38,124 MWh/yr**



137% of projected

PY9 saved **26,241 MWh/yr**

PROGRAM SATISFACTION

94% Satisfied with overall program

98% satisfied with the **Energy Efficiency Kits and Education Program**

91% satisfied with the **Weatherizaton Relief Assistance Program**

PY9 PARTICIPATION

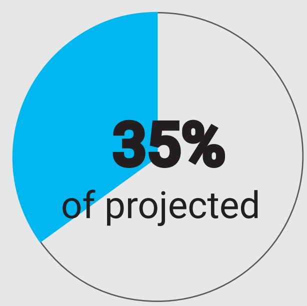
A total of **25,684** participants:

13,406 Energy Efficiency Kits and Education Program

12,242 Weatherizaton Relief Assistance Program

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$17,310**



130% of projected

PY9 expenditures **$11,404**

1 Introduction

Pennsylvania Act 129 of 2008, 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). Phase II of Act 129 began in 2013 and concluded in 2016. In late 2015, each EDC filed a new energy efficiency and conservation (EE&C) plan with the Pennsylvania Public Utility Commission (PA PUC) detailing the proposed design of its portfolio for Phase III. These plans were updated based on stakeholder input and subsequently approved by the PA PUC in 2016.

Implementation of Phase III of the Act 129 programs began on June 1, 2016, and runs until May 2021 (five program years—PY8–PY12). This report documents the progress and effectiveness of the Phase III EE&C accomplishments for PPL Electric Utilities in the second program year of Phase III, Program Year 9 (PY9, June 2017–May 2018), as well as the cumulative accomplishments of the Phase III programs since inception (June 2016–May 2018).

This report details the participation, spending, reported gross savings, verified gross savings, and verified net savings impacts of the energy efficiency programs in PY9. Compliance with Act 129 savings goals are ultimately based on verified gross savings. This report also includes estimates of cost-effectiveness according to the total resource cost test (TRC).[1]

PPL Electric Utilities has retained Cadmus as an independent evaluation contractor for Phase III of Act 129. Cadmus is responsible for the measurement and verification of the savings and calculation of gross verified and net verified savings.

Cadmus also conducted a process evaluation for selected programs to examine the design, administration, implementation, and market response to the Act 129 EE&C programs. This report presents the key findings and recommendations identified by the impact and process evaluations and documents PPL Electric Utilities' consideration of recommendations.

1.1 Executive Summary

PPL Electric Utilities has successfully continued to implement the Phase III Act 129 programs in PY9. Programs are operating effectively and are meeting or surpassing program objectives. Key programs improved performance since PY8. Therefore, Cadmus does not suggest any major course corrections. Recommendations suggest minor tuning and possible areas of inquiry in future years.

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[1] The Pennsylvania TRC Test for Phase I was adopted by PUC order at Docket No. M-2009-2108601 on June 23, 2009 (2009 PA TRC Test Order). The TRC Test Order for Phase I later was refined in the same docket on August 2, 2011 (2011 PA TRC Test Order). The 2013 TRC Order for Phase II of Act 129 was issued on August 30, 2012. The 2016 TRC Test Order for Phase III of Act 129 was adopted by PUC order at Docket No. M-2015-2468992 on June 11, 2015.

Verified energy savings achieved as of PY9 exceed those projected for the phase to date shown in PPL Electric Utilities' EE&C plan.[2] Specifically, PPL Electric Utilities exceeded the PY9 cumulative projected estimate of 629,365 MWh/yr, achieving 740,525 MWh/yr in verified savings, or 118% of projections through PY9.

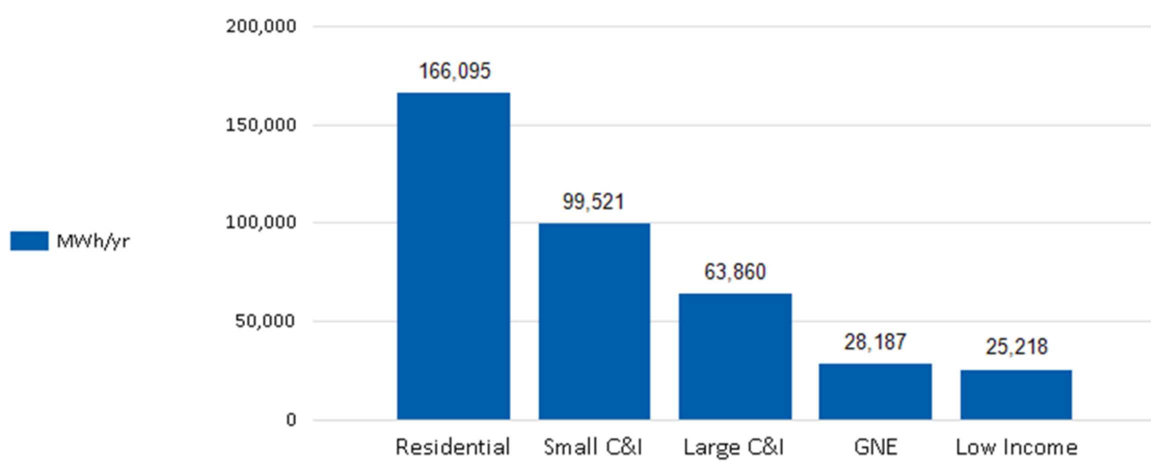
PPL Electric Utilities delivered programs for 87% of the PY9 cumulative projected budget estimated in the EE&C Plan, expending $105,297,576. The acquisition cost in PY9 is $0.14 per annual kWh (EDC expenditures/first year savings). The portfolio-level cost of conserved energy (TRC costs/net present value (NPV) lifetime kWh, at generation) is $0.04.

Achieved savings as of PY9 (740,525 MWh/yr) contributed 51% to the Phase III overall five-year compliance target of 1,443,035 MWh/yr. PPL Electric Utilities is on track to meet the Phase III overall compliance target.

PPL Electric Utilities is also on track to meet the compliance target for the low-income sector and has exceeded the compliance target for the government, nonprofit, education (GNE) sector. The low-income savings target is 79,367 MWh/yr of verified gross energy savings. PPL Electric Utilities has achieved 48% of the Phase III low-income energy-savings target. The Phase III GNE savings target is 50,507 MWh/yr of verified gross energy savings. PPL Electric Utilities has achieved 141% of the target and has placed GNE projects on a waitlist, as of January 2018.

Figure 1-1 shows PPL Electric Utilities' program year-to-date (PYTD) verified savings by sector.

Figure 1-1. PYTD Verified Savings by Sector



Note: Total residential verified MWh/yr has been adjusted to account for Home Energy Education Program savings uplift. May not sum to total due to rounding.

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2 PPL Electric Utilities revised *Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642. December 2017.

A portfolio is cost-effective if the TRC benefit-cost ratio exceeds 1.0. The PY9 portfolio is cost-effective, with a portfolio level TRC of 1.57.

Free ridership is low across the PY9 programs where it was estimated. The evaluated net-to-gross (NTG) ratio, including some spillover attributable to the programs, is 0.80. Program offerings do not need modification to address free ridership.

In Phase III, PPL Electric Utilities established a goal to achieve 80% or greater of *very satisfied* and *somewhat satisfied* customers in each sector.[3] Respondents to participant satisfaction surveys across all four sectors showed high levels of satisfaction with the programs. With the combined *very satisfied* and *somewhat satisfied* responses, portfolio satisfaction for PY9 is 88% (n=20,881); a decrease from the PY8 result of 90% (n=21,021).[4] The low-income (n=1,559) sector achieved customer satisfaction of 94%, the nonresidential (n=106) sector achieved customer satisfaction of 95%, the residential (n=19,206) sector achieved satisfaction of 84%, and the Demand Response (n=10) Program achieved customer satisfaction of 80%. All three sectors and the Demand Response Program exceeded the customer satisfaction goal of 80%.

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3 The customer satisfaction goal is listed in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642) filed December 2017.

4 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 16, 2017.

2 Summary of Achievements

2.1 Carryover Savings from Phase II of Act 129

The PA PUC's Phase III Implementation Order allowed EDCs to carry over savings in excess of the overall (portfolio) Phase II savings compliance target, in excess of the Phase II GNE savings compliance target, and in excess of the Phase II low-income savings compliance target.[5,6] PPL Electric Utilities did not have any carry over savings for the portfolio but it did exceed its Phase II compliance targets for GNE and low-income.

However, in the August 3, 2017, Compliance Order,[7] the PA PUC determined that because PPL Electric Utilities did not obtain Phase II savings in excess of its Phase II consumption reduction requirement, PPL Electric Utilities was not entitled to any GNE or low-income sector carryover savings into Phase III.

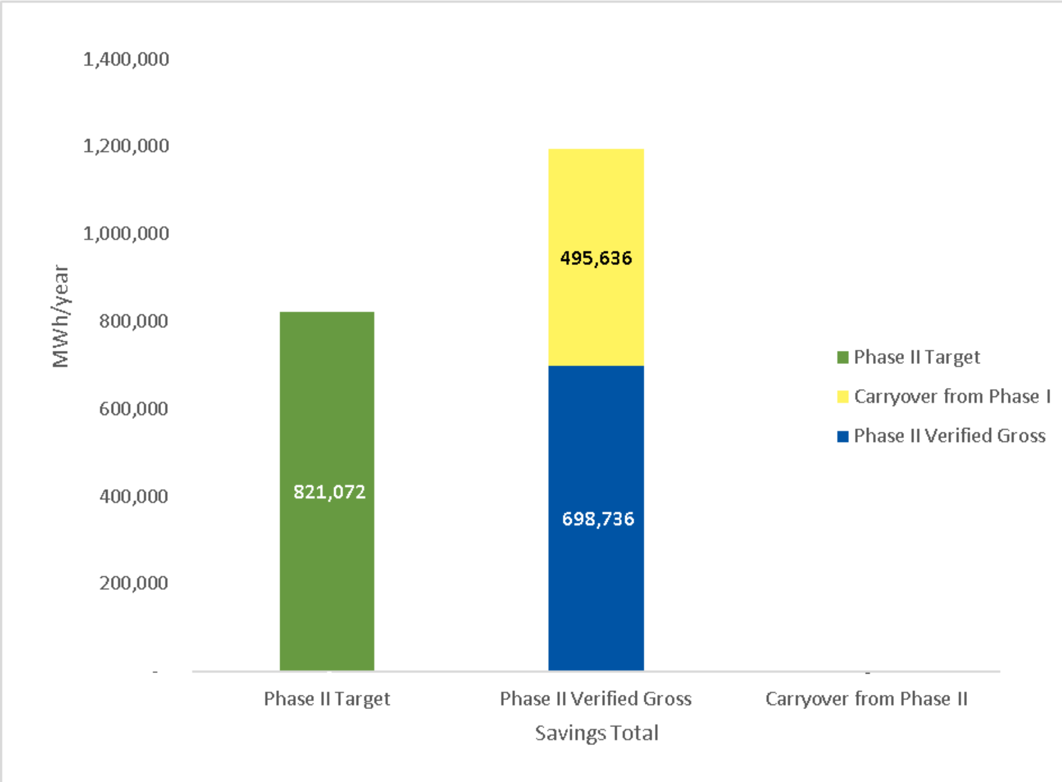
Figure 2-1 compares PPL Electric Utilities' Phase II verified gross savings to the Phase II compliance target.

5 Pennsylvania Public Utility Commission. Energy Efficiency and Conservation Program Implementation Order, Docket No. M-2014-2424864 (*Phase III Implementation Order*). Entered June 11, 2015.

6 Proportionate to those savings achieved by dedicated low-income programs in Phase III.

7 The Order addresses the EDCs' compliance with the Phase II energy reduction targets and the Petitions for reconsideration of the April 6, 2017, Compliance Order filed by Duquesne, PECO, and PPL Electric Utilities. Pennsylvania Public Utility Commission. Act 129 Phase II Final Compliance Order. Docket No. M-2012-2289411. Adopted August 3, 2017. Available online: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/energy_efficiency_and_conservation_ee_c_program.aspx

Figure 2-1. Carryover Savings from Phase II of Act 129



2.2 Phase III Energy Efficiency Achievements to Date

Table 2-1 shows the achievements to date since the beginning of PY9 on June 1, 2017. Table 2-2 shows the Phase III achievements to date. The Phase III to-date savings represent 51% of the May 31, 2021, energy-savings compliance target of 1,443,035 MWh/yr.

Table 2-1. PY9 Energy Efficiency Achievements to Date

PYTD	Reported Gross Savings (PYRTD)	Verified Savings (PYVTD) (2)	Unverified (PYRTD)
Energy Savings (MWh/yr)(1)	400,175	382,882	5
Peak Demand Savings (MW/yr) (1)	171.21	185.46	0.00

(1) Total may not sum due to rounding.
(2) The verified savings in this table have been adjusted to account for energy-savings uplift (double-counting) in the Home Energy Education Program.

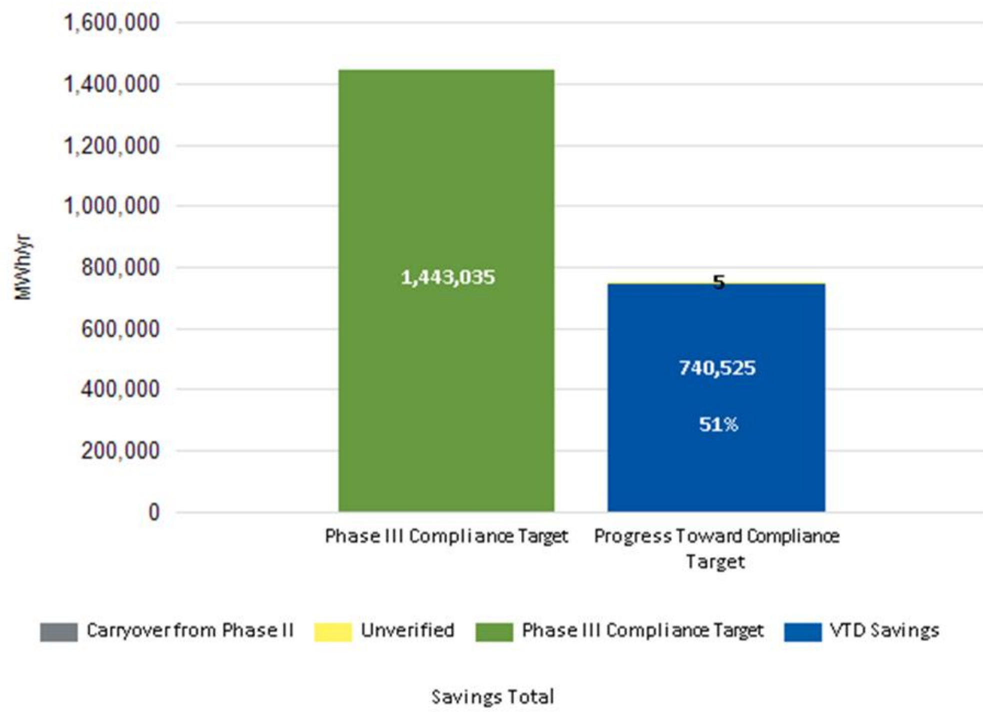
Table 2-2. Phase III Energy Efficiency Achievements to Date

P3TD	Reported Gross Savings (P3RTD)	Verified Savings (P3VTD)[2]	Unverified (P3RTD)
Energy Savings (MWh/yr) [1]	780,204	740,525	5
Peak Demand Savings (MW/yr) [1]	272.01	235.83	0.00

[1] Total may not sum due to rounding.
[2] The verified savings in this table have been adjusted to account for energy-savings uplift (double-counting) in the Home Energy Education Program.

Figure 2-2 summarizes PPL Electric Utilities' progress, verified-to-date (VTD), toward the Phase III portfolio compliance target. Note that reported savings associated with items from one PY9 Midstream Lighting project could not be verified as part of the PY9 evaluation. Savings from this project have been treated as unverified. Additional details are presented in *Chapter 6 Non-Residential Midstream Lighting Program.*

Figure 2-2. EE&C Plan Performance Toward Phase III Portfolio Target



The Phase III Implementation Order directed the EDCs to offer conservation measures to the low-income customer sector based on the proportion of electric sales attributable to low-income households. For PPL Electric Utilities, the proportionate number of measures targeted is 9.95%.[8]

PPL Electric Utilities offers a total of 96 EE&C measures (products and equipment) to its residential and nonresidential customer classes.[9] It makes 21 measures available to the low-income customer sector at no cost to the customer, which is 22% of the total number of measures offered in the EE&C plan and exceeds the target of 9.95% for the proportionate number of measures.

The PA PUC also established a low-income energy savings target of 5.5% of the portfolio savings.[10] The low-income savings target for PPL Electric Utilities is 79,367 MWh/yr of verified gross energy savings. Figure 2-3 compares the VTD performance for the low-income customer sector to the Phase III savings target. Considering verified savings through PY9, PPL Electric Utilities has achieved 48% of the Phase III low-income energy-savings target.

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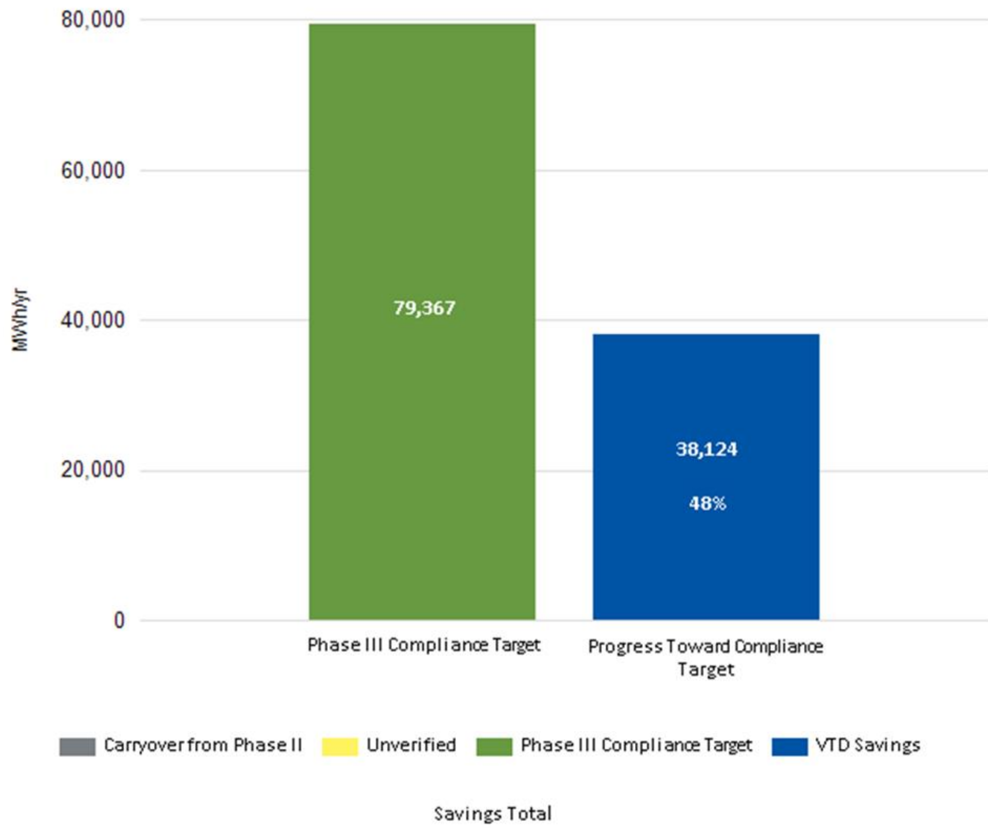
8 Pennsylvania Public Utility Commission. *Phase III Implementation Order.* Docket No. M-2014-242-2424864. June 11, 2015.

9 PPL Electric Utilities. *PPL Electric Utilities Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642. December 2017.

10 Pennsylvania Public Utility Commission. *Phase III Implementation Order.* Docket No. M-2014-242-2424864. June 11, 2015

Figure 2-3. EE&C Plan Performance Toward Phase III Low-Income Compliance Target



Low-Income WRAP includes savings for multifamily projects that are allocated to the GNE and Small C&I sectors based on the rate class of the buildings' meters (included in this figure). All savings from this program are counted toward the low-income compliance target, as set forth in PPL Electric Utilities EE&C Plan Act 129 Phase III, Docket No. M-2015-2515642, December 2017. Therefore, the total savings shown here do not match the totals in Table 5. Phase III Summary Statistics by Customer Sector. The additional savings counted toward the low-income compliance target total 1,240 MWh: 1,028 MWh from GNE and 212 MWh from Small C&I.

The Phase III Implementation Order established a GNE energy savings target of 3.5% of the portfolio savings.[11] The GNE savings target for PPL Electric Utilities is 50,507 MWh/yr of verified gross energy savings. Figure 2-4 compares the VTD performance for the GNE customer sector to the Phase III GNE savings target. Considering verified savings through PY9, PPL Electric Utilities has achieved 141% of the Phase III GNE energy savings target.

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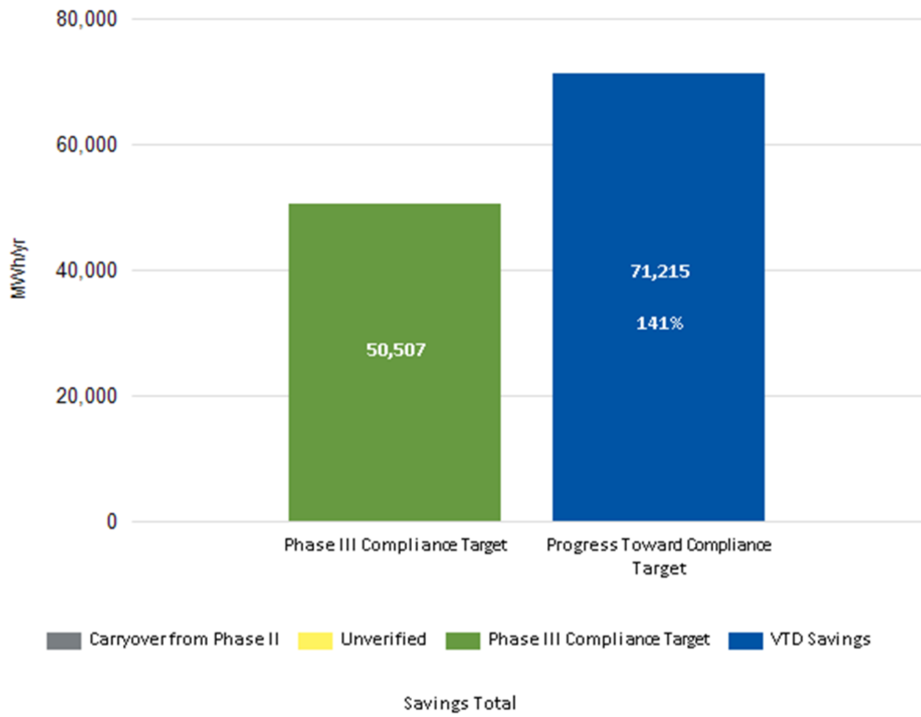
[11] Pennsylvania Public Utility Commission. *Phase III Implementation Order.* Docket No. M-2014-242-2424864. June 11, 2015.

Figure 2-4. EE&C Plan Performance Against Phase III GNE Compliance Target



Low-Income WRAP includes savings for multifamily projects that are allocated to the GNE and Small C&I sectors based on the rate class of the buildings' meters. All savings from the WRAP program are counted toward the low-income compliance target, as set forth in PPL Electric Utilities EE&C Plan Act 129 Phase III, Docket No. M-2015-2515642, December 2017. Therefore, the VTD savings in this figure do not include the 1,028 MWh of GNE savings allocated to Low Income WRAP and do not match the GNE savings in Table 5. Phase III Summary Statistics by Customer Sector.

2.3 Phase III Demand Response Achievements to Date

The Phase III demand response performance target for PPL Electric Utilities is 115 MW. Compliance targets for demand response programs are based on average performance across events and were established at the system level, which means the load reductions measured at the customer meter must be escalated to reflect transmission and distribution line losses.

Act 129 demand response events are triggered by PJM RTO's day-ahead load forecast. When the day-ahead forecast was above 96% of the peak load forecast for the year, a demand response event was initiated for the following day. In PY9, there were three demand response events called.

Table 2-3 lists the dates of the demand response events along with the verified gross demand reductions achieved by each sector. The table also lists the average demand response performance for PY9 and for Phase III to date. PPL Electric Utilities' average demand response performance to date exceeds the Phase III compliance reduction target of 92 MW by 38%.

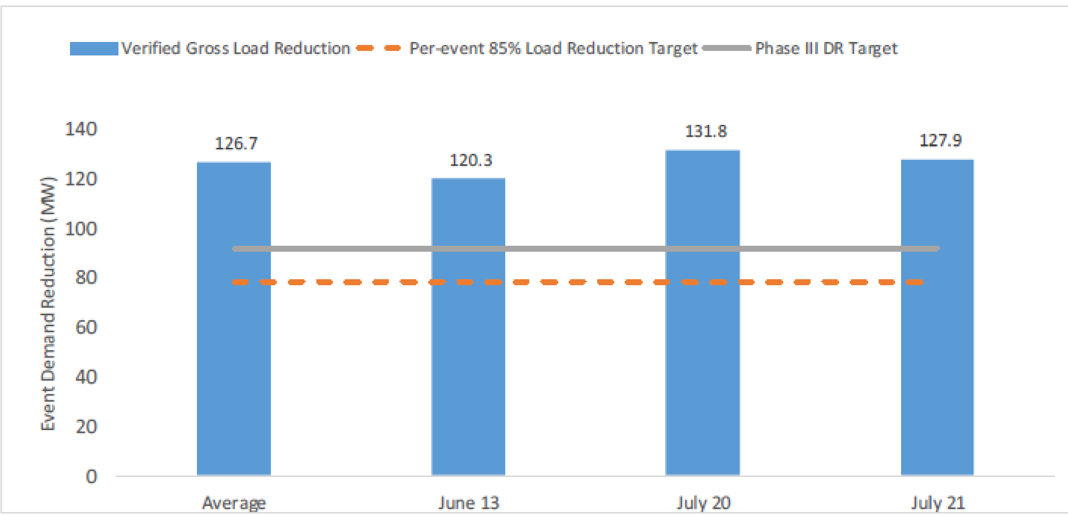
Table 2-3. PY9 Demand Response PYVTD Performance by Event

Event Date	Start Hour	End Hour	Small C&I Load Curtailment MW Impact	Large C&I Load Curtailment MW Impact	GNE Load Curtailment MW impact	Average Portfolio MW Impact(1)
June 13, 2017	2:00 p.m.	6:00 p.m.	3.0	113.9	3.5	120.3
July 20, 2017	2:00 p.m.	6:00 p.m.	0.2	127.0	4.7	131.8
July 21, 2017	2:00 p.m.	6:00 p.m.	0	123.0	4.9	127.9
PYVTD - Average PY9 Demand Response Event Performance						**126.7**
VTD(2) - Average Phase III Demand Response Event Performance						**126.7**

(1) Portfolio impact may not equal sum of individual sector impacts because of rounding error.
(2) VTD demand response impacts are the average performance across all Phase III demand response event hours. This is the best indication of cumulative performance against compliance targets.

The PA PUC's Phase III Implementation Order also established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each demand response event. For PPL Electric Utilities, this translates to a 78.2 MW minimum for each demand response event. Figure 2-5 compares the performance of each of the demand response events in PY9 to the event-specific minimum and average targets.

Figure 2-5. Event Performance Compared to 85% Per-Event Target



Note: The load impacts reported in this figure are based on Cadmus analysis of participant AMI consumption data and have been grossed up to reflect transmission and distribution losses.

2.4 Phase III Performance by Customer Sector

Table 2-4 presents the participation, savings, and spending by customer sector for PY9. The residential, small commercial and industrial (C&I), and large C&I sectors are defined by EDC tariff and the residential low-income and GNE sector were defined by statute (66 Pa. C.S. § 2806.1). The residential low-income sector is a subset of the residential customer class, and the GNE sector includes customers within the Residential, Small C&I, and Large C&I rate classes. The savings, spending, and participation values for the low-income and GNE sectors have been removed from the parent sectors in Table 2-4.

Table 2-4. PY9 Summary Statistics by Customer Sector

Parameter	Residential	Low Income	Small C&I	Large C&I	GNE	Total[1]
Number of Participants	504,044	25,484	18,735	539	1,877	**550,680**
PY9 Energy Realization Rate[2]	100%	89%	94%	99%	97%	**97%**
PYVTD MWh/yr	172,033[3]	25,218	99,521	63,860	28,187	**388,820[3]**
PY9 Demand Realization Rate[2]	119%	104%	98%	107%	130%	**109%**
PYVTD MW/yr (Energy Efficiency)	28.33[3]	2.62	15.68	8.45	4.63	**59.72[3]**
PYVTD MW/yr (Demand Response)			1.05	121.29	4.34	**126.68**
PY9 Incentives ($1000)	$8,791	$0[4]	$3,882	$3,926	$1,978	**$18,578**

[1] Total may not sum due to rounding.
[2] Realization rates exclude unverified savings. The realization rate includes reported (*ex ante*) savings only for the projects that were verified.
[3] The residential verified savings have not been adjusted to account for energy savings uplift (double-counting) in the Home Energy Education Program.
[4] The cost of measures provided to low-income participants at no cost is treated as an administrative cost, not as an incentive cost.

Table 2-5 summarizes plan performance by sector since the beginning of Phase III.

Table 2-5. Phase III Summary Statistics by Customer Sector

Parameter	Residential	Low Income	Small C&I	Large C&I	GNE	Total[1]
Number of Participants	910,347	40,084	37,582	722	2,431	**991,166**
P3TD Energy Realization Rate[2]	99%	88%	91%	98%	97%	**96%**
VTD MWh/yr	345,655[3]	36,884	169,696	126,381	72,243	**750,858[3]**
P3TD Demand Realization Rate[2]	55%	105%	90%	108%	102%	**87%**
VTD MW/yr (Energy Efficiency)	52.00[3]	3.78	27.65	16.33	10.32	**110.08**[3]
VTD MW/yr (Demand Response)			1.05	121.29	4.34	**126.68**
P3TD Incentives ($1000)	$20,972	$0[4]	$8,042	$7,481	$4,541	**$41,036**

[1] Total may not match sum of columns due to rounding.
[2] Realization rates exclude unverified savings. The realization rate includes reported (*ex ante*) savings only for the projects that were verified.
[3] The residential verified savings have not been adjusted to account for energy savings uplift (double-counting) in the Home Energy Education Program.
[4] The cost of measures provided to low-income participants at no cost is treated as an administrative cost, not as an incentive cost.

2.5 Summary of Participation by Program

Participation is defined differently for certain programs depending on the program delivery channel and data tracking practices. These distinctions are summarized by program in Table 2-6, which also provides the current participation totals for PY9 and Phase III. PPL Electric Utilities' tracking database assigns unique job identifiers to rebated projects, and these correspond to participants as noted in this table.

Table 2-6. EE&C Portfolio Participation by Program

Program	Participant Definition	PYTD Participation	P3TD Participation
Appliance Recycling	Unique job number; corresponds with each unique appliance decommissioned through the program during the program year	12,852	24,220
Demand Response	Unique job number; corresponds to a customer that participated in a demand response event	93	93
Efficient Lighting [1]	Person or business purchasing discounted bulbs. See *Section 9.1.2 Definition of a Participant* describing the approach to computing number of participants.	287,024	623,244
Energy-Efficiency Kits and Education [2]	Unique job number; corresponds to an energy-savings kit delivered to an income-eligible customer through the agency or the direct-mail delivery channel Participation is determined by the unique job numbers. Returned kits are assigned two unique job numbers: one for the distributed kit, and one for the returned kit	13,406	25,523
Energy Efficient Home	Unique job number; corresponds to a rebated project Households could have more than one rebated project	33,334	44,735
Home Energy Education	Unique bill account number (household) that receives a home energy report	161,589	202,509
Low-Income Winter Relief Assistance Program (WRAP)	Unique bill account number; corresponds to an income-eligible household that receives an audit and program services In PY8, a participant was defined as a unique job, but the PY9 updated definition is applied retroactively here. Therefore, the P3TD total will not match the PY8 total plus PY9TD	12,242	14,729
Non-Residential Energy Efficiency	Custom: Unique job number; commercially operable job that received an incentive payment during the reporting period Continuous Energy Improvement: Individual school Midstream Program: Unique job number (RBT); corresponds to each purchase of discounted products Prescriptive Lighting and Equipment: Unique job number; corresponds to each unique job that received a rebate	5,926	7,754
Student Energy Efficient Education	Number of participants is counted as the number of energy conservation kits delivered	24,214	48,359
Portfolio Total		**550,680**	**991,166**

[1] PPL Electric Utilities sold 3,011,377 bulbs through the program in PY9, of which 10% are estimated to have been purchased by small commercial customers.
[2] Participation is determined by the unique job numbers. Returned kits are assigned two unique job numbers: one for the distributed kit and one for the returned kit. Note that this is just for recordkeeping purposes, and the number of unique kits distributed by the ICSP in PY9 that were not returned is 13,203.

2.6 Summary of Impact Evaluation Results

During PY9, Cadmus completed impact evaluations for all of the energy efficiency programs in the portfolio, and a net savings analysis for some. Table 2-7 summarizes the realization rates and NTG ratios by program or evaluation initiative.

Table 2-7. Impact Evaluation Results Summary

Program	Energy Realization Rate (1)	Demand Realization Rate (1)	Net-to-Gross Ratio	Percentage of Total Portfolio Verified Gross	
				Verified MWh/yr	Verified MW/yr
Appliance Recycling	80%	84%	0.66 (2)	3%	1%
Demand Response	-	110%	1.0 (3)	0%	68%
Efficient Lighting	100%	97%	0.83 (2)	33%	9%
Energy Efficiency Kits and Education	97%	122%	1.0 (3)	3%	1%
Energy Efficient Home	87%	96%	0.75 (4)	5%	2%
Home Energy Education	107%	170%	1.0 (5)	9%	6%
Low-Income WRAP	82%	93%	1.0 (3)	4%	1%
Non-Residential Energy Efficiency	97%	102%	0.71 (6)	42%	12%
Student Energy Efficient Education	108%	111%	1.0 (3)	2%	0%
Total	**97%**	**109%**	**0.80 (8)**	**100% (7)**	**100% (7)**

(1) Realization rates exclude unverified savings.
(2) PY8 evaluated NTG ratio.
(3) No free ridership is expected, nor measured, per the evaluation plan. Therefore, the NTG ratio is 1.0.
(4) PY9 evaluated NTG ratios used for refrigerator and dehumidifier measures. PY8 evaluated NTG ratios used for all other measures. The 0.75 NTG ratio for the overall program is the verified gross population energy savings weighted average of the NTG ratios applied to each measure.
(5) Savings are determined using a randomized control trial and the NTG ratio is irrelevant.
(6) PY9 evaluated NTG ratio.
(7) Total may not match sum of rows due to rounding.
(8) Weighted by PY9 program verified gross energy savings.

Findings from net savings research are not used to adjust compliance savings in Pennsylvania. Instead, this research provides directional information for program planning purposes. Table 2-8 presents findings for PY9 high-impact measures. Findings were determined using PY9 self-report surveys for commercial lighting. Overall, high-impact measures accounted for 31% of the total portfolio verified gross energy savings.

Table 2-8. High-Impact Measure Net-to-Gross

High-Impact Measure	Free Ridership	Spillover	Net-to-Gross Ratio
Efficient Equipment Commercial Lighting (1)	31% (2)	0%	0.69
Combined Heating and Power (CHP) (3)	N/A	N/A	N/A
Total	**31%(4)**	**0%**	**0.69**

(1) Estimated from PY9 survey data.
(2) Weighted by the survey sample-verified program kWh/yr savings.
(3) No CHP participants completed a survey in PY9.
(4) Weighted by verified gross energy savings of high-impact measure population. No CHP participants completed a survey in PY9 and CHP is not included in the weighted estimate.

2.7 *Summary of Energy Impacts by Program*

Act 129 compliance targets are based on annualized savings (MWh/yr). Each program year, the annual savings achieved by EE&C program activity are recorded as incremental annual, or "first-year" savings, and added to an EDC's progress toward compliance. Incremental annual savings estimates are presented in the next section, *2.7.1 Incremental Annual Energy Savings by Program*. Lifetime energy savings incorporate the effective useful life (EUL) of installed measures and estimate the total energy savings associated with EE&C program activity. Lifetime savings are used in the TRC test, by program participants when assessing the economics of upgrades and by the statewide evaluator (SWE) when calculating the emissions benefits of Act 129 programs. Section *2.7.2 Lifetime Energy Savings by Program* presents the lifetime energy savings by program.

2.7.1 Incremental Annual Energy Savings by Program

Figure 2-6 presents a summary of the program year-to-date (PYTD) energy savings by program for PY9. The energy impacts in this report are presented at the meter and do not reflect adjustments for transmission and distribution losses. The verified gross savings are adjusted by the energy realization rate, and the verified net savings are adjusted by both the realization rate and the NTG ratio.

Figure 2-6. PY9 PYTD Energy Savings by Program

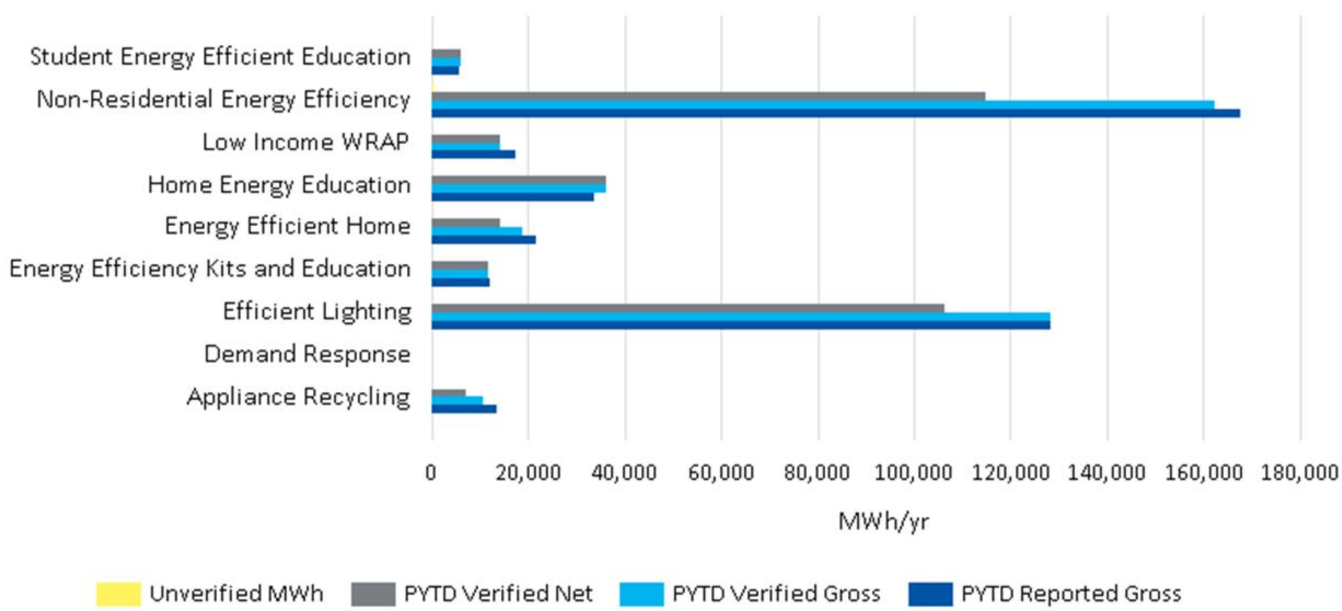
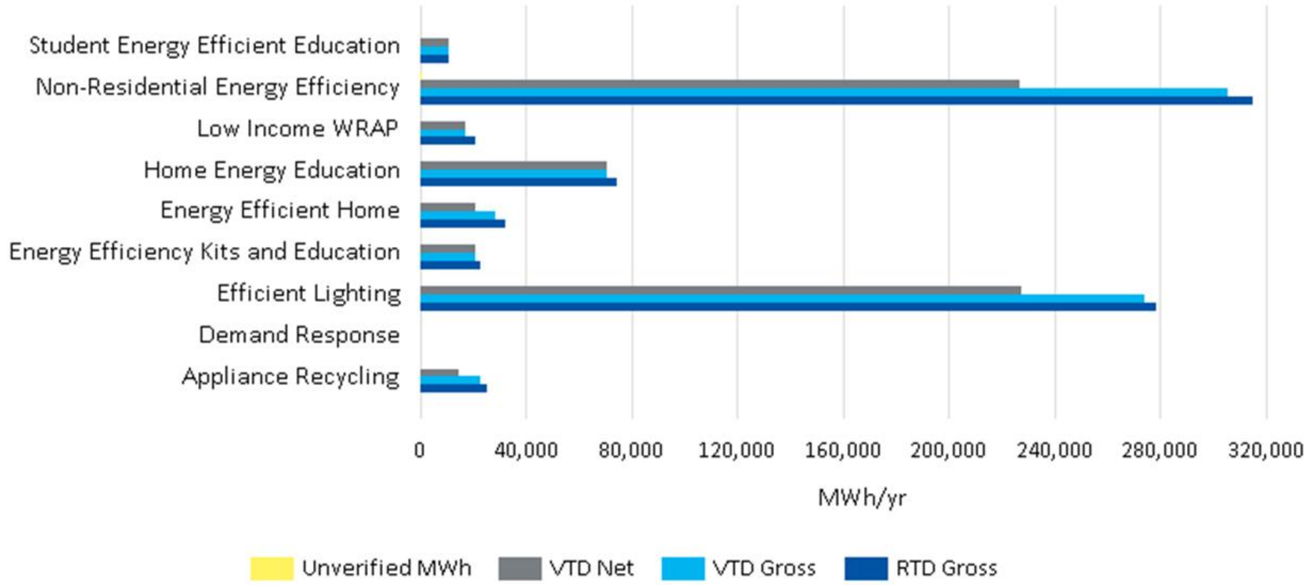


Figure 2-7 presents a summary of the energy savings by program for Phase III of Act 129.

Figure 2-7. P3TD Energy Savings by Program



A summary of energy impacts by program through PY9 is presented in Table 2-9. Demand Response is excluded from this table because it does not produce energy savings.

Table 2-9. Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD	PYVTD	PY Unverified	PYVTD Net	RTD	VTD	Unverified	VTD Net
Appliance Recycling	13,454	10,731		7,082	25,489	22,575		14,900
Efficient Lighting	128,298	128,318		106,504	278,674	274,247		227,625
Energy Efficiency Kits and Education	12,205	11,829		11,829	22,625	21,049		21,049
Energy Efficient Home	21,705	18,802		14,148	32,327	28,746		20,884
Home Energy Education	33,876	36,328		36,328	74,343	70,654		70,654
Low-Income WRAP	17,530	14,412		14,412	21,021	17,075		17,075
Non-Residential Energy Efficiency	167,510	162,377	5	114,870	315,011	305,950	5	227,046
Student Energy Efficient Education	5,597	6,024		6,024	10,715	10,562		10,562
Total[(1)]	**400,175**	**388,820**	**5**	**311,197**	**780,204**	**750,858**	**5**	**609,795**
Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings[(2)]		(5,938)				(10,333)		
Adjusted Portfolio Savings [(2)]		**382,882**				**740,525**		

[(1)] Total may not match sum of rows due to rounding.
[(2)] The adjusted verified savings in this table account for energy-savings uplift (double-counting) in the Home Energy Education Program.

2.7.2 Lifetime Energy Savings by Program

Table 2-10 presents the PYTD and P3TD lifetime energy savings by program. Lifetime savings are adjusted to account for reduced lighting savings following the 2020 Energy Independence and Security Act (EISA) backstop. Specifically, after the 2020 EISA implementation, year-one savings are reduced to the difference in energy usage between the efficient bulb and the new baseline. No savings are included beyond 15 years, for any rebated item, per the Pennsylvania TRC Order.[12]

Table 2-10. Lifetime Energy Savings

Program	Program Year 9		Phase III	
	PYVTD Gross Lifetime (MWh)	PYVTD Net Lifetime (MWh)	VTD Gross Lifetime (MWh)	VTD Net Lifetime (MWh)
Appliance Recycling	82,921	54,728	171,150	112,583
Efficient Lighting	1,018,630	845,463	2,207,379	1,832,125
Energy Efficiency Kits and Education	61,255	61,255	103,728	103,728
Energy Efficient Home	223,906	157,722	339,792	233,741
Home Energy Education	36,328	36,328	68,079	68,079
Low-Income WRAP	77,415	77,415	86,269	86,269
Student Energy Efficient Education	38,098	38,098	69,396	69,396
Non-Residential Energy Efficiency	2,408,981	1,712,266	4,364,401	3,252,348
Portfolio Total [(1)]	**3,947,534**	**2,983,275**	**7,410,194**	**5,758,268**

[(1)] Total may not match sum of rows due to rounding.

2.8 Summary of Demand Impacts by Program

PPL Electric Utilities' Phase III EE&C programs achieve peak demand reductions in two primary ways. The first is through coincident reductions from energy efficiency measures, and the second is through dedicated demand response offerings that exclusively target temporary demand reductions on peak days. Energy efficiency reductions coincident with system peak hours are reported and used in the calculation of benefits in the TRC test, but they do not contribute to Phase III peak demand reduction compliance goals. Phase III peak demand reduction targets are exclusive to demand response programs.

The two types of peak demand reduction savings are also treated differently for reporting purposes. Peak demand reductions from energy efficiency are generally additive across program years, meaning that the P3TD savings reflect the sum of the first-year savings in each program year. Demand reduction stemming from energy efficiency programs does not contribute to the Act 129 demand response requirements.

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[12] The 2016 TRC Test Order for Phase III of Act 129 was adopted by PA PUC order at Docket No. M-2015-2468992 on June 11, 2015.

Demand response goals are based on average portfolio impacts across all events called in dedicated demand response programs, so cumulative demand response performance is expressed as the *average* performance of each of the demand response events called in Phase III to date.

Because of these differences, demand impacts from energy efficiency and demand response are reported separately in the following subsections.

2.8.1 Energy Efficiency

Act 129 defines peak demand reductions from energy efficiency as the average expected reduction in electric demand from 2:00 p.m. to 6:00 p.m. EDT on non-holiday weekdays from June through August. Unlike Phase I and Phase II Act 129 reporting, the peak demand impacts from energy efficiency in this report are presented at the meter and do not reflect adjustments for transmission and distribution losses. Figure 2-8 presents a summary of the PYTD demand savings by energy efficiency program for PY9.

Figure 2-8. PYTD Demand Savings by Energy Efficiency Program

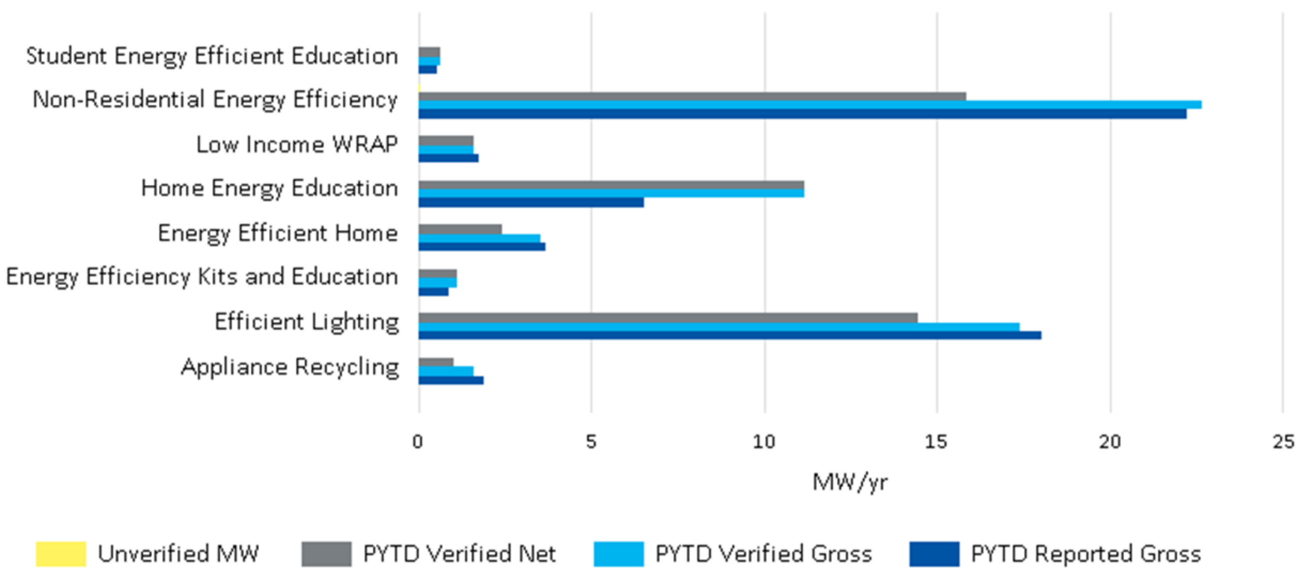
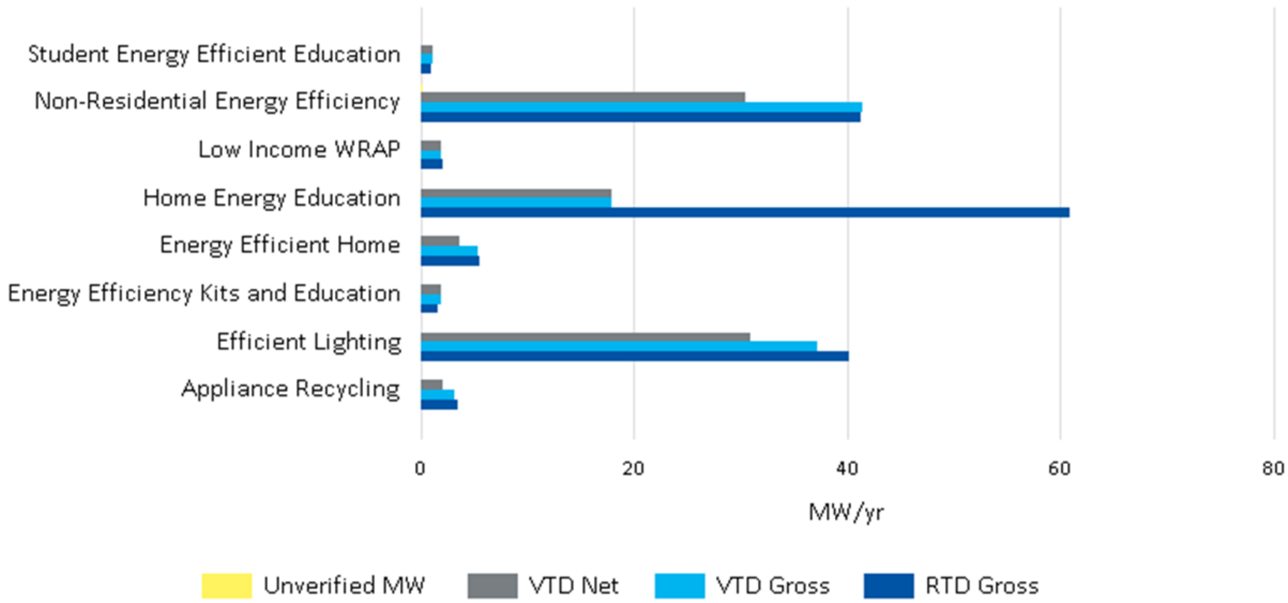


Figure 2-9 presents a summary of the P3TD demand savings by energy efficiency program for Phase III of Act 129.

Figure 2-9. P3TD Demand Savings by Energy Efficiency Program



Reported demand reduction for the Home Energy Education Program in PY8 were based on the demand reduction reported in PY7, which were unreasonably high, skewing the demand realization rate for this program and for the portfolio overall. PY9 reported demand reduction for this program use PY8 evaluated demand reduction.

A summary of the peak demand impacts by energy efficiency program through the current reporting period is presented in Table 2-11.

Table 2-11. Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD	PYVTD	PY Unverified	PYVTD Net	RTD	VTD	Unverified	VTD Net
Appliance Recycling	1.89	1.59		1.05	3.54	3.21		2.12
Efficient Lighting	18.01	17.41		14.45	40.15	37.23		30.90
Energy Efficiency Kits and Education	0.90	1.10		1.10	1.65	1.98		1.98
Energy Efficient Home	3.68	3.55		2.45	5.63	5.33		3.61
Home Energy Education	6.54	11.15		11.15	60.93	17.90		17.90
Low-Income WRAP	1.76	1.63		1.63	2.10	1.92		1.92
Non-Residential Energy Efficiency	22.22	22.67	0.00	15.87	41.34	41.40	0.00	30.49
Student Energy Efficient Education	0.56	0.63		0.63	1.02	1.11		1.11
Total(1)	**55.56**	**59.72**	**0.00**	**48.31**	**156.37**	**110.08**	**0.00**	**90.03**
Adjustment for Residential Energy-Efficiency Behavior & Education (2)		(0.93)				(0.93)		
Adjusted Total(2)	**55.56**	**58.79**	**0.00**	**48.31**	**156.37**	**109.15**	**0.00**	**90.03**

(1) Total may not match sum of rows due to rounding.
(2) The adjustment subtracts savings attributed to program uplift to avoid double counting.

2.8.2 Demand Response

Act 129 defines peak demand savings from demand response as the average reduction in electric demand during the hours when a demand response event is initiated. Phase III demand response events are initiated according to the following guidelines:

- Curtailment events shall be limited to the months of June through September.
- Curtailment events shall be called for the first six days of each program year (starting in PY9) in which the peak hour of PJM's day-ahead forecast is greater than 96% of its summer peak demand forecast for the months of June through September.
- Each curtailment event shall last four hours.
- Each curtailment event shall be called such that it will occur during the day's forecasted peak hour(s) above 96% of the PJM RTO summer peak demand forecast.
- Once six curtailment events have been called in a program year, the peak demand reduction program shall be suspended for that program year.

The peak demand impacts from demand response in this report are presented at the system level and reflect adjustments to account for transmission and distribution losses. PPL Electric Utilities uses the following line loss percentages/multipliers by sector:

- Residential = [8.75% or 1.0875]
- Small C&I = [8.75% or 1.0875]
- Large C&I = [4.20% or 1.042]

Table 2-12 summarizes the PYVTD and VTD demand reductions for the demand response program in the EE&C plan and for the demand response portfolio as a whole. VTD demand reductions are the average performance across all Phase III demand response events independent of how many events occurred in a given program year. The relative precision columns indicate the margin of error (at the 90% confidence interval) around the PYVTD and VTD demand reductions.

Table 2-12. Verified Gross Demand Response Impacts by Program

Program	PYVTD Gross MW	Relative Precision (90%)	VTD Gross MW	Relative Precision (90%)
Load Curtailment	126.7	3%	126.7	3%
Portfolio Total	126.7	3%	126.7	3%

2.9 Summary of Fuel Switching Impacts

Act 129 allows EDCs to achieve electric savings by converting electric equipment to non-electric equipment. Table 2-13 summarizes key fuel switching metrics to date in Phase III.

Table 2-13. Fuel Switching Summary

Fuel Switching Measures Offered	Electric to Fossil Fuel Central Heating Electric to Fossil Fuel Water Heating Custom Commercial Combined Heat and Power (CHP) Custom Commercial HVAC
Fuel Switching Measures Implemented	Electric to Fossil Fuel Central Heating- 151 projects Custom Commercial Combined Heat and Power (CHP) – 1 project Custom Commercial HVAC- 1 project
VTD Energy Savings Achieved via Fuel Switching (MWh/yr)	8,623 MWh/yr
P3TD Increased Fossil Fuel Consumption Due to Fuel Switching Measures (MMBTU/yr)	49,114 MMBTU/yr
P3TD Incentive Payments for Fuel Switching Measures ($1000)	$135,071

2.10 Summary of Cost-Effectiveness Results

TRC benefit-cost ratios are calculated by comparing the total NPV TRC benefits and the total NPV TRC costs. It is important to note that TRC costs are materially different from the EDC spending and rate recovery tables presented later in the report. TRC costs include estimates of the full cost incurred by program participants to install efficient equipment, not just the portion covered by the EDC rebate.

Table 2-14 shows the TRC ratios by program and for the portfolio. The benefits were calculated using gross verified impacts. PY9 benefits and costs are expressed in PY9 dollars as the analysis is completed, using program years that align nominal calendar years values to a program year. Demand Response program costs shown in Tables 2-14 through 2-18 include those incurred for PY9 after the Semi-Annual Report filed Jan. 15, 2018.

Table 2-14. PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Recycling	$3,780	$2,074	1.82	$1,705
Efficient Lighting	$61,090	$13,546	4.51	$47,544
Energy Efficiency Kits and Education	$5,626	$2,032	2.77	$3,594
Energy Efficient Home	$13,939	$16,121	0.86	($2,182)
Home Energy Education	$2,099	$1,623	1.29	$476
Low-Income WRAP [(1)]	$6,473	$9,371	0.69	($2,898)
Student Energy Efficient Education	$2,230	$1,103	2.02	$1,128
Residential (Including Low Income) Subtotal [(2)] [(3)] [(4)]	**$94,958**	**$45,870**	**2.07**	**$49,088**
Non-Residential Subtotal [(2)]	**$100,936**	**$72,573**	**1.39**	**$28,362**
Demand Response	**$6,188**	**$1,491**	**4.15**	**$4,697**
Common Portfolio Costs	-	**$8,652**	-	**($8,652)**
Portfolio Total	**$202,082**	**$128,586**	**1.57**	**$73,495**

[(1)] Programs with unverified savings do not include verified or associated participant measure costs in cost-effectiveness.
[(2)] Total may not match sum of rows due to rounding.
[(3)] Low-income is shown as a sub-sector of residential in this table.
[(4)] Residential and Portfolio Total benefits do not match sum of rows due to the exclusion of 5,938 MWh/yr and 0.93 MW of Home Energy Education uplift savings from both the residential total and portfolio total to avoid double-counting.

Table 2-15 presents PY9 cost-effectiveness using net verified savings to calculate benefits. Net savings for each program are calculated by multiplying the NTG ratios determined for the program sample to the program verified energy savings. The adjustment for net savings impacts the total energy savings, secondary energy savings, participant measure costs (reducing measure costs by NTGR), and operations and maintenance (O&M) benefits.

Table 2-15. PY9 Net TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Recycling	$2,495	$2,074	1.20	$420
Efficient Lighting	$50,705	$12,623	4.02	$38,082
Energy Efficiency Kits and Education	$5,626	$2,032	2.77	$3,594
Energy Efficient Home	$9,482	$12,153	0.78	($2,671)
Home Energy Education	$2,099	$1,623	1.29	$476
Low-Income WRAP (1)	$6,473	$9,371	0.69	($2,898)
Student Energy Efficient Education	$2,230	$1,103	2.02	$1,128
Residential (Including Low Income) Subtotal (2) (3) (4)	**$78,831**	**$40,979**	**1.92**	**$37,852**
Non-Residential Subtotal (2)	**$71,906**	**$53,374**	**1.35**	**$18,532**
Demand Response	**$6,188**	**$1,491**	**4.15**	**$4,697**
Common Portfolio Costs	**-**	**$8,652**	**-**	**($8,652)**
Portfolio Total	**$156,926**	**$104,497**	**1.50**	**$52,429**

(1) Programs with unverified savings do not include verified or associated participant measure costs in cost-effectiveness.
(2) Total may not match sum of rows due to rounding.
(3) Low-income is shown as a sub-sector of residential in this table.
(4) Residential and Portfolio Total benefits do not match sum of rows due to the exclusion of 5,938 MWh/yr and 0.93 MW of Home Energy Education uplift savings from both the residential total and portfolio total to avoid double-counting.

Table 2-16 summarizes cost-effectiveness by program for Phase III of Act 129. Benefits and costs are expressed in PY8 dollars.

Table 2-16. P3TD Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits-Costs)
Appliance Recycling	$7,544	$3,872	1.95	$3,672
Efficient Lighting	$130,471	$27,373	4.77	$103,098
Energy Efficiency Kits and Education	$7,607	$3,782	2.01	$3,825
Energy Efficient Home	$19,127	$27,293	0.70	($8,167)
Home Energy Education	$3,561	$2,353	1.51	$1,208
Low-Income WRAP (1)	$6,918	$12,719	0.54	($5,801)
Student Energy Efficient Education	$3,837	$1,929	1.99	$1,908
Residential (Including Low Income) Subtotal (2) (3) (4)	**$178,805**	**$79,321**	**2.25**	**$99,483**
Non-Residential Subtotal (2)	**$178,371**	**$132,922**	**1.34**	**$45,450**
Demand Response	**$5,749**	**$2,032**	**2.83**	**$3,717**
Common Portfolio Costs	**-**	**$15,661**	**-**	**($15,661)**
Portfolio Total	**$362,925**	**$229,936**	**1.58**	**$132,989**

(1) Programs with unverified savings do not include verified or associated participant measure costs in cost-effectiveness.
(2) Total may not match sum of rows due to rounding.
(3) Low-income is shown as a sub-sector of residential in this table.
(4) Residential and Portfolio Total benefits do not match sum of rows due to the exclusion of 5,938 MWh/yr and 0.93 MW of Home Energy Education Uplift savings excluded from both the residential total and portfolio total to avoid double counting.

Table 2-17 presents P3TD cost-effectiveness results using net verified savings to calculate benefits. Benefits and cost are expressed in PY8 dollars. Net savings for each program are calculated by multiplying the NTG ratios determined for the program sample to the program verified energy savings. The adjustment for net savings impacts the total energy savings, secondary energy savings, participant measure costs, and O&M benefits. As noted in Table 2-7, NTG ratios determined in PY8 were used for some programs.

Table 2-17. P3TD Net TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Recycling	$4,963	$3,872	1.28	$1,091
Efficient Lighting	$108,290	$24,890	4.35	$83,400
Energy Efficiency Kits and Education	$7,607	$3,782	2.01	$3,825
Energy Efficient Home	$12,883	$20,417	0.63	($7,534)
Home Energy Education	$3,561	$2,353	1.51	$1,208
Low-Income WRAP (1)	$6,918	$12,719	0.54	($5,801)
Student Energy Efficient Education	$3,837	$1,929	1.99	$1,908
Residential (Including Low Income) Subtotal (2) (3) (4)	**$147,800**	**$69,963**	**2.11**	**$77,837**
Non-Residential Subtotal (2)	**$132,878**	**$102,146**	**1.30**	**$30,732**
Demand Response	**$5,749**	**$2,032**	**2.83**	**$3,717**
Common Portfolio Costs	**-**	**$15,661**	**-**	**($15,661)**
Portfolio Total	**$286,427**	**$189,802**	**1.51**	**$96,625**

(1) Programs with unverified savings do not include verified or associated participant measure costs in cost-effectiveness.
(2) Total may not match sum of rows due to rounding.
(3) Low-income is shown as a sub-sector of residential in this table.
(4) Residential and Portfolio Total benefits do not match sum of rows due to the exclusion of 5,938 MWh/yr and 0.93 MW of Home Energy Education Uplift savings excluded from both the residential total and portfolio total to avoid double counting.

2.11 Comparison of Performance to Approved EE&C Plan

Table 2-18 presents P3TD expenditures, by program, compared to the projected budget estimates set forth in the EE&C plan through PY9. All dollars are presented in PY9 dollars.

Table 2-18. Comparison of P3TD Expenditures to Phase III EE&C Plan ($1,000)

Program	Phase III Budget from EE&C Plan through PY9	Phase III Actual Expenditures through PY9	Ratio (Actual/Plan)
Appliance Recycling	$4,221	$4,019	95%
Demand Response	$4,719	$2,383	51%
Efficient Lighting	$23,873	$21,278	89%
Energy Efficiency Kits and Education	$2,670	$3,926	147%
Energy Efficient Home	$10,228	$11,080	108%
Home Energy Education	$3,605	$2,468	68%
Low-Income WRAP	$14,872	$13,383	90%
Non-Residential Energy Efficiency	$37,619	$28,480	76%
Student Energy Efficient Education	$2,513	$2,007	80%
Total Direct Program Costs(2)	**$104,318**	**$89,025**	**85%**
Common Portfolio Costs(1)	$17,240	$16,273	94%
Portfolio Total (2)	**$121,558**	**$105,298**	**87%**

(1) Common costs include SWE costs.
(2) Total may not match sum of rows due to rounding.

Table 2-19 compares Phase III verified gross program savings to the energy savings projections filed in the EE&C plan.

Table 2-19. Comparison of Phase III Actual Program Savings to EE&C Plan Projections for Phase III

Program	EE&C Plan through PY9	VTD Gross MWh/Yr Savings through PY9	Ratio (Actual/Plan)
Appliance Recycling	25,854	22,575	87%
Efficient Lighting	187,206	274,247	146%
Energy Efficiency Kits and Education	14,770	21,049	143%
Energy Efficient Home	17,298	28,746	166%
Home Energy Education	81,224	70,654	87%
Low-Income WRAP	22,465	17,075	76%
Non-Residential Energy Efficiency	270,190	305,950	113%
Student Energy Efficient Education	10,359	10,562	102%
Adjustment for Residential Energy-Efficiency Behavior and Education (1)		(10,333)	
Portfolio Total(2)	**629,365**	**740,525**	**118%**

(1) The adjustment subtracts savings attributed to program uplift to avoid double counting.
(2) Total may not match sum of rows due to rounding.

The reasons program savings varied from projections estimated in the EE&C Plan are these:

- **Appliance Recycling (residential sector).** The Appliance Recycling Program achieved 84% of projected energy savings. Although the overall number of recycled units was higher than planned, the number of recycled refrigerators and freezers did not meet projections. The additional recycled units were all room air conditioners and dehumidifiers, both of which have lower per-unit savings than refrigerators and freezers. Starting in PY9, instead of using PA TRM defaults, Cadmus used EDC-gathered data for all open variables in the PA TRM savings equations as well as part-use factors for refrigerators and freezers. This resulted in lower per-unit savings compared to previous years.
- **Demand Response.** PPL Electric Utilities' Demand Response Program achieved demand savings that were 11.7 MW or 10% greater than projected (115 MW). The primary reason was that the implementation conservation service provider (ICSP) scheduled more nominal demand response capacity than 115 MW because of uncertainty about the performance of some participants. PY9 was the first year of the program, and it was not known how some participants would perform. Most participants provided demand savings close to their nominal capacity, causing demand savings to exceed the projected amount.
- **Efficient Lighting (residential sector).** The Efficient Lighting Program achieved 140% of its projected energy savings for PY9. The realization rate of 100% is the result of *ex post* adjustments to update the cross-sector bulb sales proportion and baseline adjustments for some bulb types.
- **Energy Efficiency Kits and Education (residential low-income sector).** The program savings achieved 154% of the estimated projections for PY9, primarily because the ICSP distributed

5,203 more kits than the 8,000 kits estimated in the EE&C Plan for PY9. PPL Electric Utilities and the ICSP made the decision to send more kits to boost the savings in the low-income sector. Kits will be phased out altogether in PY12.

- **Energy Efficient Home (residential sector).** The program exceeded its projected energy savings for the year, achieving 189% of the estimated projections. This is largely due to projected and reported savings being much lower than verified for the program in Phase III. The program also added a new measure, dehumidifiers, in PY9, which increased savings for the efficient equipment component.
- **Home Energy Education (residential sector).** Cadmus verified 88% of the estimated projections for PY9. The ICSP and home energy reports vendor stopped treatment for low-propensity customers at the beginning of Phase III, anticipating that a new wave of customers (the Phase III Expansion wave), specifically selected to optimize savings, would offset the loss of savings. However, average daily savings for the new wave were lower than expected in PY8 (0.1 kWh/day per treated customer, or 0.3% of consumption) and remained lower than expected in PY9, although savings increased from the previous year (0.3 kWh/day per treated customer, or 0.7% of consumption).
- **Low-Income WRAP (residential low-income sector).** The program's verified savings met 126% of estimated savings projected for PY9. The realization rate of 82% is the result of differences in reported and evaluated ISRs for six products and energy education.[13] The program-verified savings were better than the projections because PPL Electric Utilities estimated treating about 7,000 WRAP participants per year, but the program ended PY9 with 12,242 WRAP participants.[14]
- **Non-Residential.** The Non-Residential Energy Efficiency Program exceeded its projected energy savings for the year, achieving 119% of the estimated projections for PY9. The following factors affected the program's progress toward the estimated savings projected for PY9:
  - The Lighting and Equipment components achieved verified savings of 85% of total program projected savings for PY9, at a realization rate of 98%.
  - The Custom component achieved verified energy savings that contributed 22% of projected savings for PY9, at a realization rate of 106%.
  - The Midstream component contributed verified savings of 12% to the program, at a realization rate of 79%.
  - The GNE sector rebates were put on a waitlist in January 2018 because participation rates were higher than expected in the first two years of Phase III.

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13 The six productes are LEDs, LED nightlights, efficient showerheads, smart strips, and kitchen and bathroom aerators

14 Total number for participants counts each master-metered multifamily building as a single participant, according to the program's definition of participant. Thirty-two master-metered multifamily buildings participated in WRAP in PY9. WRAP jobs were completed in 1,818 units in these buildings.

- **Student Energy Efficient Education (residential sector)**. The Student Energy Efficient Education Program exceeded its projected energy savings for the year, achieving 116% of the estimated projections for PY9. Participation was greater (24,214 participants) than planned (24,000 participants).

Program Changes Under Consideration

The following program changes are being considered based on observations in PY9:

- **Energy Efficiency Kits and Education.** Beginning in PY10, the low-income ICSP has restructured the contents of the kits to improve the cost per kWh. Additionally, kit distribution will be limited to PY8 through PY11 and will not be part of the program in PY12.
- **WRAP.** Because of budget constraints, PPL Electric Utilities will no longer provide refrigerator replacements, heat pump water heaters, dehumidifiers, or air conditioners (change was effective in early 2018).
- **Energy Efficient Home.** New measures for PY10 include air source heat pump (ASHP) tune-up, duct sealing, and a bonus incentive for completing insulation, duct sealing, or air sealing within 90 days of a qualifying HVAC installation. This will encourage customer understanding of how HVAC system performance and energy savings can be impacted by mitigating energy loss through leaks.
- **Student Energy Efficient Education**. In PY10, the program will reduce the number of middle school participants in favor of adding Tier 2 advanced power strips to half of the high school kits. This change means the additional cost of the more advanced power strips can be budget-neutral. In addition, LED nightlights will be distributed to teachers later in the school year as a follow-up to the kits distributed earlier to help keep the program fresh in their minds.
- **Home Energy Education.** The program will be modified in PY10 (starting near the end of PY9) to include resuming treatment of the low propensity customers who were dropped from the program in PY8 and electronic treatment of the low-income waves.

PPL Electric Utilities plans to introduce these pilots:

- **Instant Rebate Pilot for Heat Pump Water Heaters.** This pilot aims to demonstrate a cost-effective program design that eliminates the additional steps typically required for rebate applications. PPL Electric Utilities customers will be able to immediately validate their utility account information through a mobile-friendly website portal and generate a unique coupon code that instantly reduces the purchase price of a heat pump water heater at checkout.
- **PPL Electric Utilities Online Marketplace.** This pilot aims to demonstrate a cost-effective, convenient e-commerce opportunity that gives PPL Electric Utilities customers the flexibility and convenience of experiencing repeat or new products, at a discounted price, courtesy of PPL Electric Utilities. The online marketplace will support data collection and analysis to compare customer interest in different products, prices, and trends.

2.12 Summary of Process Evaluation Results

This section summarizes program satisfaction and net promoter score results gathered from the participant surveys. Table 2-20 lists the programs for which Cadmus conducted participant surveys in PY9 and the number of respondents who answered the program satisfaction question. Details on each program's survey methodology are provided in the program chapters and their respective appendices.

Table 2-20. PY9 Participant Surveys and Program Satisfaction Response Counts

Sector and Program	Survey Mode	Targeted Number of Completed Surveys	Number of Satisfaction Responses (1)
Residential Sector			**19,206**
Appliance Recycling	Telephone	0	612
	Online	All records (4,355)	
Energy Efficient Home Equipment	Telephone	195	1,197
	Online	All records (4,054)	
Energy Efficient Home Weatherization	Online	All records (307)	
Energy Efficient Home In-home Audit	Online	All records (88)	
Energy Efficient Home Online Assessment	Online	All records (5,687)	
Energy Efficient Home New Homes	Telephone	0	
Home Energy Education Treatment	Telephone	250	530
	Online	250	
Student Energy Efficient Education	Home Energy Worksheets	All records (5,597)	16,867
Non-Residential Sector			**106**
Continuous Energy Improvement	Telephone	4	4
Custom	Telephone and Online	All records (69)	25
Efficient Equipment	Telephone and Online	68	65
Midstream Lighting	Telephone	17	12
Low-Income Sector			**1,559**
Energy Efficiency Kits and Education	Returned Kit Surveys	All records (13,203)	1,332
	Telephone		
Low-Income WRAP	Telephone	224	227
Demand Response			**10**
Demand Response	Telephone	10	10
Portfolio			**20,881**

(1) Includes completed and partially completed surveys. Not all survey respondents answered the program satisfaction question because respondents can refuse to answer.

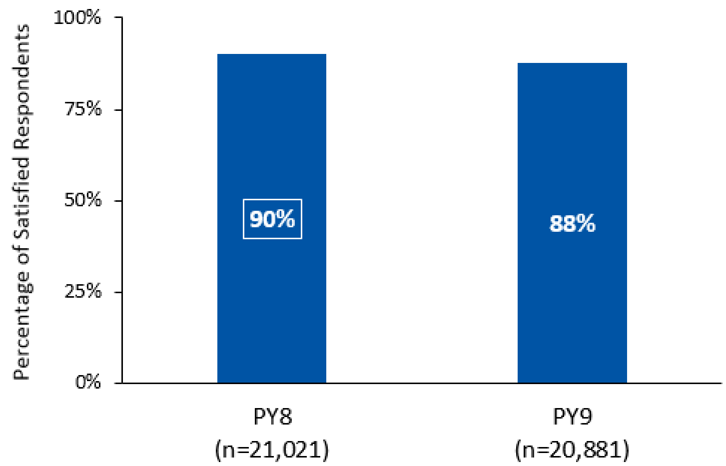
Cadmus asked respondents how satisfied they were with the program overall, using a 5-point word scale from *very satisfied* to *not at all satisfied* with a neutral midpoint. Cadmus combined the percentages of respondents who rated their satisfaction with the program as *very satisfied* or *somewhat satisfied* and computed a straight average of all programs to determine the portfolio-level and sector-level program satisfaction results.

2.12.1 Portfolio-Level Program Satisfaction

Figure 2-10 shows that as a portfolio-level average, PY9 achieved high program satisfaction. However, PY9 showed a significant decrease in program satisfaction (88%) from PY8 (90%).[15] As shown in the next section, PY9 program satisfaction decreased from PY8 in the low-income and residential sectors, contributing to the overall portfolio decrease in PY9.

Figure 2-10. Portfolio-Level Program Satisfaction

Very and *Somewhat Satisfied* Combined



The percentage in the white box indicates that the difference between PY8 and PY9 is statistically significant, p≤0.05.

Note: The program satisfaction results include all responses to the satisfaction question.

Source: Participant survey question, "How would you rate your overall satisfaction with the program?"

2.12.2 Program Satisfaction by Sector

For Phase III, PPL Electric Utilities established a sector-level satisfaction goal to achieve 80% or greater of *very satisfied* and *somewhat satisfied* customers.[16] As shown in Figure 2-11, respondents across all three sectors and the Demand Response Program showed high program satisfaction and exceeded the customer satisfaction goal of 80% or greater. The nonresidential sector achieved the highest percentage of satisfied respondents at 95% (n=106), compared to 94% for the low-income (n=1,559), 84% for the residential sector (n=19,206), and 80% for the Demand Response Program (n=10).

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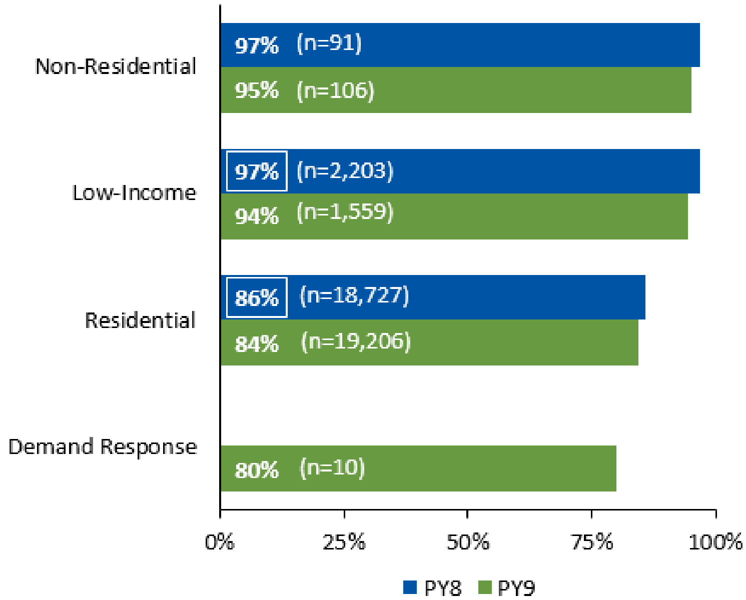
15 Difference is statistically significant, p≤0.05.

16 The customer satisfaction goal is stipulated in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642) filed with the Pennsylvania PUC December 2017.

Figure 2-11. PY9 Program Satisfaction by Sector

Very and *Somewhat Satisfied* Combined



The percentage in the white box indicates that the difference between PY8 and PY9 is statistically significant, p≤0.05.

Note: The program satisfaction results include all responses to the satisfaction question.

Source: Participant survey question, "How would you rate your overall satisfaction with the program?"

All three sectors in PY9 observed a decrease in program satisfaction from PY8. In particular, the low-income and residential sectors showed significant decreases. The PY9 non-residential sector showed a 2% decrease in satisfied respondents from PY8 (97%, n=91), though not a statistically significant decrease. The low-income sector showed a significant 3% decrease in satisfied respondents from PY8 (97%, n=2,203). The residential sector showed a significant 2% decrease from PY8 (86%, n=18,727).

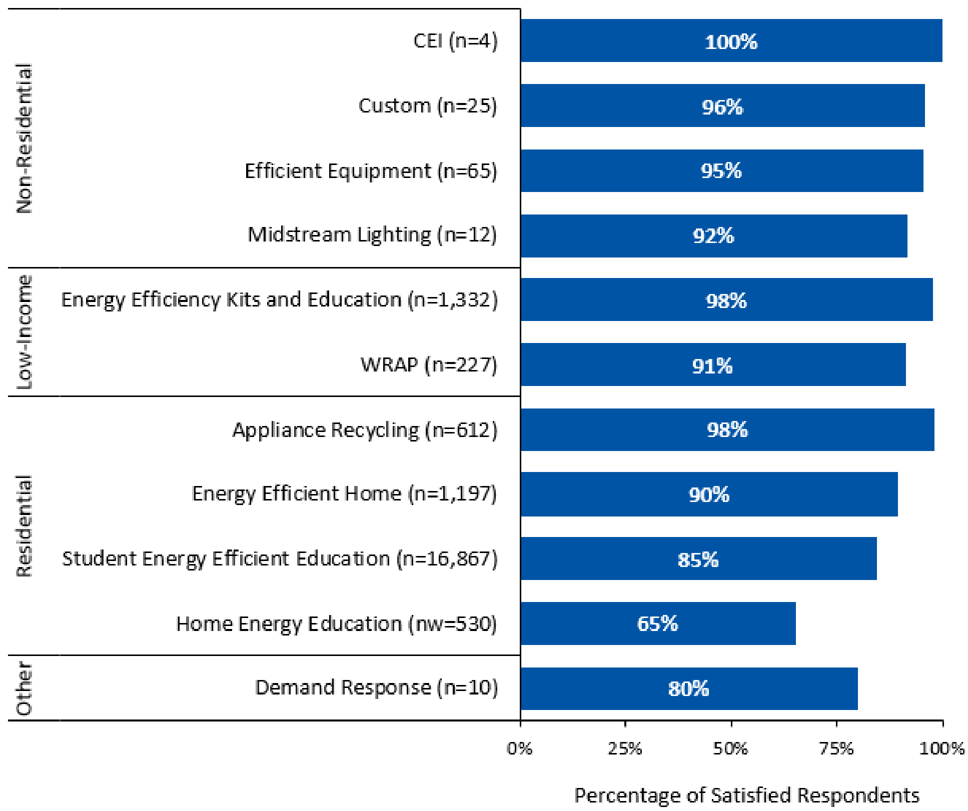
2.12.3 Program Satisfaction by Individual Program

Figure 2-12 shows the satisfaction results for each program. Among the non-residential programs, all four programs achieved high satisfaction, especially the Continuous Energy Improvement Program (100%, n=4). Both low-income programs achieved very high satisfaction, especially the Energy Efficiency Kits and Education Program (98%, n=1,583). Except for the Home Energy Education Program, all residential programs achieved high satisfaction. The Appliance Recycling Program achieved the highest satisfaction (98%, n=612). The Home Energy Education Program had the lowest satisfaction (65%, n=532); this type of program typically receives some of the lowest satisfaction scores because of the opt-out participation design and it does not offer the incentives that traditional rebate programs offer.

Further details on each program's satisfaction results are provided in the individual program chapters.

Figure 2-12. PY9 Program Satisfaction by Individual Program

Very and *Somewhat Satisfied* Combined



Notes: The program satisfaction results include all responses to the satisfaction question. Home Energy Education uses the notation nw to indicate that survey results were weighted.

Source: Participant survey question, "How would you rate your overall satisfaction with the program?"

2.12.4 Net Promoter Scores

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. The passives are excluded from the calculation. An excellent NPS is 50 and above.[17]

Participant surveys from seven of the programs asked the NPS question. As shown in Table 2-21, all programs except Home Energy Education achieved an excellent NPS. According to Cadmus' research and evaluation of other similar behavior programs, this is not atypical. Home energy report programs like the

[17] Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

Home Energy Education Program often experience a lower NPS than traditional rebate programs, possibly due to its opt-out program design.

Table 2-21. PY9 Net Promoter Score by Program

Program	Count of Respondents (n)	NPS
Appliance Recycling	603	89
Custom	25	84
Continuous Energy Improvement	4	75
Efficient Equipment	64	73
Energy Efficient Home	1,197	53
Home Energy Education	528	-14
Low-Income WRAP	219	70
Source: Participant survey question, “How likely is it that you would recommend the program to a friend, family member, or colleague? Use a 0 to 10 scale where 10 is *extremely likely* and 0 is *not at all likely*.		

2.13 Findings and Recommendations

The impact and process evaluation activities completed by Cadmus led to recommendations for program improvement. Cadmus does not have any overarching recommendations that affect more than one program.

3 Evaluation Results by Program

This chapter documents the gross impact, net impact, and process evaluation activities conducted in PY9 along with the outcomes of those activities. The list of programs is organized by the largest contributor to PY9 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.

Table 3-1 lists the activities for each program in PPL Electric Utilities' portfolio.

Table 3-1. PY9 Evaluation Activity Matrix

Program	Sector	Gross	Net	Process
Appliance Recycling	Residential	✓		✓
Demand Response	Demand Response	✓		✓
Energy Efficient Home	Residential	✓	✓	✓
Energy Efficiency Kits and Education	Low-Income	✓		✓
Efficient Lighting	Residential	✓		✓
Home Energy Education	Residential	✓		✓
Non-Residential Energy Efficiency	Nonresidential	✓	✓	✓
Student Energy Efficient Education	Residential	✓		✓
Winter Relief Assistance Program	Low-income	✓		✓

3.1 *Impact Evaluation*

Impact evaluation activities varied by program in PY9. More detailed explanations of each programs' impact evaluation methodology and analyses are contained in the program chapters and their respective appendices. The main activities that Cadmus, the evaluation, measurement, and verification conservation service provider (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 3-2 lists the impact evaluation activities conducted for each program in PY9 along with the number of site visits conducted for each program. The individual program chapters discuss the impact evaluation activities, methodology, and findings.

Table 3-2. PY9 Impact Evaluation Activities by Program

Program	Impact Evaluation Activity					
	Database Review	Records Review	Site Visits (1)	Metering	Engineering Analysis	Billing Analysis
Appliance Recycling	✓	✓			✓	
Demand Response	✓	✓				✓
Energy Efficient Home	✓	✓			✓	
Energy Efficiency Kits and Education	✓	✓			✓	
Efficient Lighting	✓	✓			✓	
Home Energy Education	✓	✓				✓
Low-Income Winter Relief Assistance Program (WRAP)	✓	✓			✓	
Non-Residential - Continuous Energy Improvement	✓	✓				✓
Non-Residential - Custom	✓	✓	33	✓	✓	✓
Non-Residential - Efficient Equipment	✓	✓	107 (2)	✓	✓	
Non-Residential - Midstream Lighting	✓	✓	37 (3)	✓	✓	
Student Energy Efficient Education	✓	✓			✓	

(1) Site visits completed by Cadmus.
(2) Includes 25 equipment visits and 82 lighting visits.
(3) The 37 site visits accounts for 110 projects.

3.2 Process Evaluation

This section summarizes the process evaluation of PPL Electric Utilities' PY9 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 PY9. Cadmus conducted these main activities:

- Program staff and ICSP interviews
- Participant surveys
- Treatment surveys
- Surveys and interviews of vendors, contractors, manufacturers, and others
- Focus groups
- Logic model reviews

Each program assessment is discussed in more detail in individual chapters of this report. The chapters discuss the findings from the program-specific evaluation activities and note any modifications to these activities from Cadmus' approved evaluation plans.

Table 3-3 lists the process evaluation activities conducted for each program in PY9 along with the total number of survey and interview respondents reached for each program. A more detailed explanation of each programs' survey methodology is in the program chapters and their respective appendices.

Table 3-3. PY9 Process Evaluation Activities by Program

Program	Process Evaluation Activity							
	Completed Participant Survey (1)	Logic Model Review	Participant Satisfaction Analysis	Stakeholder Interview	Trade Ally Interview	Market Actor Interview	Secondary Research	Focus Group
Appliance Recycling	612		✓	✓				
Demand Response	10	✓	✓	✓				
Energy Efficient Home	1,197 (2)	✓	✓	✓				
Energy Efficiency Kits and Education	1,577 (3)	✓	✓	✓			Benchmarking	
Efficient Lighting				✓				
Home Energy Education	532	✓	✓	✓			Benchmarking	
Low-Income Winter Relief Assistance Program (WRAP)	228	✓	✓	✓	3	7 (10)		
Non-Residential - Continuous Energy Improvement	4	✓	✓	✓				
Non-Residential - Custom	26	✓	✓	✓				
Non-Residential - Efficient Equipment	69 (4)	✓	✓	✓	10 (5)			
Non-Residential - Midstream Lighting	54 (6)	✓	✓	✓			Segmentation analysis	
Student Energy Efficient Education	17,223 (7)		✓	✓		6 (8)		✓ (9)
Total	**21,532**				13	13		

(1) Includes all survey modes: online, telephone, and paper. For additional detail see program chapter and appendix.
(2) Includes 460 efficient equipment, 7 in-home audit, 689 online assessment, and 41 weatherization surveys.
(3) Includes 1,347 paper surveys administered by the ICSP and 230 surveys administered by Cadmus.
(4) Includes 9 equipment, 24 direct discount lighting, and 36 prescriptive lighting surveys.
(5) Includes 5 equipment contractors and 5 lighting contractors.
(6) Includes 12 distributors, 15 end-user purchasers, 15 contractor purchasers, and 12 end-user non-purchasers.
(7) Includes 17,223 paper and online home energy worksheets administered by the ICSP.
(8) Includes teachers who participated in 2016-2017 but not in 2017-2018.
(9) Includes 7 Take Action and Take Action Pilot teachers and 8 Innovation and Innovation Pilot teachers.
(10) Includes 4 master-metered multifamily property managers and 3 manufactured home park property managers.

4 Non-Residential Energy Efficiency Program

PPL Electric Utilities' Non-Residential Energy Efficiency Program offers financial incentives to customers in a nonresidential rate class and for any building or business type. The program comprises four distinct components—Efficient Equipment, Midstream Lighting, Custom, and Continuous Energy Improvement (CEI). For the purpose of this evaluation, Cadmus treated each of these components as an individual program offering and designed a distinct set of data collection activities and research methodologies.

Descriptions of the Non-Residential Energy Efficiency Program components and the evaluation methodology, findings, conclusions and recommendations for each are provided in separate chapters.

- **Chapter 5 Non-Residential Efficient Equipment** component offers prescriptive rebates and direct discounts to small businesses for lighting and equipment products.
- **Chapter 6 Non-Residential Midstream Lighting** component offers incentives to distributors of efficient lighting products for eligible products sold to PPL Electric Utilities' customers.
- **Chapter 7 Non-Residential Custom** provides financial incentives to customers who install products or services that are not offered in PPL Electric Utilities' other programs.
- **Chapter 8 Non-Residential Continuous Energy Improvement** (CEI) initiative provides technical support for schools to develop and implement a strategic energy management plan (SEMP).

The objectives of the Non-Residential Energy Efficiency Program are these:[18]

- 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
- Encourage customers to take a comprehensive, whole-facility approach to energy efficiency by installing high-efficiency custom measures or processes
- Encourage qualifying equipment repairs, optimization, and operational or process changes that reduce electricity consumption
- Increase customer awareness of the features and benefits of energy-efficient 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, or ENERGY STAR Buildings
- Engage trade allies to stock, promote, and provide high-efficiency technology options to customers

[18] Program objectives are stipulated on PPL Electric Utilities Corporation. *Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642 Compliance Filing before the Pennsylvania Public Utility Commission. December 2017

- Promote other PPL Electric Utilities energy efficiency programs
- Collect energy and operating data from customers, as required to confirm customer and measure eligibility, and to determine energy savings and cost-effectiveness
- Obtain participation necessary to achieve approximately 810,810 MWh/year gross verified savings
- Achieve high customer and trade ally satisfaction with the program

4.1 Progress Toward Phase III Projected Savings

The Phase III EE&C plan specifies projected savings for the Non-Residential Energy Efficiency Program,[19] which provides for qualified energy efficiency equipment and custom projects that are not included in PPL Electric Utilities' other programs, combined heat and power (CHP), continuous energy improvement (CEI), and other improvements. It is possible for an individual customer to have multiple participating projects across more than one program component.

During the five program years of Phase III, the combined offerings in the Non-Residential Energy Efficiency Program are expected to reduce electricity consumption by 810,810 MWh/yr and 136 MW/yr. The program's verified savings are 119% of the projected MWh/yr savings for PY9. The program has achieved 38% of the projected Phase III total planned savings.

Table 4-1 shows the Non-Residential Energy Efficiency Program's verified gross savings and progress toward its Phase III projected energy savings across all components, as filed in the EE&C plan.

Table 4-1. Non-Residential Energy Efficiency Program Savings

	PY8 Only	PY9 Only				Phase III: PY8–PY12			
	Verified (MWh/yr)	Projected (1)	Verified	Percentage of Projected	Unverified Savings (2)	Projected (1)	Verified	Percentage of Projected	Unverified Savings
MWh/yr	143,573	136,853	162,377	119%	5	810,810	305,950	38%	5

(1) Projected savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.
(2) Unverified savings are from Midstream Lighting.

4.2 Gross Impact Evaluation

The impact and process evaluation findings for each non-residential component are described in their individual chapters. Table 4-2 presents the participation counts, reported and verified energy and demand savings, and incentive payments across all components of the Non-Residential Energy Efficiency Program in PY9 by customer segment.

19 PPL Electric Utilities Corporation. *Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642. December 2017.

Table 4-2. PY9 Non-Residential Energy Efficiency Participation and Reported Impacts

Parameter	GNE	Large C&I (Non-GNE)	Residential	Small C&I (Non-GNE)	Total[1]
PYTD # Participants	1,535	511	263	3,617	**5,926**
PYRTD MWh/yr	27,857	64,815	972	73,866	**167,510**
PYRTD MW/yr	3.95	7.90	0.09	10.27	**22.22**
PYVTD MWh/yr	27,188	63,857	979	70,353	**162,377**
PYVTD MW/yr	4.47	8.45	0.07	9.68	**22.67**
PY9 Incentives ($1000)	$1,936	$2,970	$53	$3,203	**$8,162**
[1]Total may not match sum of columns due to rounding.					

Cadmus calculated gross verified savings using data from the PPL Electric Utilities tracking database and from a combination of evaluation activities, including records review, site visits, and billing analysis. Table 4-3 shows the gross energy savings realization rates for the components of the Non-Residential Energy Efficiency Program in PY9.

Table 4-3. PY9 Non-Residential Energy Efficiency Gross Energy Savings Realization Rates by Component

Component	Energy Savings Realization Rate [1]	PYRTD MWh/yr
Efficient Equipment - Lighting	99%	114,094
Efficient Equipment - Equipment	79%	4,536
Midstream Lighting	79%	19,930
Midstream Lighting (Unverified)	N/A	5
Custom	106%	28,222
Continuous Energy Improvement	89%	723
Total [2] [3]	**97%**	**167,510**
[1] Realization rate is calculated based on total reported savings that exclude 5 MWh/yr of unverified savings for the Midstream Lighting component. [2] May not sum due to rounding. [3] Weighted by PY9 program verified gross energy savings.		

Reviewing savings accomplishments of the Non-Residential Energy Efficiency Program across the individual components reported in Table 4-3:

- The Lighting and Equipment portion of the Efficient Equipment Program had a combined total for gross verified energy savings of 115,994 MWh/yr, at a realization rate of 97.8%.
- The Midstream Lighting and Efficient Equipment Lighting (including prescriptive rebate and direct discount lighting) components had a combined realization rate of 95.3% across all Non-Residential lighting rebates.
- The Efficient Equipment component (including Lighting and Equipment) and the Midstream Lighting component had a combined realization rate of 94.8%.

Table 4-4 and Table 4-5 show the Non-Residential Energy Efficiency Program's PY9 total reported energy savings and demand reduction, respectively.

Table 4-4. PY9 Non-Residential Energy Efficiency Gross Impact Results for Energy

	PYRTD MWh/yr	Energy Realization Rate (1)	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Program Total	**167,510**	**97%**	**N/A**	**11.19%**

(1) Realization rate is calculated based on total reported savings that excludes 5 MWh/yr of unverified savings for the Midstream Lighting component.

Table 4-5. PY9 Non-Residential Energy Efficiency Gross Impact Results for Demand

	PYRTD MW/yr	Demand Realization Rate (1)	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Program Total	**22.22**	**102%**	**N/A**	**10.59%**

(1) Realization rate is calculated based on total reported savings that excludes 5 MWh/yr of unverified savings for the Midstream Lighting component.

4.3 Net Impact Evaluation

Table 4-6 shows the NTG ratios for the Non-Residential Energy Efficiency Program components in PY9.

Table 4-6. PY9 Non-Residential Energy Efficiency NTG Ratios by component

Component	NTG Ratio	Program Verified Gross MWh/yr	Percentage of Total Program Verified Gross MWh/yr
Efficient Equipment	0.69	115,994	71%
Custom	0.73	29,827	18%
Midstream Lighting	0.85	15,915	10%
Continuous Energy Improvement (1)	-	641	0%
Total (2) (3)	**0.71**	**162,377**	**100%**

(1) Data collected in PY9 was not sufficient to estimate net savings, so it is not calculated for PY9. If an NTG ratio is developed as part of PY10 activities, it will be applied to the PY9 verified gross savings and the resulting PY9 net savings will contribute to the phase-to-date net savings reported in PY10.
(2) Weighted by PY9 program verified gross energy savings.
(3) May not sum due to rounding.

4.4 Verified Savings Estimates

Table 4-7 shows the reported energy savings (PYRTD) and verified gross and net energy savings estimates for the Non-Residential Energy Efficiency Program in PY9. These program-year savings are added to savings achieved in previous program years to calculate the P3VTD program impacts for reported, gross verified, and net savings.

Table 4-7. PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PYRTD	167,510	22.22
PYVTD Gross	162,377	22.67
PYVTD Net(2)	114,870	15.87
PY Unverified Savings(1) (2)	5	0.00
P3RTD	315,011	41.34
P3VTD Gross	305,950	41.40
P3VTD Net(3)	227,046	30.49
P3 Unverified Savings(1)	5	0.00

(1) May not match due to rounding.
(2) Unverified savings are for Midstream Lighting.
(3) Net savings are not used to meet PPL Electric Utilities' energy savings compliance target.

4.5 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 4-8. The total resource cost (TRC) benefits were calculated using gross verified impacts. Net present value (NPV) PYTD costs and benefits are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). NPV costs and benefits for P3TD financials are expressed in the PY8 dollars. The TRC costs and benefits in this table do not include costs and benefits from unverified projects.

Table 4-8. Summary of Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$8,162		$16,454	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$57,046		$103,711	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	$65,210		$120,165	
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$151	-	$408	-
7	Marketing [4]	-	$309	-	$1,199
8	Program Delivery [5]	-	$5,227	-	$9,436
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	$5,687		$11,043	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**$1,676**		**$1,713**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	$72,573		$132,922	
14	Total NPV Lifetime Electric Energy Benefits	$87,558		$152,867	
15	Total NPV Lifetime Electric Capacity Benefits	$14,684		$24,032	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$4,831		$7,174	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	($6,137)		($5,702)	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	$100,936		$178,371	
19	**TRC Benefit-Cost Ratio [9]**	**1.39**		**1.34**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio-level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs.
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 4-9 presents program financials and cost-effectiveness on a net savings basis.

Table 4-9. Summary of Program Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$8,162		$16,454	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$38,302		$72,392	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	$46,464		$89,846	
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$151	-	$408	-
7	Marketing [4]	-	$309	-	$1,199
8	Program Delivery [5]	-	$5,227	-	$9,436
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	$5,687		$11,043	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**$1,224**		**$1,257**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	$53,374		$102,146	
14	Total NPV Lifetime Electric Energy Benefits	$62,222		$103,498	
15	Total NPV Lifetime Electric Capacity Benefits	$10,496		$26,569	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$3,551		$6,864	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	($4,363)		($4,054)	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	$71,906		$132,878	
19	**TRC Benefit-Cost Ratio [9]**	**1.35**		**1.30**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio-level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs.
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

4.5.1.1 Non-Energy Benefits of Natural Gas Savings

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[20] Cadmus developed values for the non-residential programs from the 2014 PA C&I baseline study (as shown in Table 4-10) for the assumptions needed to compute the heating penalty in commercial buildings.

Table 4-10. Non-Residential End Use Penetration and Fuel Shares

End Use	Penetration	Fuel Share				
		Electric	Natural Gas	Fuel Oil	Other(1)	n-values(2)
Lighting	100.0%	100.0%	0.0%	0.0%	0.0%	-
Space Heating(3)	100.0%	6.8%	84.4%	4.3%	4.5%	449
Space Cooling	84.3%	100.0%	0.0%	0.0%	0.0%	-
Plug Load	100.0%	100.0%	0.0%	0.0%	0.0%	-
Refrigeration	35.0%	100.0%	0.0%	0.0%	0.0%	-
Cooking	27.9%	53.3%	42.5%	0.0%	4.2%	659
Water Heating(3)	92.7%	37.8%	56.3%	1.9%	3.8%	540
Other(4)	100.0%	100.0%	0.0%	0.0%	0.0%	-

(1) "Other" fuel share includes LPG, purchase HW or steam, wood, and misc. fuels.
(2) n-values for fuel share only.
(3) Fuel shares for space heating and water heating are based on square footage served and tank capacity, respectively. All others are per premise.
(4) "Other" end use includes pumps, motors, and misc. equipment.
Source: Table 1-5 in *Pennsylvania Statewide Act 129 2014 Non-Residential End Use & Saturation Study*. Submitted to the Pennsylvania Public Utility Commission. Submitted by Nexant, Inc., in partnership with GDS Associates, Research Into Action, and Apex Analytics. April 4, 2014. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/SWE-2014_PA_Statewide_Act129_Non-Residential_EndUse_Saturation_Study.pdf

For the Efficient Equipment Lighting Program, Cadmus used *ex ante* values of the space cooling type provided in PPL Electric Utilities' database and applied these to the population of programs for interior lighting. Cadmus developed a gas heat fuel share for lighting projects based on the PY9 population of prescriptive lighting projects. Exterior lighting and lighting in electric heated and refrigerated spaces were assigned a value of zero for heating penalties.

Table 4-11 gives the summary of therms penalties for non-residential prescriptive lighting projects.

[20] Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

Table 4-11. Non-Residential PY9 Prescriptive Lighting Assumptions and Heating Penalty

Source	Measure Type	Gas Heat Fuel Share (1)	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therm per kWh)	Total Verified kWh	Total Penalty
Cadmus Calculated	Unknown/Non-Electric - Interior	89%	100%	65.50%	20%	0.8	0.01989	9,980,236	-198,507
Cadmus Calculated	Electric - Interior	0%	100%	65.50%	20%	0.8	-	58,510,009	-
Cadmus Calculated	Non-Electric - Interior	100%	100%	65.50%	20%	0.8	0.02235	43,911,824	-981,429

(1) The heat fuel share is calculated as the sum of all non-electric fuel shares in the statewide C&I baseline study.

For the Midstream Program, Cadmus calculated the share of interior lighting from PPL Electric Utilities' database and used the gas heat fuel share for PPL Electric Utilities' lighting projects based on the PY9 population of prescriptive lighting projects, and applied these to the calculation of heating penalties, as shown in Table 4-12.

Table 4-12. Non-Residential PY9 Midstream Lighting Assumptions and Heating Penalty

Source	Measure Type	Gas Heat Fuel Share (1)	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therm per kWh)	Total Verified kWh	Total Penalty
Cadmus Calculated	Lighting	89%	96%	65.50%	20%	0.8	0.01919	15,914,901	-316,551

(1) The heat fuel share is calculated as the sum of all non-electric fuel shares in the statewide C&I baseline study.

ppl

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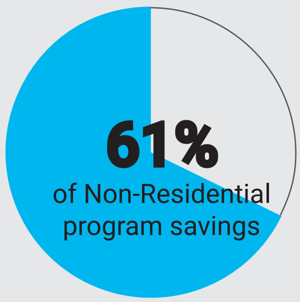
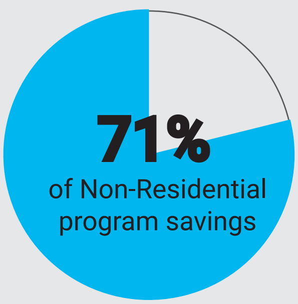
EFFICIENT EQUIPMENT PROGRAM

This program promotes the purchase and installation of high-efficiency equipment and lighting by offering customers financial incentives to offset purchase costs and by providing information on efficiency features and benefits.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **186,911 MWh/yr**





PY9 saved **115,994 MWh/yr**

PY9 PARTICIPATION

A total of **1,125** participants:

819 Prescriptive Lighting

190 Direct Discount Lighting

116 Equipment

PROGRAM SATISFACTION

95% Satisfied with overall program

95% satisfied with **Direct Discount Lighting**

97% satisfied with **Prescriptive Lighting**

88% satisfied with **Equipment**

100% satisfied with **professionalism** of the program representatives

95% satisfied with the **information provided about the application process**

93% satisfied with the **time it took to process their application**

84% satisfied with the **ease of the online application** process

80% satisfied with the **ability to track their rebates**

5 Non-Residential Efficient Equipment Program

The Efficient Equipment component of the Non-Residential Energy Efficiency Program (hereafter referred to as the Efficient 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 and equipment (HVAC, refrigeration, motors, food service, office, and agricultural) through two delivery channels—prescriptive and direct discount.

Prescriptive delivery channel. In the prescriptive delivery channel, the customer installs the equipment, submits the rebate application, and receives the rebate. The customer must obtain preapproval from PPL Electric Utilities before ordering the equipment. For all equipment offered through the Efficient Equipment Program, PPL Electric Utilities provides incentives in the range of $0.02 to $0.17 per annual kWh saved. Incentives may be capped at 50% to 100% of the total project costs (excluding internal labor), with a maximum incentive of $500,000.

Direct discount delivery channel. The direct discount delivery channel was designed to make it easier and more economical for small businesses and institutions to install energy-efficient lighting fixtures and controls, commercial refrigeration equipment and controls, and compressed air system upgrades. This channel does not have a maximum energy savings cap but is limited to small commercial and industrial facilities with GS-1 or GS-3 rate codes. 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. 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 on to the customer.

In this report, projects are referred to as either lighting or equipment (non-lighting).

5.1 Participation and Reported Savings by Customer Segment – Lighting

5.1.1 Definition of a Lighting Participant

A **prescriptive lighting participant** is defined as a unique job initiated by a customer. In PY9, the prescriptive lighting channel had 819 lighting jobs (14,238 individual database records) and 728 unique customers.

A **direct discount lighting participant** is defined as a unique job completed for a unique customer. In PY9, the direct discount lighting channel had 190 jobs (1,923 individual database records) and 185 unique customers. Cadmus evaluated the direct discount lighting jobs as a separate stratum in PY9. In

PY8, Cadmus had grouped the direct discount delivery channel lighting jobs with the prescriptive lighting stratum because the population was so small (only seven jobs).

5.1.2 Program Participation and Reported Impacts for Lighting

Table 5-1 presents the participation counts, reported energy and demand savings, and incentive payments for the lighting portion of the Efficient Equipment Program in PY9, by customer segment.

Table 5-1. Efficient Equipment Program (Lighting) Participation and Reported Impacts

Parameter	GNE	Large C&I	Residential	Small C&I	Total (1)
PYTD # Participants	233	103	19	654	**1,009**
PYRTD MWh/yr	17,144	41,962	53	54,936	**114,094**
PYRTD MW/yr	2.55	5.72	0.01	7.36	**15.63**
PY9 Incentives ($1000) (2)	**$6330**				

(1) May not match due to rounding.
(2) Incentives are tracked at the program level.

5.2 *Gross Impact Evaluation – Lighting*

The evaluation sampling strategy is shown in Table 5-2. See *Appendix D.1.1 Methodology* for additional details.

Table 5-2. Efficient Equipment Program (Lighting) Gross Impact Sample Design for PY9

Stratum	Participants (1)	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Prescriptive Lighting	819	90/10	17	Record review only
			32	Record review and site visit
Direct Discount Lighting	190	90/10	50	Record review and site visit
Program Total	**1,009**		**99**	

(1) A participant is defined as a unique job completed for a unique customer.

In PY9, the lighting portion of the Efficient Equipment Program reported energy savings of 114,094 MWh/yr, as shown in Table 5-3, and demand reduction of 15.63 MW, as shown in Table 5-4. See *Appendix D.1.3 Site Visit Findings – Lighting* for additional information.

Table 5-3. Efficient Equipment Program (Lighting) Gross Impact Results for Energy

Substratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 90% C.L.
Lighting -- Prescriptive Rebate -- Small	9,657	106%	0.13	8.02%
Lighting -- Prescriptive Rebate -- Medium	18,135	91%	0.23	12.03%
Lighting -- Prescriptive Rebate -- Large	30,072	100%	0.14	9.84%
Lighting -- Prescriptive Rebate -- Census	48,013	100%	0.01	0.00%
Lighting -- Prescriptive Rebate	**105,878**	**99%**		**3.03%**
Lighting -- Direct Discount -- Small	1,302	99%	0.03	1.17%
Lighting -- Direct Discount -- Medium	2,751	92%	0.19	9.07%
Lighting -- Direct Discount -- Large	4,164	97%	0.17	3.15%
Lighting -- Direct Discount	**8,216**	**96%**		**3.08%**
Lighting Total (1)	**114,094**	**99%**		**2.85%**
(1) May not match due to rounding.				

Table 5-4. Efficient Equipment Program (Lighting) Gross Impact Results for Demand

Substratum	PYRTD MW	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Lighting -- Prescriptive Rebate -- Small	1.45	91%	0.41	25.29%
Lighting -- Prescriptive Rebate -- Medium	2.36	116%	0.57	30.24%
Lighting -- Prescriptive Rebate -- Large	4.29	108%	0.47	32.81%
Lighting -- Prescriptive Rebate -- Census	6.77	98%	0.04	0.00%
Lighting -- Prescriptive Rebate	**14.87**	**103%**		**9.89%**
Lighting -- Direct Discount -- Small	0.11	91%	0.27	9.73%
Lighting -- Direct Discount -- Medium	0.22	93%	0.21	9.86%
Lighting -- Direct Discount -- Large	0.43	96%	0.13	2.30%
Lighting -- Direct Discount	**0.77**	**95%**		3.15%
Lighting Total (1)	**15.63**	**103%**		**9.54%**
(1) May not match due to rounding.				

5.2.1 Realization Rate for Lighting

Lighting projects achieved 112,402 MWh per year of verified energy savings with an 98.5% energy realization rate. Lighting projects achieved 16,060 kW/yr of verified demand reduction with an 102.7% demand realization rate. The primary contributors to the energy and demand realization rates that were less than 100% were differences in verified versus reported facility type, lower verified custom lighting fixture hours of use, reduced verified existing and/or installed fixture quantities, and differences in verified space conditioning types. Overall, these factors did not have a substantial impact on the verified savings. Table D-7 and Table D-8 in *Appendix D* summarize results of the site visits for the prescriptive and direct discount lighting projects.

5.3 Net Impact Evaluation – Lighting

Common methods used to determine net savings for downstream programs are provided in the Evaluation Framework.[21] Cadmus used self-report surveys, administered online and by phone, to assess free ridership and spillover for this program, and reviewed communication documents for surveyed participants to provide additional context about free ridership (*Appendix D.3 Net Impact Evaluation – Lighting and Equipment)*.

Table 5-5 lists the methods and sampling strategy used to determine net savings for the lighting portion of the Efficient Equipment Program in PY9. Additional details about methodology are in *Appendix D.3 Net Impact Evaluation – Lighting and Equipment*.

Table 5-5. Efficient Equipment Program (Lighting) Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population Size	Achieved Sample Size	NTG Activity
Lighting [1]	Participants	1,009[1]	57[3]	Self-report survey
Program Total		**1,009**	**57**	

[1] Prescriptive lighting and direct discount lighting combined.
[2] Combined population of prescriptive lighting and direct discount lighting participants.
[3] Three of the 60 total respondents did not answer the NTG questions and are not included in the NTG analysis.

Table 5-6 shows the free ridership, spillover, and NTG ratios by program stratum.

Table 5-6. Efficient Equipment Program (Lighting) Net Impact Evaluation Results

Stratum	Number of Surveys	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 90% C.L.	*Ex Post* kWh/yr Gross Population Savings
Lighting	57	31%[1]	0%	0.69	11%	112,402,069
Lighting Total	**57**	**31%**	**0%**	**0.69**	**11%**	**112,402,069**

[1] 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 equipment-level free ridership estimate than do the respondents who achieved lower energy savings.

5.3.1 High-Impact Measure Research

The Phase III Evaluation Framework requires the identification and oversampling of high-impact products and services to assess free ridership with greater certainty.[22] In the Efficient Equipment Program, Cadmus determined that commercial lighting projects contributed greater than 5% of the overall PY9 PPL Electric Utilities savings to the sector and classified commercial lighting as a high-impact measure. For net savings calculations, Cadmus exceeded the evaluation requirement for sampling high-

21 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC. October 21, 2016.

22 Ibid.

impact measures by completing 57 self-report surveys with lighting participants. The relative precision of the high-impact measure NTG estimate is 11% at 90% confidence.

5.4 Verified Savings Estimates – Lighting

In Table 5-7, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the lighting portion of the Efficient Equipment Program in PY9. In future years, these totals are added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 5-7. Efficient Equipment Program (Lighting) PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PYRTD Gross	114,094	15.63
PYVTD Gross	112,402	16.06
PYVTD Net(1)	77,557	11.08
PY Unverified Savings (2)	-	-
P3RTD Gross	183,531	24.94
P3VTD Gross	179,648	25.64
P3VTD Net(1)	129,337	18.45
P3 Unverified Savings (2)	-	-

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.

5.5 Participation and Reported Savings by Customer Segment – Equipment

5.5.1 Definition of an Equipment Participant

An equipment participant is defined as a unique job initiated by a unique customer. A unique customer can submit multiple equipment jobs in different equipment categories (HVAC, refrigeration, motors, food service, office, and agricultural). In PY9, the equipment portion of this program had 116 unique jobs and 104 unique equipment customers (259 database records). All of the PY9 equipment jobs followed the prescriptive delivery channel.

5.5.2 Program Participation and Reported Impacts for Equipment

Table 5-8 presents the participation counts, reported energy and demand savings, and incentive payments for the equipment portion of Efficient Equipment Program in PY9, by customer segment.

Table 5-8. Efficient Equipment Program (Equipment) Participation and Reported Impacts

Parameter	GNE	Large C&I	Residential	Small C&I	Total (1)
PYTD # Participants (2)	30	7	2	77	**116**
PYRTD MWh/yr	878	888	14	2,756	**4,536**
PYRTD MW/yr	0.07	0.04	0.00	0.26	**0.37**
PY9 Incentives ($1000) (3)	**N/A**				

(1) May not match due to rounding.
(2) Participants are defined as a unique job initiated by a unique customer.
(3) Incentives are tracked at the program level.

5.6 Gross Impact Evaluation – Equipment

The evaluation sampling strategy is shown in Table 5-9. See *Appendix D.2.1 Methodology* for additional details.

Table 5-9. Efficient Equipment Program (Equipment) Gross Impact Sample Design for PY9

Stratum	Participation (Unique Jobs)	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Prescriptive Equipment	116	85/15	1	Record review only
			29	Record review and site visit
Total	**116**	**85/15**	**30**	

In PY9, the equipment portion of the Efficient Equipment Program reported energy savings of 4,536 MWh/yr, as shown in Table 5-10, and demand reduction of 0.37 MW, as shown in Table 5-11.

Table 5-10. Efficient Equipment Program (Equipment) Gross Impact Results for Energy

Substratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
HVAC	238	98%	0.06	3.11%
HVAC – Occupancy Sensors	136	12%	N/A	N/A
Motors	2,296	84%	N/A	11.26%
Other (1)	110	100%	0.00	0.00%
Refrigeration	1,755	75%	N/A	25.34%
Total (2)	**4,536**	**79%**	**N/A**	**10.04%**

(1) The *Other* substratum includes agricultural projects.
(2) May not match due to rounding.

Table 5-11. Efficient Equipment Program (Equipment) Gross Impact Results for Demand

Substratum	PYRTD MW	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
HVAC	0.06	93%	0.09	5.24%
HVAC – Occupancy Sensors	0.01	0%	N/A	N/A
Motors	0.12	92%	N/A	1.17%
Other (1)	0.02	100%	0.00	0.07%
Refrigeration	0.16	71%	N/A	34.65%
Total (2)	**0.37**	**80%**	**N/A**	**11.94%**

(1) The *Other* substratum includes agricultural projects.
(2) May not match due to rounding.

5.6.1 Realization Rate for Equipment

Equipment projects achieved 3,592 MWh per year of verified energy savings with an 79.2% energy realization rate. Equipment projects achieved 295.78 kW of verified demand reduction with an 80.4% demand realization rate. The primary contributors to the energy and demand realization rates that were less than 100% were reduced in-service rates, disabled controls, and misclassification of equipment. Additional information is in *Appendix D.2 Gross Impact Evaluation – Equipment.*

5.7 Net Impact Evaluation – Equipment

Table 5-12 lists the methods and sampling strategy used to determine net savings for the equipment portion of the Efficient Equipment component of the Non-Residential Energy Efficiency Program in PY9. Additional details about methodology are in *Appendix D.3 Net Impact Evaluation – Lighting and Equipment*.

Table 5-12. Efficient Equipment Program (Equipment) Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population Size	Achieved Sample Size	NTG Activity
Prescriptive Equipment	Participants	116	8(1)	Self-report survey
Total		**116**	**8**	

(1) One respondent of the nine total respondents did not answer the NTG questions and is not included in the analysis.

Table 5-13 shows the free ridership, spillover, and NTG ratios by program stratum.

Table 5-13. Efficient Equipment Program (Equipment) Net Impact Evaluation Results

Stratum	Number of Surveys	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 85% C.L.	*Ex Post* kWh/yr Gross Population Savings
Prescriptive Equipment	8	44%(1)	0%	0.56	11%	3,592,078
Total	**8**	**44%**	**0%**	**0.56**	**11%**	**3,592,078**

(1) 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 equipment-level free ridership estimate than do the respondents who achieved lower energy savings.

5.8 Verified Savings Estimates – Equipment

In Table 5-14, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the equipment portion of the Efficient Equipment Program in PY9. In future years, these totals will be added to the verified savings achieved in previous program years to calculate the Phase III (P3VTD) program impacts.

Table 5-14. Efficient Equipment Program (Equipment) PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PYRTD Gross	4,536	0.37
PYVTD Gross	3,592	0.30
PYVTD Net(1)	2,012	0.17
PY Unverified Savings (2)	-	-
P3RTD Gross	8,667	0.72
P3VTD Gross	7,263	0.59
P3VTD Net(1)	4,875	0.40
P3 Unverified Savings (2)	-	-

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.

5.9 Process Evaluation – Lighting and Equipment

5.9.1 Research Objectives

The main research objectives for the PY9 evaluation of the Efficient Equipment Program focused on customer experience, program performance, and program influence.

5.9.2 Evaluation Activities

The PY9 process evaluation for the Efficient Equipment Program involved these research activities:

- Interviews with PPL Electric Utilities and ICSP program managers
- Telephone interviews with design engineers and contractors
- Online participant surveys
- Telephone participant surveys
- Logic model review

The research activities were consistent with the Efficient Equipment evaluation plan with one exception. Participation was low in the equipment stratum so Cadmus did not reach the targeted number of completed surveys in this stratum, but did reach the overall target of 68 completed surveys.

Table 5-15 lists the process evaluation sampling strategy for the lighting and equipment rebates. Additional details about sampling methodology are in *Appendix D.4.2 Survey Approach*.

Table 5-15. Process Evaluation Sampling Strategy for the Efficient Equipment Program

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Records Selected for Sample Frame [1]	Percent of Sample Frame Contacted to Achieve Sample [2]
Equipment and Lighting								
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone in-depth interview	2	N/A	2	2	N/A	100%
Participants	Equipment	Online survey	116	0.5	23 [3]	2	61	100%
		Telephone survey		0.5		7		
	Prescriptive lighting	Online survey	819	0.5	23	12	574	100%
		Telephone survey				24		
	Direct discount lighting	Online survey	190	0.5	23	4	109	100%
		Telephone survey				20		
Contractors and Design Engineers	Equipment	Telephone in-depth interview	32	N/A	5	5	32	100%
	Lighting	Telephone in-depth interview	184	N/A	5	5	85	46%
Program Total			**1,343**		**81**	**81**		

[1] Sample frame is a list of participants with contact information who had a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database. After selecting all unique records, Cadmus removed any records from the population that had participated in a survey in the last three months, were selected for another program survey, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey. See *Appendix D.4.2 Survey Approach*.
[2] Percent contacted means the percentage of the sample frame contacted to complete surveys.
[3] Cadmus exhausted all available records but was unable to reach the target.

5.9.2.1 Survey Methodology

Cadmus conducted online and telephone surveys with 69 participants of the Efficient Equipment Program using a stratified random sample. Fifty-one participants responded to the online survey and 18 to the telephone survey between November 2017 and July 2018. These surveys asked identical questions to assess program satisfaction, net savings, and the influence of the program and of the contractor or design engineer on project design, purchase decision, and program participation.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based survey items to reduce order effects

The SWE team and PPL Electric Utilities reviewed and approved the survey in PY8 before fielding the survey for PY9.

5.9.2.2 Program Staff and ICSP Interview Methodology

In December of 2017 and January of 2018, Cadmus conducted interviews with the program managers from PPL Electric Utilities and the ICSP. The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and understanding the areas that are working well and any possible challenges.

5.9.2.3 Design Engineer and Contractor Interview Methodology

In June 2018, Cadmus conducted interviews with contractors and design engineers who provided design and installation services to lighting and equipment participants of the Efficient Equipment Program. Cadmus interviewed five lighting contractors and five equipment contractors. The interviews assessed program influence, contractor satisfaction, program challenges and areas that are working well.

Cadmus relied on the PPL Electric Utilities' tracking database to develop the contractor list and filtered out any projects that did not have a contractor name or were self-installed. Thirty-two equipment contractors and 184 lighting contractors were identified as eligible for interviews.

5.9.3 Process Evaluation Findings

5.9.3.1 Program Delivery

The Efficient Equipment Program was delivered effectively in PY9 and maintains high levels of customer satisfaction. The ICSP delivered the PY9 Program the same as in PY8, with two primary exceptions. PPL Electric Utilities initially accepted applications for the GNE sector in PY9; however, funds for the GNE sector were exhausted more quickly than anticipated and GNE projects are on a waitlist as of January 2018. In PY9, the ICSP expanded marketing efforts to include more targeted marketing to small businesses.

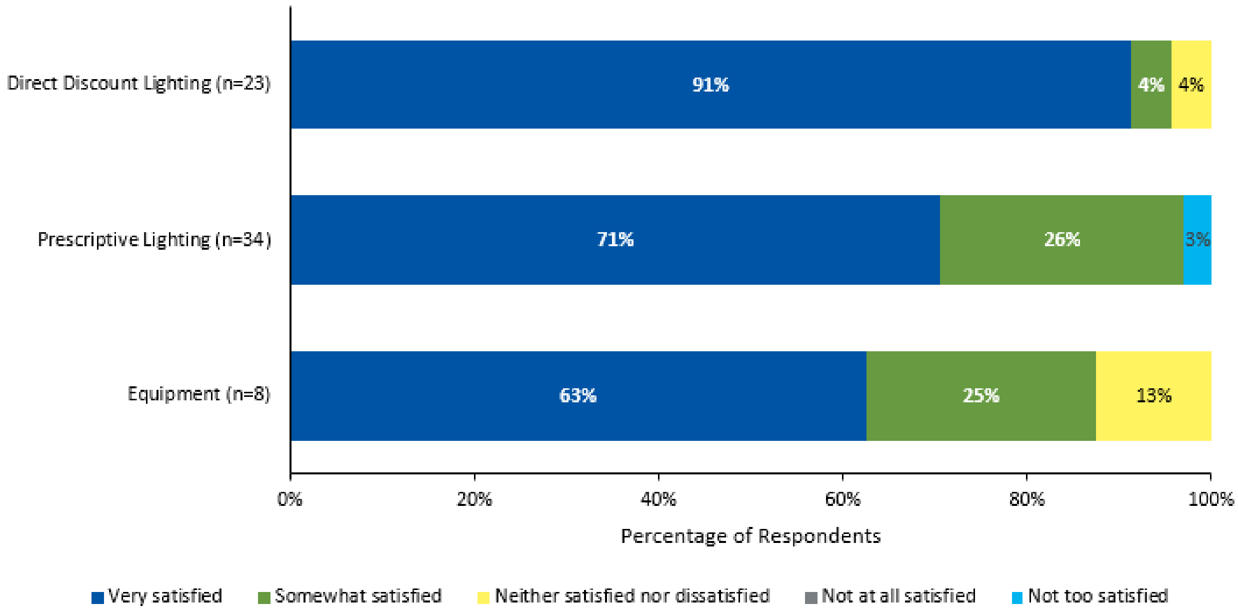
5.9.3.2 Program Satisfaction

Program satisfaction among customers, contractors, and design engineers was high.

Overall Satisfaction

Of the 65 participants who responded to the survey, 77% were *very satisfied* with the program overall and 18% were *somewhat satisfied*. These results are similar to PY8, where 80% of participant respondents (n=69) were *very satisfied* with the program, and 17% were *somewhat satisfied*.[23] Figure 5-1 shows the satisfaction results break down by the lighting and equipment participants.

Figure 5-1. PY9 Overall Satisfaction of Program Participants



Source: Survey question, "Now, thinking about your overall experience with PPL Electric Utilities' business energy-efficiency program, how would you rate your satisfaction?"

All five equipment contractors were either *very satisfied* or *somewhat satisfied* with the program. Two equipment contractors said the responsiveness of PPL staff was a commendable feature of the program.

Three lighting contractors were *very satisfied* with the program, one was *somewhat satisfied*, and one was *neither satisfied nor dissatisfied*. One lighting contractor said that it is not always clear if a project will qualify for a rebate and recommended offering more rebate categories to define eligible projects more clearly.

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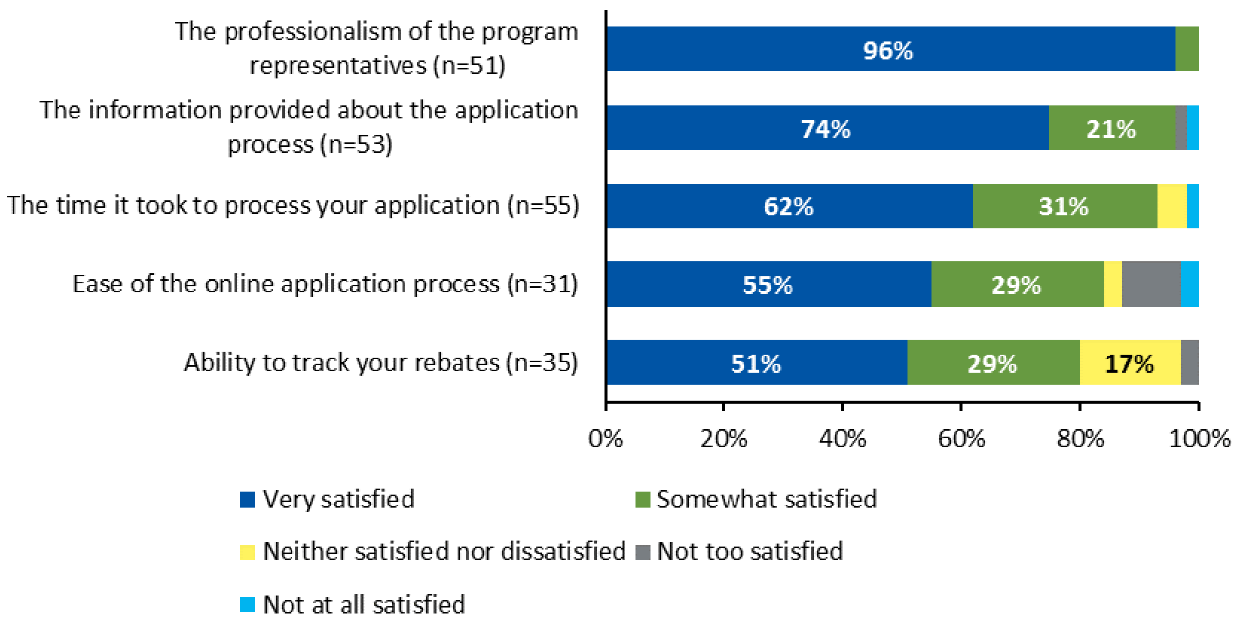
23 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

Satisfaction with Elements of the Efficient Equipment Program

Figure 5-2 shows participant satisfaction with elements of the Efficient Equipment Program. Participants were most satisfied with the professionalism of the program representatives (96%) and least satisfied with the ability to track their rebates (51%). This is similar to PY8, where 57% (n=55) of respondents were *very satisfied* with the ability to track rebates.[24] Four prescriptive (n=23) and two direct discount lighting (n=9) respondents were *neither satisfied nor dissatisfied* with rebate tracking; one prescriptive lighting respondent was *not at all satisfied*.

Figure 5-2. Participant Satisfaction with Different Program Components



Source: Survey Question "Please indicate how satisfied you are with each one."

Almost half of respondents (43%; 29 of 68) provided recommendations to improve the program. The most common suggestion for improvement was to simplify the application (31%; n=29) followed by outreach to increase program awareness (17%). Table 5-16 shows the suggested improvements.

24 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

Table 5-16. Suggested Improvements

Suggested Improvement	Percentage of Responses
Simplify application	31%
Outreach to increase program awareness	17%
Higher rebates	10%
Extend or expand the program	7%
Other suggestions	34%
Source: Survey question, "What is the one thing PPL Electric Utilities or CLEAResult could change about the program to improve it?" (n=29) May not sum to 100% due to rounding.	

Other responses included more involvement from program staff, better contractor training, list of qualified contractors, improved project tracking, graph of energy savings resulting from implemented improvements, lower rates for customers who participated in the program, decreased time for project approval, better communication, and follow through using the established rebate check guidelines.

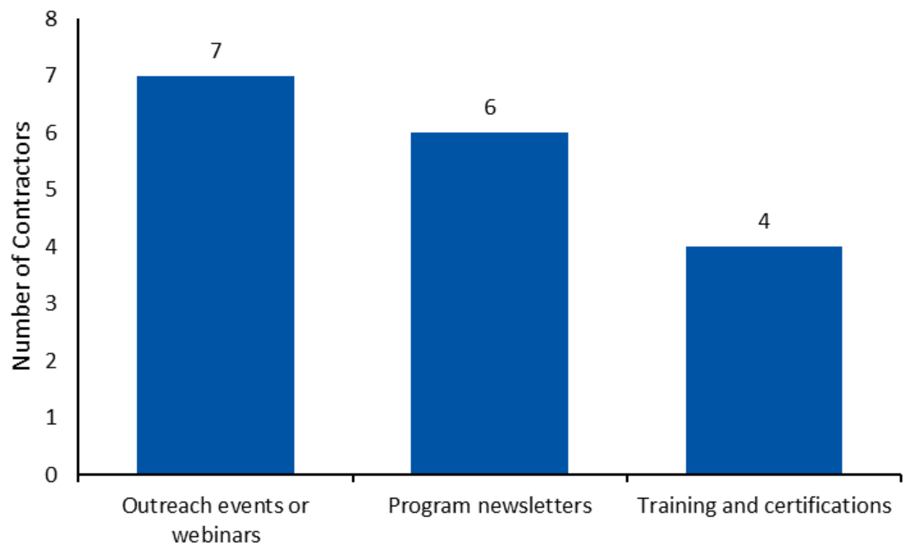
Of the 31 respondents who answered the question about the ease of the online application process, four (13%)—one with an equipment project and three with a lighting project—were *not too satisfied* or *not at all satisfied.* They provided the following reasons for their dissatisfaction:

- "If I wanted to edit anything or go back at all and check [something], nothing saves, and you have to start all over. [I'm] not sure if I'm doing something wrong."
- "It's confusing. [I] did not feel that help was readily available to come up with solutions. In the end, the calculations were incorrect and caused a budget problem."
- "The linked spreadsheets with the ability to manually add info is not user friendly. It's not clear if it worked properly. I needed help from PPL. If you're not an engineer, it's difficult to complete."
- "It was very difficult to understand what information was needed; (my) contractor was not knowledgeable about the process so a lot of the work fell to me."

Program Support

Lighting and equipment contractors answered questions about the type of support they may have received to promote high-efficiency lighting and equipment (Figure 5-3). The most common was an outreach event or webinar (seven of 10).

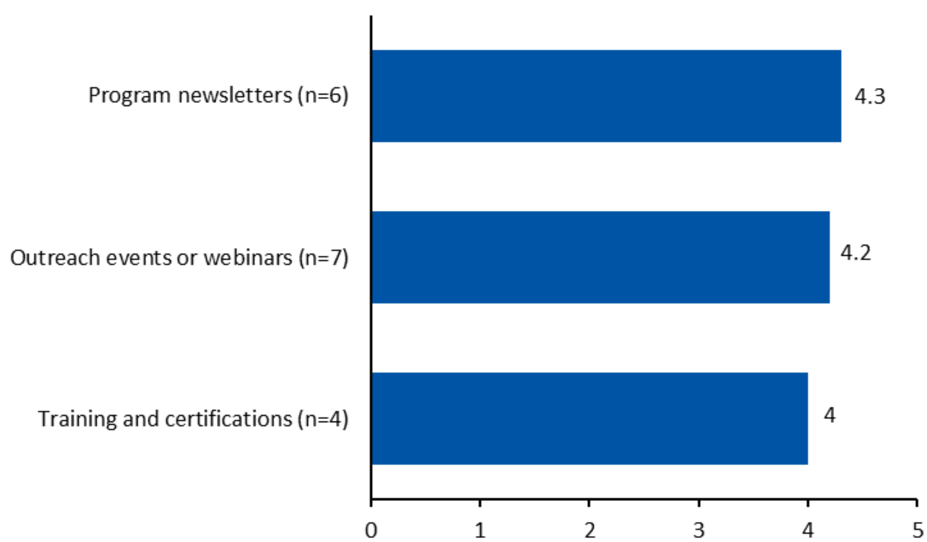
Figure 5-3. Types of Support Contractors Received



Source: Survey question, "Have you received any support to help you promote high efficiency equipment/lighting? (n=10)

Figure 5-4 shows mean scores for the helpfulness of each type of support (on a 5-point scale where 1 means *not at all helpful* and 5 means *extremely helpful*). One of five lighting contractors said the program newsletter was *neither helpful nor unhelpful* because the firm does major replacement projects "only every 20 years or so." One direct discount lighting contractor said the training and/or certifications provided by PPL Electric Utilities was *neither helpful nor unhelpful* and recommended a joint sales event with an outreach person to improve this type of support.

Figure 5-4. Contractors' Mean Ratings for Helpfulness of Support



Source: Survey question, "How helpful was this support?"

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. As shown in Table 5-17, the Efficient Equipment Program achieved an NPS of 73, indicating there are more promoters than detractors among the respondents. The passives are excluded from the calculation. An excellent NPS is 50 and above.[25]

Table 5-17. Net Promoter Score Likelihood to Recommend the Program

Rating Classification	PY8 Percentage of Respondents (n=69)	PY9 Percentage of Respondents (n=64)
Promoters (9-10)	82%	78%
Passives (7-8)	17%	17%
Detractors (0-6)	0%	5%
NPS	**82**	**73**

The NPS decreased to 73 in PY9 from 82 in PY8.[26] In PY8, respondents said providing more information could improve the program overall. Therefore, the decline in the NPS could be because sufficient program information has not been available. For example, two of the three detractors (5% of 64 respondents) said they were not given enough information to accurately complete the application. One respondent had difficulty managing the linked spreadsheets and one had incorrect calculations that caused a problem with the project budget.

Opinion of PPL Electric Utilities

The survey asked respondents if their opinion of PPL Electric Utilities has changed after participating in the program (Figure 5-5). In PY9, 24% of lighting respondents (n=56) said their opinion of PPL Electric Utilities had *improved significantly* after participating in the program compared to 16% in PY8.[27] This result was not significantly different. The opinion of one lighting program respondent *decreased somewhat;* this respondent reported not receiving adequate assistance to navigate the application process.

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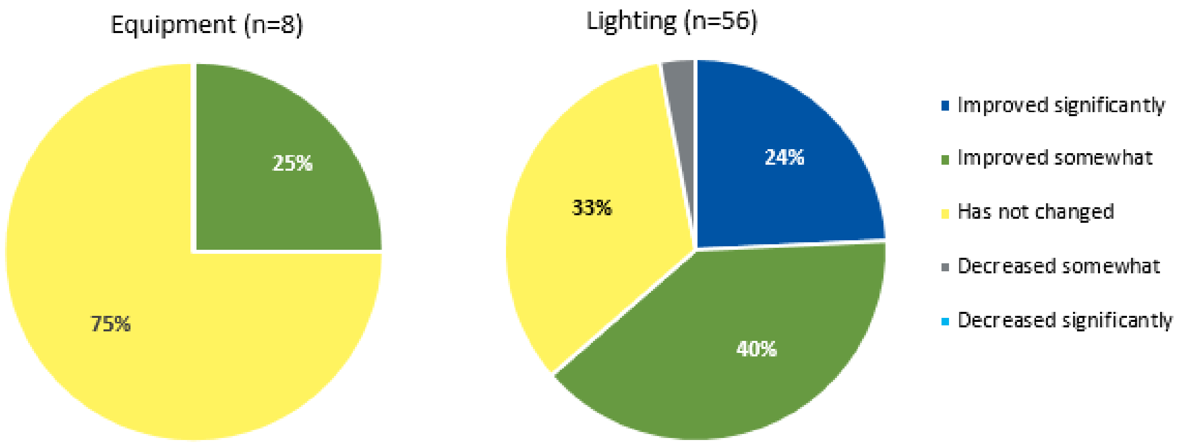
25 Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

26 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

27 Ibid.

Figure 5-5. PY9 Shifts in Opinion of PPL Electric Utilities Because of Participation in Program

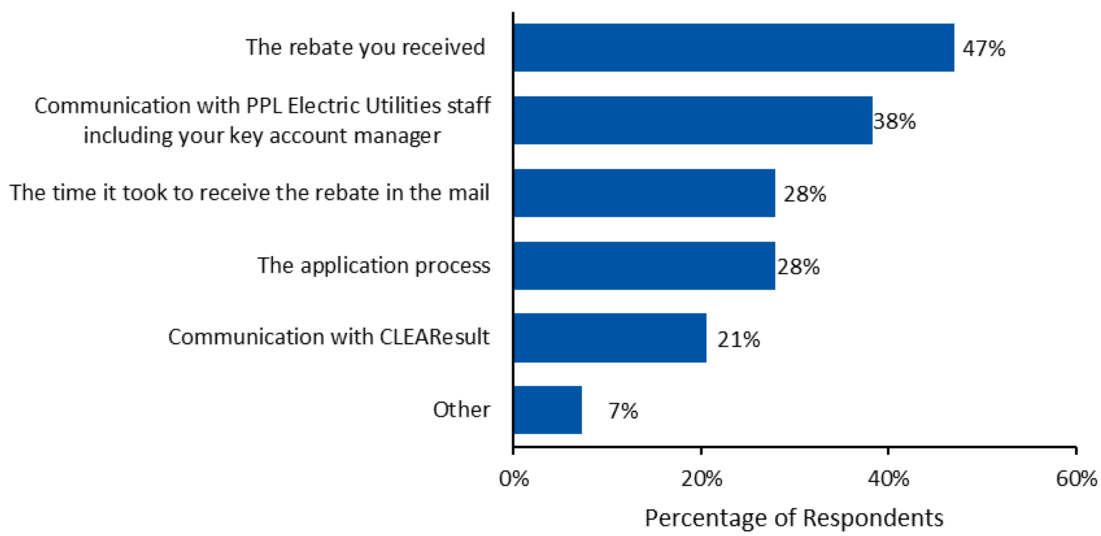


Source: Survey question, "After participating in the PPL Electric Utilities business energy-efficiency program, has your opinion of PPL Electric Utilities' …?"

Areas Working Well

Participants thought the rebates they received, communication with PPL Electric Utilities staff, and the time it took to receive the rebate were the top three program elements that worked well (Figure 5-6).

Figure 5-6. PY9 Areas Working Well in the Efficient Equipment Program



Source: Question, "Thinking about what worked well with the business energy-efficiency program, what one item worked best? What worked next best?" (n=68) Multiple responses allowed.

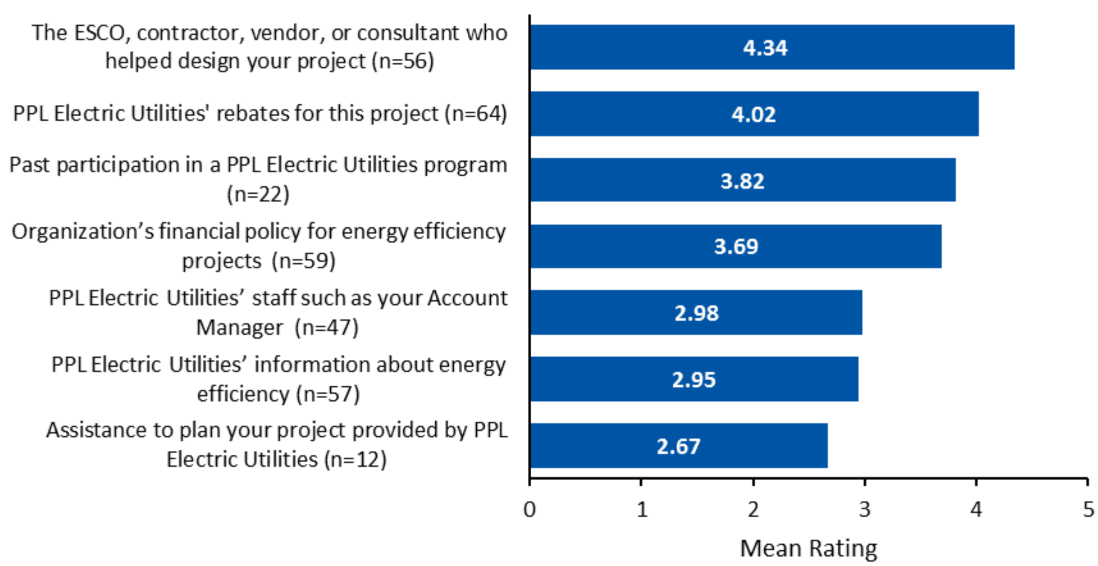
Lighting and equipment contractors said the application process, application layout, and modeling software worked particularly well (n=10). Three contractors said the rebates their customers received were advantageous features of the program. One lighting contractor chose the direct discount lighting program because the rebate was too low in the prescriptive lighting component. One prescriptive and two direct discount lighting contractors, however, said the time it took to get project approval posed a challenge to them and their customers. They suggested establishing a quicker turnaround from the invoice to application review and final payment.

Program Influence

The survey asked respondents' about how much influence the program components had on their decision to complete the project in the way they did. Figure 5-7 shows the average influence of different items on respondents' projects, where 5 was *extremely influential* and 1 was *no influence*.

In PY9, the energy services company (ESCO), contractor, vendor, or consultant who helped design the project were the most influential, with an overall average score of 4.34 (n=56). Rebates from PPL Electric Utilities scored an average of 4.02 (n=64). These were also the top two influencers in PY8, where the ESCO, contractor, vendor, or consultant scored an average of 4.37 (n=55) and rebates from PPL Electric Utilities scored an average of 3.91 (n=68).[28] Direct discount lighting program participants reported PPL Electric Utilities' rebates as *extremely influential* at a statistically significant higher rate than did prescriptive lighting and equipment participants.[29]

Figure 5-7. Participants' Average Influence Score for Different Items



Source: Survey question "Please rate each item on how much influence it had on the decision to complete the project the way it was completed on a scale from 1 to 5 where 5 is *extremely influential* and 1 is *no influence*."

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28 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

29 Statistically significant at the 5% level.

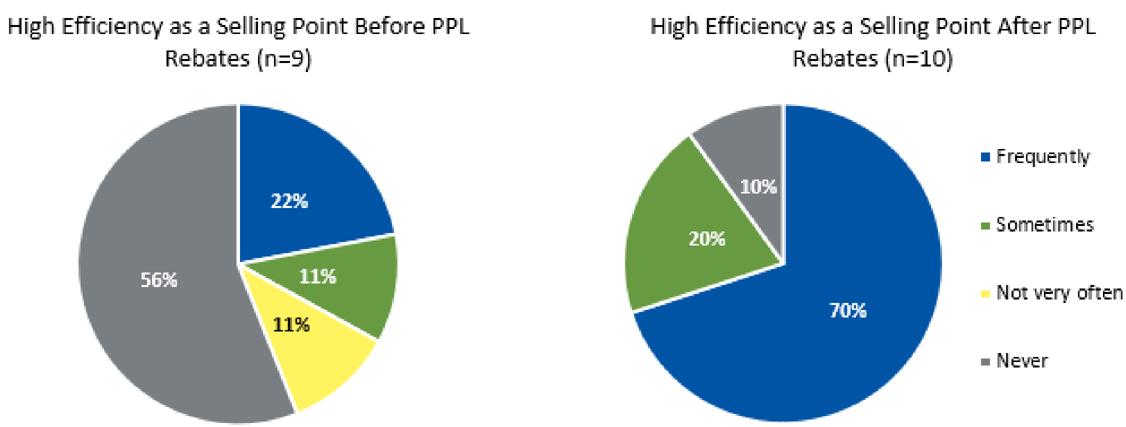
Contractors (n=7) were asked for their perception about the importance of the program's rebates on the customer's decision to purchase more efficient equipment. Four lighting and one equipment contractor said the rebates were *very important*. One equipment contractor said the rebates were *somewhat important*, and one said the rebates were *not at all important*.

Impact of Program Rebates

The 10 contractors were asked about the impact of PPL Electric Utilities' rebate program on their sales of high-efficiency equipment and lighting. Figure 5-8 shows a large increase in the frequency that high efficiency is a selling point. Reasons for the change included greater awareness of energy consumption by customers and new codes that have pushed for higher energy efficiency standards.

Broken down by contractor groups, four lighting contractors and two equipment contractors said high efficiency was *not very often* a selling point for their customers before PPL Electric Utilities rebates became available. After rebates became available, all five lighting contractors and four of five equipment contractors said high efficiency was *frequently* or *sometimes* a major selling point to their customers.

Figure 5-8. Impact of Rebates as a Selling Point



Source: Survey question "How frequently is high efficiency a selling point for your customers?" (n=10) and "before PPL Electric rebates were available, how frequently was high efficiency a selling point to customers? (n=9)

Asked about their sales of high-efficiency equipment, contractors said that 76% (on average) of their high-efficiency lighting sales qualify for PPL Electric Utilities rebates. This was an increase from PY8, where an average of 49% of high-efficiency lighting sales qualified for PPL Electric Utilities rebates. Of high-efficiency equipment sales, 35% qualified for PPL Electric Utilities rebates, a slight decrease from the 42% in PY8.

Equipment contractors said they expected their sales of high-efficiency equipment to remain the same over the next three years or to increase by 20% to 30%, at the most. Lighting contractors expected a similar increase for high-efficiency lighting purchases over the next three years, although one expected a 20% increase within the next year and a 50% increase in three years.

5.10 Cost-Effectiveness Reporting

Because the Efficient Equipment component is part of the Non-Residential Energy Efficiency Program, cost-effectiveness is presented in section *4.5 Cost-Effectiveness Reporting.*

5.11 Recommendations – Lighting and Equipment

The lighting portion of the Efficient Equipment Program performed well in PY9. The clarity and completeness of evaluation sample project documentation provided by the ICSP improved over PY8. The lighting portion achieved overall energy and demand realization rates of 98.5% and 102.7%, respectively. The equipment portion of the Efficient Equipment Program did not perform as well as in PY8, mainly due to verification discrepancies during the evaluation site visit for a couple of large projects in the sample. The equipment portion achieved overall energy and demand realization rates of 79.2% and 80.4%, respectively. Overall, participants in the Efficient Equipment Program are satisfied with the program and are likely to recommend the program to friends and colleagues. Recommendations are provided in Table 5-18, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: Although 95% of survey participants (62 of 65) were *very* or *somewhat satisfied* with the program, they were least satisfied with the ability to track rebates. Nine participants recommended improvements to the application. Two of the three detractors (5% of 64 respondents) said they were not given enough information to accurately complete the application, one respondent had difficulty managing the linked spreadsheets, and one had incorrect calculations that caused a problem with the project budget. (See section *5.9.3.2 Program Satisfaction.*)

Conclusion: The application process is challenging for some customers. Also, the ability to track rebate status is a concern for customers. Both of these aspects could be leading to decreased satisfaction. While the program provides instruction about how to complete the application and offers customers a way to track rebate status, findings suggest that additional information is needed to improve customers' understanding and satisfaction with the rebate application process.

Recommendation #1: Consider providing customers with more information that shows how to complete an application and how to track rebate status. This information could be added to the online portal and to other customer outreach materials.

Finding: PPL Electric Utilities' rebates were one of the most influential aspects of customers' decisions to install energy efficient equipment (rated 4.02 out of 5, where 5 is extremely influential). This was especially true of direct discount lighting participants. (See section *Program Influence* in *5.9.3.2 Program Satisfaction.*)

Finding: Additionally, five of seven contractors said PPL Electric Utilities' rebate programs were *very important* in their customers' decision to purchase more efficient equipment. (See section *Program Influence* in *5.9.3.2 Program Satisfaction.*)

Finding: Three of 10 contractors said that before PPL Electric Utilities rebates were available, high efficiency equipment and lighting products were *sometimes or frequently* a selling point but after rebates were available nine of 10 contractors said they were *sometimes or frequently* a selling point. (See section *Program Influence* in *5.9.3.2 Program Satisfaction.*)

Conclusion: PPL Electric Utilities rebates have had a large impact on the way customers and contractors design and implement equipment and lighting projects and have increased the number of energy efficient jobs that are completed.

Recommendation #2: Knowing that rebates are an effective tool to increase the energy efficiency of the commercial sector, PPL Electric Utilities could consider targeted marketing campaigns in underserved markets or to promote specific technologies.

Finding: During verification site visits for a few of the large (greater than 50,000 kWh/yr reported savings) equipment projects, Cadmus found variations in installed equipment quantities, types, and project completion status. See section *5.6 Gross Impact Evaluation – Equipment* for details. These verification findings had a substantial impact on the energy savings and demand realization rates for the equipment portion of the Efficient Equipment Program. In terms of the realization rates, adjustments for equipment measures reduced reported savings by 21% for energy and 20% for demand.

Finding: The PPL Electric Utilities website states that the final rebate application should not be submitted until a project is installed and fully commissioned. If the project timeline is delayed, PPL may grant a rebate reservation extension on a case-by-case basis. The ICSP's QC protocol calls for an on-site inspection and once it confirms completion, the participant can submit the job as complete. However, Cadmus' verification site visits found at least one project that was incomplete, with equipment installed in stages. (See *Appendix D.2.3 Site Visit Findings – Equipment.*)

Conclusion: The ICSPs' current post-inspection and QA/QC process did not catch several discrepancies between reported and actual project characteristics.

Recommendation #3: PPL Electric Utilities and the ICSP could consider reviewing their post-inspection and QA/QC process, especially for large equipment projects. Consider including photos of installed and related equipment (e.g., equipment controlled by the incentivized measure) and detailed notes about project start and completion dates in the post-inspection documentation.

Recommendation #4: PPL Electric Utilities and the ICSP could remind contractors and customers when projects can be submitted as "complete" and that projects can request a rebate reservation extension if the installation is delayed.

5.11.1 Status of Recommendations

Table 5-18 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 5-18. Status of Recommendations for the Efficient Equipment Program

Efficient Equipment Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Consider providing customers with more information that shows how to complete an application and how to track rebate status. This information could be added to the online portal and to other customer outreach materials.	Being considered.
2	Knowing that rebates are an effective tool to increase the energy efficiency of the commercial sector, PPL Electric Utilities could consider targeted marketing campaigns in underserved markets or to promote specific technologies.	Being considered.
3	PPL Electric Utilities and the ICSP could consider reviewing their post-inspection and QA/QC process, especially for large equipment projects. Consider including photos of installed and related equipment (e.g., equipment controlled by the incentivized measure) and detailed notes about project start and completion dates in the post-inspection documentation.	Being considered.
4	PPL Electric Utilities and the ICSP could remind contractors and customers when projects can be submitted as "complete" and that projects can request a rebate reservation extension if the installation is delayed.	Being considered.

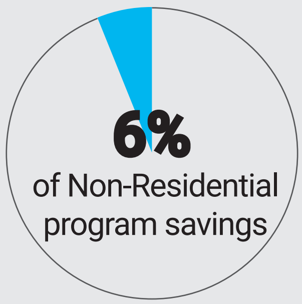
CADMUS

MIDSTREAM LIGHTING

Midstream Lighting is designed to make choosing and procuring high-efficiency lighting from a participating lighting distributor simple and fast, by discounting qualifying LED lamps, bulbs, and fixtures at the point of sale.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **17,832 MWh/yr**



PY9 saved **15,915 MWh/yr**

PROGRAM SATISFACTION

96% Satisfied with overall program

91% **distributors** satisfied with program

100% **contractors** satisfied with program

100% **end-users** satisfied with program

PY9 PARTICIPATION

17 distributors participated
4,685 jobs (sales)
2,046 unique PPL Electric Utilities customers

Most distributors said **contractors or electricians** made up **approximately 70%** of their **total lighting sales**, and **business owners or managers** and **residential customers** combined made up the **remaining 30%**.

6 Non-Residential Midstream Lighting Program

The Midstream Lighting component of the Non-Residential Energy Efficiency Program is designed to make choosing and procuring high-efficiency lighting simpler and faster than typical downstream methods. Contractors and PPL Electric Utilities customers may purchase qualifying LED lamps, bulbs, and fixtures directly from a participating lighting distributor. The purchaser receives an instant discount through a discounted list price at the point of sale. PPL Electric Utilities pays the distributor the discount, and the distributor is required to pass this discount along to the purchaser.

In PY9, CLEAResult, the ICSP, introduced limited-time sales performance incentives (SPIFFs) to encourage distributor sales staff to promote program-discounted products.

6.1 Participation and Reported Savings by Customer Segment

6.1.1 Definition of a Participant

A Midstream Lighting participant is defined by a unique job, that is, a participating distributor's sale of qualified products. The jobs involved the sale of 35,973 lighting products; 81% of these were 4-foot linear LED lamps.

For purposes of the process evaluation, distributors are considered the participants because they receive the incentives. In PY8, 12 distributors reported 789 jobs (sales) to 437 unique PPL Electric Utilities customers (distinct account numbers). In PY9, 17 distributors reported 4,685 jobs (sales) to 2,046 unique PPL Electric Utilities customers (distinct account numbers).

6.1.2 Program Participation and Reported Impacts

Table 6-1 presents the participation counts, reported energy and demand savings, and incentive payments for all the components of the Efficient Equipment Program in Phase III, by customer segment.

Table 6-1. Midstream Lighting Component PY8 and PY9 Participation and Reported Impacts

Parameter	GNE	Large C&I	Residential	Small C&I	Total (1)
PY8RTD # Participants	180	36	24	549	**789**
PY8RTD MWh/yr	611	145	29	1,815	**2,601**
PY8RTD MW/yr	0.12	0.03	0.01	0.34	**0.50**
PY9RTD # Participants	1,240	367	239	2,839	**4,685**
PY9RTD MWh/yr	6,195	2,953	435	10,351	**19,935**
PY9RTD MW/yr	1.06	0.46	0.09	2.05	**3.65**
(1) May not match due to rounding.					

6.2 Gross Impact Evaluation

Savings from Midstream Lighting were unverified in PY8. In PY9, savings for PY8 and PY9 were verified and reported jointly. Cadmus sampled Midstream Lighting jobs quarterly to meet a level of 90%

confidence with 10% precision, using a coefficient of variation of 0.5. Cadmus conducted 51 site visits involving 99 jobs in PY8, and 37 site visits involving 110 jobs in PY9. The evaluation defines a site as a business located at a given address. A job refers to a sale of a rebated lighting product associated with a site.

The evaluation sampling strategy is shown in Table 6-2. See *Appendix F.1.1 Methodology* for additional details about methodology.

Table 6-2. Midstream Lighting Component Gross Impact Sample Design for PY8 and PY9

Stratum	Population Size (Jobs)	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Midstream Lighting PY8	789 (1)	0.5	99	Records review and site visits
Midstream Lighting PY9	4,685		110	
Program Total	**5,474**		**209**	
(1) There were 796 records corresponding to 789 unique jobs in Midstream Lighting.				

In PY8, Midstream Lighting reported energy savings of 2,601 MWh/yr and, in PY9, 19,935 MWh/yr, for a total of 22,536 MWh/yr for Phase III to date, as shown in Table 5-3. In PY8, Midstream Lighting reported demand reduction of 0.50 MW/yr and, in PY9, 3.65 MW, for a total of 4.14MW/yr, as shown in Table 5-4.

Table 6-3. Midstream Lighting Component PY8 and PY9 Gross Impact Results for Energy

Stratum	P3RTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	Relative Precision at 90% C.L.
Midstream Lighting – Large	1,281	168%	N/A	N/A	N/A
Midstream Lighting – Medium-Large	5,034	37%	1.28	56.82%	66.05%
Midstream Lighting – Medium	6,646	86%	1.12	37.84%	43.64%
Midstream Lighting – Small	7,935	95%	1.32	26.82%	30.75%
Midstream Lighting – T8	144	20%	2.43	316.55%	405.07%
Midstream Lighting – Convenience Sample	1,492	38%	2.95	0.00%	0.00%
Midstream Lighting – Unverified	5	-	-	-	-
Midstream Lighting Total (1)	**22,536**	**79%**	**N/A**	**16.10%**	**19.41%**
(1) May not match due to rounding.					

Cadmus implemented the sampling strategy outlined in PY8 and PY9 evaluation plans for the joint PY8 and PY9 evaluation which called for the completion of 68 sample points at 90% confidence with 10% precision, and an assumed coefficient of variation of 0.5. The evaluation verified 209 total jobs and 86 randomly sampled jobs over the course of PY8 and PY9. The evaluation sampling strategy described in *Appendix F.1.1 Methodology* shows that after post-stratification, the gross savings verification effort under-achieved sample targets in the larger strata.

However, there was significant variability around findings for sampled jobs within each stratum, as evidenced by the precision estimates. Error ratios were high across all strata in spite of the smaller size strata exceeding sample targets. The realization rates across strata for individual jobs range from 0% to 460%, largely driven by duplicate and program ineligible jobs (new construction), and updated hours of use reflecting in situ conditions. To achieve precision targets within the current plan-defined stratum definitions, would require a large increase in sample sizes.

In PY10, Cadmus will investigate factors that contributed to the variability in verified savings, and use an exploratory analysis to determine which variables are correlated with high/low realization rates and use a stratification method that includes those variables.

Table 6-4. Midstream Lighting Component PY8 and PY9 Gross Impact Results for Demand

Stratum	P3RTD MW/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	Relative Precision at 90% C.L.
Midstream Lighting – Large	0.16	244%	N/A	N/A	N/A
Midstream Lighting – Medium-Large	0.90	34%	1.31	58.11%	67.55%
Midstream Lighting – Medium	1.29	76%	0.63	21.19%	24.44%
Midstream Lighting – Small	1.55	84%	1.33	27.07%	31.03%
Midstream Lighting – T8	0.03	20%	2.48	323.03%	413.35%
Midstream Lighting – Convenience Sample	0.22	44%	2.39	0.0%	0.0%
Midstream Lighting – Unverified	0.001	--	--	--	--
Midstream Lighting Total (1)	**4.14**	**74%**	**N/A**	**14.09%**	**16.11%**
(1) May not match due to rounding.					

The following major factors led to the variation between reported and verified savings and to the observed realization rates. For some projects, these variations increased the verified savings; for other projects, they decreased the verified savings:

- Five sampled jobs in PY9 have zero verified savings because the rebated equipment was installed at New Construction facilities, while two additional jobs were found to be installed partially at a New Construction facility . New Construction projects are excluded from the Midstream Lighting component of the Non-Residential Program.
- Seven sampled jobs in PY9 have zero verified savings because the jobs were found to be duplicates, i.e., erroneously uploaded into the tracking system twice.
- Three records in PY8 have zero verified savings because the baseline and rebated equipment were the same.
- The Interim Measure Protocol (IMP) for Lighting Improvements for Midstream Delivery Programs prescribes full lamp wattage for T8 replacements, for example with LED tubes.[30] But a

[30] The Interim Measure Protocol (IMP) prescribes methods to calculate savings for midstream programs. *2016 TRM – Interim Measure Protocol: Lighting Improvements for Midstream Delivery Programs,* version approved October 2017, effective June 1, 2017.

32-watt T8 lamp in a 4-foot two-lamp fixture with standard ballast draws only 29.5 watts, or 92% of the IMP baseline watts.[31]

- **A**djustment were made to the baseline wattages in the calculation of verified savings for high/low bay fixtures for all but three of the 25 sampled jobs. The Midstream IMP assumed metal halide baselines with 400- or 750-watt lamps, based on the lumen output of the LED lighting.[32] However, the verified baseline fixtures were found to be a mix of high output linear fluorescent or lower wattage metal halide.
- Cadmus site visits found two records for jobs where 25-watt T8 lamps, and one job for exterior LED lighting, that replaced the same type of fixture.
- Other adjustments to the realization rate hours of use were mainly due to *in situ* findings of baseline equipment types and wattages and annual operating hours.
- Reported savings associated with items from one PY9 project that were returned by the customer to the distributor could not be verified as part of the PY9 evaluation. Savings from this project have been treated as unverified.

6.3 Net Impact Evaluation

The methods used to determine net savings for midstream programs are provided in the Evaluation Framework,[33] which discusses the common methods to determine free ridership and spillover. Cadmus used self-report surveys to assess free ridership for Midstream Lighting.

Free ridership 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.

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.

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

Table 6-5 lists the methods and sampling strategy used to determine net savings for each component of Midstream Lighting in PY9. Additional details about methodology are in *Appendix F.*

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31 The T8 lamp wattage and T8-lamp fixture wattage are prescribed in the PA TRM, Appendix C Fixture Identities worksheet.

32 *2016 TRM – Interim Measure Protocol: Lighting Improvements for Midstream Delivery Programs*, version approved October 2017, effective June 1, 2017.

33 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* October 21, 2016.

Table 6-5. Midstream Lighting Component Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population Size	Achieved Sample Size	NTG Activity
Midstream Lighting	End users (purchasers and non-purchasers)	1,581	27	Self-report survey
Program Total		**1,581**	**27**	

Table 6-6 shows the free ridership, spillover, and NTG ratios by program stratum.

Table 6-6. Midstream Lighting Component Net Impact Evaluation Results

Stratum	Number of Surveys	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 90% C.L.	*Ex Post* kWh/yr Gross Population Savings
Midstream Lighting	27	15%(1)	0%	0.85	11%	15,914,901
Program Total	**27**	**15%**	**0%**	**0.85**	**11%**	**15,914,901**

(1) Weighted by the survey sample-verified program kWh/yr savings. This method ensures that respondents who achieved higher energy savings through program products have a greater influence on the measure-level free ridership estimate than do respondents who achieved lower energy savings.

End users in Midstream Lighting are the businesses where the lighting was installed and are the ultimate beneficiary of the program discount. Cadmus determined that end users were the most appropriate program actors to answer the survey questions used to estimate free ridership (see *Self-Report Survey* section in *Appendix F.2.1 Net-to-Gross Ratio Methodology*).

- End-user purchasers are the decision-makers at these businesses who determine when to make upgrades and how much to invest in lighting equipment.
- End-user non-purchasers are the customers for whom contractors purchased lighting products.

In PY9, Midstream Lighting's free ridership was 15%, determined using participant end users' survey data (see *Appendix F.2.3 Net-to-Gross Ratio Findings*). One respondent estimated as a 0% free rider accounted for 29% of the verified energy savings in the analysis sample.

Assessing spillover in commercial settings via phone surveys is difficult because respondents cannot provide the level of detail needed to quantify spillover. Therefore, Cadmus collected self-reported survey data and reviewed the data qualitatively for spillover activity but did not quantify spillover.

6.4 Verified Savings Estimates

In Table 6-7, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for Midstream Lighting in PY8 and PY9. In future years, these totals will be added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 6-7. Midstream Lighting Component PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PY8RTD Gross	2,601	0.50
PY8VTD Gross	1,917	0.34
PY8VTD Net(1)	1,648	0.29
PY8 Unverified Savings	0	0
PY9RTD Gross	19,935	3.65
PY9VTD Gross	15,915	2.74
PY9VTD Net(1)	13,528	2.33
PY9 Unverified Savings	5	0.001
P3RTD Gross	22,536	4.14
P3VTD Gross	17,832	3.08
P3VTD Net(1)	15,176	2.62
P3 Unverified Savings(2)	5	0.001

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.

6.5 Process Evaluation

6.5.1 Research Objectives

The process evaluation of Midstream Lighting focused on these main research objectives:

- Assess customer satisfaction and customer experience
- Emphasize areas of program success and challenges
- Make recommendations for program modification and improvement
- Identify best practices that can be implemented in future years
- Compare end-use customers to lighting downstream rebate participants

6.5.2 Evaluation Activities

The PY9 process evaluation activities for Midstream Lighting included these:

- Interview PPL Electric Utilities and ICSP program managers
- Review tracking data
- Conduct telephone interviews with participating distributors
- Conduct telephone interviews with end users and contractor purchasers
- Review the logic model
- Conduct end-user segmentation analysis

The evaluation activities were consistent with the evaluation plan.

Table 6-8 lists the process evaluation sampling strategy. Additional details about sampling methodology are included in *Appendix F*.

The SWE team and PPL Electric Utilities reviewed and approved the surveys in PY8 . Interviews collected self-reported data, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the interviews to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based interview items to reduce order effects
- Provide clear interview instructions to ensure interviews were conducted consistently

Table 6-8. Process Evaluation Sampling Strategy for Midstream Lighting

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Records Selected for Sample Frame [1]	Percent of Sample Frame Contacted to Achieve Sample [2]
Midstream Lighting								
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone in-depth interview	N/A	N/A	4	4	N/A	100%
Participating Distributors	Distributors	Telephone in-depth interview	17	N/A	17	12	N/A	100%
End-User Purchasers	End-use customers who purchase directly from distributors	Telephone in-depth interview	936	N/A	15	15	936	8.4%
Contractor Purchasers	Contractor purchaser for whom contact data were provided	Telephone in-depth interview	89	N/A	15	15	89	47.2%
End-User Non-Purchasers	End users for whom contractors purchased lighting	Telephone in-depth interview	632	N/A	15	12	632	29.1%
Program Total			**1,674**		**66**	**58**	**1,657**	

[1] Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database. After selecting all unique records, Cadmus removed any duplicate records from the population.
[2] Percent contacted means the percentage of the sample frame contacted to complete surveys.

6.5.2.1 Participating Distributor Interview Methodology

In PY9, 17 distributors participated in the Midstream Lighting component. Cadmus conducted in-depth interviews with 12 distributors, representing approximately 82% of reported PY9 incentives. Of these 12 distributors, seven were interviewed for the first time in PY9, and five had also been interviewed in PY8. Cadmus asked the first-time interviewees about stocking practices and the estimated proportion of sales of efficient versus standard-efficiency products before and after participation in this program. Cadmus asked the five distributors interviewed in PY8 about sales in PY9 and any observed changes over the past year.

Cadmus designed the distributor interview guide to inform the following objectives:

- Assess distributor satisfaction with Midstream Lighting
- Identify motivations for and barriers to participating in Midstream Lighting
- Determine whether stocking and sales changed after Midstream Lighting launched
- Assess influence of program on promotional practices
- Gather insights into lighting market changes

6.5.2.2 Purchaser and End User Interview Methodology

Cadmus conducted interviews with purchasers (contractors, n=15, and end-use customers, n=15) and non-purchasers (customers for whom contractors purchased lighting products, n=12). Cadmus developed the purchaser and end-user interview guide to inform the following objectives:

- Identify respondent characteristics (type of end-use facilities, contractors' client makeup)
- Assess purchaser satisfaction with Midstream Lighting
- Assess influence of both distributor and instant discounts on purchaser decisions
- Measure the influence of the program on contractors' business
- Identify barriers to participation
- Estimate free ridership and spillover
- Track market progress indicators (MPIs):
    - Perceptions of the cost-effectiveness of efficient lighting products
    - Incorporation of efficient products into project design considerations

6.5.3 Process Evaluation Findings

Additional detail regarding the process evaluation methodology and findings can be found in *Appendix F.3 Process Evaluation for Midstream Lighting.*

6.5.3.1 Program Delivery

In PY9, Midstream Lighting ramped up significantly—overall sales were more than eight times (in quantity of products) than reported in PY8. All distributors reported more sales in PY9 than in PY8. Five of the 17 distributors reported sales in PY9 for the first time.

Sales Performance Incentives

In PY9, the ICSP introduced limited-time sales performance incentives (SPIFFs) to encourage distributor sales staff to promote program products and reported that these appeared to be effective in driving sales. Distributors responded positively when asked about these incentives but agreed SPIFFs were a less important driver of sales than were the discounts passed to customers.

Five out of 12 distributors reported that SPIFFs positively impacted their sales by helping sales staff become aware of the program and motivating them to change their behavior. Two distributors said SPIFFs helped sales staff be more proactive in making cold calls to promote qualifying products to potential customers. One distributor said his company's sales of program-eligible products doubled during the period SPIFFs were available.

Several distributors requested a 30-day notice before the next time SPIFFs were offered to better prepare sales staff.

6.5.3.2 Program Satisfaction

Overall Satisfaction

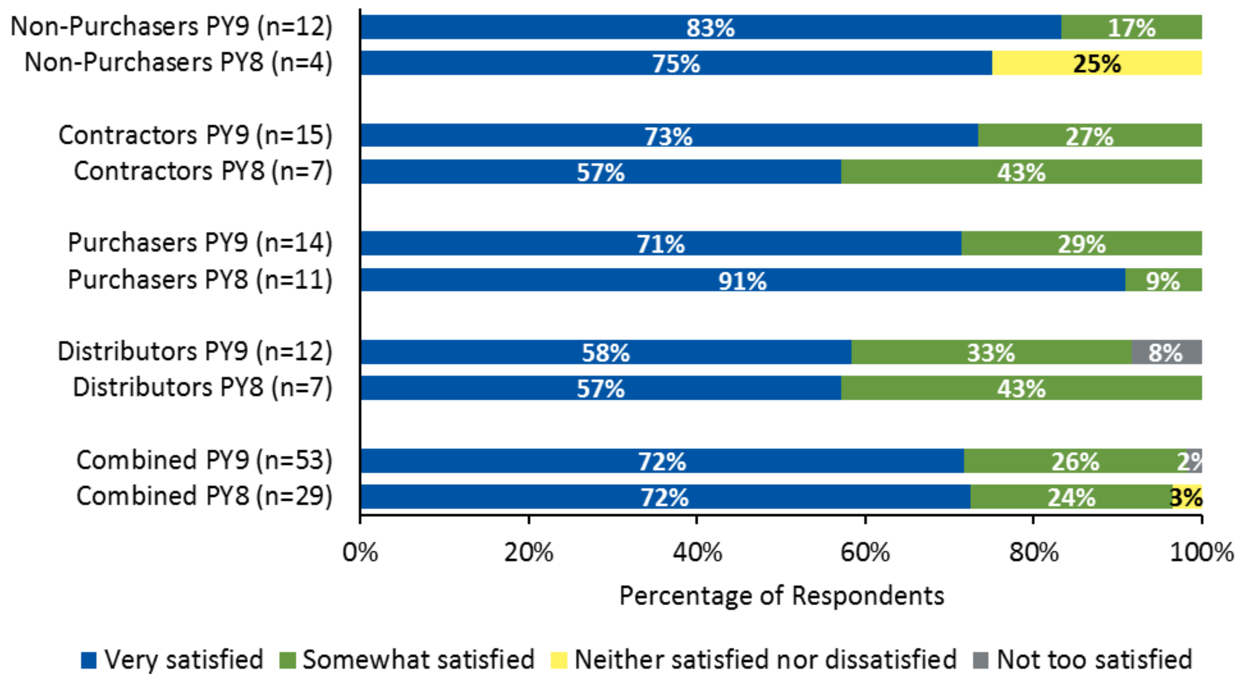
Satisfaction with Midstream Lighting is relatively high, with the majority of respondents stating that they were *very satisfied*. In PY9, as in PY8, all interviewed purchasers and contractors said they were either *somewhat satisfied* or *very satisfied* with Midstream Lighting. Only one respondent, a distributor, was *not too satisfied* with Midstream Lighting in PY9.

In PY9, 77% of all end users surveyed (n=26) were *very satisfied*; this is not significantly different from PY8, when 87% (n=13) of end users were *very satisfied*. Note that the non-purchasers and purchasers constitute the end users; Figure 6-1 disaggregates the end-users.

Overall, results across all groups in PY9 are not statistically different from PY8,[34] as shown in Figure 6-1.

[34] Differences from PY8 are not statistically significant at 90% confidence.

Figure 6-1. Distributor, Contractor, and End-User Satisfaction



Source: Distributor (H7), Contractor (I4), and End-User (I4) survey question: Thinking about your overall experience with PPL Electric Utilities' Midstream Lighting Program, how would you rate your satisfaction? Would you say you are…?

Satisfaction with Program Implementation

Half of the distributors interviewed (six of 12) reported no issues with program implementation. For those who did, three reported problems with how they received incentive payments from the ICSP, three reported problems with the data required by the ICSP, and two reported problems providing information to customers about the program:

- The ICSP does not include invoice numbers on the check, so it is difficult to match payments with lighting purchases (2 of 3 distributors who reported problems with incentive payments)
- Data collection and submittal requirements created a very manual and time-consuming order process (3 distributors)
- Data collection requirements slowed the point-of-sale order process and caused frustration for both customers and sales staff (1 distributor who was *not too satisfied* with the Midstream Lighting delivery channel in PY9, although happy with the rebate levels)
- ICSP did not reimburse some incentive payments because distributor either made mistakes filling out the required forms or did not receive the correct information from the customer (2 distributors)
- Difficulty getting sales staff to educate customers and explain the program requirements in detail (2 distributors).

Satisfaction with Energy Savings

Of the 42 end users and contractors who were interviewed, 34 said they (or their clients) were satisfied with the energy savings from the lighting products they purchased through Midstream Lighting. The remaining eight were unsure because they do not see the electricity bill.

Opinion of PPL Electric Utilities

Cadmus asked end users and contractors if they viewed PPL Electric Utilities as a leader in new energy-efficient technologies. The majority (11 out of 15 purchasers, nine out of 12 non-purchasers, 12 out of 15 contractors) said they did, and eight said they were unsure. Only two said they did not; they thought new energy-efficient technologies were more likely to come from suppliers or distributors than from PPL Electric Utilities.

Areas Working Well

Overall, most distributors (9 of 12) and contractors (14 of 15) thought program incentives were sufficient to encourage customers to purchase program products. Distributors agreed that the instant discounts help drive sales. Several distributors said the variety of program-eligible products was sufficient to allow them to meet most of their customers' needs. This is an improvement over PY8, when most distributors recommended expanding the list of eligible products. Two distributors in PY9 said they had experience with a different utility's midstream program and preferred PPL Electric Utilities' program because of its wider selection of eligible products. Distributors also spoke favorably of the program's simplicity and straightforward rules, and one distributor said the program is "easy to sell." Finally, one distributor appreciated having a point person with the ICSP with whom to work directly.

End users and contractors appreciated the ease of participating in the program compared to the traditional rebate program, specifically because the discount is applied instantly. One contractor said "the fact that the customer gets the rebate right away is great—it's so streamlined." An end user commented that "the [Midstream] program has a positive impact on customers—keep up the good work!"

Suggested Improvements

Cadmus asked respondents about their top recommendations to improve the program. End users and contractors most often requested additional information about program eligible products and more program support from PPL, both online and on the phone, while distributors recommended reducing the administrative burden by making verifying program information easier and putting the invoice numbers on incentive payments so that they can more easily reconcile their finances. Respondents also requested more products be added to the program, such as outdoor lighting (parking lot and area lights), plug-in CFL-LED replacement kits, 8-foot T8s, and LED panels, such as 2x2 and 2x4 flat panels.[35] Additional detail regarding the suggested improvements can be found in can be found in *Appendix F Suggested Improvements.*

[35] These products are eligible and discounted in PY10.

6.5.4 End User Segmentation Analysis

Cadmus compared the annual consumption and reported lighting savings to assess differences among these groups:

- Midstream Lighting participants
- Phase III Efficient Equipment prescriptive rebate lighting participants
- Phase III Efficient Equipment direct installation lighting participants
- Phase II Efficient Equipment prescriptive rebate lighting participants
- Phase II Efficient Equipment direct installation lighting participants

The Midstream Lighting component is composed more heavily of smaller jobs (overall savings, per customer account) and smaller customers (annual kWh consumption) than both the prescriptive lighting and Direct Discount components of the Efficient Equipment Program. In Phase III, prescriptive rebate projects were comprised of larger customers and jobs than in Phase II, whereas the Direct Discount participants were more evenly distributed over consumption and savings quartiles than in Phase II. These findings demonstrate that smaller customers and jobs gravitated toward the Midstream Lighting program component in Phase III.

The tables and additional discussion supporting these findings can be found in *Appendix F End-User Segmentation Analysis*.

6.5.5 Market Effects

Cadmus proposed to analyze sales data to assess market effects of Midstream Lighting on sales of efficient products outside of the program, if sufficient data were available. However, sales data could not be secured from a sufficient sample of distributors. Therefore, Cadmus made a qualitative assessment using data from interviews with distributors, purchasers (including contractors), and end users.

In PY9, distributors said their stocking practices were driven by customer demand or, in the case of multistate distributors, corporate policies. Nevertheless, they attributed some increase in customer demand to utility program rebates, including those offered by Midstream Lighting.

Likewise, although most contractors tended to recommend efficient lighting upgrades to all of their clients, they credited Midstream Lighting and distributors' recommendations in their clients' decisions to do so. Four of 15 contractors interviewed said Midstream Lighting had increased their sales of high-efficiency lighting that did not qualify for rebates (because either the products or end-user customers were not eligible).

These findings indicate that, although the commercial lighting market is on a relatively rapid trajectory toward energy efficiency, the increased access to instant discounts offered by Midstream Lighting has probably helped maintain this momentum and could be having some impact on the market outside of the program. For more detail regarding these specific findings, see *Distributors' Stocking and Sales*

Patterns and *Program Influence on Contractors' Promotional Practices and Business* sections in *Appendix F.3.1 Additional Findings*.

6.6 Cost-Effectiveness Reporting

Because the Midstream Lighting component is part of the Non-Residential Energy Efficiency Program, cost effectiveness is presented in section *4.5 Cost-Effectiveness Reporting.*

6.7 Recommendations

The combined impact evaluation for PY8 and PY9 and the process evaluation activities in PY9 led to the following findings and recommendations from Cadmus to PPL Electric Utilities. Table 5-18 lists the recommendations, along with a summary of how PPL Electric Utilities plans to address the recommendation.

Finding: Overall, the Midstream Lighting component has been running effectively and saw a dramatic increase in reported sales from PY8 to PY9. This lighting delivery channel is used by a wide range of commercial customers, from single owner-operator businesses to large corporations. Satisfaction among program actors was high in PY9. Distributors, especially, were more satisfied with the diversity of eligible products in PY9 than in PY8. See section *6.5.3.2* and *Appendix F*.

Finding: Although demand for efficient lighting (LED products, specifically) has been on the rise, such that these products represent the majority of participating distributors' lighting sales, both distributors and contractors reported that customers are still cost-conscious and that utility program incentives are very influential in maintaining sales of efficient products. See *Distributors' Stocking and Sales Patterns* and *Influence on Contractors' Promotional Practices and Business* in *Appendix F.3.1 Additional Findings*.

Finding: Some distributors found it challenging to collect reliable information regarding the installation locations of all purchases, especially when contractors purchased the discounted products on behalf of the end-user. As a result, some distributors are concerned about the risk of not being reimbursed for instant discounts they advance on sales. See section *6.5.3.2.*

Finding: Both distributors and customers said their program experience could be improved if they could access information about product eligibility and incentives online, rather than using the current system wherein each distributor maintains a list of products they carry that qualify for incentives and must obtain pre-approval from the ICSP to add new products to their list. Distributors also suggested that the program automatically include all ENERGY STAR- or DesignLights Consortium-certified products in defined categories (e.g., LED replacements for 4-foot linear fixtures), rather than requiring the ICSP's preapproval before the distributor can complete a discounted sale. See *section 6.5.3.2.*

Finding: Distributors and contractors play an important role in driving sales of efficient lighting by building on their relationships with customers. Specifically, they can influence customers' decisions to invest in upgrades, especially ENERGY STAR- or DesignLights Consortium certified products (see *Contractors' Promotional Practices and Business* in *Appendix F.3.1 Additional Findings*). Distributors use the Midstream Lighting instant discounts to drive sales of efficient products (see *Motivations for*

Participating in *Appendix F*). However, awareness of the Midstream Lighting component is still relatively low among participants in other components of the Non-Residential Energy Efficiency Program, as shown in Table F-9 in *Appendix F*.

Conclusion: Distributors and purchasers could benefit from a tool (e.g., an online portal) to verify customer and product eligibility and to submit information to the ICSP. The online portal the ICSP is developing could potentially eliminate the preapproval requirement for products that meet eligibility criteria. Such a tool could mitigate delays related to preapproval and reduce the distributors' risk of selling discounted products that do not qualify for reimbursement. Eliminating preapproval and assuring reimbursement for discounted products will improve distributor and purchaser experience with the program.

Recommendation #1: Encourage the ICSP to continue to develop and provide an online tool so distributors can verify customer and product eligibility. Additionally, consider investigating the feasibility of including all ENERGY STAR- or DesignLights Consortium certified models in product categories that are included in the program and have savings assumptions defined in the IMP.

Finding: The lighting market, for both products and prices, continues to evolve. Distributors predict a market shift toward including lighting products in systems that incorporate controls and sensors (see *Distributors' Stocking and Sales Patterns* in *Appendix F.3.1 Additional Findings*).

Conclusion: The program must adapt readily to changes in the commercial lighting market to remain in a strong position to drive sales of emerging technology. This involves identifying new products to add to the program and maintaining optimal incentive levels.

Recommendation #2: Consider encouraging the ICSP to solicit regular feedback from distributors about trends in pricing, of both program and competing products, and in demand for additional or auxiliary energy-efficient lighting products, and determine if these can be included as part of program offerings.

Finding: Distributors appreciate receiving SPIFFs, and a few said SPIFFs motivated staff to be more proactive in driving sales of program products. However, they agreed that SPIFFs had less influence on sales than did the instant discounts passed on to customers. Distributors also preferred being made aware of SPIFFs in advance (30 days was suggested), so they could prepare their sales staff (see section *6.5.3.1, Program Delivery).*

Conclusion: SPIFFs have the potential to change the behavior of distributor sales staff but would be more effective if distributors knew about the limited-time offerings in advance.

Recommendation #3: Continue efforts to work with distributors to optimize advance notice and the timing of SPIFFs, if they are offered in the future.

Finding: Some distributors said reconciling their internal bookkeeping was challenging because in the ICSP's reimbursement process the checks did not include the distributors' invoice numbers (see section *6.5.3.1*, *Suggested Improvements)*.

Finding: The ICSP reported savings of over 500 MWh for projects that were duplicate records (see *Appendix F.1.2)*.

Conclusion: The ICSP reimbursement process could be improved by adding information to help efficiently reconcile invoices.

Recommendation #4: Consider asking the ICSP to add information (such as the distributor's invoice number) on reimbursement checks, and any program tracking or supporting documentation. A unique identifier of a rebated purchase that is used consistently in documentation will allow all parties including PPL Electric Utilities, the ICSP, the distributor and the evaluation team to track information across different stages of the project.

Finding: Reported savings for new construction projects, ineligible under the program, adversely affected savings realization rate (see *Appendix F.1.2)*.

Conclusion: Distributors require additional information or reminders about program eligibility guidelines.

Recommendation #5: The ICSP should remind distributors that new construction projects are not eligible for discounted products offered by the Midstream Lighting program.

6.7.1 Status of Recommendations

Table 6-9 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 6-9. Status of Recommendations for Midstream Lighting

Midstream Lighting Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Encourage the ICSP to continue to develop and provide an online tool so distributors can verify customer and product eligibility. Additionally, consider investigating the feasibility of including all ENERGY STAR- or DesignLights Consortium certified models in product categories that are included in the program and have savings assumptions defined in the IMP.	Implemented. Distributor portal launch planned for Q1 2019. This is being considered for the all ENERGY STAR and DesignLights Consortium models.
2	Consider encouraging the ICSP to solicit regular feedback from distributors about trends in pricing, of both program and competing products, and in demand for additional or auxiliary energy-efficient lighting products, and determine if these can be included as part of program offerings.	Being considered.
3	Continue efforts to work with distributors to optimize advance notice and the timing of SPIFFs, if they are offered in the future.	Being considered.
4	Consider asking the ICSP to add information (such as the distributor's invoice number) on reimbursement checks, and any program tracking or supporting documentation. A unique identifier of a rebated purchase that is used consistently in documentation will allow all parties including PPL Electric Utilities, the ICSP, the distributor and the evaluation team to track information across different stages of the project.	Being considered.
5	The ICSP should remind distributors that new construction projects are not eligible for discounted products offered by the Midstream Lighting program.	Implemented.

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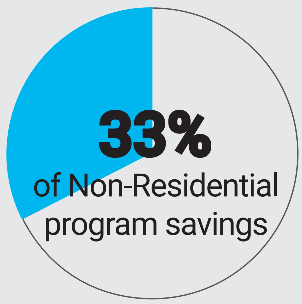
CADMUS

CUSTOM PROGRAM

The program offers financial incentives to customers who install equipment that is not offered in PPL Electric Utilities' other commercial programs.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **100,566 MWh/yr**



PY9 saved **29,827 MWh/yr**

PROGRAM SATISFACTION

96% Satisfied with overall program

100% satisfied with the **professionalism of the program representatives**

92% satisfied with the **ease of the online application process**

87% satisfied with the **information** provided about the **application process**

81% satisfied with the **time it took to process the application**

58% satisfied with the **ability to track your rebates**

PY9 PARTICIPATION

A total of **100** participants:

- 34 Motors
- 10 Refrigeration
- 1 Combined Heating and Power (CHP)
- 3 Agricultural
- 18 HVAC
- 34 Other unspecified

7 Non-Residential Custom Program

The Custom Program, a component of the Non-Residential Energy Efficiency Program, offers financial incentives to customers who install equipment that is not offered in PPL Electric Utilities' other commercial programs or is not addressed in the Pennsylvania Phase III Technical Reference Manual (hereafter referenced as the PA TRM).[36] Equipment may include new or replacement energy-efficient products, retrocommissioning, repairs, equipment optimization, new construction, operational and process improvements, combined heat and power (CHP), and behavioral changes that result in cost-effective energy savings. In a continuous energy improvement (CEI) component, which is reported separately, PPL Electric Utilities works closely with customers, primarily school districts, to identify ways to reduce their electricity usage through improved O&M and behavioral changes.

The Custom Program offers incentives for the avoided or reduced energy consumption—in kilowatt hours per year (kWh/yr)—that result from the completed project. Incentives are subject to an annual cap for each project ($500,000) 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. Projects with TRC test score of greater than 0.7 are eligible for an incentive. The cost-effectiveness threshold was lowered to 0.7 in PY9 from 1.0 in PY8. The new threshold applies to all Custom Program projects regardless of equipment or project type.

PPL Electric Utilities pays the incentive to the customer following successful implementation of a cost-effective project, and the incentive may vary by the type or size of the equipment, system, or improvement. For projects where expected savings are greater than 500,000 kWh/yr, PPL Electric Utilities bases the incentive payment on verified savings, rather than reported savings. This approach is called real-time evaluation, and is a cornerstone of the Custom Program.

The ICSP, CLEAResult, manages the program and handles application intake, assesses eligibility, and calculates project energy savings and incentives.

[36] Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2016. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

7.1 *Participation and Reported Savings by Customer Segment*

7.1.1 Definition of a Participant

A PY9 participant is defined as a project that was commercially operable and received an incentive payment between June 1, 2017, and May 31, 2018.[37] Projects for which customers submitted an application during this period but did not receive an incentive are not counted as participants in PY9. An individual customer may have multiple participating projects. Typical custom projects may take more than one quarter to complete.

7.1.2 Program Participation and Reported Impacts

Table 7-1 presents the participation counts, reported energy and demand savings, and incentive payments for the Custom Program in PY9 by customer segment.

Table 7-1. PY9 Custom Program Participation and Reported Impacts

Parameter	GNE	Large C&I	Residential	Small C&I	Total[(1)]
PYTD # Participants	16	34	3	47	**100**
PYRTD MWh/yr	2,917	19,012	470	5,823	**28,222**
PYRTD MW/yr	0.27	1.69	0.00	0.61	**2.57**
PYVTD MWh/yr	3,099	19,792	519	6,417	**29,827**
PYVTD MW/yr	0.26	2.33	0.00	0.55	**3.14**
PY9 Incentives ($1000)	$702	$1,234	$28	$20	**$1,983**
[(1)]Total may not match sum of columns due to rounding.					

Table 7-2 lists the types of projects completed in PY9 and percentage of reported savings.

Table 7-2. PY9 Program Custom Project Types

Project Type	Number of Projects (n=100)	Percentage of Reported Savings Represented by Projects (n=100%)
Motors	34	21%
HVAC	18	15%
Refrigeration	10	5%
Combined Heating and Power (CHP)	1	23%
Lighting	0	0%
Other [(1)]	34	35%
Agricultural	3	2%
[(1)] The *Other* project type had two participants whose projects were installed in PY8 but verified in PY9; the final incentive was paid in PY9. The savings for these projects were reported and verified in PY8 and are reflected in the Phase III savings to date.		

37 As defined by the Phase III Evaluation Framework, EDC claimed savings are determined by the date the equipment is "installed and commercially operable." Equipment that is installed and not commissioned, or operating as intended, is not considered "commercially operable."

7.2 Gross Impact Evaluation

Table 7-3 shows the evaluation sampling strategy. The target levels of confidence and precision for each stratum were chosen to meet an overall program target of 85% confidence and 15% precision. More details are in *Appendix E.1.1 Methodology*.

Table 7-3. Custom Program Gross Impact Sample Design for PY9

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Large	8	Census	8	8	File review, site-specific measurement and verification plans, baseline and post-installation visits, metering installed (if required), verified savings analysis and report
Small	91	CP= 85/20 Cv = 0.64 (assumed)	15	15	File review, site-specific measurement and verification plans, post-installation visit, metering installed (if required), verified savings analysis and report
CHP	1	Census	1	1	File review, site-specific measurement and verification plans, baseline and post-installation visits, metering installed (if required), verified savings analysis and report
Program Total	**100**	**N/A**	**24**	**24**	

In PY9, the Custom Program reported energy savings of 28,222 MWh/yr, as shown in Table 7-4, and demand reduction of 2.57 MW/yr, as shown in Table 7-5. These include reported savings from the large, small, and CHP strata. The realization rate is 100% for the real-time evaluated projects in the large stratum because savings were verified before the incentive was paid.

The achieved precision for the program-level results was in compliance with the Evaluation Framework, exceeding the requirements to meet 85% confidence and 15% precision (85/15).[38] Results for the program overall, including large and small strata, are reported with 7.78% precision at the 85% confidence level.

Table 7-4. PYRTD Custom Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Custom – CHP	6,438	100%	N/A	N/A
Custom – Large	6,076	100%	N/A	N/A
Custom – Small	15,708	110%	0.38	13.66%
Program Total[(1)]	**28,222**	**106%**	**N/A**	**7.78%**
[(1)]Total may not match sum of rows due to rounding. Totals exclude PY8 projects that were reported in PY8 and verified in PY9.				

[38] Evaluation Framework for Pennsylvania Act 129 EE&C Programs, October 21, 2016.

Table 7-5. PYRTD Custom Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Custom – CHP	0.00	N/A	N/A	N/A
Custom – Large	0.75	98%	N/A	N/A
Custom – Small	1.82	91%	0.48	17.11%
Program Total[(1)]	**2.57**	**122%**	**N/A**	**8.91%**
[(1)]Total may not match sum of rows due to rounding. Totals exclude PY8 projects that were reported in PY8 and verified in PY9.				

In PY8, the Custom Program reported unverified savings for three large projects (representing 35% of PY8 reported savings). Verification of these projects was completed in PY9. The three projects achieved 24,372 MWh per year of verified energy savings with a 98.2% energy realization rate, as shown in Table 7-6, and 3.22 MW of demand reductions at a demand realization rate of 124.1%, as shown in Table 7-7.

Table 7-6. PY8 Unverified Custom Program Gross Impact Results for Energy (Verified in PY9)

Stratum	PY8 Unverified RTD MWh/yr	PY8 Verified in PY9 VTD MWh/yr	PY8 -Verified in PY9 Energy Realization Rate
Custom – Large (Verified in PY9)	24,815	24,372	98.2%
PY8 Program Total[(1)]	**24,815**	**24,372**	**98.2%**
[(1)]The Custom Program reported a total of 71,332 MWh/yr in savings in PY8, including the unverified projects. The PY8 evaluation verified 46,516 MWh/yr at a realization rate of 100%.			

Table 7-7. PY8 Unverified Custom Program Gross Impact Results for Demand (Verified in PY9)

Stratum	PY8 Unverified RTD MW/yr	PY8 Verified in PY9 VTD MW/yr	PY8 Verified in PY9 Demand Realization Rate
Custom – Large (Verified in PY9)	2.59	3.22	124.1%
Program Total[(1)]	**2.59**	**3.22**	**124.1%**
[(1)]The Custom Program had verified demand reductions of 5.3 MW at a realization rate of 83% in PY8.			

The reported savings for large stratum projects matched the savings provided by Cadmus to PPL Electric Utilities and the ICSP with two exceptions. For one project, the ICSP did not report kW/yr savings. For another project, the ICSP used an average kW/yr savings instead of the peak demand kW/yr savings.

Cadmus found that all projects verified in PY9 involved equipment or processes that were operating as planned. Following the site visit, Cadmus updated the assumed parameters or equipment operations used to determine the reported savings and calculated the verified savings (See *Appendix E.1 Gross Impact Evaluation*).

7.2.1 Realization Rate

For the large and CHP strata, the demand savings realization rates were not 100% because of two data entry errors in PPL Electric Utilities' tracking database where the recorded value did not match the documentation provided by the ICSP. The documentation reported the correct demand savings.

For the small stratum, several factors led to differences between the reported and verified savings and to the observed realization rates. Each may have caused an increase or decrease in project energy savings, depending on the specific circumstances of that project. Further discussion on the sources of the factors affecting the realization rate is found in *Appendix E.1.2 Realization Rate Findings.*

7.3 Net Impact Evaluation

The methods used to determine net savings for downstream, upstream, and midstream programs are provided in the Evaluation Framework,[39] which discusses the common methods to determine free ridership and spillover. Cadmus used self-report surveys, administered online and by phone, to assess free ridership and spillover for the Custom Program and reviewed communication documents for surveyed participants to provide additional context about free ridership.

Free ridership 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. 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. Spillover increases net savings attributable to PPL Electric Utilities.

Cadmus calculated net savings only to inform future program planning. Energy savings and demand reduction compliance targets were met using verified gross savings.

Table 7-8 lists the methods and sampling strategy used to determine net savings for the Custom Program in PY9. Cadmus conducted online and telephone self-report surveys with 26 of 70 Custom Program participants between November 2017 and July 2018.[40] Four participants responded to the online survey and 22 to the telephone survey. One of the 26 participants did not answer the free ridership questions leaving 25 surveys for net impact analysis. Additional details about the methodology are in *Appendix E.3.2 Survey Approach*.

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[39] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC. October 21, 2016.

[40] The final sample frame includes unique records in the PPL Electric Utilities tracking database. After selecting all unique records, Cadmus removed any records from the population if the customers had participated in a survey in the last three months, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey. This left 70 records available to contact for the survey.

Table 7-8. PY9 Custom Program Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population [(1)]	Achieved Sample Size [(2)]	Response Rate [(3)]	NTG Activity
Custom	Participants	100	25	36%	Self-report surveys
Program Total	**N/A**	**100**	**25**	**36%**	**N/A**

[(1)] The total population was 100 but after selecting unique participants and removing customers had participated in a survey in the last three months, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey, the sample frame was 70.
[(2)] Twenty-six participants completed the survey but only 25 answered free ridership questions.
[(3)] Response rate is calculated as the percentage of respondents who answered the free ridership questions (n=25) divided by the number of unique records in the population (n=70). Email invitations were sent to all unique participants who had not completed a survey in the past three months, had not opted out, had valid contact information, or were not on the do not call list. Following the online survey, Cadmus attempted to contact respondents who did not complete the online survey via telephone. Cadmus completed 26 surveys, but one participant did not answer the free ridership questions.

Table 7-9 shows the free ridership, spillover, and NTG ratio for the Custom Program. Additional details are in *Appendix E.2 Net Impact Evaluation*.

Table 7-9. Custom Program Net Impact Evaluation Results

Stratum	Number of Surveys [(1)]	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 85% C.L.
Custom (all projects)	25	27%	0%	0.73	18%
Program Total	**25**	**27%**	**0%**	**0.73**	**18%**

[(1)] Twenty-six participants completed the survey but only 25 answered the free ridership questions.

Free ridership for the Custom Program was 27% in PY9, weighted by the size of the project completed by respondents. All customers were contacted to complete a survey, and 25 responded.[41] These 25 respondents represented 28% of the program's verified population savings. Four respondents had large stratum projects, 21 had small stratum projects. The CHP participant did not complete a survey so Cadmus did not conduct a free ridership analysis.

Table 7-10 shows PY9 Custom Program free ridership by stratum. One of the four large stratum projects in the free ridership analysis represents 75% of the verified savings for the large stratum and was estimated at 0% free ridership. The overall large stratum free ridership estimate of 9% is heavily weighted toward this one project.

Small stratum free ridership includes six motor projects, five HVAC projects, three VFD projects, two compressed air projects, one refrigeration project and four custom projects, representing 28% of the total verified savings for the small stratum population (91 projects). Although not randomly selected, these 21 projects are probably representative of other projects in the small stratum for verified savings and free ridership. Fourteen of the 21 respondents said they would have done the exact same project on

41 Twenty-six participants completed the surveys but only 25 answered free ridership questions. The same survey is used to collect data for both the process and the net savings analysis.

the same schedule in the absence of the Custom Program. These 14 projects are the main contributors to the small stratum free ridership estimate of 41%.

Three of the 21 respondents said they would have canceled or postponed their project at least one year in the absence of the Custom Program. One respondent would have reduced the size and scope of the project in the absence of the Custom Program, and three respondents did not know what they would have done.

Table 7-10. PY9 Custom Program Free Ridership Comparison by Stratum

Stratum	Number of Respondents	Weighted Free Ridership (%)[1]	Percentage of Analysis Sample Verified Savings	Percentage of Program Population Stratum Verified Savings	Relative Precision at 85% C.L.
Small	21	41%	58%	28%	21%
Large	4	9%	42%	59%	21%
Program Total	**25**	**27%**	**100%**	**36%**	**18%**
[(1)]Weighted by verified kWh/yr savings.					

No data collected in the participant surveys indicated spillover activity attributable to PPL Electric Utilities.

7.3.1 High-Impact Measure Research

Because Custom projects are unique and nearly all are high impact, a separate group of high-impact projects was not selected for the net savings analysis in PY9. Cadmus did not identify any high-interest projects that were not already selected into the large stratum, small stratum, or the CHP stratum.

7.4 Verified Savings Estimates

Table 7-11 shows the realization rates Cadmus applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the PY9 Custom Program component of the Non-Residential Energy Efficiency Program. In the future, Cadmus will add these totals to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 7-11. Custom Program PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr)[1]	Demand (MW/yr)[1]
PYRTD	28,222	2.57
PYVTD Gross	29,827	3.14
PYVTD Net [2]	21,773	2.29
P3RTD	99,554	11.54
P3VTD Gross	100,566	11.65
P3VTD Net[2]	77,658	9.02
P8 Savings Verified in PY9	24,372	3.2

[1] Total may not match sum of rows due to rounding.
[2] Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.

7.5 Process Evaluation

7.5.1 Research Objectives

The main research objectives for the PY9 process evaluation of the Custom Program focused on customer experience and satisfaction, program performance, and program influence.

7.5.2 Evaluation Activities

The PY9 process evaluation activities for the Custom Program were consistent with the evaluation plan and included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Logic model review
- Online participant surveys
- Telephone participant surveys

Table 7-12 lists the process evaluation sampling strategy. Additional details about sampling methodology are included in *Appendix E.3.2 Survey Approach*.

Table 7-12. PY9 Custom Program Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame (1)	Percent of Sample Frame Contacted to Achieve Sample (2)
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone In-depth Interview	2	N/A (3)	2	2	2	100%
Participants	Custom	Online	100	N/A (3)	All participants	4	70	100%
		Telephone				22		100%
Program Total			**102**			**28**	**72**	**100%**

(1) Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities tracking database. After selecting all unique records, Cadmus removed any records from the population if the customers had participated in a survey in the last three months, were selected for another program survey, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey. This left 70 records available to contact for the survey.
(2) Percent contacted means the percentage of the sample frame contacted to complete surveys.
(3) Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.

7.5.2.1 Survey Methodology

Cadmus conducted online and telephone self-report surveys with 26 of 100 Custom Program participants between November 2017 and July 2018. Twenty-two participants responded to the telephone survey and four to the online survey. These surveys asked identical questions to assess satisfaction, net savings, and the influence of the program and of the contractor or design engineer on project design, purchase decisions, and program participation. Because respondents could skip questions, not every question was answered by all 26 respondents.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based survey items to reduce order effects

The SWE team and PPL Electric Utilities reviewed and approved the survey in PY8 before fielding the survey for PY9.

7.5.2.2 Program Staff and ICSP Interview Methodology

In December of 2017 and January of 2018, Cadmus conducted interviews with program managers from PPL Electric Utilities and the ICSP. The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and understanding the areas that are working well and any challenges.

7.5.3 Process Evaluation Findings

In presenting interview and survey data in this section, the percentage or frequency of responses is followed by the sample size for the particular question. Sample size (denoted by "n") refers to the number of respondents who answered the question. Sample sizes may vary by question, because of survey logic and skipped questions. Respondents could skip questions if they did not want to answer them; not all respondents provided an answer to every question.

7.5.3.1 Program Delivery

The Custom Program was delivered effectively in PY9 and maintains high levels of customer satisfaction. The ICSP delivered the program in PY9 similar to PY8 except for two modifications. PPL Electric Utilities initially accepted applications for the GNE sector in PY9; however, funds for the GNE sector were exhausted more quickly than anticipated and GNE projects are on a waitlist, as of January 2018. The cost-effectiveness threshold was lowered to 0.7 in PY9 from 1.0 in PY8. The new threshold applies to all Custom Program projects regardless of equipment type.

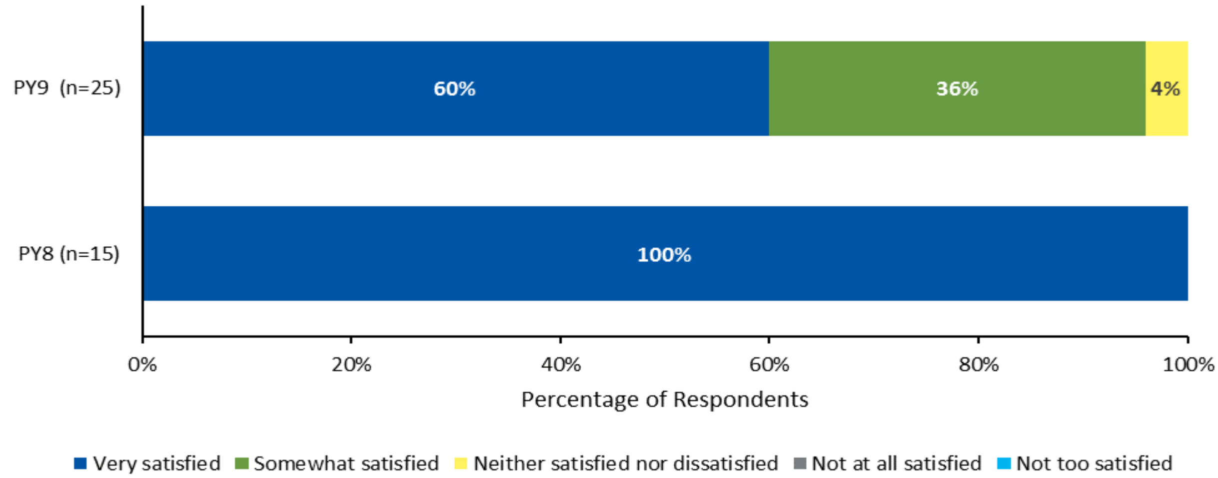
7.5.3.2 Program Satisfaction

The program contributed to a positive customer experience because the ICSP and Cadmus coordinate in conducting site visits and collecting site-specific data and in minimizing the number of data requests, metering installations, and other customer requests. Cadmus and the ICSP were in contact weekly and shared the goal of determining accurate savings for each project.

Satisfaction among Custom Program respondents was high. Twenty-four survey respondents (96%; n=25) were *very satisfied* or *somewhat satisfied* with the program (Figure 7-1). The remaining respondent was *neither satisfied nor dissatisfied*. This was a slight decrease from PY8, where 100% of participant survey respondents (n=15) were *very satisfied*.[42]

[42] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

Figure 7-1. PY9 Overall Custom Program Satisfaction



Source: Survey question, "Now, thinking about your overall experience with PPL Electric Utilities' business energy-efficiency program, how would you rate your satisfaction?"

Nine of 25 respondents provided recommendations to improve the program. Five comments focused on improving communication, ranging from more communication to providing an update regarding available funding. These are verbatim responses focused on communication:

- "Because it was a custom install it was complicated, so communication could have been improved [there was] lots of waiting."
- "Keep [the] owner copied on additional information when [the] contractor is submitting [the] rebate [application]."
- "Communication of where you are at in the process [tracking rebates was very difficult]. [We] had to do a lot of follow-up."
- "Tracking tool for rebates."
- "Sometimes [it was] hard to determine if the program is still functioning. They [PPL Electric Utilities] ran out of funds and [then] you aren't sure if there are still rebates available."

Additionally, one comment suggested improving the application process, one comment suggested increasing the rebate amount, one suggested providing more opportunities for rebates, and one suggested that the website could be clearer about the types of projects that qualify.

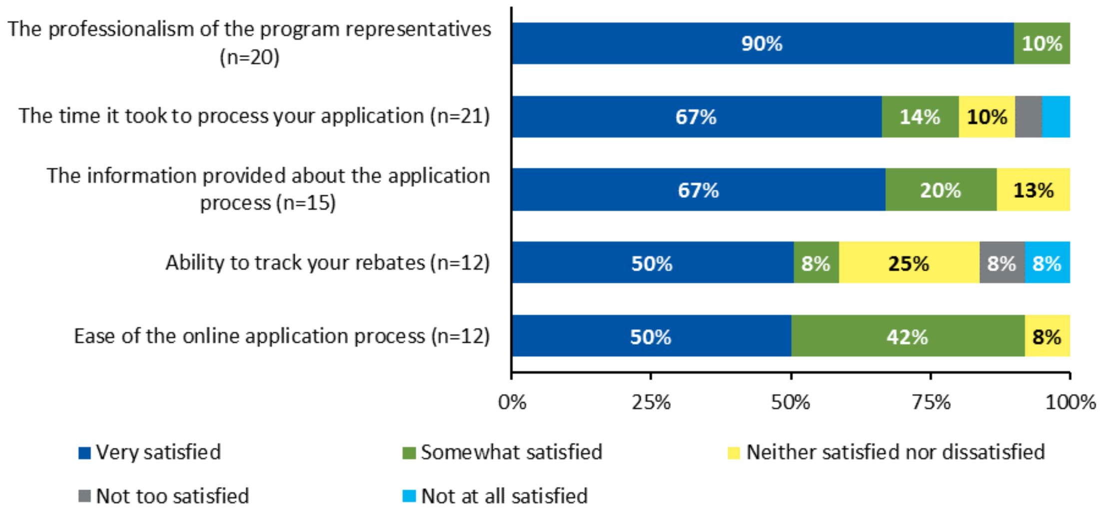
Overall Satisfaction

Participants were most satisfied with the professionalism of program representatives (90% were *very satisfied*; n=20).

Respondents were least satisfied with the ability to track their rebates and the ease of the online application process. Specifically, 50% of respondents (n=12) were *very satisfied* with the ability to track their rebates, a decrease from PY8, where 62% of the respondents (n=15) said they were *very satisfied* with their ability to track their rebates. Additionally, 50% of participants were *very satisfied* with the ease of the online application process (n=12), which was also a decrease from PY8, where 67% of participants were *very satisfied* (n=13) with the ease of the online application.[43]

Figure 7-2 presents these results.

Figure 7-2. PY9 Participant Satisfaction with Different Custom Program Components



Source: Survey Question "Please indicate how satisfied you are with each one."

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. As shown in Table 7-13, the Custom Program achieved an NPS of 84, indicating there are more promoters than detractors among the respondents. The passives are excluded from the calculation. An excellent NPS is 50 and above.[44]

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43 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

44 Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

Table 7-13. PY9 Net Promoter Score Likelihood to Recommend the Custom Program

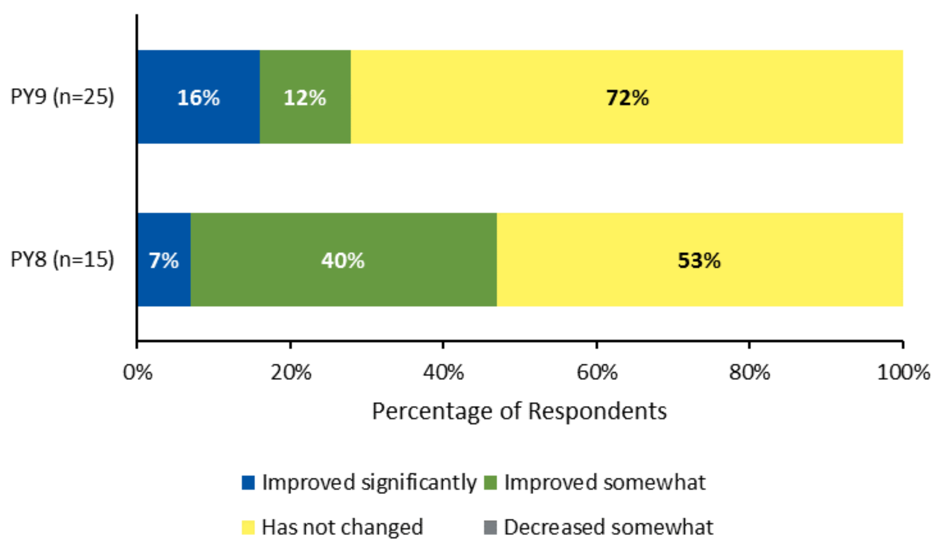
Rating Classification	PY8 Percentage of Respondents (n=15)	PY9 Percentage of Respondents (n=25)
Promoters (9-10)	73%	84%
Passives (7-8)	20%	16%
Detractors (0-6)	7%	0%
NPS	**66**	**84**
Source: Survey question "How likely is it that you would recommend this program to a friend, family member, or colleague?"		

The NPS of 84 is an increase from PY8 because number of detractors and passives decreased, suggesting that customers are more likely to recommend the program in PY9 than they were in PY8.

Opinion of PPL Electric Utilities

The evaluation survey asked participants if their opinion of PPL Electric Utilities had changed after participating in the program (Figure 7-3). More than twice as many (16%) PY9 survey participants said their opinions of PPL Electric Utilities have *improved significantly* compared to 7% who said this in PY8.

Figure 7-3. PY8 and PY9 Opinion Shifts of PPL Electric Utilities Due to Custom Program

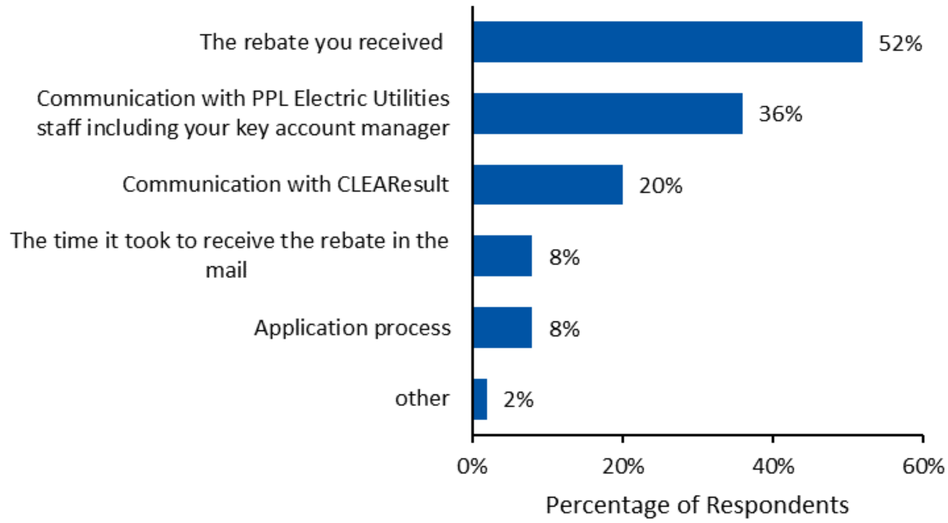


Source: Survey question, "After participating in the PPL Electric Utilities business energy-efficiency program, has your opinion of PPL Electric Utilities' …?"

Areas Working Well

Survey respondents (n=25) said the top three components that worked well in the Custom Program were the rebates they received, communication with PPL staff or account manager, and communication with CLEAResult (Figure 7-4). On the other hand, only 8% thought that the time it took to receive their rebate in the mail and the application process worked well. These findings are not surprising as the ease of the application process and ability to track rebates received the fewest high satisfaction ratings.

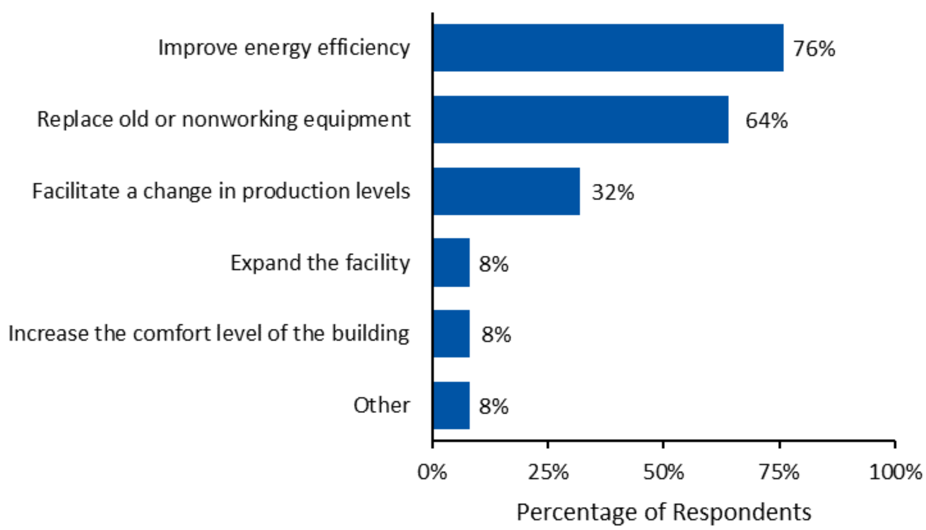
Figure 7-4. PY9 Custom Program Areas that Are Working Well



Source: Question, "Thinking about what worked well with the business energy-efficiency program, what one item worked best? What worked next best?" (n=25) Multiple responses allowed.

Three quarters of the surveyed participants said their organization completed the project to improve energy efficiency (76%, n=25). The second most common reason to complete the energy efficiency project was to replace equipment (64%). Figure 7-5 shows these results.

Figure 7-5. PY9 Reasons Participants Completed Custom Program Energy Efficiency Project

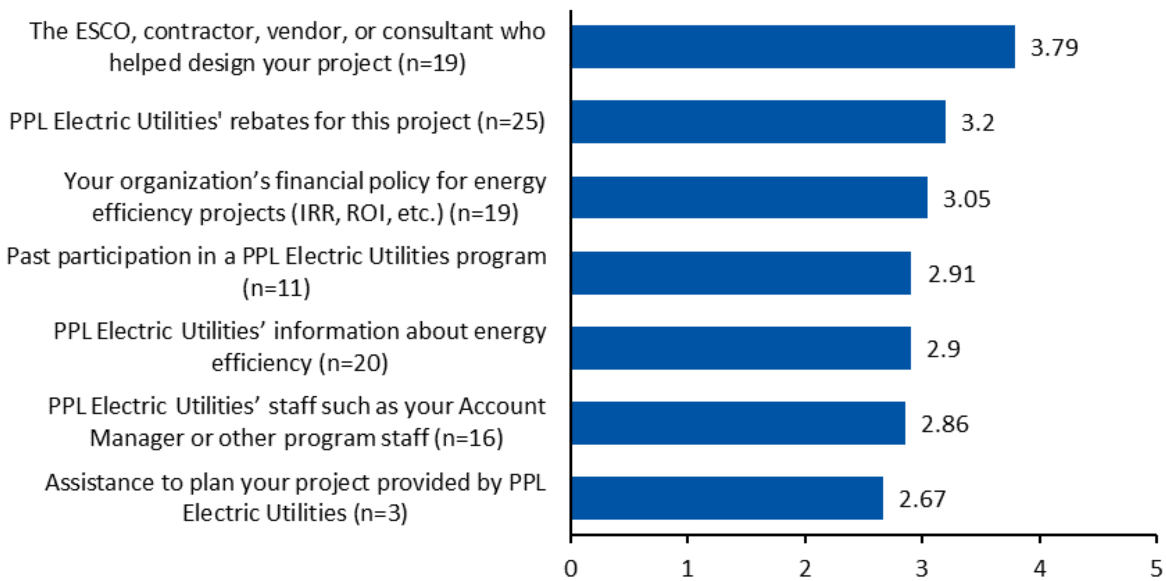


Source: Survey question "Please describe why your organization completed this project." Multiple responses allowed.

Eighty-six percent (n=22) said the equipment was already scheduled for replacement or an upgrade before the respondent decided to participate in the Custom Program.

The evaluation survey asked questions about how much influence the Custom Program had on participants' decision to complete the project the way they did. Figure 7-6 shows the average level of influence different items had on respondents' projects, where 5 was *extremely influential* and 1 was *no influence*. The most influential factor was the help of an energy services company (ESCO), contractor, vendor, or consultant during the design of the project (average score of 3.79, n=19). This was an increase from PY8, where respondents rated the influence of an ESCO, contractor, vendor, or consultant with a mean score of 3.33 (n=11).[45]

Figure 7-6. PY9 Average Influence Score for Different Items in the Custom Program



Source: Survey question "Please rate each item on how much influence it had on the decision to complete the project the way it was completed on a scale from 1 to 5 where 5 is *extremely influential* and 1 is *no influence*."

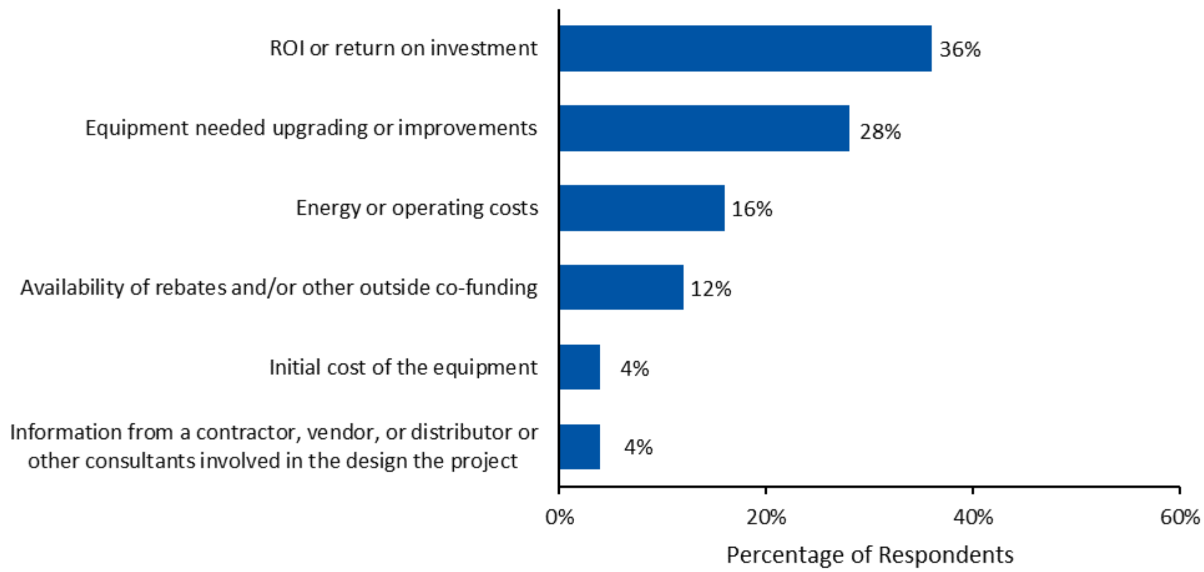
Six respondents (n=20) said their contractor, vendor, or consultant helped them select and install the specific equipment for their project. According to survey feedback, the vendor sales team helped with much of the rebate process and served as the intermediary to gather technical information for the rebates.

According to communication documentation provided by the ICSP for 17 customers, nine learned about the program from PPL Electric Utilities staff, five learned of the program from a contractor and the other three learned from other sources. This documentation indicates that PPL Electric Utilities staff are often the first source providing energy-efficiency information for their customers and may be influencing the design of their projects.

[45] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

To complete the project, 36% of respondents said the return on investment was the most important criteria in deciding to move forward (n=25), as shown in Figure 7-7. Information from energy services contract staff, contractors, vendors, and/or distributors who were involved in the design of the project was not mentioned as an important criteria when deciding to move forward, despite receiving high influence ratings for the project and implementation design. Interestingly, the second most common reason to complete a project and to participate in the program was to upgrade or replace old equipment, although PPL Electric Utilities' rebates were the second most influential factor to complete a project.

Figure 7-7. PY9 Most Important Criteria for Completing a Custom Program Project



Source: Survey question "Which of the following criteria was the most important in deciding whether the project would go forward? (n=25)

7.6 Cost-Effectiveness Reporting

Because the Custom component is part of the Non-Residential Energy Efficiency Program, cost effectiveness is presented in section *4.5 Cost-Effectiveness Reporting* of the *Non-Residential Energy Efficiency Program* chapter*.*

7.7 Recommendations

Overall, the Custom Program has been highly successful, with the verified savings of 29,827 MWh/year. None of the 26 participants who completed a survey said they were dissatisfied with the program. Recommendations are provided in Table 7-14, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: Although 96% of survey participants (24 of 25) were *very or somewhat satisfied* with the program overall, they were least satisfied with the ability to track rebates. Satisfaction with this component dropped in PY9 (50% *very satisfied*) from PY8 (62% *very satisfied*). (See section *7.5.3.2 Program Satisfaction.*)

Conclusion: The ability to track rebate status is a concern for customers and could be leading to lower satisfaction in PY9. Although the program offers customers a way to track rebate status, not all customers may be aware of it or the online portal may be difficult to use.

Recommendation #1: PPL Electric Utilities and the ICSP could consider providing customers with more information about how to track rebate status in the online portal. They could also consider adding this information to their standard outreach materials.

Finding: Using a rating scale from 1 to 5, survey respondents said the two most influential items in their decision to complete the project were the contractor or vendor who designed the project (rating this a 3.79 out of 5, where 5 is extremely influential) and PPL Electric Utilities' rebate (3.2 out of 5). (See *Program Influence* section in *7.5.3.2 Program Satisfaction.*)

Finding: Communication documentation showed that most customers learned about the program from PPL Electric Utilities staff (53%; n=17) or through contractors (29%; n=17). (See *Program Influence* section in *7.5.3.2 Program Satisfaction.*)

Conclusion: Most participants learn about the program from PPL Electric Utilities staff and design their projects to be energy efficient because of the contractor or the PPL Electric Utilities rebate.

7.7.1 Status of Recommendations

Table 7-14 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 7-14. Status of Recommendations for the Custom Program

Custom Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	PPL Electric Utilities and the ICSP could consider providing customers with more information about how to track rebate status in the online portal. They could also consider adding this information to their standard outreach materials.	Being considered.

CADMUS

CONTINUOUS ENERGY IMPROVEMENT PROGRAM

This program targets school districts, providing technical support for schools to develop an energy-efficiency master plan and implement it over two years.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **641 MWh/yr**

PY9 saved **641 MWh/yr**

PROGRAM SATISFACTION

100% Satisfied with overall program

Areas working well:

- School engagment
- Early diagnosis and intervention of higher than expected energy consumption
- Learning from peers

PY9 PARTICIPATION

4 school **districts**
1 pilot school in each district
18 participating **schools**

10 **Elementary** schools
4 **Middle** schools
4 **High** schools

8 Non-Residential Continuous Energy Improvement Program

Continuous Energy Improvement (CEI), a component of the Non-Residential Energy Efficiency Program, targets school districts for which PPL Electric Utilities provides technical support for schools to develop and implement an energy master plan over at least two years. At the end of each year, school districts receive an incentive of $0.05 per kilowatt-hour of savings achieved. Savings are verified using a billing analysis.

In PY8, CLEAResult, the ICSP, worked with PPL Electric Utilities to recruit four school districts to participate during PY9 through PY10. The ICSP helped each district select one pilot school to focus on during the first year. The ICSP conducted an audit at the pilot school and developed an energy master plan along with a methodology for measuring energy savings. The energy master plan included improvements in equipment and O&M and changes in the energy-related behaviors of staff, faculty, and students. Most equipment upgrades were eligible for a rebate through other components of PPL Electric Utilities' Non-Residential Program, such as Efficient Equipment and Custom Incentive.

Each district identified an energy manager, who could be a facility manager, energy expert, teacher, or administrator. The districts collaborated and shared best practices during monthly meetings, workshops, and conference calls led by the ICSP. Each district developed an energy reduction goal. Although the first year of participation focused on the pilot school, other schools could also implement some changes (such as HVAC control settings) and claim savings associated with these changes during the same period. Most Continuous Energy Improvement activities will be implemented throughout the other schools in the four districts during the second year.

8.1 Participation and Reported Savings by Customer Segment

8.1.1 Definition of a Participant

A participant in the Continuous Energy Improvement component is defined as an individual school and is listed in PPL Electric Utilities' tracking database as an individual job. The name of the school district is also recorded.

In PY9, four school districts participated, with a total of 18 participating schools (ten elementary schools, four middle schools, and four high schools). Each district chose one pilot school—two were elementary schools and two were high schools. However, no savings were reported for one of the pilot elementary schools. Additionally, the ICSP determined it was not possible to estimate savings at one of the elementary schools because data were not available for the energy generated by this school's solar photovoltaic system. Therefore, there are 16 participants, because savings were reported for 16 schools.

The types of schools in each district are listed in Table 8-1.

Table 8-1. Participating Schools in Each District in the Continuous Energy Improvement Program

District	Elementary Schools	Middle Schools	High Schools	Total
1	3	1	1	5
2	2	1	1	4
3[1]	3	1	1	5
4	0	1	1	2
Total	**9**	**4**	**4**	**16**
[1] The pilot elementary school at this district is excluded because no savings were reported.				

8.1.2 Program Participation and Reported Impacts

Table 8-2 presents the participation counts and reported energy and demand savings by customer segment for the Continuous Energy Improvement Program in PY9. Because the program targets school districts, all participants are in the GNE sector.

Table 8-2. PY9 Continuous Energy Improvement Program Participation and Reported Impacts

Parameter	GNE	Total[1]
PYTD # Participants	16	**16**
PYRTD MWh/yr	723	**723**
PYRTD MW/yr	0.00	**0.00**
PYVTD MWh/yr	641	**641**
PYVTD MW/yr	0.43	**0.43**
[1]Total may not match sum of columns due to rounding.		

8.2 Gross Impact Evaluation

Table 8-3 shows the evaluation sampling strategy. More details are in *Appendix G.1.1 Methodology.*

Table 8-3. PY9 Continuous Energy Improvement Program Gross Impact Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Schools	16	N/A	16	Document review and regression analysis
Program Total	**16**	**N/A**	**16**	

In PY9, the Continuous Energy Improvement Program reported energy savings of 723 MWh/yr, as shown in Table 8-4, and demand reduction of 0 MW/yr, as shown in Table 8-5.

Table 8-4. Continuous Energy Improvement Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Continuous Energy Improvemet	723	89%	0.07	10.74%
Program Total[1]	**723**	**89%**	**N/A**	**10.74%**
[1]Total may not match sum of rows due to rounding.				

Table 8-5. Continuous Energy Improvement Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Continuous Energy Improvemet	0.00	N/A	0.06	8.99%
Program Total[1]	**0.00**	**N/A**	**N/A**	**8.99%**
[1]Total may not match sum of rows due to rounding.				

The energy savings realization rate was 89%. Many factors contributed to the variations between *ex ante* and *ex post* savings, including the frequency of data used, modeling techniques, selection of independent variables, calculation of heating degree days (HDDs) and cooling degree days (CDDs), and capital project savings, as discussed further in *Appendix G.1.4 Realization Rate Findings*.

Cadmus did not calculate a realization rate for demand savings because PPL Electric Utilities did not report demand savings.

8.3 Net Impact Evaluation

Cadmus assesses net savings only to inform future program planning. Energy savings and demand reduction compliance targets are met using verified gross savings.

Table 8-6 lists the methods and sampling strategy used to determine net savings for the Continuous Energy Improvement Program in PY9. Cadmus conducted telephone self-report interviews with energy managers at all four districts between May and June 2018. The NTG questions focused on Continuous Energy Improvement activities conducted at each districts' pilot school. Additional details are in *Appendix G.1.1 Methodology*.

Table 8-6. Continuous Energy Improvement Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population Size	Achieved Sample Size	Response Rate [1]	NTG Activity
School Districts	School districts	4	4	100%	Interview
Program Total	Total	4	4	100%	**Interview**
[1] Response rate is calculated as the percentage of respondents who completed the interview (n=4) divided by the number of unique records in the population (n=4).					

Because of the small sample size, with responses representing only three of the 16 schools with reported savings,[46] Cadmus determined it was not possible to quantify net savings for PY9. In PY10, Cadmus will interview energy managers again and aim to collect information for a larger sample of participating schools.

Because a billing analysis was used to estimate energy savings, PY9 spillover savings are included in the savings estimates for the schools in the four districts.

46 Savings were not reported for one pilot school.

8.4 Verified Savings Estimates

Table 8-7 shows the verified savings for the PY9 Continuous Energy Improvement component. In the future, Cadmus will add these totals to the verified savings achieved in previous program years to calculate the P3TD program impacts.

Table 8-7. Continuous Energy Improvement PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr)[1]	Total Demand (MW/yr)[1]
PYRTD	723	0.00
PYVTD Gross	641	0.43
PYVTD Net[2]	-	-
P3RTD	723	0.00
P3VTD Gross	641	0.43
P3VTD Net[2]	-	-

[1]Total may not match sum of rows due to rounding.
[2] Net savings are not used to meet PPL Electric Utilities' energy saving compliance target. Net savings were not estimated in PY9. See section *8.3 Net Impact Evaluation* for additional information.

8.5 Process Evaluation

8.5.1 Research Objectives

The main research objectives for the Continuous Energy Improvement component of the Non-Residential Energy Efficiency Program focused on these questions:

- How satisfied are energy managers with their experience in Continuous Energy Improvement activities?
- How closely is program delivery adhering to program design?
- In what areas is the program succeeding?
- What challenges are energy managers facing in implementing behavior change in their districts?
- What more could the program do to help energy managers reach their goals?

8.5.2 Evaluation Activities

The PY9 process evaluation activities for the Continuous Energy Improvement component included these:

- Document review
- Logic model review
- Interviews with PPL Electric Utilities and ICSP program managers
- Telephone interviews with the energy manager representing each of the four participating school districts

The research activities were consistent with the evaluation plan with one exception:

- Cadmus conducted telephone interviews with the energy managers at the four districts instead of conducting an online survey.

Table 8-8 lists the process evaluation sampling strategy. Each of the four participating school districts has one energy manager leading the Continuous Energy Improvement activities. The energy manager is the primary contact for all process evaluation activities.

Table 8-8. PY9 Continuous Energy Improvement Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame [1]	Percent of Sample Frame Contacted to Achieve Sample [2]
PPL Electric Utilities Program and ICSP Staff	Staff	Phone interview	2	N/A [3]	2	2	2	100%
School Districts	School district energy managers	Phone interview	4	N/A [3]	4	4	4	100%
Program Total			**6**		**6**	**6**	**6**	**100%**

[1] Sample frame is a list of participants with contact information who have a chance to complete the interview.
[2] Percent contacted means the percentage of the sample frame contacted to complete interviews.
[3] Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.

8.5.2.1 Participant Interview Methodology

Cadmus conducted telephone interviews with the energy manager of each of the four participating school districts. These interviews focused on the topics described above in section *8.5.1 Research Objectives*.

Interviews employed the self-report method, which can result in validity issues and biases (e.g., recall, social desirability). Cadmus designed the interviews to minimize such issues and biases using best practices to avoid questions that are leading, ambiguous, or contain more than one topic.

The SWE team and PPL Electric Utilities reviewed and approved the interview guide before fielding.

8.5.2.2 Program Staff and ICSP Interview Methodology

In May and June of 2018, Cadmus conducted interviews with the program managers from PPL Electric Utilities and the ICSP. The interviews discussed operations and identified areas that are working well and areas that may benefit from change.

8.5.3 Process Evaluation Findings

In this section, Cadmus presents interview findings. Findings from reviewing the Continuous Energy Improvement component process map and logic model can be found in *Appendix G.3.1 Additional Findings.*

8.5.3.1 Program Delivery

PPL Electric Utilities and ICSP staff said the Continuous Energy Improvement Program was operating well, and the energy managers reported they were happy with it and the ICSP. Cadmus reviewed the logic model detailing expected program outcomes and created a process map to outline the flow of activities by program actor. Cadmus determined that the Continuous Energy Improvement Program is operating as expected.

The Continuous Energy Improvement Program's ICSP in Phase III is different than in Phase II, but the same program lead was hired in Phase III. The program lead incorporated her first-hand experience from Phase II, providing consistency in administering the Continuous Energy Improvement Program in Phase III.

PPL Electric Utilities initially planned for a new cohort of five school districts to join each program year through PY11; however, funds for the GNE sector were exhausted more quickly than anticipated and GNE projects are on a waitlist as of January 2018. The PY9 cohort will continue to receive incentives for savings in their first and second years (PY9 and PY10), but the program is not recruiting new school districts to participate in PY10.

The ICSP reported it does not have any key performance indicators. The ICSP tracks energy savings, but there is no formal target for the Continuous Energy Improvement Program. The Continuous Energy Improvement savings contribute to the savings of the Custom Incentive component of the Non-Residential Energy Efficiency Program.

Other Program Participation

Cadmus determined whether the schools in the Continuous Energy Improvement Program participated in other programs during PY9. Savings from projects completed under other programs must be subtracted from the school savings to avoid double-counting. Also, participation in other programs indicates that the energy managers are aware of PPL Electric Utilities' other offerings.

As one recruitment strategy, PPL Electric Utilities and the ICSP targeted school districts that had previously participated in any of PPL Electric Utilities' incentive programs because this participation indicated the district's interest in energy efficiency and greater likelihood of being interested in the Continuous Energy Improvement Program . Two schools from the same district had previously participated in other components of the Non-Residential Energy Efficiency Program. Both received rebates for LED fixtures through the prescriptive lighting component of the Non-Residential Energy Efficiency Program. One of these schools had also received a rebate for a new air source heat pump through the prescriptive equipment component of the Non-Residential Energy Efficiency Program.

The ICSP encourages participation in other programs because schools can receive the rebate more quickly than waiting until the end of each year of engagement in the Continuous Energy Improvement Program (note that the rebate amount is the same, at $0.05 per kWh saved). During PY9, five schools from two districts also participated in PPL Electric Utilities' Midstream Lighting component and received discounts on 4-foot linear LED lamps and exterior LED fixtures. One school also received a prescriptive (downstream) rebate for LED fixtures from the lighting component of the Non-Residential Energy Efficiency Program.

During PY9, only one of the four pilot schools also participated in PPL Electric Utilities' Student Energy Efficient Education (SEEE) Program, but the energy manager reported that there had been no collaboration between representatives running the two programs. The Student Energy Efficient Education Program relies on teachers to promote energy efficiency education in the curriculum and to distribute energy-savings kits with efficient products to students to take home. It may be possible to combine the Student Energy Efficient Education Program classroom presentations with Continuous Energy Improvement component activities to help schools maintain engagement with both efforts.

8.5.4 Program Satisfaction

Overall Satisfaction

All four energy managers said they were v*ery satisfied* with both their experience with the ICSP and the level of support they received from their advisor.

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others.[47] Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100, which represents the difference between the percentage of promoters and detractors. An excellent NPS is 50 and above. As shown in Table 8-9, the Continuous Energy Improvement Program achieved an NPS of 75 and there are no detractors among the respondents. (The passives are excluded from the calculation.)

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[47] Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

Table 8-9. Net Promoter Score Likelihood to Recommend the Continuous Energy Improvement Program

Rating Classification	PY9 Percentage of Respondents (n=4)
Promoters (9-10)	75%
Passives (7-8)	25%
Detractors (0-6)	0%
NPS	**75**
Source: Survey question "How likely is it that you would recommend CEI to another school district? Use a 0 to 10 scale where 10 is extremely likely and 0 is not at all likely?"	

Opinion of PPL Electric Utilities

Two of the four energy managers said their opinion of PPL Electric Utilities had *improved somewhat* after participating in the Continuous Energy Improvement Program; the others said their opinion *did not change*. Of the two whose opinion improved, one already had a high opinion of PPL Electric Utilities and the other reiterated appreciation for the support the Continuous Energy Improvement Program provided and the level of accomplishment the school had achieved through these activities.

Areas Working Well

PPL Electric Utilities, the ICSP, and energy managers mentioned three areas in particular where the Continuous Energy Improvement Program was working well: school engagement, early diagnosis and intervention of higher than expected energy consumption, and learning from peers.

Engagement

All of the pilot schools have been very engaged with the Continuous Energy Improvement Program and have an energy team consisting of staff dedicated to managing energy use and promoting energy efficiency. Each district created a mission statement focused on energy efficiency awareness and education. The pilot schools involved faculty, staff, and students in the Continuous Energy Improvement Program activities. All four energy managers cited engagement, either internally with teachers and students or with the ICSP's active involvement, as a particularly positive element. One mentioned having heard feedback indicating students changed their behavior at home based on what they learned through Continuous Energy Improvement Program activities.

The ICSP recommends Continuous Energy Improvement Program activities tailored for each district and provides advice on how to make the activity effective. Each school can then choose the activities it is interested in. The pilot school's energy teams also propose and implement activities. These are some examples of activities that schools have implemented:

- The ICSP presents a webinar on energy awareness, including suggestions on how to create effective awareness campaigns. The ICSP reported that effective awareness techniques vary from district to district, but it has found the activity has to be something relevant to the faculty and students. For example, both pilot high schools formed student-led clubs that meet regularly to plan engagement activities. In one elementary school, the music teacher wrote a song about energy efficiency, and teachers reinforced students' energy-saving behaviors by awarding them green stars.

- The ICSP recommended student poster contests, including suggestions for content and how to present the contest in energy team meetings and morning announcements. Poster contests give continuous energy improvement a personal touch, make students feel proud, and help teachers feel supportive.
- Some schools asked students to bring in home energy bills to discuss during class, so teachers could explain to students why the school decided to participate in the Continuous Energy Improvement Program.
- One high school organized a quiz, administered by its in-house television studio, where students and staff were asked to guess the dollar amount of the school's monthly electric bill. This activity was intended to encourage students and staff to think about the possible impacts of behavior changes on the cost of the school's energy.
- Both pilot high schools started an official school energy club to motivate students to take an active role with continuous energy improvement. One energy manager mentioned that, as an official club, the team could maintain a financial account, which the energy manager was hoping to fund with program incentives.
- At both pilot elementary schools, teachers joined the energy teams and led the activities. One elementary school also had some student-led engagement activities. One example of this was students quizzing their teachers regarding energy efficiency.

Earlier Diagnosis and Intervention

As one continuous energy improvement activity, the energy managers monitored the pilot schools' electricity and gas bills and meter data, which can lead to earlier identification of higher-than-expected energy consumption than if the energy bills were not regularly monitored. For example, one building used more energy than the energy manager expected based on previous usage, so the energy manager contacted the ICSP to help diagnose the issue. They found that the school was opening dampers earlier in the morning than previously, and they were able to correct the damper schedule.

Learning from Peers

Energy managers reported that the monthly meetings with the ICSP and other districts have been useful, and all four participated regularly in these meetings. The energy managers asked questions, talked about where they need more support, and reported on success. Two of the four energy managers specifically mentioned being reassured to hear that other districts experienced similar challenges in motivating and maintaining behavior changes. The ICSP invited the school districts that had participated in the Phase II Continuous Energy Improvement Program to join the meetings and workshops offered to the new PY9 participants. About half of the Phase II districts were interested in attending these events and shared their knowledge and experience with the new districts.

Challenges

PPL Electric Utilities, the ICSP, and the energy managers mentioned five main challenges in PY9: a lack of resources, balancing occupant comfort with saving energy, lack of support from the principals or superintendents, maintaining engagement, and measuring energy savings.

Lack of Resources

School staff wear many hats and often do not have the time or technical knowledge about energy to take actions that reduce energy use. Two of the four energy managers cited their own lack of time as a challenge in implementing continuous energy improvement activities. One specifically said the coordination involved in implementing activities took more time than expected and was concerned about being able to manage the additional demands involved in rolling the Continuous Energy Improvement Program out to the rest of the district the next year. This energy manager also said maintaining interest was a challenge because teachers are also busy. Another said high school students, especially those who volunteer for the energy club, tend to be very enthusiastic about helping to save energy, but they are very busy with academics and juggle competing priorities.

As a benefit of participating in continuous energy improvement activities, the ICSP provides technical support, which can be a large time commitment and sometimes extends beyond the Continuous Energy Improvement Program. For example, the ICSP helps schools draft language for RFPs for the capital equipment improvements identified during the audit. If the contractor who installed the capital equipment does not submit the rebate form on behalf of the school, the ICSP walks the schools through the process and helps them collect the required documentation. The ICSP also recommends PPL Electric Utilities' Midstream Lighting component to schools since no rebate form is required.

Balancing Occupant Comfort with Saving Energy

Two energy managers mentioned challenges with balancing occupant comfort with saving energy. One said the superintendent did not want to change HVAC settings, preferring to leave the systems on. Another mentioned it was challenging to convince school faculty and students to accept a reasonable amount of seasonal temperature fluctuation. The ICSP also said classrooms sometimes used decorative lighting, which may not be energy-efficient.

Lack of Support from the School Principal or District Superintendent

Although the Continuous Energy Improvement Program requires the district superintendent to sign an agreement to participate and dedicate resources to continuos energy improvement activities, the principals or superintendents sometimes lacked interest. Two of the four energy managers said not all principals in the district were interested in energy efficiency. They said having the principal's support was key to engaging school faculty and to successfully implementing continuous energy improvement, but if staff and students have competing priorities, this lack of support from principals or superintendents made it even more difficult to prioritize energy efficiency.

Maintaining Engagement with Students and Staff

Energy managers said changing culture and/or habits was both an objective and a challenge in implementing behavior-based initiatives, which rely on cooperation among students, teachers, and facility maintenance staff who are busy and have competing priorities. One energy manager said people are more likely to comply with turning out the lights when leaving a room, for example, when such pleas come from students.

Measuring Energy Savings

Energy managers reported reviewing their monthly bills to track energy usage. However, monthly bills do not adjust for differences in weather. For example, one energy manager described a contest involving an attempt to reduce kWh consumption over the same period as the previous year; unfortunately, the weather was colder than the previous year and they did not see savings on the monthly bill.

The program documentation showed that in May 2017 the ICSP provided training on a web-based energy and cost-savings tracking tool called EnergyCenter, which does adjust for weather and can also be used for communicating progress towards energy savings targets. However, not all energy managers were consistently using EnergyCenter. One said the tool contained too much information and did not align with consumption shown on the school's utility bills. Another preferred the ENERGY STAR Portfolio tool, and another preferred to use spreadsheets tied directly to individual meters.

Program Roll-Out to the Other Schools in Year Two

In Phase II, rolling continuous energy improvement out to the other schools in each district was a challenge. The ICSP believed there was insufficient communication to help the schools succeed and that the rollout took longer than anticipated. Aware of this in Phase III, the ICSP began raising awareness about continuous energy improvement in the spring of 2018 so school staff could prepare for continuous energy improvement activities when they returned in the fall. The ICSP conducted a webinar discussing best practices for implementing continuous energy improvement activities and provided templates, flyers, and emails. Three of the four energy managers said they planned to have energy audits conducted at the other schools in their districts in PY10; one understood they would conduct the audits at other schools themselves, based on what they had observed of the ICSP's audit of the pilot school.

Suggestions for Improvement

Energy managers were asked how the Continuous Energy Improvement Program could help address their challenges. None had any suggestions to improve the program, and all said they were *very satisfied* with the support they received from the ICSP. All emphasized that the ICSP's regular support was important to maintaining engagement.

8.6 Cost-Effectiveness Reporting

Because the Continuous Energy Improvement component is part of the Non-Residential Energy Efficiency Program, cost-effectiveness is presented in section *4.5 Cost-Effectiveness Reporting*.

8.7 Recommendations

Overall, the Continuous Energy Improvement component of the Non-Residential Energy Efficiency Program saved energy, PPL Electric Utilities and the ICSP reported it is operating well, and all four energy managers said they were *very satisfied* and would recommend it to other school districts.

Recommendations are provided in Table 7-14, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: According to energy managers, maintaining behavior-based changes can be challenging and often requires buy-in from principals and administrative staff as well as teachers and students. Student engagement in particular contributes to the success of Continuous Energy Improvement and is often more effective than directives from facility staff. (See section *8.5.4.*)

Conclusion: Because students, faculty, and staff have competing priorities, continuous energy improvement activities work best and are more likely to maintain the necessary momentum for success when they involve regular engagement with the ICSP, are relevant to the education objectives of students and faculty, or are part of the activities of organized school clubs that involve students, staff, and faculty.

Finding: Energy managers track their bills, but not all regularly check EnergyCenter, which reports weather-adjusted savings. Feedback from energy managers indicates that being able to demonstrate monetary savings helps promote and maintain student, staff, and principal engagement with continuous energy improvement activities. (See section *8.5.4*.)

Conclusion: Energy managers are interested in tracking bill savings but may not see savings in their bills because of weather or other factors. Encouraging energy managers to use EnergyCenter, in addition to tracking their bills, will provide the information needed to demonstrate material savings attributable to continuous energy improvement, especially when differences in weather complicate year-over-year comparisons.

Recommendation #1: Consider placing more emphasis on using EnergyCenter, which quantifies energy savings. These energy savings can be regularly communicated to students and faculty so they recognize the results of their efforts and are motivated to stay involved.

Finding: Three of four energy managers were not aware of PPL Electric Utilities' Student Energy Efficient Education Program, which offers classroom energy efficiency education and energy-savings kits with products for students to install at home. One energy manager was aware, but not directly involved, that a teacher at the pilot school was in this program. (See section *8.5.3.1.*)

Conclusion: There may be potential for Student Energy Efficient Education Program and Continuous Energy Improvement Program activities, which both include behavior change, to produce greater energy savings in participating schools and homes. Coordinating the efforts of ICSPs, energy managers, teachers, and students could help maintain the momentum needed to keep students and faculty engaged.

Recommendation #2: Consider cross-promoting the Student Energy Efficient Education Program and encouraging the collaboration of Continuous Energy Improvement program manager and Student Energy Efficient Education Program manager to combine and enhance energy-efficiency education activities at schools participating in both programs. For example, Continuous Energy Improvement energy team members could talk to students about school-based activities and how they relate to the Student Energy Efficient Education Program energy-savings kits, curriculum, and recommendations. Likewise, recipients of the energy-savings kits could share their experiences of installing products at home with Continuous Energy Improvement energy team members, and together they could encourage others to install efficient products and share their experiences. These types of regular interactions among students in both programs could mitigate some challenges related to maintaining momentum and encouraging behavior change in students and faculty.

Finding: The energy savings realization rate was 89%.

Conclusion: Overall, the ICSP models based on monthly billing data are performing well in comparison to the evaluation models created with daily data and using machine-learning to choose the optimal specification.

8.7.1 Status of Recommendations

Table 8-10 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 8-10. Status of Recommendations for Continuous Energy Improvement Program

Continuous Energy Improvement		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Consider placing more emphasis on using EnergyCenter, which quantifies energy savings. These energy savings can be regularly communicated to students and faculty so they recognize the results of their efforts and are motivated to stay involved.	Being considered.
2	Consider cross-promoting the Student Energy Efficient Education Program and encouraging the collaboration of Continuous Energy Improvement program manager and Student Energy Efficient Education Program manager to combine and enhance energy-efficiency education activities at schools participating in both programs.	Being considered.

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CADMUS

EFFICIENT LIGHTING PROGRAM

The program encourages residential customers to purchase and install LED bulbs by providing upstream incentives to participating manufacturers to discount the prices of a variety of bulbs sold at local retail stores.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **274,247 MWh/yr**

94% of projected

140% of projected

PY9 saved **128,318 MWh/yr**

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$21,278**

59% of projected

80% of projected

PY9 expenditures **$8,116**

PY9 BULBS SOLD

A total of **3,011,377** bulbs sold

BULB TYPE

71%	LED A-line bulbs
19%	LED reflector bulbs
7%	LED candelabra bulbs
2%	LED globes
1%	LED fixtures

RETAIL CHANNEL

31%	from independent hardware stores
28%	from do-it-yourself stores
20%	from mass market stores
16%	from membership stores
3%	from nonprofit agencies
1%	from specialty stores
<1%	from other channels

9 Efficient Lighting Program

The Efficient Lighting Program encourages residential customers to purchase and install LED bulbs by providing upstream incentives to participating manufacturers to discount the prices of a variety of bulbs sold at local retail stores. The program targets residential customers but is available to all PPL Electric Utilities customers and anyone who purchases discounted bulbs from participating retailers.

The program is primarily delivered upstream, where the incentives are paid directly to manufacturers for bulbs sold at reduced prices at participating retailers, but includes occasional giveaway events, where bulbs are given directly to customers at no cost. The ICSP, CLEAResult, managed program operations and provided support to participating retailers and manufacturers.

The objectives of the Efficient Lighting Program are these:[48]

- Provide a mechanism for customers to easily obtain discounted LED bulbs in local retail stores
- Achieve widespread visibility of discounts through independent and regional retailers that carry program-eligible LED bulbs
- Develop and execute strategies aimed at transforming the market for LED bulbs
- Educate customers on new lighting technologies
- Engage retailers by educating and training retail sales associates about LED bulbs
- Obtain approximately 293,000 MWh/year gross verified savings in Phase III
- Achieve high customer and trade ally satisfaction with the program

9.1 Progress Toward Phase III Projected Savings

The Efficient Lighting Program obtained 140% of the projected MWh/yr savings planned for PY9. It has achieved 94% of the projected Phase III total planned savings and spent 59% of its Phase III budget.

Table 9-1 shows the program's verified gross program savings and progress toward its Phase III projected energy savings, as filed in the EE&C Plan.

Table 9-1. Efficient Lighting Program Estimated Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified	Projected	Verified	Percentage of Projected	Projected (1)	Verified	Percentage of Projected
MWh/yr	145,929	91,454	128,318	140%	292,853	274,247	94%
(1) Savings are projected in the PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.							

[48] Program objectives are listed in PPL Electric Utilities revised *Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642. December 2017.

9.2 Participation and Reported Savings by Customer Segment

9.2.1 Definition of a Participant

A participant is a person or business purchasing discounted bulbs. Because of the upstream design of the Efficient Lighting Program, the identities of purchasers are not known. Cadmus estimated the number of participants by dividing the total number of bulbs discounted or given away in PY9 by a bulb-per-participant count derived from residential and commercial customer telephone survey data collected in PY8.[49] Cadmus applied these estimates in PY9.

9.2.2 Program Participation and Reported Impacts

Table 9-2 presents the participation counts, reported energy and demand savings, and incentive payments for the Efficient Lighting Program in PY9 by customer segment.

Table 9-2. PY9 Efficient Lighting Program Participation and Reported Impacts

Parameter	Residential	Small C&I	Total [(1)]
PYTD # Participants [(2)]	272,133	14,890	**287,024**
PYRTD MWh/yr	96,721	31,577	**128,298**
PYRTD MW/yr	11.15	6.86	**18.01**
PYVTD MWh/yr	99,517	28,800	**128,318**
PYVTD MW/yr	11.47	5.95	**17.41**
PY9 Incentives ($1,000)	$5,904	$649	**$6,553**

[(1)] Total may not equal sum because of rounding.
[(2)] The reported participant counts by sector use PY8 cross-sector sales proportions, as described in the PY8 Annual Report. PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

9.3 Gross Impact Evaluation

9.3.1 Database Review

Cadmus reviewed the PPL Electric Utilities tracking database, manufacturer invoices, and ICSP reports to ensure consistency across all data sources, as detailed below.

9.3.1.1 Lighting Manufacturer Invoice Audit

Cadmus audited copies of lighting manufacturer invoices provided by the ICSP to ensure PPL Electric Utilities' tracking database records matched the invoices provided by manufacturers. Cadmus sampled 70 invoices, as shown in Table 9-3, and confirmed the bulb model numbers and quantities from the

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[49] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

tracking database matched the counts reported in the invoices provided by the ICSP. This review found no errors.

Table 9-3. PY9 Efficient Lighting Program Manufacturer Invoice Sample Sizes

PY9 Quarter(s)	Invoice Count	Invoices Sampled
Q1 and Q2	268	30
Q3	126	20
Q4	163	20
Total	**557**	**70**

For products indicated in PPL Electric Utilities' database as multi-packs, Cadmus verified the number of bulbs per pack using the manufacturer invoices. If invoices did not include pack size information, Cadmus researched bulb information online via the websites of manufacturers, traditional brick-and-mortar retailers (e.g., The Home Depot), or other online retailers (e.g., Amazon). This review found no errors.

9.3.1.2 Tracking Data Review

Cadmus reviewed PPL Electric Utilities' tracking database extracts and compared them to ICSP reports to ensure consistency and reasonableness of data inputs. Cadmus confirmed the following:

- Bulb-specific inputs such as bulb type, lumens, and wattages were consistent across all records for the same stockkeeping unit (SKU)
- Reported wattages were consistent with the wattages provided in bulb type descriptions
- Reported lumens were reasonable with respect to bulb type and wattage

Prior to computing savings using PA TRM algorithms, Cadmus checked baseline wattages for each SKU against the baseline tables by bulb type in PA TRM tables 2-2, 2-3, and 2-4 and made adjustments for records that did not align with these tables.[50] For bulbs with lumen ratings outside the ranges specified in PA TRM tables 2-2, 2-3, and 2-4, Cadmus used manufacturer-rated baseline wattages, as stipulated in the PA TRM.

Cadmus adjusted baselines for roughly 13% of program bulbs, mostly to account for specialty bulb types exempt from the Energy Independence and Security Act (EISA) ruling covering general service lamps (GSLs), and for some reflector lamp types. These adjustments, in aggregate, increased energy and demand savings by 16% among adjusted bulbs but increased overall program savings by only 2%. All baseline adjustments are documented in *Appendix H.1.2 Baseline Adjustments*.

[50] Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards. June 2016. Available online: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

9.3.1.3 ENERGY STAR Verification

The program aims to offer incentives exclusively for ENERGY STAR lighting products. Cadmus used the ENERGY STAR identification numbers or model numbers of every bulb recorded in PPL Electric Utilities' tracking database to confirm that all bulbs sold through the program meet current ENERGY STAR certification criteria.

The SWE, as part of its PY8 audit, developed and provided to Cadmus a list of bulb model numbers sold through the program and that indicated whether each bulb model number could be found in the current ENERGY STAR qualified product list. Using the SWE's list,[51] bulb model, and ENERGY STAR numbers provided in the PY9 tracking data along with current and historical Qualified Products Lists (QPLs), Cadmus verified that at least 98% of program bulbs sold in PY9 were ENERGY STAR-qualified.[52]

Cadmus found a few products for which the ENERGY STAR identification numbers in the tracking data and QPL did not match. Because ENERGY STAR identification numbers use a standardized format, they are typically easier to match between sources than are manufacturer model numbers. These discrepancies could probably be resolved by an ICSP review of the ENERGY STAR identification numbers.

9.3.2 Cross-Sector Sales Estimation

According to the Efficient Lighting Program evaluation plan, Cadmus did not conduct a cross-sector sales analysis in PY9 and instead applied PY8 cross-sector analysis results to PY9 sales. To learn more about the methodology and results of the PY8 cross-sector sales analysis, refer to Appendix A. Upstream Lighting Cross-Sector Sales in the PY8 Annual Report.[53]

PY9 sales recorded in PPL Electric Utilities' tracking database prior to mid-October 2017 reflected PY6 cross-sector sales analysis results,[54] which allocated 88% of sales to the residential sector. The updated PY8 results allocates 90% of sales to the residential sector. Because the PA TRM attributes lower per-bulb savings to residential customers than to commercial customers, these adjustments decreased program savings by approximately 1%.

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[51] Cadmus assumed bulbs labeled as "Match" in the list provided by SWE were on the ENERGY STAR Qualified Products List (QPL).

[52] Of bulbs sold in PY9, Cadmus found 92.2% on the current ENERGY STAR Qualified Products List (QPL); 6.1% were on a historical QPL.

[53] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

[54] 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

9.3.3 Impact Evaluation Sampling

The impact evaluation sampling strategy is summarized in Table 9-4. Additional details about the evaluation methodology are in *Appendix H*.

Table 9-4. PY9 Efficient Lighting Program Gross Impact Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Tracking data	260,729 (1)	N/A	N/A	Census database review, QA/QC and *ex post* adjustments
Manufacturer invoices	557	N/A	70	Manufacturer invoice audit, strategic sample

(1) Number of observations in PPL Electric Utilities tracking database.

In PY9, the Efficient Lighting Program reported energy savings of 128,298 MWh/yr, as shown in Table 9-5, and demand reduction of 18.01 MW/yr, as shown in Table 9-6.

Table 9-5. Efficient Lighting Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Upstream Lighting	128,298	100%	0.33	4.26%
Program Total	**128,298**	**100%**	**0.33**	**4.26%**

Table 9-6. Efficient Lighting Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Upstream Lighting	18.01	97%	0.33	4.26%
Program Total	**18.01**	**97%**	**0.33**	**4.26%**

The baseline wattage adjustments (as described in *9.3.1.2* Tracking Data Review) and cross-sector sales adjustments (as described in section *9.3.2 Cross-Sector Sales Estimation*) together produced a minimal effect on energy savings, as the program achieved a kWh/yr realization rate of 100% (Table 9-5).

9.4 Net Impact Evaluation

For the program's PY9 NTG results, Cadmus used the results from its PY8 NTG analysis, which used demand elasticity modeling to estimate participant free ridership.[55]

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55 The savings that participants would have achieved absent the program—in this case, the purchase and installation of LED light bulbs—are subtracted from verified gross savings. Because the demand elasticity model relies solely on program tracking data, the model estimates free ridership only and does not produce estimates of spillover. Details are in Section D.2 of the PY8 Annual Report: http://www.puc.pa.gov/pcdocs/1544671.pdf.

9.5 Verified Savings Estimates

In Table 9-7, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the Efficient Lighting Program in PY9. These program year totals are added to the savings achieved in previous program years to calculate the Phase III (P3VTD) program impacts.

Table 9-7. PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PYRTD Gross	128,298	18.01
PYVTD Gross	128,318	17.41
PYVTD Net (2)	106,504	14.45
P3RTD Gross	278,674	40.15
P3VTD Gross	274,247	37.23
P3VTD Net (2)	227,625	30.90

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.

9.6 Process Evaluation

9.6.1 Research Objectives

The purpose of the process evaluation was to monitor program delivery, pace, and to assess any changes to the Efficient Lighting Program.

9.6.2 Evaluation Activities

The PY9 process evaluation activities for the Efficient Lighting Program are these:

- Interview with three PPL Electric Utilities and ICSP program staff
- Database review of a census of records

Cadmus conducted interviews with PPL Electric Utilities and the ICSP midway through PY9 to gain a thorough understanding of the program's objectives, design, and progress to support well-rounded and balanced observations and recommendations. Interviews covered topics such as the program's strategy for engaging the market in PY9, following up on Cadmus' recommendations in PY8 that included possibilities to scale back if the program continues to exceed forecasted sales.

Cadmus conducted quarterly database reviews to determine the number of bulbs sold by type and retail channels.

The research activities in PY9 were consistent with the evaluation plan except for conducting a logic model review. Because the program did not change in PY9, Cadmus did not repeat its review of the program's logic and program theory.

9.6.3 Process Evaluation Findings

The program is tracking well ahead of program plans, with total program sales now roughly within 6% of the Phase III estimated savings. In consideration of the program's success, Cadmus' interview with PPL Electric Utilities focused on program progress and plans through PY10 and PY11, after which PPL Electric Utilities anticipates it will retire the program.

Table 9-8 shows program sales by retail channel, and Table 9-9 shows sales broken down by bulb type across PY8 and PY9.

Table 9-8. Program Sales by Retail Channel and Program Year

Retail Channel	PY8 Program Sales		PY9 Program Sales	
	Count	Percentage	Count	Percentage
DIY [1]	1,260,256	36%	843,044	28%
Club [2]	954,278	27%	490,089	16%
Mass Market	560,310	16%	616,730	20%
Independent Hardware	523,752	15%	927,954	31%
Specialty	135,273	4%	44,860	1%
Nonprofit	70,301	2%	77,931	3%
Hard-to-Reach Markets [3]	16,574	<1%	2,997	<1%
Grocery	6,929	<1%	5,660	<1%
Giveaway bulbs	0	0%	2,112	<1%
Program Total	3,527,673	100%	3,011,377	100%

[1] Do-it-yourself stores, such as Lowe's and The Home Depot.
[2] Membership stores, such as Costco or Sam's Club.
[3] Independent stores in lower-income neighborhoods.

Table 9-9. Program Sales by Bulb Type and Program Year

Bulb Type	PY9 Program Sales		PY8 Program Sales	
	Count	Percentage	Count	Percentage
LED A-Line	2,144,613	71%	2,480,811	70%
LED Reflector	560,997	19%	654,439	19%
LED Candelabra	219,182	7%	307,943	9%
LED Globe	63,167	2%	84,476	2%
LED Fixture	23,418	1%	4	< 0.1%
Program Total	3,011,377	100%	3,527,673	100%

In PY9, PPL Electric Utilities sold fewer bulbs through do-it-yourself (DIY) retailers and club retailers and more through independent hardware franchise locations compared to PY8.

The program also gave away more than 2,000 bulbs in PY9. According to the ICSP, giveaways typically consist of singular events (e.g., at a workplace event) where the ICSP delivers presentations to customers and distributes packets (which include free bulbs) afterward. As such, giveaways do not play a significant role in program plans or energy savings.

The ICSP continued adding incentives for LED fixtures in PY9, as requested by PPL Electric Utilities. As a result, the program sold more than 20,000 fixtures in PY9, comprising about 1% of PY9 sales.

Prices of general service LEDs continued to decline through PY9, driving sales and increasing the relative magnitude of the initial PY9 incentives with respect to retail prices. To control the pace of the program into PY10 and not exceed the forecasted Phase III budget, the ICSP compensated for pricing changes by moderating program incentive levels for a wide array of SKUs.

9.7 Cost-Effectiveness Reporting

A detailed breakdown of Efficient Lighting Program finances and cost-effectiveness is presented in Table 9-10. TRC benefits were calculated using gross verified impacts. NPV PYTD benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). NPV costs and benefits for P3TD financials are expressed in the PY8 dollars. Participant costs are equal to the total of differences between retail bulb prices and baseline bulb costs.[56]

[56] Baseline bulb costs are from the Statewide Evaluator's Incremental Cost database, version 3.1.

Table 9-10. Summary of Efficient Lighting Program Finances – Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$6,553		$17,601	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$5,430		$6,670	
4	**Incremental Measure Costs (Sum of rows 1 through 3) (1)**	**$11,983**		**$24,271**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development (2)	-	-	-	-
6	Administration, Management, and Technical Assistance (3)	$44	-	$135	-
7	Marketing (4)	-	$280	-	$514
8	Program Delivery (5)	-	$1,239	-	$2,453
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11(6)	**Program Overhead Costs (Sum of rows 5 through 10) (1)**	**$1,563**		**$3,102**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) (7)**	**$13,546**		**$27,373**	
14	Total NPV Lifetime Electric Energy Benefits	$37,231		$78,512	
15	Total NPV Lifetime Electric Capacity Benefits	$6,831		$14,269	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$18,801		$39,335	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	($1,772)		($1,646)	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) (8) (1)**	**$61,090**		**$130,471**	
19	**TRC Benefit-Cost Ratio (9)**	**4.51**		**4.77**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 9-11 presents program financials and cost-effectiveness on a net savings basis.

Table 9-11. Summary of Efficient Lighting Program Finances – Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$6,553		$17,601	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$4,506		$3,579	
4	**Incremental Measure Costs (Sum of rows 1 through 3) (1)**	**$11,060**		**$21,180**	
		EDC	**CSP**	**EDC**	**EDC**
5	Design & Development (2)	-	-	-	-
6	Administration, Management, and Technical Assistance (3)	$44	-	$135	-
7	Marketing (4)	-	$280	-	$514
8	Program Delivery (5)	-	$1,239	-	$2,453
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11(7)	**Program Overhead Costs (Sum of rows 5 through 10) (1)**	**$1,563**		**$3,102**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**-**		**$608**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) (7)**	**$12,623**		**$24,890**	
14	Total NPV Lifetime Electric Energy Benefits	$30,902		$65,165	
15	Total NPV Lifetime Electric Capacity Benefits	$5,669		$11,844	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$15,604		$32,648	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	($1,471)		($1,367)	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) (8) (1)**	**$50,705**		**$108,290**	
19	**TRC Benefit-Cost Ratio (9)**	**4.02**		**4.35**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Lighting Interactive Effects

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[57] A summary of the methodologies Cadmus used to calculate the non-energy benefits of saved water, natural gas therms, and lighting interactive effects can be found in *Appendix P.*

Cadmus included heating penalties as a negative benefit in the TRC test for efficient lighting, per the Guidance Memo.

Table 9-12. Efficient Lighting - Gas Heating Penalties Calculations

Equipment Type	Gas Heat Fuel Share	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therm per kWh/yr)
LED Lighting	29%	90.48%	65.5%	20%	0.8	0.00586

Per the Guidance Memo, Cadmus assumed that there is a natural gas therms penalty. The results are shown in Table 9-13. Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Table 9-13. Efficient Lighting –Gas Heating Penalty

Equipment Type	Number of LEDs Distributed	*Ex Post T*otal kWh/yr	Heating Penalty (Therm per kWh/yr)	Total Heating Penalty (Therms)
LED Lighting	3,011,377	128,229,914	0.00586	**-751,952**

9.8 Recommendations

Overall, the program has continued to exceed planned sales as LED prices continue to decline, adoption among customers increases, and the proportion of program bulbs certified by ENERGY STAR approaches 100%. Program data are complete, consistent, and accurate, and PPL Electric Utilities remains pleased with the implementation and performance of the program.

Recommendations are provided in Table 9-14, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: As detailed in *Section 9.3.1.2*, baseline wattages reported for some specialty bulb types do not reflect the fact that these bulbs are exempt from the EISA ruling covering general service lamps—that is, the reported baseline wattages used in the *ex ante* reported savings calculations are too low.

Conclusion: Reported savings for some specialty bulbs would be more accurate, that is, higher, if the baselines for EISA-exempt bulbs were used.

57 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

Recommendation #1: The ICSP should review the baseline wattage for EISA-exempt lamp types to ensure they reflect the TRM baseline wattage for exempt lamps and for reflector lamps to ensure they use either the applicable TRM baseline wattage, the current federal standard for reflector lamps, or the manufacturer-rated wattage equivalent for reflector lamp types exempt from current federal standards.

9.8.1 Status of Recommendations

Table 9-14 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 9-14. Status of Recommendations for Efficient Lighting

Efficient Lighting Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	The ICSP should review the baseline wattage for EISA-exempt lamp types to ensure they reflect the TRM baseline wattage for exempt lamps and for reflector lamps to ensure they use either the applicable TRM baseline wattage, the current federal standard for reflector lamps, or the manufacturer-rated wattage equivalent for reflector lamp types exempt from current federal standards.	Being considered. In reviewing the TRM there appears to be no reference to the usage of “the current federal standard for reflector lamps.” The baseline wattage and energy savings assumptions were developed based on following the TRM as closely as possible.

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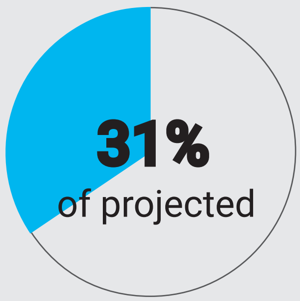
CADMUS

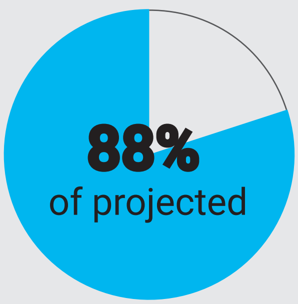
HOME ENERGY EDUCATION PROGRAM

The program encourages customers to save energy by sending them home energy reports that provide data about their energy use, a comparison of household energy use to similar customers in the same geographic area, and tips for saving energy (such as turning off lights and taking short showers) and product recommendations (such as LEDs, smart strips, and appliances).

VERIFIED ENERGY SAVINGS

Phase III has so far saved
70,654 MWh/yr





PY9 saved
36,328 MWh/yr

PROGRAM SATISFACTION

65% Satisfied with Home Energy Reports

71% satisfaction with Home Energy Reports **among low-income respondents**

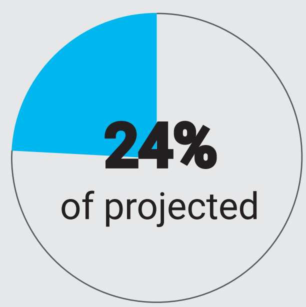
63% satisfaction with Home Energy Reports **among general residential respondents**

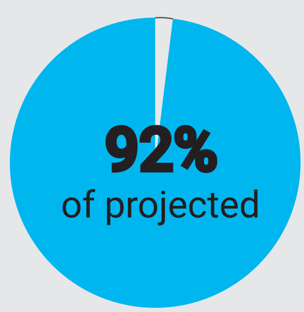
PY9 PARTICIPATION

A total of
162,010
residential customers including
26,698
low-income customers received Home Energy Reports

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far
$2,468





PY9 expenditures
$1,623

10 Home Energy Education Program

The Home Energy Education Program encourages customers to save energy by sending them home energy reports that provide data about their energy use, a comparison of household energy use to similar customers in the same geographic area, and tips for saving energy (such as turning off lights and taking short showers) and product recommendations (such as LEDs, power strips, and appliances). These reports also guide customers to PPL Electric Utilities' online energy management portal, My Ways To Save,[58] on which they can take a home energy assessment by entering detailed information about their home and request a kit with energy-saving products.[59]

CLEAResult, the ICSP for all of PPL Electric Utilities' residential programs,[60] administered the Home Energy Education Program and provided oversight of the home energy reports vendor. The ICSP subcontracted with Tendril to develop and distribute the program's educational offerings—the home energy reports, online energy management portal, and online home energy assessments.

In PY9, the program mailed six print home energy reports to customers. Customers with valid email addresses also received these reports in electronic format and could ask to receive only the electronic reports. Customers could also access the program's energy management portal on which they could set energy-saving goals, receive recommendations toward reaching these goals, and check off any actions they had completed. Customers could also contact the call center with any questions or comments pertaining to the usage feedback and educational offerings.

The objectives of the Home Energy Education Program were these:[61]

- Encourage customers to adopt energy-efficient behaviors and install high-efficiency products
- Help customers become more aware of how their behavior and practices affect energy use
- Educate customers about no- and 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 123,000 customers through 2021 with a total of approximately 228,000 MWh/year gross verified savings
- Achieve high customer satisfaction with the program

58 PPL Electric Utilities' Customer Engagement Hub (My Ways to Save) is a website with information about all available rebates. All PPL Electric Utilities' customers have access to the hub and to the energy management portal; however, treatment group customers received specific encouragement through the home energy reports to visit the energy management portal.

59 The savings for the kits and energy-saving products are reported in the Energy Efficient Home Program.

60 In January 2018, CLEAResult acquired Ecova, the ICSP for PY8.

61 Program objectives and targets are listed in PPL Electric Utilities' revised EE&C Plan, December 2017.

The program operated as a randomized controlled trial where eligible customers were randomly assigned to a treatment group or a control group. Customers in the treatment group received the home energy reports. Treatment group customers who did not wish to receive the reports could opt out of the program at any time. Customers in the control group did not receive the reports nor were they told they were part of the control group. The consumption data of control group customers provided the baseline for estimating the savings from the home energy reports.

The same treatment and control group assignments from Phase II carried over into Phase III. The home energy reports vendor identified new treatment and control group customers to expand the program for Phase III, and Cadmus conducted the random assignments of these additional customers in early PY8.

Early in PY8, the home energy reports vendor removed low-propensity customers, defined as customers in the treatment group predicted to have low program engagement and energy savings. To identify these customers, the vendor reviewed pre- and post-treatment usage data, conducted a common traits analysis, and selected the 10% of treatment group customers with the lowest propensity to save. The vendor sent these customers a letter notifying them they would automatically stop receiving the home energy reports unless they opted back in by replying to a survey linked in the letter. Customers had up to three months to opt back in. At the end of PY9, however, the ICSP and home energy reports vendor resumed treatment for these customers to increase program savings.

Also, at the start of PY8, the ICSP and home energy reports vendor ceased treatment of two waves of low-income customers from Phase II. At the end of PY8, the ICSP resumed treatment of these low-income customers by sending print home energy reports. Regular delivery of home energy reports resumed in late PY9 (February), when customers for whom PPL Electric Utilities had valid email addresses received an electronic home energy report. This emailing reached 38% of Low-Income Wave 1 treatment customers and 27% of Low-Income Wave 2 treatment customers. These customers received a second electronic report in April of PY9.[62]

10.1 Progress Toward Phase III Projected Savings

The Home Energy Education Program verified savings are 88% of the projected MWh/yr savings for PY9. The program has achieved 31% of the projected Phase III total savings and is making progress toward its the Phase III projected savings, but it is behind the pace projected in the EE&C Plan.

Table 10-1 shows the program's verified gross energy savings and progress toward its Phase III project energy savings, as filed in the EE&C plan.

62 In PY9, one-third of low-income customers received only two electronic home energy reports. This was because, for Phase III, PPL Electric Utilities and the ICSP originally did not plan to include the low-income customers who had been receiving home energy reports in Phase II; however, they reversed this decision at the end of PY8. Nevertheless, because of contractual and budget constraints in PY9, PPL Electric Utilities was unable to deliver six home energy reports (print and electronic) to all low-income customers.

Table 10-1. Home Energy Education Program Projected Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified	Projected (1)	Verified	Percentage of Projected	Projected (1)	Verified	Percentage of Projected
MWh/yr	34,326	41,080	36,328	88%	227,938	70,654	31%
(1) Savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.							

The following factor affected the program's progress toward its projected savings for PY9:

- **Savings from the Phase III Expansion wave have not offset savings lost from ceasing treatment of low-propensity customers.** The ICSP and home energy reports vendor stopped treatment for low-propensity customers at the beginning of Phase III, anticipating that a new wave of customers (the Phase III Expansion wave), specifically selected to optimize savings, would offset the loss of savings. However, average daily savings for the new wave were lower than expected in PY8 (0.1 kWh/day per treated customer or 0.3% of consumption) and remained lower than expected in PY9, although savings increased from the previous year (0.3 kWh/day per treated customer or 0.7% of consumption). To offset lost savings from low-propensity customers, the Phase III Expansion wave would have needed to save between 0.8 kWh/day and 1.1 kWh/day per treated customer in PY8 and between 0.6 kWh/day and 1.0 kWh/day per treated customer in PY9.

10.2 Participation and Reported Savings

10.2.1 Definition of a Participant

A participant in the Home Energy Education Program is defined as a residential customer assigned to the treatment group who received home energy reports. A participant who only received one report is retained in the treatment group for analysis, even if the participant subsequently opted out.

The customer population is divided into six cohorts of customers known as "waves" that are based on when customers began receiving the home energy reports:

- Phase I Legacy Wave 1 received first report in PY2, April or May 2010
- Phase I Legacy Wave 2 received first report in PY3, June 2011
- Phase II Expansion Wave received first report in PY6, October or December 2014
- Phase II Low-Income Wave 1 received first report in PY6, October or December 2014
- Phase II Low-Income Wave 2 received first report in PY7, June 2015
- Phase III Expansion Wave received first report in PY8, June 2016

Cadmus evaluated the energy savings of all six waves.

10.2.2 Program Participation and Reported Impacts

Table 10-2 presents the participation counts, reported energy and demand savings for the Home Energy Education Program in PY9 by customer segment. The count of participants is based on the number of unique job numbers (referring to an account number for one household) in PPL Electric Utilities' tracking database.

Table 10-2. PY9 Home Energy Education Program Participation and Reported Impacts

Parameter	Residential	Total [1]
PYTD # Participants	161,589	**161,589**
PYRTD MWh/yr	33,876	**33,876**
PYRTD MW/yr	6.54	**6.54**
PYVTD MWh/yr	36,328	**36,328**
PYVTD MW/yr	11.15	**11.15**
PY9 Incentives ($1000)	$0	**$0**

[1] Total may not match sum of columns due to rounding.

10.3 Gross Impact Evaluation

The impact evaluation estimated the Home Energy Education Program's energy savings. The program's experimental design and the large number of customers in the randomized treatment and control groups made it possible for Cadmus to obtain accurate and precise estimates of the program's causal impacts. For each wave, Cadmus conducted a regression analysis of monthly billing consumption of customers in the treatment and control groups. Because the home energy reports encouraged customers to participate in PPL Electric Utilities' other energy efficiency programs, Cadmus also estimated home energy reports energy savings from participation in these programs (see *Appendix C.1.4 Uplift Analysis Methodology* for details). (Cadmus subtracted the uplift savings from the home energy reports savings to avoid double-counting the uplift savings.)

The PY9 sampling strategy is summarized in Table 10-3. Cadmus included treatment group customers in the regression analysis regardless of whether or not they received treatment (a home energy report) from the home energy report vendor. The regression analysis therefore results in an estimate of the intent-to-treat treatment effect. Additional details about methodology and attrition are in *Appendix C.1*.

Table 10-3. PY9 Home Energy Education Program Gross Impact Sample Design

Stratum	Population Size (1)		Assumed Proportion or Cv in Sample Design (2)	Achieved Sample Size (3)		Impact Evaluation Activity
	Treatment	Control		Treatment	Control	
Legacy Wave 1	50,000	50,000	N/A	48,103	48,122	Regression analysis on monthly billing data to estimate treatment effect (by stratum)
Legacy Wave 2	55,040	25,003	N/A	50,622	22,930	
Expansion Wave 1	48,722	12,654	N/A	47,479	12,342	
Low-Income Wave 1	73,500	18,560	N/A	71,905	18,151	
Low-Income Wave 2	21,401	10,046	N/A	20,238	9,482	
Phase III Expansion Wave 1	27,697	11,096	N/A	27,059	10,849	
Program Total (4)	**276,360**	**127,359**	**N/A**	**265,406**	**121,876**	

(1) Population size is based on the number of customers originally randomized prior to the start of the program.
(2) The population for each wave is based on data at the time of enrollment. Cadmus did not sample customers for inclusion in the analysis and therefore did not assume a proportion or Cv.
(3) Cadmus included all customers in the analysis who had at least 11 months of pre-treatment and at least one month of post-treatment billing data (details on attrition can be found in *Appendix C.1 Methodology*).
(4) Total may not sum to all rows due to rounding.

In PY9, the Home Energy Education Program reported energy savings of 33,876 MWh/yr, as shown in Table 10-4, and demand reduction of 6.54 MW/yr, as shown in Table 10-5.

Table 10-4. PY9 Home Energy Education Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Legacy Wave 1	9,346	97%	0.04	5.27%
Legacy Wave 2	11,735	99%	0.05	7.51%
Expansion Wave 1	9,176	89%	0.08	11.84%
Low-Income Wave 1	539	798%	0.13	18.72%
Low-Income Wave 2	55	302%	1.01	145.93%
Phase III Expansion Wave 1	3,026	99%	0.13	18.78%
Program Total (1)	**33,876**	**107%**	**N/A**	**4.73%**

(1) Total may not sum to all rows due to rounding.

Table 10-5. Home Energy Education Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Legacy Wave 1	1.81	177%	0.17	24.30%
Legacy Wave 2	2.30	172%	0.18	25.21%
Expansion Wave 1	1.64	160%	0.19	27.37%
Low-Income Wave 1	0.27	287%	0.35	51.09%
Low-Income Wave 2	0.01	283%	1.12	160.63%
Phase III Expansion Wave 1	0.50	108%	0.36	51.11%
Program Total (1)	**6.54**	**170%**	**N/A**	**13.78%**
(1) Total may not sum to all rows due to rounding.				

The following factor led to variation between the reported and verified savings and to the observed realization rates:

- Cadmus evaluated substantially more energy savings for the two low-income waves than were reported, estimating realization rates of 798% and 302% for Low-Income Wave 1 and Low-Income Wave 2 respectively. Cadmus counted home energy report savings for 12 months after customers received their latest Phase III home energy reports, following the measure life assumption in SWE Evaluation Framework.[63] Since many customers in these two waves received home energy reports in May 2017, the last month of PY8, Cadmus evaluated savings accrued from June 2017 through April 2018 of PY9. The ICSP did not include these savings when reporting savings for PY9, which led to the large realization rates in these waves. Although the low-income realization rates are large, the kWh savings for these waves are relatively small, resulting in minimal impact on the program realization rate of 107%.

10.4 Net Impact Evaluation

The Home Energy Education Program evaluation resulted in an estimate of net savings. The estimate included any spillover that may have occurred within treated customer homes. No free ridership was anticipated, because customers did not choose to receive the home energy reports and no incentives were provided. The evaluation did not estimate Home Energy Education Program gross savings; therefore, the NTG ratio is irrelevant in this analysis.

10.5 Uplift Analysis

Cadmus estimated Home Energy Education Program uplift (the effect of the program on participation in other PPL Electric Utilities efficiency programs) and the energy savings resulting from uplift in PY9. Participation uplift savings appeared in the regression-based estimate of Home Energy Education

63 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by the Statewide Evaluation Team (NMR Group Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC). Contracted under the Pennsylvania Public Utility Commission's RFP 2015-3 for the Statewide Evaluator. Final version August 29, 2016.

Program savings and the savings of any other PPL Electric Utilities efficiency programs that experienced uplift. Therefore, the Home Energy Education Program savings that were counted in other programs were subtracted from PPL Electric Utilities' residential portfolio savings to avoid counting the savings twice.

The Phase III Evaluation Framework requires the estimation of home energy report savings attributable to current and past efficiency program participation. For example, installation of a high-efficiency air conditioner in PY4 is expected to yield savings in PY9 and through the expected life of the product. To estimate the home energy report savings in PY9 that are attributable to the prior adoption of high-efficiency air conditioners and other products, Cadmus collected historical energy efficiency program data from PPL Electric Utilities' tracking database. See *Appendix C.1.4 Uplift Analysis Methodology* for details on participation uplift and uplift savings estimation methodology.

10.5.1 Participation Uplift

To estimate the effect of the Home Energy Education Program on participation in PPL Electric Utilities' other efficiency programs, Cadmus compared the rates of participation between treatment and control group customers in other Act 129 programs in PY9. Home energy reports had a positive average effect on participation in other programs where rates of cross-program participation were greater for treatment group customers.

Table 10-6 shows participation uplift results for PY9. On average, across all waves, treatment customers participated in other PY9 programs at a 6% greater rate than did control customers. Legacy Wave 1 customers had the greatest participation uplift compared to the other waves; on average, treatment customers in this wave participated in other PPL Electric Utilities programs at a 6% greater rate than control customers. Participation uplift was positive for both legacy waves and the Phase III Expansion wave, but was negative for both low-income waves and Expansion Wave I. It is important to note that these values are not cumulative across each waves' existence. These values only reflect customers' cross-program participation starting in PY9.

Table 10-6. PY9 Home Energy Education Participation Uplift Summary

Wave	Control Group Participation Rate (per 1,000 Customers)	Participation Uplift (Treatment Effect on Participation Rate)	Percentage Participation Uplift
Legacy Wave 1	38.4	2.4	6%
Legacy Wave 2	50.8	0.6	1%
Expansion Wave 1	42.6	-0.5	-1%
Low-Income Wave 1	63.3	-0.4	-1%
Low-Income Wave 2	55.1	-6.6	-14%
Phase III Expansion Wave	41.1	0.6	1%
Program Total	**46.5**	**2.9**	**6%**

10.5.2 Savings Uplift

Cadmus estimated savings uplift to determine whether treatment group customers saved more than control group customers from cross-participation in other programs. Cadmus calculated savings uplift as the difference in treatment and control groups' average cross-program savings per customer, multiplied by the number of treatment group customers. Savings uplift is positive if the per-customer savings accrued in PY9 from current or previous participation in other Act 129 programs was greater for the treatment group than for the control group. Cadmus accounted for the timing of product installations in other programs and annualized their net savings using a weather-effects weight based on the product's end use.

Table 10-7 and Table 10-8 show energy and demand savings uplift results for PY9 resulting from PPL Electric Utilities' downstream programs. Across all waves, uplift accounted for just over 10% and 4% of Home Energy Education Program energy and demand savings, respectively. Note that cross-program energy savings as a percentage of program total savings are greatest in Low-Income Wave 1 and Low-Income Wave 2, likely because of the cross-program promotion these customers received in Phase II when their home energy reports included low-income-specific modules, suggested by the uplift experienced in these waves attributed to PPL Electric Utilities' two low-income programs. (See *Appendix C.1.4 Uplift Analysis Methodology* for details on uplift by program.) Expansion Wave 1 energy uplift savings are the lowest. No waves' savings are negative, which means that the average treatment customer is saving more energy than the average control customer from cross-program participation. Legacy Wave had the highest demand savings and Low-Income Wave 2 had the lowest.

Table 10-7. PY9 Home Energy Education Downstream Uplift Energy Savings Summary

Wave	Average Cross-Program Savings per Customer (kWh/yr)			Total Uplift Savings (MWh/yr)	Percent of Program Total Savings
	Treatment Group	Control Group	Difference		
Legacy Wave 1	345.71	320.19	25.52	720.59	7.93%
Legacy Wave 2	548.20	518.51	29.69	945.28	8.14%
Expansion Wave 1	316.55	316.01	0.54	19.39	0.24%
Low-Income Wave 1	353.36	326.85	26.51	1,252.79	29.15%
Low-Income Wave 2	251.79	240.73	11.06	137.40	83.58%
Phase III Expansion Wave 1	281.37	259.22	22.15	614.72	20.44%
Program Total [1]	**364.43**	**344.70**	**19.72**	**3,690.16**	**10.16%**

[1] May not match due to rounding.

Table 10-8. PY9 Home Energy Education Downstream Uplift Demand Savings Summary

Wave	Average Cross-Program Savings per Customer (kW/yr)			Total Uplift Savings (MW/yr)	Percent of Program Total Savings
	Treatment Group	Control Group	Difference		
Legacy Wave 1	0.0594	0.0556	0.0038	0.1060	3.30%
Legacy Wave 2	0.0871	0.0818	0.0052	0.1664	4.20%
Expansion Wave 1	0.0498	0.0492	0.0006	0.0212	0.81%
Low-Income Wave 1	0.0429	0.0408	0.0021	0.0969	12.34%
Low-Income Wave 2	0.0294	0.0291	0.0003	0.0031	10.30%
Phase III Expansion Wave 1	0.0461	0.0432	0.0029	0.0800	14.86%
Program Total (1)	**364.4279**	**344.7039**	**19.7240**	**0.4736**	**4.25%**
(1) May not match due to rounding.					

Cadmus estimated the Home Energy Education Program's impact on upstream lighting (LED) purchases by applying the default upstream lighting reduction factors from the Phase III Evaluation Framework, as shown in Table 10-9 and Table 10-10. See *Appendix C.1.4 Uplift Analysis Methodology* further details on the uplift analysis for upstream lighting.

Table 10-9. PY9 Home Energy Education Upstream Lighting Uplift Savings Summary

Stratum	Population Verified Savings (MWh/yr) (1)	Years in Program	Reduction Factor	Upstream Lighting Uplift (MWh/yr)
Legacy Wave 1	8,371.19	8	3.00%	251.14
Legacy Wave 2	10,669.47	7	3.00%	320.08
Expansion Wave 1	8,132.93	3.5	3.00%	243.99
Low-Income Wave 1	3,044.48	3.5	3.00%	91.33
Low-Income Wave 2	26.99	3	2.25%	0.61
Phase III Expansion Wave 1	2,393.07	2	1.50%	35.90
Program Total (2)	**32,638.14**	**N/A**	**N/A**	**943.05**
(1) Savings are adjusted to remove downstream uplift. (2) Total may not sum to all rows due to rounding.				

Table 10-10. PY9 Home Energy Education Upstream Lighting Uplift Savings Summary

Stratum	Population Verified Savings (MW/yr) (1)	Years in Program	Reduction Factor	Upstream Lighting Uplift (MW/yr)
Legacy Wave 1	3.11	8	3.00%	0.09
Legacy Wave 2	3.79	7	3.00%	0.11
Expansion Wave 1	2.60	3.5	3.00%	0.08
Low-Income Wave 1	0.69	3.5	3.00%	0.02
Low-Income Wave 2	0.03	3	2.25%	0.00
Phase III Expansion Wave 1	0.46	2	1.50%	0.01
Program Total (2)	**10.67**	**N/A**	**N/A**	**0.31**
(1) Savings were adjusted to remove downstream uplift shown in Table 10-8. (2) Total may not sum to all rows due to rounding.				

Additionally, Cadmus deducted 1,305 MWh/yr and 0.0.14 MW/yr from the residential sector to account for the 45,000 LED bulbs that PPL Electric Utilities mailed to high-energy use customers in the low-income waves' treatment groups, distributed through the Phase II Residential Retail Program. PPL Electric Utilities claimed savings from these bulbs in PY7. Cadmus deducted these savings from the residential sector because the savings were counted in the residential Home Energy Education program in PY9 (there is no separate low-income program that claimed these savings in PY9).

In total, Cadmus deducted Home Energy Education Program uplift savings of 5,938 MWh/yr and 0.93 MW/yr from the residential portfolio savings. Cadmus deducted program uplift savings from the residential portfolio as opposed to from the Home Energy Education Program savings because uplift savings are attributable to this program as well as the other programs through which Cadmus verified savings.

10.6 Verified Savings Estimates

In Table 10-11, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the Home Energy Education Program in PY9. These totals are added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts. Because the NTG ratio is irrelevant in this analysis, net savings are the same as verified gross savings.

Table 10-11. Home Energy Education PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Demand (MW/yr) (1)
PYRTD Gross	33,876	6.54
PYVTD Gross	36,328	11.15
PYVTD Net (2) (3)	N/A	N/A
P3RTD Gross	74,343	60.93
P3VTD Gross	70,654	17.90
P3VTD Net (2) (3)	N/A	N/A

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.
(3) The NTG ratio is irrelevant; net savings are the same as verified gross savings.

10.7 Process Evaluation

10.7.1 Research Objectives

The evaluation of the Home Energy Education Program involved these research objectives:

- Assess the effectiveness of the program to save energy through the behavioral change model
- Evaluate customer satisfaction with the program

10.7.2 Evaluation Activities

The PY9 process evaluation activities for the Home Energy Education Program included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Logic model review
- Customer satisfaction surveys with treatment group (telephone and online)
- Benchmarking research

The PY9 process evaluation activities were consistent with the evaluation plan except for the customer satisfaction surveys. No surveys were planned for PY9; however, Cadmus conducted a customer satisfaction survey in PY9. Table 10-12 lists the process evaluation sampling strategy.

10.7.2.1 Survey Methodology

Cadmus completed 532 phone and online surveys with treatment group customers, using a stratified random sampling approach by treatment wave. Table 10-12 contains the final number of completed surveys by strata. The surveys assessed participant satisfaction; the number of completed surveys produced a measurement of program satisfaction with ±3% precision at 90% confidence.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based survey items to reduce order effects

Cadmus used the same questionnaire for the phone and online surveys conducted in PY9 so survey data were collected consistently. The SWE team and PPL Electric Utilities reviewed and approved the survey before fielding.

Additional details about Cadmus' approach to contacting customers, sample attrition, and survey weighting methodology are presented in *Appendix I.1.2 Survey Approach*.

10.7.2.2 Program Staff and ICSP Interviews

In January and February of 2018, Cadmus conducted interviews with the program managers from PPL Electric Utilities and the ICSP. The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and learning what areas are working well and about any possible challenges.

Table 10-12. Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size [1]	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame [2]	Percent of Sample Frame Contacted to Achieve Sample [3]
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone In-depth Interview	2	N/A	2	2	2	100%
Customer Satisfaction Surveys with Treatment Group	Phase I Legacy Waves	Telephone Survey	12,755	0.5	50	52	8,946	23%
	Phase II Expansion Wave	Telephone Survey	8,333	0.5	50	51	5,686	
	Phase III Expansion Wave	Telephone Survey	6,140	0.5	50	50	4,240	
	Phase II Low-Income Wave 1	Telephone Survey	7,526	0.5	50	51	4,078	
	Phase II Low-Income Wave 2	Telephone Survey	1,768	0.5	50	50	1,261	
	Phase I Legacy Waves	Online Survey	37,223	0.5	50	63	9,930	43%
	Phase II Expansion Wave	Online Survey	24,106	0.5	50	60	6,237	
	Phase III Expansion Wave	Online Survey	19,249	0.5	50	50	4,631	
	Phase II Low-Income Wave 1	Online Survey	26,328	0.5	50	55	4,729	
	Phase II Low-Income Wave 2	Online Survey	5,659	0.5	50	50	3,963	
Program Total			**149,089**	**N/A**	**502**	**534**	**53,703**	**34%**

[1] Population size is the total number of customers in the treatment with a valid phone number or email address qualified to take the survey. These numbers may not match those reported in the impact analysis sections of this report due to the survey criteria (e.g., current recipients of home energy reports and valid phone number or email address). See sample attrition discussed in Appendix I.1.2.
[2] Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities tracking database. After selecting all unique records, Cadmus removed any records from the population if the customer had participated in a survey in the last three months, was selected for another program survey, did not have valid contact information (email or telephone number), was on the do not call list, or opted out of the online survey.
[3] Percent contacted means the percentage of the sample frame contacted to complete surveys.

10.7.3 Process Evaluation Findings

The following section presents program delivery, customer satisfaction, and benchmarking findings. The logic model review and treatment customer demographics are found in *Appendix I.1.1 Additional Findings*.

10.7.3.1 Program Delivery

Treatment group customers in all six waves received the home energy reports in PY9. The ICSP and home energy reports vendor made changes to the report product and launched a new outreach method, in the form of challenge emails, to improve customer satisfaction and to increase savings.

Program Changes

The home energy reports vendor redesigned the look and content of the print and digital reports so that reports looked more like an infographic and less like a business letter, as was the PY8 design. The PY9 reports contained less text and more images with clear call-to-action messages that factored in the customer's heating type (central heating or electric baseboard heating).

Despite the redesign, the reports did not appear to have an impact on improving customer satisfaction. As described in *section 10.7.3.2*, customers did not mention dissatisfaction with the design of the reports but rather with the accuracy of the reports and not perceiving them as having any value.

At the end of PY9, the ICSP and home energy reports vendor launched the challenge emails. Once each week, customers received an email with a savings tip and a challenge, in which they were encouraged to log into the My Ways To Save energy management portal to document their completion of the challenge. The impact on customer satisfaction and savings of this late outreach will be assessed in the PY10 evaluation.

10.7.3.2 Overall Satisfaction

In PY9, 65% of treatment group respondents said they were satisfied with the home energy reports, as shown in Figure 10-1, a significant decrease from PY8 where 73% of respondents said they were satisfied.[64] The percentage of *very satisfied* respondents did not change from the previous program year (36% in PY8 and PY9), but the percentage of *somewhat satisfied* respondents decreased significantly from 37% in PY8 to 29% in PY9.[65] Of the 48 respondents who said they were *not too satisfied* or *not at all satisfied,* Cadmus asked a follow-up question about their reasons. They most often said they did not believe the home energy reports had accurate data (35%) and did not find the reports to be of value (19%). Notably, none of these dissatisfied respondents completed the online home assessment, which improves the accuracy of the reports by utilizing the assessment's responses to update the data used to generate the home energy reports.

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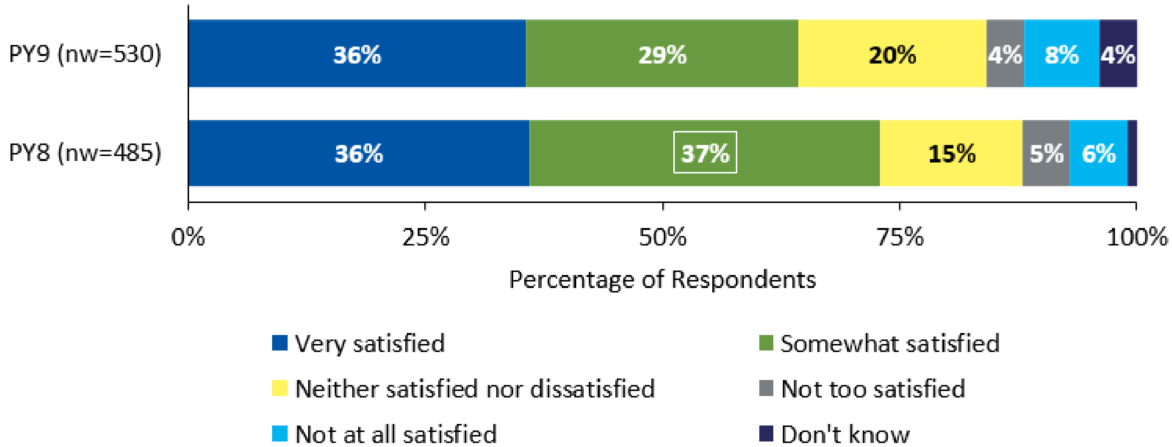
64 Difference is statistically significant, p≤0.05.

65 Difference is statistically significant, p≤0.05.

Figure 10-1. Overall Satisfaction with Home Energy Reports



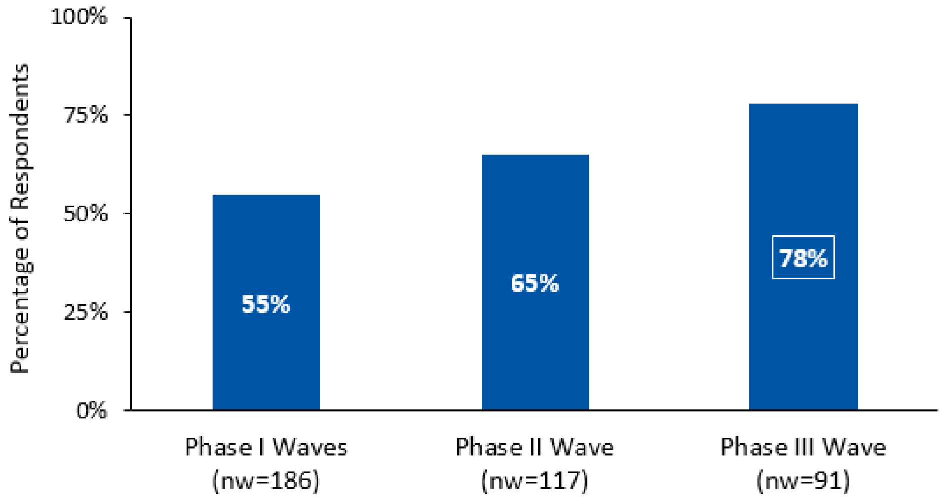
The percentage in the white box indicates that the difference between PY8 and PY9 is statistically significant, p≤0.05.
Note: Weighted survey data are indicated by the notation n_w.
Source: Survey question, "How would you rate your overall satisfaction with the Home Energy Reports?"

Moreover, the waves that launched in Phase I and II exhibited significantly lower satisfaction with the home energy reports compared to the most recent wave launched in Phase III.[66] Figure 10-2 shows the percentage of satisfied customers in PY9 by the phase in which they first started receiving the home energy reports (excluding the low-income waves). Phase I waves had the lowest proportion of satisfied respondents (55%), Phase II wave had the second lowest proportion (65%), and Phase III wave has had the highest proportion (78%).

This pattern suggests possible report fatigue among the customers who have been receiving the home energy reports the longest. Remarkably, satisfaction had an inverse relationship to savings; Phase I waves had the highest percentage of daily savings (1.5% to 1.9%), Phase II wave had the second lowest (1.1%), and Phase III wave had the lowest (0.7%) in PY9.

[66] Difference between Phase III wave and Phase I waves is statistically significant, and difference between Phase III wave and Phase II wave is statistically significant, p≤0.05.

Figure 10-2. Percentage of PY9 Satisfied Customers by Home Energy Report Launch Phase



The white box indicates that the difference between Phase III wave and Phase I waves and between Phase III wave and Phase II wave in percentage satisfied is statistically significant, $p \leq 0.05$.
Note: Excludes respondents from the low-income waves. Weighted survey data are indicated by the notation n_w.
Source: Survey question, "How would you rate your overall satisfaction with the Home Energy Reports?"

Cadmus also found that report satisfaction differed between general residential and low-income customers. A significantly higher proportion of low-income respondents (71%, n_w=135) than residential respondents (63%, n_w=395) were satisfied with the reports.[67] This higher satisfaction can be explained—low-income customers have a stronger belief in the accuracy of the report (i.e., the comparison of similar homes). In the PY7 annual evaluation, Cadmus found that low-income respondents exhibited a significantly stronger belief in the accuracy of the comparison of similar homes (6.9 mean rating out of 10, n_w=160) than did residential customers (4.8 mean rating out of 10, n=292).[68]

Suggested Report Improvements

Cadmus asked respondents to name one thing that PPL Electric Utilities could change to improve the home energy reports, and 156 respondents gave suggestions. The most frequent suggestions were about improving the accuracy of the reports, such as the accuracy of the usage data, comparisons, and home characteristics (22%). The second most common response suggested that PPL Electric Utilities stop sending the reports and instead invest in something that would help customers lower their bill (14%). These suggestions reinforce the reasons customers were dissatisfied with the reports (reasons were inaccurate data and lack of value).

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67 Difference is statistically significant, $p \leq 0.05$.

68 Cadmus. *Annual Report to the Pennsylvania Public Utility Commission: Phase II of Act 129, Program Year 7 (June 1, 2015—May 31, 2016) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan*. November 15, 2016. Available online: http://www.puc.pa.gov/pcdocs/1489206.pdf

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. The passives are excluded from the calculation. An excellent NPS is 50 and above.[69]

As shown in Table 10-13, the home energy reports achieved an NPS of -14, indicating there are more detractors (44%) than promoters (30%) among the respondents. Although the NPS improved in PY9 with 5% more promoters and 6% fewer detractors, the home energy reports still yielded a very low NPS relative to other residential programs. According to Cadmus' research and evaluation of other similar behavior programs, this is not atypical. Home energy report programs often experience a lower NPS than traditional rebate programs, possibly due to its opt-out program design.

Table 10-13. Net Promoter Score: Likelihood to Recommend the Home Energy Reports in PY8 and PY9

Rating Classification	PY8 Percentage of Respondents (n_w=479)	PY9 Percentage of Respondents (n_w=528)
Promoters (9-10)	25%	30%
Passives (7-8)	24%	20%
Detractors (0-6)	50%	44%
NPS	**-25**	**-14**

Opinion of PPL Electric Utilities

Despite the decrease in satisfaction, the home energy reports did not negatively affect customer opinion of PPL Electric Utilities. The majority of respondents (65%, n_w=527) did not change their opinion of PPL Electric Utilities after receiving the home energy reports. Of the remaining respondents, 8% said their opinion of PPL Electric Utilities had *improved significantly*, 20% said their opinion *improved somewhat*, 2% said their opinion *decreased somewhat*, and 3% said their opinion *decreased significantly*. These PY9 shifts of opinion did not differ from PY8.

10.7.3.3 Benchmarking Research

In PY9, PPL Electric Utilities began exploring ideas and products for a future iteration of the program. These include customer engagement products and services that offer customers real-time (AMI) usage data and appliance disaggregation.

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[69] Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

Cadmus researched several utilities that are currently testing home energy management system (HEMS) program designs. HEMS can give customers real-time usage data and monitoring, appliance disaggregation, tips, alerts, peak demand event notifications, home automation controls, and marketing—all through a digital interface. After discussions with PPL Electric Utilities, Cadmus focused its HEMS benchmarking research on two vendors, Bidgely and Powerley. Both offer HEMS that can couple with other devices and different program designs, making them adaptable to a utility's needs and the changing market.

Bidgely offers its software as a service to implement a HEMS program. Energy monitoring devices can be added on to support real-time usage data feedback and appliance disaggregation. Customer usage data, tips, alerts, event notifications, and marketing can be delivered through any or all of these channels: a web portal, an app, text, and email.

Powerley offers an app to implement a HEMS program. Customer usage data, tips, alerts, event notifications, marketing, and home automation and controls can be delivered through the app. A device called the Energy Bridge can be added on to support real-time usage data feedback and appliance disaggregation.

Table 10-14 shows the benchmarking results of Bidgely and Powerley HEMS programs by program design, annual savings, customer engagement, and satisfaction. Cadmus found limited evidence of verified savings for implementing HEMS because many programs were in the pilot phase or have yet to conduct verification activities. Of those that did, the savings and customer engagement appear to be on par with or better than the Home Energy Education Program.

Table 10-14. Benchmarking of Home Energy Management Systems

Vendor	Current Utility Clients	Region	Program Design	Average Annual Electric Savings	Number of Participants	Customer Engagement and Satisfaction
Bidgely	London Hydro[1]	Canada (Ontario)	HEMS Behavioral (replaced previous home energy report program)	2.25% (verified savings)	6,000	53% email open rate. 40% active user retention rate.
	Pacific Gas & Electric[2]	Northern California	HEMS Time of Use with Demand Response	7.7% (reported savings)	850	65% email open rate. 75% active user retention rate. 8.1 out of 10 satisfaction.
	ComEd[3]	Northern Illinois	HEMS Behavioral	N/A	2,500	N/A
	Duke Energy[4]	North Carolina	HEMS Behavioral	N/A	10,000	N/A
	Hawaiian Electric[5]	Hawaii (Oahu)	HEMS Behavioral with Demand Response	N/A	750	N/A
Powerley	DTE Energy[6]	Michigan	HEMS Behavioral	1.08% with app only and 3.2% with app + Energy Bridge (after adjusting for any double-counted savings)	100,000 to 200,000	65% active user retention rate. 7.5 out of 10 satisfaction.
	AEP Ohio[7]	Ohio	HEMS Behavioral with Demand Response	N/A	N/A	N/A
	BC Hydro[8]	Canada (British Columbia)	HEMS Behavioral and Customer Engagement Tool	N/A	N/A	N/A

Note: All except DTE Energy's program are pilot programs. The DTE Insight app was accepted as a measure in the 2016 Michigan Energy Measure Database (MEMD), which is Michigan's equivalent of a TRM. Pacific Gas & Electric's program has high savings (7.7%) because the energy monitoring device was paired with a time-of-use program design.

[1] Bidgely. "Case Study Energy Efficiency." 2017. Available online: http://bidgely.com/wp-content/uploads/2017/06/Case-Study-Energy-Efficiency-London-Hydro.pdf.
[2] Bidgely. "PG&E Pilot Yields 7.7% Energy Savings." April 14, 2015. Available online: http://www.bidgely.com/blog/pge-pilot-yields-7-7-energy-savings/.
[3] Business Wire. "Bidgely and ComEd to Deploy Real-Time Energy Disaggregation in Northern Illinois." February 5, 2015. Available online: https://www.businesswire.com/news/home/20150205005240/en/Bidgely-ComEd-Deploy-Real-Time-Energy-Disaggregation-Northern.
[4] Smart Grid Consumer Collaborative. "Connecting with Customers on the Go." SGCC Peer Connect Webinar Series. February 16, 2017. Available online: http://smartenergycc.org/wp-content/uploads/2017/02/SGCC-Peer-Connect-PP-Customers-on-the-Go.pdf.
[5] Blue Planet Foundation. "You Have the Power." n.d. Available online: https://blueplanetfoundation.org/you-have-the-power/.
[6] DTE Energy and Navigant. "Behavioral Effects of the DTE Energy Insight Smart Phone App." Presentation at the Behavior, Energy, and Climate Change Conference. October 21, 2015. Available online: https://beccconference.org/wp-content/uploads/2015/10/presentation_olig.pdf. DTE Energy and Navigant. "DTE Insight: Energy Bridge Electric Savings." White paper submission for the Michigan Energy Measures Database. 2016. Available online: https://www.michigan.gov/documents/mpsc/DTE_Insight_Electric_Energy_Bridge_522660_7.pdf.
[7] Walton, Robert. "AEP Ohio taps Powerley's home energy management platform for residential program." July 17, 2017. Utility Dive. Available online: https://www.utilitydive.com/news/aep-ohio-taps-powerleys-home-energy-management-platform-for-residential-pr/447216/.
[8] Walton, Robert. "BC Hydro taps Powerley for smart home pilot." August 15, 2017. Utility Dive. Available online: https://www.utilitydive.com/news/bc-hydro-taps-powerley-for-smart-home-pilot/449329/.

10.8 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 10-15. Cadmus calculated TRC benefits using gross verified impacts. The net present value program year to date (NPV PYTD) benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). Net present value costs and benefits for P3VTD financials are expressed in PY8 dollars. Because the NTG ratio is irrelevant in this analysis, net savings are the same as verified gross savings. Cadmus did not include a summary of program finances for net verified savings.

Table 10-15. Summary of Home Energy Education Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	**-**		**-**	
		EDC	**ICSP**	**EDC**	**ICSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$25	-	$61	-
7	Marketing [4]	-	$212	-	$340
8	Program Delivery [5]	-	$1,387	-	$1,951
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	$1,623		$2,353	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	$1,623		$2,353	
14	Total NPV Lifetime Electric Energy Benefits	$1,324		$2,533	
15	Total NPV Lifetime Electric Capacity Benefits	$775		$1,028	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	-		-	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	-		-	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	$2,099		$3,561	
19	**TRC Benefit-Cost Ratio [9]**	**1.29**		**1.51**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio-level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs.
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

10.9 Recommendations

Overall, the Home Energy Education Program is behind the pace of the EE&C Plan on savings and customer satisfaction. The program achieved 88% of its projected savings for PY9 and saw a significant decrease in satisfaction (65%) with the home energy reports from PY8 (73%). Recommendations are provided in Table 10-16, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Program Delivery and Performance

Finding: Legacy Wave 1 and Legacy Wave 2 waves, both launched in Phase I, produced savings in their eighth and seventh years of treatment (respectively). Expansion Wave 1 and Low-Income Wave 1, both in their fourth year of treatment, also produced savings. The program as a whole remains cost-effective. (See sections *10.3 Gross Impact Evaluation* and *10.8 Cost-Effectiveness Reporting.*)

Finding: Legacy Wave 1, Legacy Wave 2, and Expansion Wave 1 maintained consistent savings through PY9a (June 2017 through May 2018, the majority of PY9) and continued to achieve the largest percentage savings ranges of all waves, with savings ranging from 1.1% (Expansion Wave 1) to 1.9% (Legacy Wave 1). (See *Appendix C.1.3 Ex Post Verified Savings Methodology*.)

Finding: Legacy Wave 1, Legacy Wave 2, and Expansion Wave 1 included customers with the largest pre-treatment energy consumption of all waves, with average annual consumption per customer ranging from 18,535 kWh/yr (Legacy Wave 1) to 27,648 kWh/yr (Legacy Wave 2) in the year before treatment began. Average annual consumption in the remaining three waves ranged between 7,967 kWh/yr (Low-Income Wave 2) and 15,178 kWh/yr (Phase III Expansion Wave). (See *Appendix C.1.2 Verification of Balanced Treatment and Control Groups*.)

Conclusion: Since Phase I, home energy reports have continued to provide dependable and cost-effective savings.

Conclusion: PPL Electric Utilities likely enrolled the largest potential savers in the first waves, which likely explain why the older waves continue to produce the largest savings compared to the newer waves.

Finding: All waves exhibited positive uplift savings, ranging between 251.8 and 548.2 kWh/yr on average per customer. (See section *10.5.2 Savings Uplift*.)

Conclusion: Home energy reports are successfully promoting PPL Electric Utilities' other energy efficiency programs.

Finding: The Phase III wave exhibited significantly higher satisfaction with the home energy reports than the Phase I and II waves. Phase I waves had the lowest proportion of satisfied respondents (55%), Phase II wave had the second lowest proportion (65%), and Phase III wave had the highest proportion (78%). (See Figure 10-2 in section *10.7.3.2 Overall Satisfaction* .)

Conclusion: The older waves continue to save the most for the program, but they are also the least satisfied with the home energy reports. Customers who have been receiving the home energy reports the longest may be showing a combination of persistence effects from previous phases' reports and report fatigue.

Recommendation #1: To strategically boost savings and improve satisfaction by wave, consider changing how the program is delivered based on the customer's savings, satisfaction, and report history. Although information in the home energy reports is tailored to each customer, the program currently does not alter the number of reports and customer touches by savings, satisfaction, and report history. For example, PPL Electric Utilities and the ICSP could consider the following program delivery adjustments:

- **1a. Provide one fewer report to high-saving fatigued customers such as those in Phase I Legacy Wave 1 and Phase I Legacy Wave 2.** Because of their high savings, long history with the reports, and low satisfaction, these customers may appreciate receiving fewer reports and program communication.
- **1b. Provide one additional report to low-saving non-fatigued customers such as those in Phase III Expansion Wave.** Because of their low savings, short history with the reports, and high satisfaction, these customers may continue to need encouragement to save energy.

Report Design

Finding: The home energy reports vendor redesigned the look and content of the reports. Compared to the PY8 reports, the PY9 reports contained less text and more images with clear call-to-action messages that factored in the customer's heating type (central heating or electric baseboard heating). (See section *10.7.3.1 Program Delivery*.)

Finding: Percentage savings in Phase III Expansion Wave 1 significantly increased from 0.3% to 0.7% of consumption from PY8 to PY9. (See *Appendix C.1.3 Ex Post Verified Savings Methodology.*)

Finding: Percentage savings in Expansion Wave 1 decreased statistically significantly from PY8 with 90% confidence, dropping by 0.26% in PY9, though the difference could reflect year-to-year changes in weather. (See *Appendix C.1.3 Ex Post Verified Savings Methodology.*)

Finding: Satisfaction with the home energy reports significantly decreased in PY9 from PY8. In PY9, 65% of treatment group respondents said they were satisfied with the reports compared to 73% of respondents in PY8. (See section *10.7.3.2 Overall Satisfaction* .)

Finding: Dissatisfied respondents most often said they did not believe the home energy reports had accurate data (35%) and did not find the reports to be of value (19%). Moreover, respondents suggested improving the accuracy of the reports and offering something else other than the report that would help lower their bill. (See the section *10.7.3.2 Overall Satisfaction* .)

Conclusion: Satisfaction with the home energy reports decreased from the previous year as customers continued to be dissatisfied with the accuracy and value of the reports.

Recommendation #2: To measure the effectiveness of changes made to the report format in PY9, consider framing and A/B testing messages about data accuracy and report value. Experiment with framing messages in new ways that encourage customers to think about the accuracy and value of the home energy reports in a different light. Framing is a behavior change technique where choices are presented differently (e.g., dollars saved vs. energy saved) to influence the desired behavior. Consider framing and A/B testing messages about data accuracy and report value.

Low-Income

Finding: In PY9, Low-Income Wave 1 achieved significant savings of 0.9%, which was lower than the savings in PY7 (1.4%) when customers in this wave consistently received print home energy reports every other month (six per year),[70] and it is lower than in the last month of PY8 when treatment resumed (after stopping in the beginning of PY8). Differences are significant with 90% confidence. (See Table C-5 in *Appendix C.1.3 Ex Post Verified Savings Methodology*.)

Finding: Only 38% of Low-Income Wave 1 treatment customers and 27% of Low-Income Wave 2 treatment customers received electronic home energy reports in PY9. (See introduction to *Chapter 10*.)

Finding: Low-Income Wave 2 experienced high total attrition (23%) from its first treatment at the beginning of PY7 to the beginning of PY9. (See Table C-1 in *Appendix C.1.1 Data Preparation*.)

Finding: Low-Income Wave 2 did not achieve statistically significant savings in PY9 at the 90% confidence level. (See Table C-5 in *Appendix C.1.3 Ex Post Verified Savings Methodology*.)

Finding: Back in PY7, the previous home energy reports vendor included two modules—Winter of 68 and Low-Income Energy Assistance Program (LIHEAP)—in the low-income home energy reports specifically to elicit a behavior change. The PY7 evaluation showed that a significantly higher proportion of treatment group respondents (47%; nw=206) than control group respondents (36%; nw=57) reported always turning down the heating thermostat temperature when leaving or sleeping, which could be attributed to the Winter of 68 module. 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. [71]

Conclusion: Though Low-Income Wave 1 has consistently achieved significant savings and represents the majority of low-income wave savings, previous savings may not predict future savings now that only electronic reports are sent to customers who provided email addresses.

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70 Cadmus. *Annual Report to the Pennsylvania Public Utility Commission: Phase II of Act 129, Program Year 7 (June 1, 2015—May 31, 2016) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan*. November 15, 2016. Available online: http://www.puc.pa.gov/pcdocs/1489206.pdf

71 Ibid.

Conclusion: The small number of customers in Low-Income Wave 2 hindered Cadmus' ability to detect the small percentage savings in this group, and this group will likely continue to have high attrition in the following years.

Recommendation #3: PPL Electric Utilities plans to operate the low-income waves as a standalone Low-income segment of the Home Energy Education Program in PY10 (if this plan revision is approved by the PA PUC) to claim savings for the low-income sector. However, Low-Income Wave 2 may never achieve significant savings given its sample size, and there is uncertainty about Low-Income Wave 1 savings. PPL Electric Utilities already provides email address updates to the vendor on a weekly basis to send HER to low income customers. PPL Electric Utilities and the ICSP could consider additional actions to boost savings from the low-income waves:

- **3a. Discontinue Low-Income Wave 2.** It is unlikely that Low-Income Wave 2 will generate significant savings given the current treatment plan, as email addresses are available for only 20% of this group to receive electronic home energy reports.
- **3b. Treat Low-Income Wave 1 customers with print reports.** Savings achieved by Low-Income Wave 1 customers spiked after they received one paper home energy report in May, 2017. Consider using program dollars saved from discontinuing electronic reports for customers in Low-Income Wave 2 to provide one paper report to all eligible treatment customers, allowing PPL Electric Utilities to claim 12 months of savings for all customers in this wave, as opposed to the 31% of customers who will currently receive electronic home energy reports only.
- **3c. Include special modules in the reports.** Some low-income customers in the previous phase responded to the two modules featured in the home energy reports by taking the energy-saving actions promoted in the modules.

10.9.1 Status of Recommendations

Table 10-16 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 10-16. Status of Recommendations for the Home Energy Education Program

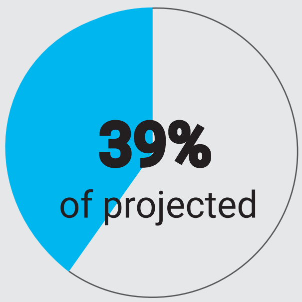
Home Energy Education Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1a	Provide one fewer report to high-saving fatigued customers such as those in Phase I Legacy Wave 1 and Phase I Legacy Wave 2.	Being considered.
1b	Provide one additional report to low-saving non-fatigued customers such as those in Phase III Expansion Wave.	Being considered.
2	To measure the effectiveness of changes made to the report format in PY9, consider framing and A/B testing messages about data accuracy and report value. Experiment with framing messages in new ways that encourage customers to think about the accuracy and value of the home energy reports in a different light.	Being considered.
3a	Discontinue Low-Income Wave 2. It is unlikely that Low-Income Wave 2 will generate significant savings given the current treatment plan, as email addresses are available for only 20% of this group to receive electronic home energy reports.	Being considered.
3b	Treat Low-Income Wave 1 customers with print reports. Savings achieved by Low-Income Wave 1 customers spiked after they received one paper home energy report in May, 2017. Consider using program dollars saved from discontinuing electronic reports for customers in Low-Income Wave 2 to provide one paper report to all eligible treatment customers, allowing PPL Electric Utilities to claim 12 months of savings for all customers in this wave, as opposed to the 31% of customers who will currently receive electronic home energy reports only.	Being considered. (Rejected in March 2018 due to budget constraints. PPL Electric Utilities will discuss again in light of the recommendation.)
3c	Include special modules in the reports. Some low-income customers in the previous phase responded to the two modules featured in the home energy reports by taking the energy-saving actions promoted in the modules.	Implemented in Februry 2018 (after the customer survey was completed).

ENERGY EFFICIENT HOME PROGRAM

The program offers a wide range of energy efficient products, rebates, education, and services that give customers a variety of customizable solutions to increase their home's energy efficiency.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **28,746 MWh/yr**



189% of projected

PY9 saved **18,802 MWh/yr**

PROGRAM SATISFACTION

90% Satisfied with overall program

81% satisfied with the **clarity of application** requirements

80% satisfied with **rebates** for qualifying equipment and services

84% satisfied with the **information** about how to save energy

PY9 PARTICIPATION

A total of **33,334** received rebates for:

23,201 Online and in-home audit and energy conservation kits

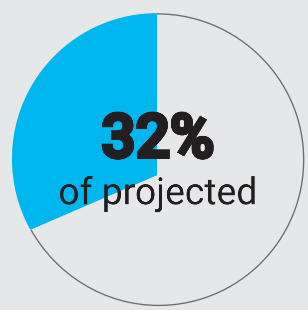
8,695 Efficient equipment

837 Energy efficient new homes

601 Weatherization

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$11,080**



120% of projected

PY9 expenditures **$6,143**

11 Energy Efficient Home Program

The Energy Efficient Home Program is designed for new construction and existing homes. The program offers a wide range of energy-efficient products, rebates, education, and services that give customers a variety of customizable solutions to increase their home's energy efficiency. The program has these five components: new home construction incentives, in-home energy audits (including energy-savings kits), online home energy assessments (including energy-savings kits), weatherization, and energy-efficient equipment.

In PY9, the new homes component offered up to $2,500 in incentives for the construction of energy-efficient new homes through either $0.30 per annual kWh/yr saved for homes at least 15% above the residential building code (2009 IECC) or $0.35 per annual kWh saved for ENERGY STAR®-rated homes at least 15% above code.

The in-home energy audit and the online home energy assessment components provide tools and information that help residential customers make decisions about actions they can take to improve the energy efficiency of their homes. Energy savings accrue from the low-cost energy-efficient products mailed to the customers. The kits currently contain LEDs, faucet aerators, energy-efficient showerheads, pipe insulation, and weatherstripping.

The weatherization component provides rebates to customers who make any of these three eligible home improvements: attic insulation, wall insulation, or air sealing.

The efficient-equipment component offers rebates for eligible products, including air source heat pumps (SEER 16+), ductless heat pumps (< 5.4 tons, ≥ SEER 15, ≥ HSPF 8.6), central air conditioners (SEER 16+), heat pump water heaters (≥ 2.3 EF), efficient pool pumps (variable speed drive), ENERGY STAR refrigerators and dehumidifiers, advanced smart thermostats, and fuel-switching to non-electric high-efficiency central heating equipment (natural gas or propane furnace, oil furnace, or fossil fuel boiler).

PPL Electric Utilities' energy efficiency program staff provide overall strategic direction and program management. Its EM&V staff oversees evaluation activities and coordinates with program staff.

CLEAResult, the ICSP, manages the program and delivers the audit, weatherization, and efficient equipment portions of the program to customers. This involves maintaining a call and rebate processing center, conducting in-home audits, recruiting and educating trade allies (HVAC contractors, heat pump water heater retailers, in-home energy auditors, new home builders), and marketing the program to achieve sufficient participation. Performance Systems Development (PSD) is a subcontractor to the ICSP and is responsible for the program's new home component, processing applications, and assisting builders and Home Energy Rating System (HERS) raters.

In PY9, the objectives of the Energy Efficient Home Program were these:[72]

- Encourage customers to view energy efficiency in a holistic manner
- Provide customers with education, audits, surveys, and energy-saving solutions
- Promote the construction of energy-efficient new homes
- Educate construction industry professionals and other trade allies about the benefits of energy-efficient homes
- Reduce energy consumption by approximately 73,000 MWh/year in gross verified savings
- Achieve high customer and trade ally satisfaction with the program

11.1 Progress Toward Phase III Projected Savings

The Energy Efficient Home Program's verified savings are 189% of the projected MWh/yr savings PY9. It has achieved 39% of the projected Phase III total planned savings and is making good progress toward meeting the Phase III projected savings, as intended.

Table 11-1 shows the program's verified gross program savings and progress toward its Phase III projected energy savings, as filed in the EE&C Plan.

Table 11-1. Energy Efficient Home Program Projected Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified	Projected[1]	Verified	Percentage of Projected	Projected [1]	Verified	Percentage of Projected
MWh/yr [2]	9,943	9,941	18,802	189%	73,721	28,746	39%

[1] Projected savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.
[2] Total may not sum due to rounding.

11.2 Participation and Reported Savings by Customer Segment

11.2.1 Definition of a Participant

For all components of the Energy Efficient Home Program, a participant is defined as a rebated project, and each project is assigned a unique job number in the program tracking data. For the new homes component, a participant is defined as the single-family home or a tenant unit in a newly constructed multifamily building.[73]

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72 Program objectives are listed in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

73 In PY9, the new homes participation is estimated at 75% single-family homes and 25% multifamily units, based on the percentages found in the 40 records reviewed.

11.2.2 Program Participation and Reported Impacts

Table 11-2 presents the participation counts, reported energy and demand savings, and incentive payments for the Energy Efficient Home Program in PY9 by customer segment.

Table 11-2. Energy Efficient Home Program Participation and Reported Impacts

Parameter	GNE	Residential	Small C&I	Total (1)
PYTD # Participants	110	33,152	72	**33,334**
PYRTD MWh/yr	153	21,469	83	**21,705**
PYRTD MW/yr	0.07	3.59	0.03	**3.68**
PYVTD MWh/yr	135	18,587	80	**18,802**
PYVTD MW/yr	0.07	3.45	0.03	**3.55**
PY9 Incentives ($1000)	$17	$2,473	$30	**$2,520**
(1) May not match due to rounding.				

11.3 Gross Impact Evaluation

Cadmus conducted these research activities to inform the gross impact evaluation:

- Program database review
- Records reviews of participant rebate applications and supporting documentation
- REM/Rate modeling review for new homes[74]
- Participant surveys

Cadmus conducted a database review of each component to ensure that appropriate data were collected and to confirm that *ex ante* savings were properly calculated using the appropriate PA TRM algorithms. Cadmus also reviewed a sample of records to evaluate the savings impacts of the in-home audit and assessment, weatherization, and efficient equipment program components. The records reviews accomplished the following:

- Verified that product types were correctly categorized based on the verified installed products
- Verified that reported equipment data in PPL Electric Utilities' tracking database matched information from rebate applications, Air Conditioning, Heating, and Refrigeration Institute (AHRI) certificates, invoices, and other supporting documentation
- Calculated *ex post* savings using the PA TRM algorithms and verified equipment data

Cadmus used the results of telephone and online participant surveys from PY9 to calculate the in-service rate (ISR) for dehumidifiers in the equipment component. For all other products, Cadmus used ISRs from surveys conducted in PY8.

74 More information about REM/Rate software and applications is available online: http://www.remrate.com/

For the new homes component, Cadmus reviewed a sample of 40 REM/Rate models, reviewed their HERS rater documentation, and conducted engineering analyses to verify their energy and demand savings. Cadmus used these results to determine the *ex post* savings.

Cadmus did not conduct site visits in PY9. To supplement the data used to verify energy and demand savings, Cadmus also referred to site visit findings, realization rates, and ISRs from PY8.

The lighting and appliance data contained in the PY9 REM/Rate models and PPL Electric Utilities' tracking database were insufficient to verify reported energy and demand savings. Cadmus requested additional data from HERS raters and received data for 10 homes from one HERS rater. These data were also used to supplement appliance characteristics not documented in REM/Rate or the tracking database.

The evaluation sampling strategy is summarized in Table 11-3. Cadmus evaluated all components with basic levels of rigor. For all of the sampled components, Cadmus used simple random sampling to select records for reviews. The gross impact evaluation activities produced results with ±2.82% precision at 85% confidence.

Table 11-3. PY9 Energy Efficient Home Program Gross Impact Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
New Homes	837	0.5	40	40	REM/Rate modeling review
Audit and Kit (1)	98(2)	0.5	40	40	Records review (3)
Weatherization	601	0.5	40	40	Records review (4)
Efficient Equipment	7,263 (5)	0.5	70	72	Verification phone and online survey (5)
		0.5	120	120	Records review (6)
Program Total	**8,799**				

(1) Includes online assessment and in-home audit components. Both channels delivered energy-savings kits to customers.
(2) In-home audit component population size.
(3) Cadmus sampled 40 in-home audit projects.
(4) Cadmus sampled 20 air sealing projects and 20 insulation projects.
(5) The number of unique rebates available in PPL Electric Utilities' tracking database at the time of the final survey effort.
(6) The phone and online surveys verified installation for dehumidifiers only.
(7) Records reviews were conducted for 40 participants each in the following components: heat pump water heaters, dehumidifiers, and ductless heat pumps.

In PY9, the Energy Efficient Home Program reported energy savings of 21,705 MWh/yr, as shown in Table 11-4, and demand reduction of 3.68 MW/yr, as shown in Table 11-5.

Table 11-4. Energy Efficient Home Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
New Homes	2,558	78%	0.13	2.87%
Audit and Kit [1]	8,729	74%	N/A	8.31%
Weatherization	631	86%	0.66	0.00%
Efficient Equipment	9,788	100%	0.51	0.00%
Program Total [2]	**21,705**	**87%**	**N/A**	**2.75%**

[1] Includes online assessment and in-home audit components. Both channels delivered energy-savings kits to customers.
[2] Program total does not match sum of rows due to rounding.

Table 11-5. Energy Efficient Home Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
New Homes	0.72	76%	0.75	16.96%
Audit and Kit [1]	0.89	77%	N/A	7.41%
Weatherization	0.06	85%	0.59	0.00%
Efficient Equipment	2.01	113%	0.56	0.00%
Program Total [2]	**3.68**	**96%**	**N/A**	**3.10%**

[1] Includes online assessment and in-home audit components. Both channels delivered energy-savings kits to customers.
[2] Program total may not match sum of rows due to rounding.

The following factors led to variation between the reported and verified savings and to the observed realization rates of less than or greater than 100% for energy savings and/or demand reduction:

- **New homes.** Cadmus found that most of the variation between reported *ex ante* and verified *ex post* savings was caused by the lighting and appliance assumptions the ICSP used to calculate *ex ante* energy and demand savings. Cadmus evaluated the energy savings reported in the REM/Rate models provided by the ICSP's subcontractor and determined that the ICSP used REM/Rate assumptions to calculate all savings, which is inconsistent with the PA TRM. The REM/Rate software uses an outdated method that overestimates lighting energy savings. The software calculates energy savings for every appliance even if the appliance was not installed. These factors led to a realization rate of 78% for energy savings and 76% for demand savings. Additional information can be found in *Appendix J.*
- **Audit and kit.** Cadmus conducted a records review for the in-home audit and kits component and a database review for the online assessment component. One factor affecting realization rates was in-home audit documentation showing that the water heater setback was not performed although a post-setback temperature was recorded in the tracking data. Also, the evaluated ISRs used by Cadmus to adjust savings for kit products were lower than ISRs used by the ICSP in reported savings calculations. Cadmus applied ISRs calculated in PY8 to calculate *ex post* demand savings for the kits delivered through the in-home audit and online assessment

components in PY9. The in-home audit and assessment components had a 74% energy realization rate. Additional information can be found in *Appendix J*.

- **Weatherization.** Cadmus' database and records review found 72 data entry inconsistencies across insulation participants. The main error was that the baseline R-value was incorrectly calculated for these participants. Other errors were missing installation date for the central air conditioning system, incorrect existing inches of insulation, incorrect added R-value, and an error for an air sealing record. These errors led to an 86% energy realization rate for the weatherization component. Additional information can be found in *Appendix J.*
- **Efficient equipment.** Overall, the efficient equipment component had a 100% energy realization rate. Cadmus' database and records review found 1,032 errors across ductless heat pump, fuel switching, heat pump water heater, smart thermostat, ENERGY STAR refrigerator, and ENERGY STAR dehumidifier participants. Errors were primarily incorrect or missing inputs used in calculated savings. For ductless heat pumps, Cadmus found that in PPL Electric Utilities' database, the AHRI number was entered in the "model number" field (the AHRI number is not required on the rebate forms; the model number is, however). Cadmus confirmed that the error came from the ICSP's tracking data. In addition, these AHRI numbers were only for outdoor units and AHRI numbers for indoor units were not recorded. In some instances, rebate applications and contractor invoices listed different model numbers, and model numbers could not always be located in the AHRI directory.[75] Cadmus had difficulty looking up specifications for indoor units because model numbers were not recorded by the ICSP. No errors were found in the review of pool pumps, air source heat pump, or central air conditioner participants. Additional information can be found in *Appendix J*.

11.4 Net Impact Evaluation

In PY9, Cadmus used the results of PY8 participant surveys to calculate free ridership and spillover and determine net savings for most Energy Efficient Home Program components. Cadmus used self-report surveys to assess free ridership and spillover only for dehumidifiers and refrigerators in the efficient equipment stratum in PY9, because these represented changes to the program. The ICSP changed incentive levels for refrigerators and added dehumidifiers as a new piece of eligible equipment. A detailed explanation of the methodology used to calculate net savings and the findings from PY8 can be found in the PY8 Annual Report, Appendix J.2.[76]

Free ridership 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. Spillover credits the additional savings that participants achieved on their own. This refers to participants whose experience

[75] Air-Conditioning, Heating, and Refrigeration Institute. AHRI Directory of Certified Product Performance. Available online: https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f

[76] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Spillover increases gross savings.

Cadmus calculates net savings only to inform future program planning. Energy savings and demand reduction compliance targets are met using verified gross savings.

Table 11-6 lists the methods and sampling strategy used to determine net savings for dehumidifiers and refrigerators in the Energy Efficient Home Program's efficient equipment stratum in PY9. Additional details about methodology are in *Appendix J.2*.

Table 11-6. PY9 Energy Efficient Home Program Net Impact Evaluation Sample Design

Stratum	Stratum Boundaries	Population Size (1)	Achieved Sample Size	Respondents' % of Reported Savings	NTG Activity
Participants (Customers) (1)	Efficient Equipment - Refrigerators	2,012	105	5%	Participant telephone and online surveys
	Efficient Equipment - Dehumidifiers	1,283	72	6%	Participant telephone and online surveys
Program Total		**3,295**	**177**	**5%**	

(1) Population refers to unique projects. The sample frame after cleaning and removing duplicate customer accounts is contained in Table J-9 in *Appendix J.3.2 Survey Approach*.

Table 11-7 shows the efficient equipment stratum free ridership, spillover, and NTG ratios by equipment category. Cadmus surveyed only the refrigerator and dehumidifier equipment categories in PY9 for NTG; the rest of the equipment category NTG estimates are from PY8.

Table 11-7. Energy Efficient Home Program –
Efficient Equipment Stratum Net Impact Evaluation Results

Equipment Category	PYVTD kWh/yr	Evaluation Year	Free Ridership (%) (1)	Spillover (%)	NTG Ratio	Relative Precision at 85% C.L.
Refrigerator	122,012	PY9	63%	11%	0.48	9%
Dehumidifier	235,702	PY9	48%	16%	0.68	7%
HVAC	6,681,720	PY8	44%	7%	0.63	11%
HPWH	831,957	PY8	22%	7%	0.85	10%
Other	1,958,047	PY8	47%	7%	0.60	21%
Stratum Total (2) (3)	**9,829,438**		**43%**	**7%**	**0.64**	**27%**

(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 have a greater influence on the equipment-level free ridership estimate than do respondents who achieved lower energy savings.
(2) Equipment- level free ridership, spillover, and NTG estimates were weighted by the product's verified kWh/yr program population savings to arrive at the efficient equipment stratum NTG ratio of 0.64.
(3) May not match due to rounding.

Table 11-8 shows the free ridership, spillover, and NTG ratios by program component.

Table 11-8. Energy Efficient Home Program Net Impact Evaluation Results

Stratum	PYVTD kWh/yr	Evaluation Year	Free Ridership (%) (1)	Spillover (%)	NTG Ratio	Relative Precision at 85% C.L.
New Homes	1,994,063	PY8	51%	0%	0.49	35%
Online Assessment Kit	6,397,908	PY8	7%	9%	1.02	8%
Audit – In-Home	39,238	PY8	4%	1%	0.97	5%
Weatherization	541,603	PY8	49%	7%	0.58	14%
Efficient Equipment	9,829,438	PY9(2) & PY8	43%	7%	0.64	27%
Program Total (3) (4)	**18,802,250**		**32%**	**7%**	**0.75**	**35%**

(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 equipment-level free ridership estimate than do the respondents who achieved lower energy savings.
(2) Refrigerators and dehumidifiers were the only products evaluated for NTG in PY9. PY8 NTG results were used for all other equipment categories of the efficient equipment stratum.
(3) The stratum-level free ridership, spillover, and NTG estimates were weighted by the product's verified kWh/yr program population savings to arrive at the final Energy Efficient Home Program NTG ratio of 0.75.
(4) May not match due to rounding.

11.5 Verified Savings Estimates

In Table 11-9, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the Energy Efficient Home Program in PY9. These totals are added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 11-9. PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Demand (MW/yr) (1)
PYRTD Gross	21,705	3.68
PYVTD Gross	18,802	3.55
PYVTD Net (2)	14,148	2.45
P3RTD Gross	32,327	5.63
P3VTD Gross	28,746	5.33
P3VTD Net (2)	20,884	3.61

(1) May not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy savings compliance target.

11.6 Process Evaluation

11.6.1 Research Objectives

The purpose of the process evaluation was to assess the effectiveness of the Energy Efficient Home Program and provide recommendations to help the program achieve its objectives. The main research objectives focused on customer satisfaction, identifying changes in program design and delivery from PY8 to PY9, and determining the areas that are working well and any challenges.

11.6.2 Evaluation Activities

The PY9 process evaluation for the Energy Efficient Home Program included these activities:

- Interviews with PPL Electric Utilities and ICSP program managers
- Logic model review
- Online participant surveys
- Telephone participant surveys

These activities were consistent with the evaluation plan with one exception. Cadmus completed only an online survey (rather than phone and online surveys) for weatherization participants because of the small population size. Table 11-10 lists the process evaluation sampling strategy. Additional details about Cadmus' approach to contacting customers and the sample attrition are presented in *Appendix J.3.2 Survey Approach*.

The new homes component is excluded from Table 11-10, since interviews were planned only for PY8 and PY11.

11.6.2.1 Survey Methodology

Cadmus completed 1,197 online and telephone surveys with Energy Efficient Home Program participants, as shown in Table 11-10, to assess program satisfaction.[77] Cadmus administered the online survey four times throughout PY9—during quarter 1 (Q1), Q2, Q3, and Q4—to capture respondent feedback and to provide timely information to PPL Electric Utilities and the ICSP. The survey was sent to a random sample of participants in each program component (except in-home audit, which used a census). Completed participant surveys produced a measurement of program satisfaction with ±1% precision at 90% confidence.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based survey items to reduce order effects
- Use consistent survey wording and response options for online and phone surveys when relevant

Cadmus used the same online questionnaire for all four suhrveys distributed in PY9 so survey data were collected consistently. The SWE team and PPL Electric Utilities reviewed and approved the survey before fielding.

[77] The sample sizes reported throughout this report may vary by survey question. Although Cadmus considered anyone who answered the overall satisfaction question as one completed survey, some questions were incompletely answered. Cadmus analyzed all responses. Additionally, respondents could skip questions if they chose not to answer, therefore, not all respondents provided answers to every question.

Table 11-10. Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size (1)	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size (2)	Number of Records Selected for Sample Frame (3)	Percent of Sample Frame Contacted to Achieve Sample (4)
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone in-depth interview	N/A	N/A	3	3	N/A	N/A
Participants (1)	In-Home Audit and Kit	Online survey	98	90/10	All records	7	88	90%
	Online Assessment	Online survey	19,727	90/10	All records	689	5,687	29%
	Equipment	Online survey	7,263	90/10	All records	335	4,054	56%
		Telephone survey		90/10	195	125 (5)	721	10%
	Weatherization	Online survey	601	85/15	All records	41	370	62%
Program Total			**27,689**			**1,200**	**10,920**	

(1) For participants, population refers to unique projects at the time of the survey.

(2) Achieved sample size is based on number of respondents answering the Overall Satisfaction question. Cadmus tracks this as a completed survey to estimate confidence and precision around satisfaction metrics. Some respondents completed surveys but did not answer the Overall Satisfaction question. Therefore, data captured from additional surveys contributed to various analyses discussed in this report. The number of responses is indicated in the discussion.

(3) Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities' tracking database at the time of the survey. After selecting all unique records, Cadmus removed any records from the population if the customers had participated in a survey in the last three months, were selected for another program survey, did not have valid contact information (email or telephone number), were on the national Do Not Call list, or opted out of the online survey.

(4) Percent contacted means the percentage of the sample frame called to complete surveys. (5) Equipment count: 34 refrigerators, 28 air source heat pumps, 17 heat pump water heaters, 15 ductless heat pumps, 14 dehumidifiers, 10 smart thermostats, 4 central air conditioners, 2 pool pumps, and 1 fuel switching.

11.6.2.2 Program Staff and ICSP Interviews

In February 2018, Cadmus conducted interviews with Energy Efficient Home Program staff from PPL Electric Utilities (n=2) and the ICSP (n=1). The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and understanding the areas that are working well and any possible challenges. In July 2018, Cadmus also followed up with the ICSP to check on the status of recommendations made in PY8.

11.6.3 Process Evaluation Findings

The following sections describe the program delivery and satisfaction findings. Additional detail regarding Cadmus' approach to assessing response differences by survey mode and survey attrition are in *Appendix J.*

11.6.3.1 Program Satisfaction

Overall Satisfaction

Cadmus assessed participant satisfaction through the surveys. Results for equipment, online assessment, weatherization, and in-home audit are reported in this section.[78]

In PY9, 90% of respondents (n=1,197) reported they were satisfied with the Energy Efficient Home Program; 66% were *very satisfied* and 24% were *somewhat satisfied* (Figure 11-1). Only 4% reported dissatisfaction with the program. Overall satisfaction did not significantly differ from PY8; of 409 respondents, 65% of respondents were *very satisfied* and 22% were *somewhat satisfied*. Respondents for the online assessment component were significantly less satisfied with the program (55% *very satisfied*, n=689) compared to respondents in the equipment component (79% *very satisfied*, n=460) and the weatherization component (88% *very satisfied*, n=41; *p*s≤.10).[79] These results were also consistent with PY8.

Participants were also asked about their satisfaction with these elements of program delivery:

- Clear rebate application requirements
- Rebates for qualifying energy-efficient equipment and services
- Information about how to save energy that they learned from PPL Electric Utilities website

In PY9, respondents were equally satisfied with these three elements—80% to 84% of respondents were *very satisfied* or *satisfied* (Figure 11-2).

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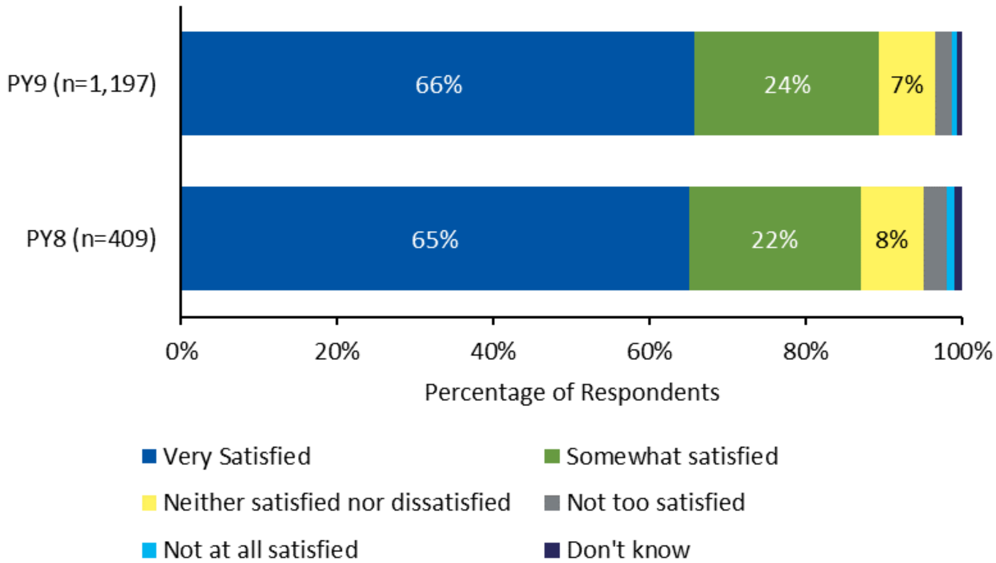
78 No interviews were conducted for the new homes component in PY9.

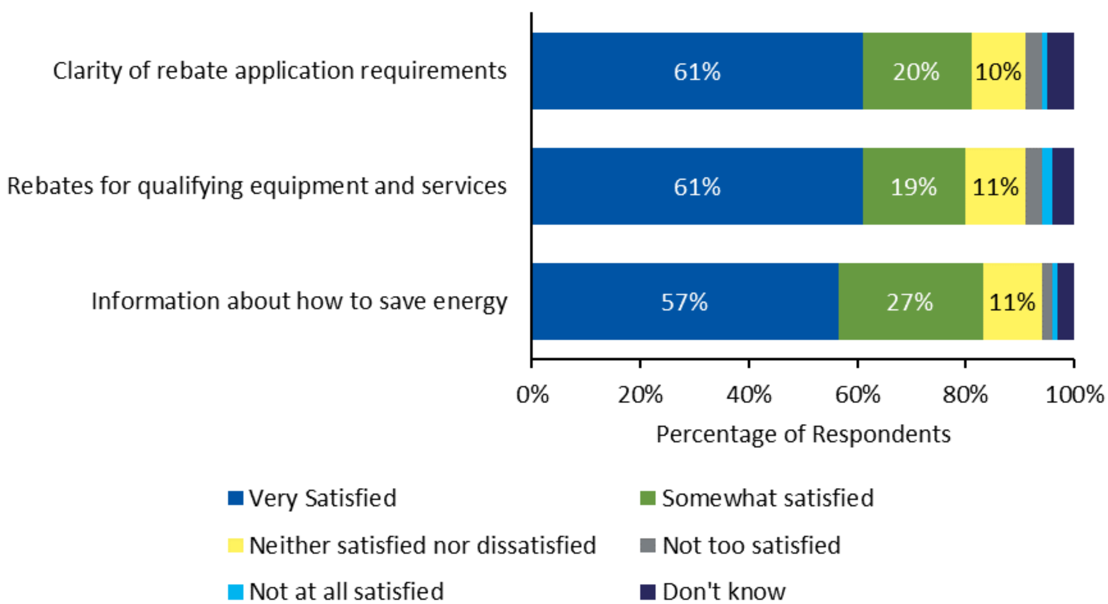
79 The in-home audit sample size was too small (n=7) to include in this component comparison analysis.

Figure 11-1. Overall Program Satisfaction for PY9 and PY8



Source: Survey question, "Now, thinking about your overall experience with PPL Electric Utilities' (weatherization rebate/online home energy assessment/in-home audit/efficient equipment rebate) program, how would you rate your satisfaction?"

Figure 11-2. PY9 Program Feature Satisfaction: All Program Delivery Elements



Source: Survey questions, "Please indicate how satisfied you are with each of the following program components: Clarity of application requirements, Information you have learned online from PPL Electric Utilities about how to save energy, PPL Electric Utilities' rebates for qualifying energy-efficient equipment and services." (Equipment ns=448-474, Weatherization ns=40-42, In-Home Audit ns=6-7, Online Assessment ns=552-735)

However, between PY9 and PY8 satisfaction significantly differed for two elements—rebates for qualifying equipment and services and online information about how to save energy.

Specifically, PY9 respondents were significantly less satisfied with the rebates for qualifying equipment and services (61% *very satisfied*, n=1,158) compared to PY8 respondents (75% *very satisfied*, n=170; *p*≤.10). This decrease was because online assessment respondents were asked satisfaction questions in PY9 but not PY8. If online assessment respondents were removed from the analysis, the percentage who were *very satisfied* with the rebates in PY9 (79%) does not significantly differ from PY8 (75%). In fact, removing online assessment respondents also affects the *clarity of the rebate application requirement*—the percentage of respondents who were *very satisfied* would be 70% (from 61%, as shown in Figure 11-2), which is significantly greater than in PY8 (61%; *p*≤.10).

On the other hand, PY9 respondents were significantly more satisfied with the online information about how to save energy (57% *very satisfied*, n=1,229) compared to PY8 respondents (45% *very satisfied*, n=157; *p*≤.10).

Satisfaction with the specific program delivery elements also differed significantly by program component.[80] Respondents in the online home energy assessment component were significantly less satisfied with the clarity of the application requirement (54% *very satisfied*, n=641), rebates for qualifying equipment and services (45% *very satisfied*, n=552), and information about how to save energy (54% *very satisfied*, n=735) than were respondents in the weatherization (clarity: 74%, rebates: 90%, and information: 68% *very satisfied*, respectively) and energy-efficient equipment (clarity: 71%, rebates: 78%, and information: 63% *very satisfied*, respectively) components (*p*s≤.10). Respondents in the energy-efficient equipment component were also significantly less satisfied with the rebates for qualifying equipment and services (78% *very satisfied*, n=471) compared to respondents in the weatherization component (90% *very satisfied*, n=42; *p*≤.10).

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. The passives are excluded from the calculation. As shown in Table 11-11, the Energy Efficient Home Program achieved an NPS of +53 in PY9, indicating there are more promoters than detractors among the respondents. An excellent NPS is 50 and above.

[80] The in-home audit sample size was too small (ns=6-7) to include in this component comparison analysis.

Table 11-11. Net Promoter Score Likelihood to Recommend the Program

Rating Classification	PY8 Percentage of Respondents (n=171)	PY9 Percentage of Respondents (n=1,197)
Promoters (9-10)	77%	68%
Passives (7-8)	17%	18%
Detractors (0-6)	6%	15%
NPS	**+71**	**+53**

Of the 176 detractors (n=1,197), 81% were online assessment respondents and 18% were equipment respondents, and half of the detractors suggested improvements. The most common were to increase the number of rebate options available, advertise the rebates more, simplify and provide more clarity on the application process, and increase the rebate amounts. Table 11-12 shows the improvement and the number of respondents who suggested the improvement by program component.

As noted in the PY8 evaluation of the Energy Efficient Home Program, more advertising and higher rebate levels are frequently suggested improvements regardless of the resources allocated by the utility or program administrator.[81] Nevertheless, ways to convert customers to promoters could be to make the application process easier and expand the types of equipment eligible for rebates, the two complaints made most frequently by detractors (Table 11-12). Helping customers better understand the purpose of each product and how to install the products may also help convert passives and detractors to promoters, particularly in the online assessment component where satisfaction was lowest.

Table 11-12. Suggested Improvements

Suggested Improvement	Frequency (Number of Respondents who Provided Suggestion)			
	In-Home Audit	Online Assessment	Weatherization	Equipment
Increase the rebate-eligible equipment	--	13 of 118	2 of 10	32 of 146
Advertise program more	--	23 of 118	2 of 10	17 of 146
More clarity on/simplify application process	--	--	4 of 10	38 of 146
Increase rebate amount	1 of 3	--	--	31 of 146
More items in kit/help understand items in kit	1 of 3	27 of 118	--	--
More help understanding potential savings/bill	--	24 of 118	--	8 of 146
Increase speed of rebate process/make automated or online	--	4 of 118	2 of 10	20 of 146
Increase income limits/more options for renters	--	11 of 118	--	--
Lower electricity rates/switch to TOU	--	8 of 118	--	--
Send kit as promised	--	5 of 118	--	--
Better customer service/follow up	--	4 of 118	--	--

81 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

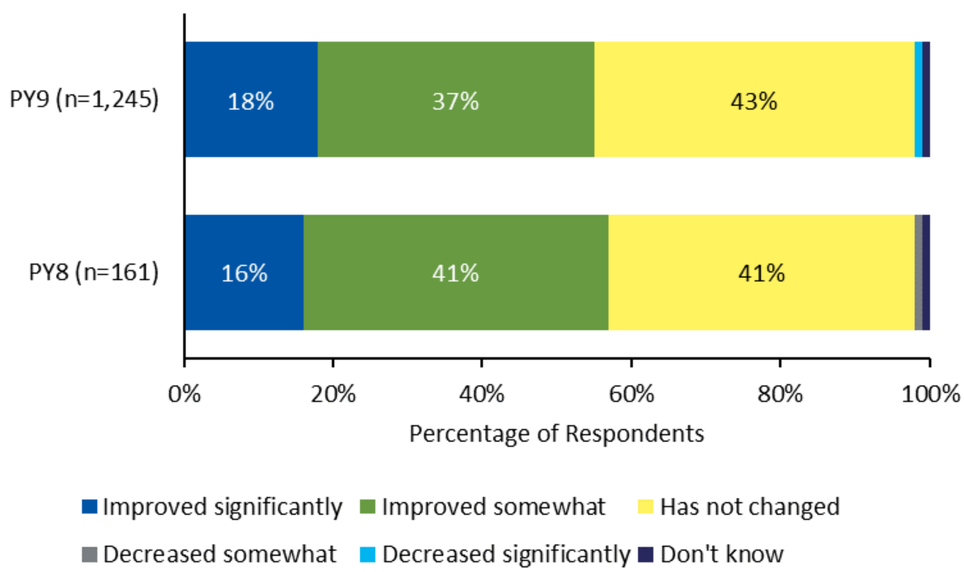
Opinion of PPL Electric Utilities

Of all survey respondents (n=1,245), 55% said their opinion of PPL Electric Utilities had improved after participating in the Energy Efficient Home Program (Figure 11-3). Opinions of PPL Electric Utilities did not differ between PY9 and PY8. However, opinions did significantly differ by program components—opinions of PPL Electric Utilities were significantly more improved for weatherization participants (44% *improved significantly*, n=39) compared to equipment (17% *improved significantly*, n=469) and online assessment (18% *improved significantly*, n=730) participants (*p*s≤.10).[82]

Of the respondents who said their opinion of PPL Electric Utilities had decreased (n=20), 13 were online energy assessment participants and seven were energy-efficient equipment participants. Thirteen of these 20 respondents provided an explanation for why their opinion fell.

- 5 online assessment participants said their electric bill was very high or the products included in the kit did not meaningfully reduce energy consumption
- 4 efficient-equipment participants complained about the clarity of the application
- 2 efficient-equipment participants had to call PPL Electric Utilities several times to receive the rebate
- 1 online assessment participant said PPL Electric Utilities did not listen to its customers
- 1 online assessment participant said the household’s energy usage was still hard to understand

Figure 11-3. Opinion Shifts of PPL Electric Utilities Since Participating in Energy Efficient Home Program



Source: Survey question, “After participating in the PPL Electric Utilities (weatherization rebate/online home energy assessment/in-home audit/efficient equipment rebate) program, has your opinion of PPL Electric Utilities’ …?”

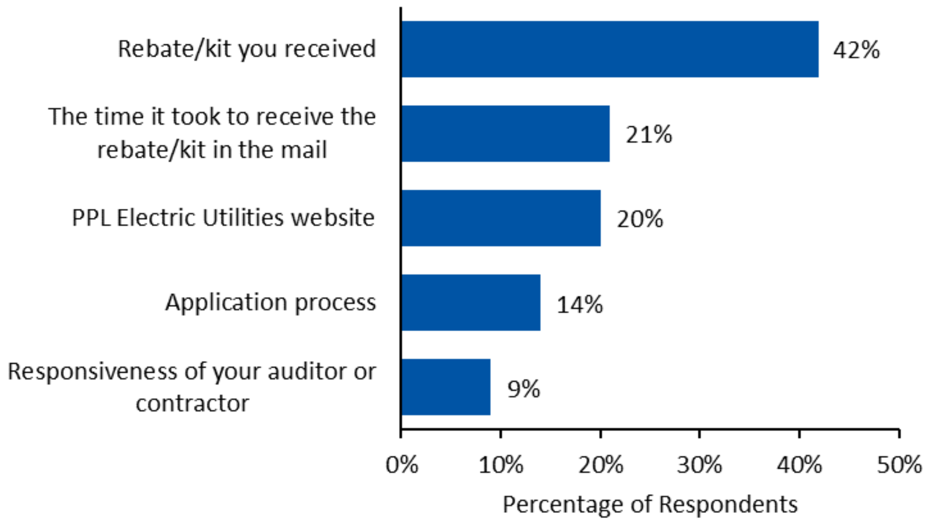
[82] The in-home audit sample size was too small (n=7) to include in this component comparison analysis.

Areas Working Well

When asked which areas of the program were working well, respondents (n=1,248) most frequently selected the rebate, energy-savings kit, or online energy assessment findings they received. Figure 11-4 depicts the areas working well in the PY9 Energy Efficient Home Program across the equipment, weatherization, and in-home audit components. Figure 11-5 depicts the areas working well in the PY9 online assessment component.

Participants in the equipment and weatherization components were significantly more likely to say the time it took to receive the rebate or the energy-savings kit (21%) were working well compared to online assessment participants (5%).[83] Interestingly, online assessment participants cited the energy assessment they received (53%) more often than they did the energy-savings kit (36%).

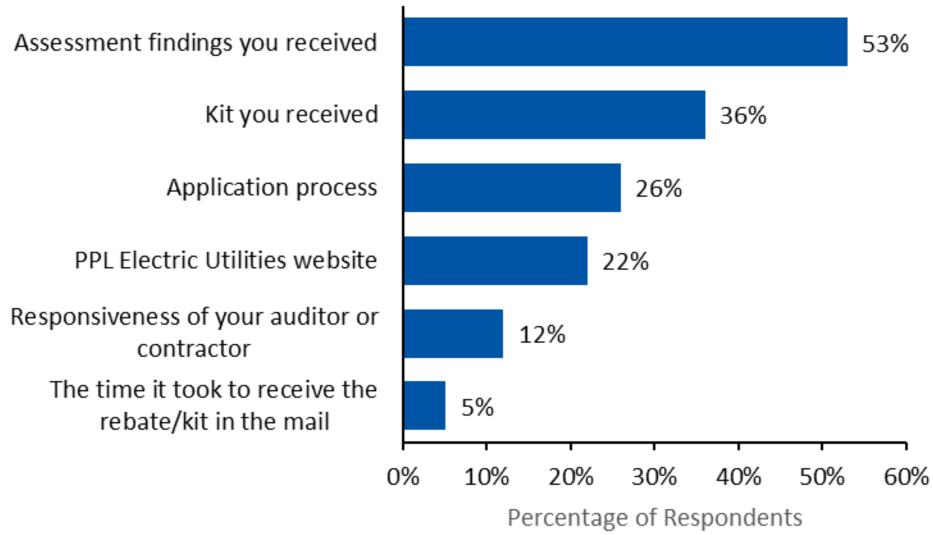
Figure 11-4. Areas Working Well: Equipment, Weatherization, and In-Home Audit Components



Source: Question, "Thinking about what worked well with the PPL Electric Utilities (weatherization rebate/in-home audit/efficient equipment rebate) program , what one item worked best? What worked next best?" (Equipment n=474, Weatherization n=42, In-Home Audit n= 7) Multiple responses allowed.

83 The in-home audit sample size was too small (n=7) to include in this component comparison analysis.

Figure 11-5. Areas Working Well: Online Assessment Component



Source: Question, "Thinking about what worked well with the PPL Electric Utilities online home energy assessment program, what one item worked best? What worked next best?" (n=735) Multiple responses allowed.

11.7 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 11-13. Cadmus calculated the TRC benefits using gross verified impacts. The net present value program year to date (NPV PYTD) benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). Net present value costs and benefits for P3TD financials are expressed in PY8 dollars.

Table 11-13. Summary of Energy Efficient Home Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$2,520		$4,075	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$9,849		$16,095	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	**$12,369**		**$20,170**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$45	$0	$116	$0
7	Marketing [4]	-	$212	-	$388
8	Program Delivery [5]	-	$3,365	-	$6,065
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$3,622**		**$6,569**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	$130		$554	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	**$16,121**		**$27,293**	
14	Total NPV Lifetime Electric Energy Benefits	$8,870		$13,269	
15	Total NPV Lifetime Electric Capacity Benefits	$2,185		$3,122	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$365		$396	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$2,519		$2,340	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	**$13,939**		**$19,127**	
19	**TRC Benefit-Cost Ratio [9]**	**0.86**		**0.70**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) Rows 1-11 are presented in nominal dollars.
(7)Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 11-14 presents program financials and cost-effectiveness on a net savings basis.

Table 11-14. Summary of Energy Efficient Home Program Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$2,520		$4,075	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	$5,928		$9,262	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	**$8,448**		**$13,337**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$45	-	$116	-
7	Marketing [4]	-	$212	-	$388
8	Program Delivery [5]	-	$3,365	-	$6,065
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$3,622**		**$6,569**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	$83		$512	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	**$12,153**		**$20,417**	
14	Total NPV Lifetime Electric Energy Benefits	$6,186		$9,062	
15	Total NPV Lifetime Electric Capacity Benefits	$1,456		$2,057	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$233		$272	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$1,606		$1,492	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	**$9,482**		**$12,883**	
19	**TRC Benefit-Cost Ratio [9]**	**0.78**		**0.63**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as “Program Delivery” costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[84] A summary of the methodologies Cadmus used to calculate the non-energy benefits of saved water, natural gas therms, and lighting interactive effects can be found in *Appendix P Non-Energy Benefits*.

Non-Energy Benefits of Water Saving Equipment

The Energy Efficient Home Program offers energy-efficient showerheads and faucet aerators distributed through the audit and kit stratum. Table 11-15 summarizes the data used to determine non-energy benefits for water-saving products for this program.

Table 11-15. Energy Efficient Home Program Non-Energy Benefits for Water Saving Products

Products	TRM #	Gallons of Water Saved per Unit (1)	Distributed Units	ISR(2)	Gallons of Water Saved(1)
Showerheads – Single-Family	2.3.9	3,153.60	11,329	42%	15,171,796.80
Showerheads – Multifamily	2.3.9	2,950.53	2,332	42%	2,921,911.20
Faucet Aerators (Bathroom) – Single-Family	2.3.8	504.58	11,329	53%	3,031,393.22
Faucet Aerators (Bathroom) – Multifamily	2.3.8	704.92	2,332	53%	871,753.98
Faucet Aerators (Kitchen) – Single-Family	2.3.8	2,069.55	11,329	61%	14,328,069.52
Faucet Aerators (Kitchen) – Multifamily	2.3.8	1,638.39	2,332	61%	2,334,893.14

(1) Per-unit water savings calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Sections 5.4.4. and 5.4.5 and PA TRM inputs from sections 2.3.8 and 2.3.9.
(2) ISRs can be found in the *Appendix J.1.5 Installation Verification Methodology*.

Non-Energy Benefits of Natural Gas Savings

Residential thermostats were offered through the program's efficient equipment stratum but only to homes with electric space heating, according to program eligibility guidelines. Therefore, there are no fossil fuel savings associated with the rebated thermostats.

Envelope products in homes with natural gas, propane or fuel oil heating systems will reduce fossil fuel consumption. This affects all products in Section 2.6 of the PA TRM. The Energy Efficient Home Program included the following products or program components with natural gas savings:

- Residential new construction
- Air sealing and insulation
- One kit from the in-home audit component which included water-saving products, which the ICSP mistakenly sent to a home with a natural gas water heater

For new construction, the REM/Rate model inputs indicate the space heating and water heating fuel types as well as natural gas savings. Air sealing, insulation, and thermostat natural gas savings are

84 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

calculated using the per-home gas savings determined for the sampled 40 homes and for the homes with fossil fuel heating reported by the ICSP (and recorded in PPL Electric Utilities' tracking database).

For several products, Cadmus consulted the Illinois TRM to identify an appropriate algorithm to calculate therm savings (this TRM provided a comprehensive and credible source for the products in the below table), in a manner consistent with methodological guidance provided by the SWE.[85] Cadmus used the Illinois TRM to confirm assumptions or identify calculation methods where the PA TRM was lacking. In some cases, the guidance provided by the SWE was sufficient, yet for transparency and replicability of results, Cadmus supplied the Illinois TRM reference where the exact algorithm could be found. In all cases, however, Cadmus used PA TRM inputs in the therm calculations.

Table 11-16. Energy Efficient Home Non-Energy Benefits for Natural Gas Savings

Products	TRM #	Natural Gas Saved (Therms)	Number of Projects	Source and Assumptions
Residential New Construction	2.6.3, 2.6.5	173,121(1)	607	REM/Rate model estimates and the PPL Electric Utilities reference home. Natural gas savings estimates from REM/Rate model include electric measure interaction.
Air Sealing (Retrofit)	2.6.6	3,633	30	Calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Section 5.6.1, and inputs from PA TRM. Multiplied by *ex post* kWh/yr realization rate to account for adjustments. Used 0.8 AFUE per PA Guidance Memo, and 0.85 distribution efficiency per IL TRM, as equipment efficiency is not sufficient to calculate efficiency of heating system.
Insulation (Retrofit)	2.6.1	6,504	142	Calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Section 5.6.4, and inputs from PA TRM. Multiplied by square feet of insulation and by *ex post* kWh/yr realization rate to account for adjustments. Used 0.8 AFUE per PA Guidance Memo, and 0.85 distribution efficiency per IL TRM, as equipment efficiency is not sufficient to calculate efficiency of heating system.
Audit and Kit – Pipe Insulation	2.3.7	3.53	1	Calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Section 5.4.1, and inputs from PA TRM Section 2.3.7. Per unit savings of 1.10 therms/year. Multiplied by square feet of insulation installed (6 ft) and the installation rate (53%) from PY8 Online Assessment participant surveys.
Audit and Kit – Showerhead (Single-Family)	2.3.9	6.56	1	Calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Section 5.4.5, and inputs from PA TRM Section 2.3.9. Per unit savings of 15.44 therms/year multiplied by the ISR in Table 11-16.
Audit and Kit – Faucet Aerator (Bathroom) – Single-Family	2.3.8	0.88	1	Calculated using algorithm from Illinois TRM Version 6.0, Volume 3, Section 5.4.5, and inputs from PA TRM Section 2.3.8. Per unit savings of 1.66 therms/year multiplied by the ISR in Table 11-16.

85 Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3: Residential Measures.* February 8, 2017. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_3_Res_020817_Final.pdf.

Products	TRM #	Natural Gas Saved (Therms)	Number of Projects	Source and Assumptions
Audit and Kit – Faucet Aerator (Kitchen) – Single-Family	2.3.8	5.11	1	Calculated using algorithm from Illinois TRM V. 6.0, Section 5.4.5, and inputs from PA TRM Section 2.3.8. Per unit savings of 8.37 therms/year multiplied by the ISR in Table 11-16.
(1) Natural gas savings for new homes include lighting interactive effects.				

Lighting Interactive Effects

Cadmus included heating penalties as a negative benefit in the TRC test for efficient lighting, according to the Guidance Memo.

Table 11-17. Energy Efficient Home Lighting Gas Heating Penalties Calculations

Measure	Gas Heat Fuel Share	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therm per kWh/yr)
LED	29%	90.48%	65.5%	20%	0.8	0.00586

Per the Guidance Memo, Cadmus assumed there is a natural gas therms penalty. The results are shown in Table 11-18. Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Table 11-18. Energy Efficient Home Lighting Gas Heating Penalty

Stratum/Measure	Number of LEDs Distributed	*Ex Post* Total kWh/yr	ISR	Heating Penalty (Therm per kWh/yr)	Total Heating Penalty (Therms)
In-Home Audit and Kit/9W LED	19	1,936	89%	-0.00586	-10.09
Online Assessment/9W LED	6,180	613,564	89%	-0.00586	--3,195.99

11.8 Recommendations

Overall, the Energy Efficient Home Program was successfully delivered and administered in PY9. Participants were satisfied with the program component in which they participated. The program achieved 19,623 MWh/yr in savings (197% of the PY9 projected savings).

Recommendations are provided in Table 11-19, along with a summary of how PPL Electric Utilities plans to address the recommendations.

New Home Component

Finding: Cadmus found a 78% realization rate for energy savings and a 76% realization rate for demand reduction. These realization rates are primarily due to differences in the ICSP's calculations using the REM/Rate software to report savings and the PA TRM calculations used to verify saving for lighting and appliances.

- The PA TRM requires that REM/Rate software be used to verify heating and cooling savings; therefore, realized savings for that component are the same as reported savings (*Appendix J.1.2*).
- Reported lighting savings used REM/Rate calculations, which differ from the calculations in the PA TRM (see section *11.3 Gross Impact Evaluation*). The PA TRM specifies that energy savings should be calculated per lamp, based on the wattage of the installed lamp, the wattage of the baseline lamp (determined by lumen output), the hours of use, interactive effects, and the ISR.
- Reported appliance energy savings were calculated as the difference in energy consumption between parameters in the REM/Rate reference home and those documented in the home's as-built REM/Rate model. However, according to REM/Rate software and HERS rater training (see *Appendix J.1.2*), appliances are always recorded in the model even if no appliance was installed in the home at the time of the HERS rating. For example, Cadmus found just one home with an ENERGY STAR clothes washer installed, but the REM/Rate model had recorded a clothes washer installed in every home (see *Appendix J.1.2*). This model setting overestimated the reported appliance energy savings.

Conclusion: REM/Rate software and PA TRM calculations do not follow the same methodology, leading to differences between reported and *ex post* savings. Significant changes to *ex ante* savings calculation methods are needed to align with the PA TRM.

Recommendation #1: Consider strategies to improve the realization rate for the new homes component. Three possible strategies include the following:

- **Strategy #1**: The ICSP could collect additional data for lighting and appliances, as established by the TRM, for each home. For lighting, this would include an inventory of wattage, lamp style, technology, and location. For appliances, this would involve gathering make and model of all installed ENERGY STAR appliances with their size, capacity, rated energy usage, efficiency, and configuration (for refrigerators). The ICSP and Cadmus would use these data with PA TRM equations and assumptions to calculate energy and demand savings. Theoretically, aligning the *ex ante* and *ex post* calculation methodology will result in an improved realization rate.
- **Strategy #2**: The software could be modified to calculate lighting and appliance savings according to the TRM. The current data inputs that REM/Rate uses to determine energy savings are defined by the RESNET. The ICSP and its subcontractor would need to work with RESNET to update key areas of misalignment:
  - Lighting energy usage calculations in REM/Rate use a baseline that has not been updated to current EISA requirements. RESNET should update this.

- REM/Rate is not indicating the presence of appliances in the homes during the time of the rating, yet the default values assume appliances are installed, causing erroneous savings.

- **Strategy #3**: If RESNET is unable to update its parameters for the software, and the ICSP continues to use REM/Rate to calculate the *ex ante* savings, then the ICSP could consider applying an adjustment to reported savings to account for the modeled savings inaccuracies. This would improve alignment with *ex post* savings calculations.

Equipment Component

Finding: The dehumidifier component had a kWh/yr realization rate of 79%. Cadmus found 891 errors in dehumidifier records. This was because the ICSP used the 2016 ENERGY STAR-qualified unit liters of water per kWh/yr consumed values (L/kWh_{ee}) for the capacity of the efficient unit rather than the values listed in the PA TRM, which are the 2012 ENERGY STAR standard values. There were also several instances where the ICSP recorded the incorrect product capacity. (See *Appendix J.1.3* and *0*.)

Conclusion: The ICSP used the 2016 ENERGY STAR standards to calculate the efficient dehumidifier capacity (which is incorrect according to the PA TRM and does not constitute EDC data gathering) and made several errors when recording efficient product capacity.

Recommendation #2: Require that the ICSP use the current PA TRM when gathering inputs and calculating *ex ante* savings in accordance with the TRM, even if more recent ENERGY STAR standard values are available.

Finding: For ductless heat pumps, Cadmus found that the AHRI number was recorded instead of the model number in the PPL Electric Utilities tracking database. Also, only outdoor unit AHRI numbers were recorded, even for indoor units. Cadmus had difficulty looking up specifications because model numbers were not recorded in the PPL Electric Utilities tracking database or were conflicting. Rebate applications and contractor invoices listed different model numbers in some instances. Absent an AHRI certificate or AHRI number for each unit, there is no reliable way to look up a unit's specifications in the AHRI database. (See section *11.3 Gross Impact Evaluation*.)

Conclusion: The ICSP recorded the wrong information, or did not record information, for ductless heat pump model numbers and AHRI numbers in the PPL Electric Utilities tracking database. Reconciling conflicting or missing information is time intensive. In response, in PY10, PPL Electric Utilities made improvements to the ductless heat pump rebate application by clarifying the requirement to include AHRI information for all components of the ductless heat pump units. It also added language to the website clarifying the requirement.

Recommendation #3: In addition to improvements made in PY10, consider requiring that the ICSP review rebate forms and supporting contractor invoices and reconcile the AHRI and model numbers when data differ. Encourage contractors to help customers fill out rebate forms, or at least indicate to customers where important information about their product is located. PPL Electric Utilities may also consider adding information, such as how to find equipment specifications, on their website, e.g., where to find the requested information on the rebated equipment.

Finding: Although satisfaction was high in the Energy Efficient Home Program, participants, particularly in the equipment component, reported challenges with the application process (see Table 11-12). More than one-fourth of equipment respondents (38 of 146) suggested simplifying the application process and making the form easier to complete because they had difficulty understanding what information was needed and some even believed the application was intentionally made difficult to discourage participation. One respondent reported filling out the application completely, only to find out later that additional information was required to process the rebate. For some products, little equipment-specific information is required—for example, refrigerators require only manufacturer and model number. However, other equipment requires more detail—for example, central air conditioners require indoor and outdoor coil model numbers. Many participants need the contractor's help with the application details.

Conclusion: The application process was challenging for many participants, particularly those in the equipment component.

Recommendation #4: Consider encouraging or requiring that contractors help participants with the application, especially with specifications in the equipment component, to alleviate participants' uncertainty with the application process. To help participants understand how to accurately complete the application, consider adding information, such as how to find equipment specifications, on the PPL Electric Utilities website.

In-Home Audit Component

Finding: The in-home audit component had a realization rate of 74% for kWh/yr. Cadmus used evaluated ISRs for kit products were lower than ISRs used in deemed savings calculations; this affected the realization rate. Cadmus also found that the in-home auditor did not perform the water heater temperature setback; however, the temperature (post-setback) was filled in for these fields in the tracking data. (See section *11.3 Gross Impact Evaluation* and *Appendix J*.)

Conclusion: Auditors are not performing all components of the audit, and adjustments to savings for kit products differ between the ICSP and Cadmus.

Recommendation #5: The ICSP could consider adjusting their calculations for reported savings for kit products to include evaluated ISRs from the prior year. Also consider investigating why auditors are not performing water heater temperature setbacks. If setbacks are not performed, the field on the application form listing water heater temperature should be left blank (indicating no setback was completed) to avoid confusion when interpreting the ICSP's data.

Weatherization Component

Finding: The insulation component had a kWh/yr realization rate of 85%. Cadmus found 72 instances where the ICSP recorded incorrect R-values in the PPL Electric Utilities tracking database. In some instances, an R-value of 5.25 was applied where there were zero previous inches of insulation. In others, an R-value of 5 was applied where there was existing insulation. (See section *11.3 Gross Impact Evaluation* and *Appendix J*.)

Conclusion: The ICSP incorrectly applied some inputs to calculate insulation savings.

Recommendation #6: The ICSP should use the PA TRM defaults and assign an R-value of 5 where there are no existing inches of insulation. Where previous insulation exists, the ICSP could use a linear extrapolation using the PA TRM defaults to report the existing R-value.

11.8.1 Status of Recommendations

Table 11-19 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 11-19. Status of Recommendations for the Energy Efficient Home Program

Energy Efficient Home Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Consider strategies to improve the realization rate for the new homes component. Three possible strategies include the following: ***Strategy #1***: The ICSP could collect additional data for lighting and appliances, as established by the TRM, for each home. For lighting, this would include an inventory of wattage, lamp style, technology, and location. For appliances, this would involve gathering make and model of all installed ENERGY STAR appliances with their size, capacity, rated energy usage, efficiency, and configuration (for refrigerators). The ICSP and Cadmus would use these data with PA TRM equations and assumptions to calculate energy and demand savings. Theoretically, this alignment on *ex ante* and *ex post* calculation methodology will result in an improved realization rate. ***Strategy #2***: The software could be modified to calculate lighting and appliance savings according to the TRM. The current data inputs that REM/Rate uses to determine energy savings are defined by the Residential Energy Services Network (RESNET). The ICSP and its subcontractor would need to work with RESNET to update key areas of misalignment: (1) Lighting energy usage calculations in REM/Rate use a baseline that has not been updated to current EISA requirements. RESNET should update this. (2) REM/Rate is not indicating the presence of appliances in the homes during the time of the rating, yet the default values assume appliances are installed, causing erroneous savings. ***Strategy #3***: If RESNET is unable to update its parameters for the software, and the ICSP continues to use REM/Rate to calculate the *ex ante* savings, then the ICSP could consider applying an adjustment to reported savings to account for the modeled savings inaccuracies. This would improve alignment with *ex post* savings calculations.	Being considered.

Energy Efficient Home Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
2	Require that the ICSP use the current PA TRM when gathering inputs and calculating *ex ante* savings in accordance with the TRM, even if more recent ENERGY STAR standard values are available.	Implemented. Already doing this.
3	In addition to improvements made in PY10, consider requiring that the ICSP review rebate forms and supporting contractor invoices and reconcile the AHRI and model numbers when data differ. Encourage contractors to help customers fill out rebate forms, or at least indicate to customers where important information about their product is located. PPL Electric Utilities may also consider adding information, such as how to find equipment specifications, on their website, e.g., where to find the requested information on the rebated equipment.	Being considered.
4	Consider encouraging or requiring that contractors help participants with the application, especially with specifications in the equipment component, to alleviate participants' uncertainty with the application process. To help participants understand how to accurately complete the application, consider adding information, such as how to find equipment specifications, on the PPL Electric Utilities website.	Being considered.
5	The ICSP could consider adjusting their calculations for reported savings for kit products to include evaluated ISRs from the prior year. Also consider investigating why auditors are not performing water heater temperature setbacks. If setbacks are not performed, the field on the application form listing water heater temperature should be left blank (indicating no setback was completed) to avoid confusion when interpreting the ICSP's data.	Being considered.
6	The ICSP should use the PA TRM defaults and assign an R-value of 5 where there are no existing inches of insulation. Where previous insulation exists, the ICSP could use a linear extrapolation using the PA TRM defaults to report the existing R-value.	Implemented. Already doing this.

ppl

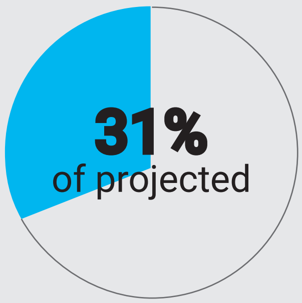
CADMUS

WEATHERIZATION RELIEF ASSISTANCE PROGRAM (WRAP)

The program offers products and services to income-qualified customers to help to reduce their electric consumption.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **17,075 MWh/yr**



126% of projected

PY9 saved **14,412 MWh/yr**

PROGRAM SATISFACTION

91% Satisfied with overall program

94% satisfied with the **quality of work** provided by WRAP auditor

93% satisfied with **quality of energy efficiency products**

91% satisfied with the **ease of program enrollment**

87% satisfied with the **energy education received**

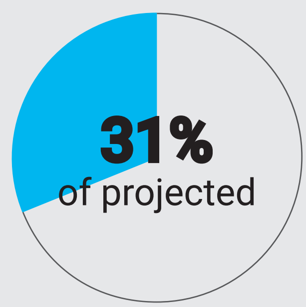
PY9 PARTICIPATION

A total of **14,028** participants:

- **6,680** Baseload jobs
- **4,428** Low-cost jobs
- **139** Full-cost jobs
- **963** Manufactured homes (all job types)
- **1,818** Multifamily units (all job types)

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$13,383**



127% of projected

PY9 expenditures **$9,371**

12 Winter Relief Assistance Program

The Act 129 Winter Relief Assistance Program (WRAP), also known as Low-Income WRAP, operates in parallel with PPL Electric Utilities' Universal Services Programs' Low-Income Usage Reduction Program (USP LIURP) WRAP. Both programs are designed to reduce electric consumption for low-income customers.

PPL Electric Utilities offers services to income-qualified customers residing in single-family homes, master-metered multifamily units, individually metered multifamily units, and manufactured homes.[86] Act 129 WRAP is delivered by CMC Energy, the ICSP, which is responsible for outreach, customer recruitment, audits, education, and the direct installation of equipment in customers' homes. The ICSP also operates a customer call center and supports marketing and tracking activities. The ICSP uses qualified community-based organizations (CBOs) and contractors for tasks, including the installation of energy-savings products and services and replacement of outdated and inefficient equipment with program-qualifying energy-efficient equipment. Franklin Energy, a subcontractor to the ICSP, is responsible for targeted outreach and recruitment for the program component that targets manufactured homes located in manufactured or mobile home parks.

All qualifying customers receive a free energy audit that evaluates their home for eligible energy-saving products. The home energy auditor refers to a preapproved list of products and services along with criteria to determine if appliances and other large equipment can be replaced cost-effectively, within the program's budget (program acquisition cost and total funding). For all qualifying customers, PPL Electric Utilities offers direct installation of a range of energy efficiency products and services,[87] including HVAC, lighting, weatherization, water saving/heating, appliances, appliance recycling, and home health and safety. WRAP also offers energy education delivered by auditors who make recommendations to encourage customers to conserve energy.

Through WRAP, PPL Electric Utilities provides four types of service (also known as job types) at no cost to the income-qualified customer. These services include baseload (offered to customers without electric heat and without an electric water heater), low-cost (offered to customers without electric heat but with electrically heated water), full-cost (offered to customers with electric heat), and an initiative offering services to targeted manufactured home park customers.

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[86] Individually metered low-income multifamily residences are eligible for the same improvements as individually metered single-family low-income residences under Low-Income WRAP. Furthermore, individually metered manufactured homes are eligible for the same improvements as any other type of individually metered home receiving services from Low-Income WRAP.

[87] PPL Electric Utilities eliminated refrigerators, HPWHs, and window air conditioners from the program in February 2018.

In PY9, the majority of jobs implemented through Act 129 WRAP were baseload and low-cost jobs,[88] specifically to individually metered customers in single-family and multifamily buildings and master-metered buildings for homes occupied by low-income residents. New construction projects are also eligible to receive WRAP items, but these items are at a cost to the property owner or builder; only LEDs are offered at no cost.

Baseload jobs may include these products:

- Energy education
- Replacement of lighting with LEDs
- Refrigerator replacement
- Air conditioner replacement
- Tier 2 advanced power strips

Low-cost jobs include all baseload products as well as products for electrically heated water such as these:

- Water heater replacement with a heat pump water heater
- Water heater pipe insulation
- Faucet aerators
- Efficient showerheads

Full-cost jobs include all baseload and low-cost products (if water heat is present) and may include shell and HVAC products such as these:

- Insulation (e.g., attic, floor, wall)
- Infiltration (e.g., caulking, weather-stripping, blower door testing)
- HVAC repair or replacement
- Duct insulation

The PPL Electric Utilities' program component that targets manufactured homes located in manufactured or mobile home parks offers all baseload and low-cost job products, with the addition of air sealing that is installed without blower door testing.

The objectives of Low-Income WRAP are these:[89]

- Provide low-income customers with an array of no-cost energy-saving equipment and education to help reduce their energy costs
- Increase the health and safety of low-income customers' homes by installing no-cost items such as smoke and carbon monoxide detectors, which may be coordinated with or implemented by the USP LIURP WRAP (operating outside of Act 129 WRAP)
- Achieve high customer and trade ally satisfaction through high-quality service and an impactful program offering

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88 Most full-cost jobs will be implemented through PPL Electric Utilities' Universal Services Low-Income Usage Program (USP LIURP) and not through the Act 129 WRAP program.

89 Program objectives are listed in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

- Promote other PPL Electric Utilities energy efficiency programs, specifically other low-income assistance programs such as On-Track and Low-Income Home Energy Assistance Program (LIHEAP)
- Achieve a total approximate reduction in energy use of 55,546 MWh/year gross verified savings

12.1 Progress Toward Phase III Projected Savings

WRAP's verified savings are 126% of the projected MWh/yr savings for PY9. The program has achieved 31% of the projected Phase III total planned savings and is making progress toward the Phase III project savings.

Table 12-1 shows the program's verified gross savings and progress toward its Phase III projected energy savings, as filed in the EE&C plan.[90]

Table 12-1. Low-Income WRAP Projected Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified(1)	Projected(2)	Verified	Percentage of Projected	Projected(1)	Verified	Percentage of Projected
MWh/yr	2,663	11,404	14,412	126%	55,546	17,075	31%

(1) 16 MWh/yr of reported savings for full cost jobs were unverified in PY8. Cadmus reported 2,652 MWh/yr of verified savings in PY8 excluding full-cost jobs. In PY9, Cadmus calculated the verified savings for PY8 full-cost jobs as 11 MWh/yr and therefore the total verified savings for PY8 increased to 2663 MWh/yr.

(2) Projected savings are based on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

12.2 Participation and Reported Savings by Customer Segment

12.2.1 Definition of a Participant

An Act 129 WRAP participant is defined as a PPL Electric Utilities customer who lives in an income-eligible household that receives a WRAP audit. At a minimum, the audit includes energy education and may lead to the installation of other WRAP products and services. Each treated household (single-family or multifamily) is identified in the PPL Electric Utilities' tracking database with a unique billing account number.

Each master-metered multifamily building has a unique billing account number. As shown in Table 12-2, Low-Income WRAP participation counts each master-metered multifamily building as a single participant based on the definition. Cadmus performed home audit records review and engineering analysis for individual tenant units in master-metered multifamily buildings. Therefore, the population size for the WRAP gross impact sample design counts individual tenant units in master-metered multifamily buildings individually as shown in Table 12-3.

90 PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

12.2.2 Program Participation and Reported Impacts

Table 12-2 presents the participation counts, reported energy and demand savings, and incentive payments for WRAP in PY9 by customer segment. (See *Appendix K.1.4 Records Review Findings* for additional discussion about participant counts.)

Table 12-2. Low-Income WRAP Participation and Reported Impacts

Parameter	Government/ Nonprofit/ Education (GNE) [(1)]	Low Income	Small C&I [(2)]	Total [(3)]
PYTD # Participants	156	12,078	8	**12,242** [(4)]
PYRTD MWh/yr	1,126	16,105	299	**17,530**
PYRTD MW/yr	0.10	1.63	0.03	**1.76**
PYVTD MWh/yr	811	13,389	212	**14,412**
PYVTD MW/yr	0.08	1.52	0.02	**1.63**
PY9 Incentives ($1000)	$0	$0	$0	**$0**

[(1)] GNE category consists of 156 participants; including 24 master-metered multifamily buildings and 132 apartment units in individually-metered multifamily buildings. Installation of WRAP products and services were provided to 1,251 apartment units in 24 master-metered multifamily buildings classified under GNE.
[(2)] Small C&I category consists of 8 master-metered multifamily buildings. Installation of WRAP products and services were provided to 567 apartment units in 8 master-metered multifamily buildings classified under Small C&I.
[(3)] Total may not match sum of columns due to rounding.
[(4)] Total number for participants counts each master-metered multifamily building as a single participant based on the participant definition.

12.3 Gross Impact Evaluation

12.3.1 Data Collection

In PY9, Cadmus collaborated with PPL Electric Utilities and the ICSP to collect the required data to verify energy savings and demand reduction for WRAP. Cadmus obtained the ICSP's Energy Reduction Management System (ERMS) database extract for verification and assessment of participant records. The ICSP also provided audit records for a random sample of sites.

Cadmus conducted a records review of a random sample of homes and a phone survey with a sample of program participants to verify that products were installed as reported. In the phone surveys, Cadmus collected supporting data to analyze the impact of energy education for WRAP participants as well.

12.3.2 Sample Design

The sample design consisted of five strata: one for each job type (baseload, low-cost, and full-cost), one for master-metered multifamily units, and one for manufactured home participants. This strategy allowed for an examination of savings by stratum. Within each stratum, Cadmus applied a simple random sampling method to select a sample of homes for records review verification. The sampling strategy is summarized in Table 12-3.

Table 12-3. PY9 WRAP Gross Impact Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Baseload	6,680	0.8	88	Records review and engineering analysis
Low-Cost	4,428	0.6	51	
Full-Cost	139	0.5	17	
Manufactured Home Initiative (all job types)	963	0.5	36	
Master-Metered Multifamily (all job types)	1818 (1)	0.5	43	
Program Total	**14,028**		**235**	

(1) Total number for participants counts each master-metered multifamily building as a single participant based on the participant definition. However, 32 master-metered multifamily buildings that participated in WRAP in PY9 have 1,818 tenant units and therefore 1,818 jobs were added to the total number of jobs. Cadmus performed home audit records review and engineering analysis for individual tenant units in master-metered multifamily buildings. Therefore, the population size for the WRAP gross impact sample design counts individual tenant units in master-metered multifamily buildings individually. See *Appendix K.1.3* for additional discussion about participant counts.

12.3.3 Gross Impact Evaluation Activities

Cadmus performed the activities described below to evaluate the Winter Relief Assistance Program gross impacts. See *Appendix K.1.3* for details on these activities.

- **Database review.** Cadmus reviewed the census of records in PPL Electric Utilities' tracking database and compared these to the records in the participant data provided by the ICSP. Cadmus verified discrepancies with the ICSP prior to conducting any analyses.
- **Audit records review.** Cadmus reviewed a random sample of ICSP's home-audit records for the five strata listed in Table 12-3. Audit records reviews involved verifying reported quantities and other relevant inputs for savings calculations from the records obtained by the home energy auditors at each job site. Cadmus verified all data fields in PPL Electric Utilities' tracking database, including, but not limited to, home address, water heater fuel type, heating fuel type, reported quantities, and baseline conditions for each item in the audit records.
- **Engineering analysis.** Cadmus conducted an engineering analysis for the five strata listed in Table 12-3 and used the findings from the audit records review as inputs to the engineering algorithms from the PA TRM.[91]

[91] Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2016. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

To evaluate full-cost job savings, Cadmus conducted an audit records review and an engineering analysis in PY9 in lieu of a billing analysis in PY10 for the following reasons:

- Cadmus planned to conduct an IPMVP Option C regression analysis for full-cost jobs using the customer's historical consumption data where the whole-home is treated (consistent with the Evaluation Framework).[92] Cadmus found that the full-cost jobs offered in PY8 and PY9 typically had a single full-cost job product or service, so whole-home treatment was limited and therefore the interactive effects were minimal, and all improvements could be verified using a TRM protocol. Attic insulation was provided to most full-cost jobs. Of 139 full-cost jobs, 109 received attic insulation. However, the remaining full-cost job improvements were provided to a limited number of full-cost jobs in PY9: 1 received wall insulation, 3 received programmable thermostats, 7 received smart thermostats, and 17 received HVAC maintenance/repair. See the *Appendix K Ex Post Verified Savings Methodology* section for details of the analysis.
- For all full-cost job improvements, Cadmus had sufficient data provided by the ICSP to calculate gross program savings using algorithms listed in the 2016 PA TRM.[93]

12.3.4 Gross Impact Evaluation Results

In PY9, WRAP reported energy savings of 17,530 MWh/yr and a realization rate of 82%, weighted by stratum. The realization rates substantially improved in the second half of PY9, increasing to 87% from 73% in the first half of PY9. The ICSP's program delivery improvements, following the recommendations in the PY8 annual report, contributed to this improvement.

Table 12-4 shows the reported energy savings by program stratum.

Table 12-4. Low-Income WRAP Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio [2]	Relative Precision at 85% C.L.
Baseload	7,740	80%	N/A	1.90%
Low-Cost	6,892	84%	N/A	1.86%
Full-Cost	314	141%	N/A	7.61%
Manufactured Home Initiative (all job types)	1,267	80%	N/A	3.35%
Master-Metered Multifamily (all job types)	1,317	71%	N/A	1.99%
Program Total [1]	**17,530**	**82%**	**N/A**	**1.17%**

(1) Total may not match sum of rows due to rounding. Program totals are weighted by stratum and stratum population in first and second half of PY9. See *Appendix K.1.3* for additional discussion about participant counts.
(2) The strata listed above were stratified further according to whether projects were implemented in the first or second half of the program year. The Cv values in each individual stratum were between 0.05 to 0.30.

92 Evaluation Framework for Pennsylvania Act 129 EE&C Programs, October 21, 2016.

93 Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2016. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

In PY8, Cadmus did not evaluate the full-cost stratum. The full-cost stratum contained only seven jobs and reported unverified savings of 16 MWh/yr (representing 0.005% of PY8 reported savings).

In PY9, Cadmus completed the verification of the full-cost jobs. These achieved 11 MWh/yr of verified energy savings with a 71% energy realization rate, as shown in Table 12-5, and 0.0013 MW/yr of demand reductions at a demand realization rate of 80%, as shown in Table 12-7.

Table 12-5. PY8 Unverified Low-Income WRAP Gross Impact Results for Energy (Verified in PY9)

Stratum	PY8 Unverified RTD MWh/yr	PY8 Verified in PY9 VTD MWh/yr	PY8 - Verified in PY9 Energy Realization Rate
Full-Cost Job	16	11.4	71%
PY8 Program Total[(1)]	**16**	**11.4**	**71%**

[(1)] WRAP reported a total of 3,491 MWh/yr in savings in PY8, including the unverified projects. The PY8 evaluation verified 2,652 MWh/yr at a realization rate of 76%.
[2] Percentages may not match ratio of columns due to rounding.

Table 12-6 shows the reported demand reduction by program stratum.

Table 12-6. Low-Income WRAP Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio [(2)]	Relative Precision at 85% C.L.
Baseload	0.80	95%	N/A	2.14%
Low-Cost	0.68	93%	N/A	1.97%
Full-Cost	0.03	93%	N/A	9.07%
Manufactured Home Initiative (all job types)	0.12	87%	N/A	3.13%
Master-Metered Multifamily (all job types)	0.12	80%	N/A	3.37%
Program Total [(1)]	**1.76**	**93%**	**N/A**	**1.30%**

[(1)] Total may not match sum of rows due to rounding. Program totals are weighted by stratum and stratum population in first and second half of PY9.
[(2)] The strata listed above were stratified further according to whether projects were implemented in the first or second half of the program year. The Cv values in each individual stratum were between 0.07 to 0.50.

Table 12-7. PY8 Unverified Low-Income WRAP Gross Impact Results for Demand (Verified in PY9)

Stratum	PY8 Unverified RTD MW/yr	PY8 Verified in PY9 VTD MW/yr	PY8 Verified in PY9 Demand Realization Rate[(2)]
Full-Cost Job	0.0016	0.0013	80%
Program Total[(1)]	**0.0016**	**0.0013**	**80%**

[(1)] WRAP reported a total of 0.34 in demand savings in PY8, including the unverified projects. The PY8 evaluation verified 0.29 MWh/yr at a realization rate of 86%.
[(2)] Percentages may not match ratio of columns due to rounding.

Cadmus identified the following factors that led to differences between reported and verified savings and the overall realization rate for WRAP:

- Differences in reported and evaluated **ISRs for six products** (LEDs, LED nightlights, efficient showerheads, power strips, and kitchen and bathroom aerators) drove the differences in savings. Compared to PY8, Cadmus found an improvement in every product's ISR in PY9.

- For **energy education,** the ICSP reported *ex ante* savings of 160 kWh/yr for every participant based on results from the PY6 report.[94] Cadmus estimated energy education savings for the first half of PY9 as 27 kWh/yr and for the second half of PY9 as 81 kWh/yr. This is the straight average of estimated energy education savings for the first half of PY9 (27 kWh/yr) and for the second half of PY9 (81 kWh/yr).
- **Tier 2 advanced power strips** commonly installed with entertainment centers had only one or two devices plugged into them.[95] Cadmus assigned "unspecified' savings to better reflect the savings achieved.[96]
- Cadmus corrected the unit energy consumption of the baseline refrigerator for **refrigerator replacements,** reducing the ICSP's assumptions from 1,271 kWh/yr to 1,111 kWh/yr. Cadmus also corrected the installed ENERGY STAR refrigerator consumption for **refrigerator replacements,** increasing the ICSP's assumptions from 272 kWh/yr to the range of 309 kWh/yr to 356 kWh/yr, depending on the model.

See *Appendix K.1.4 Records Review Findings* for additional details.

12.4 Net Impact Evaluation

WRAP is offered to income-eligible customers in the low-income community, and no free riders are anticipated among participants. That is, income-constrained customers are not likely to purchase the energy efficiency products on their own. Cadmus discussed this with the SWE and PPL Electric Utilities early in PY8 and all agree that an NTG ratio of 1.0 is appropriate.

12.5 Verified Savings Estimates

In Table 12-8, the realization rates determined by Cadmus were applied to the reported energy and demand savings estimates to calculate the verified savings estimates for WRAP in PY9. In future years, these totals will be added to the verified savings achieved in previous program years to calculate the Phase III to date (P3TD) program impacts.

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94 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

95 The audit records indicate where the smart strip is installed in either an "entertainment center" or "unspecified" and how many devices are plugged into the Tier 2 smart strip.

96 The "entertainment center" savings is about 300 kWh/yr and "unspecified savings" is about 200 kWh/yr. Section 2.5.3 of the 2016 PA TRM refers to page 30, "Advanced Power Strip Research Report," NYSERDA, August 2011.

Table 12-8. Low-Income WRAP PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) [1]	Total Demand (MW/yr) [1]
PYRTD Gross	17,530	1.76
PYVTD Gross	14,412	1.63
PYVTD Net [2] [3]	14,412	1.63
P3RTD Gross	21,021	2.10
P3VTD Gross	17,075	1.92
P3VTD Net [2] [3]	17,075	1.92
PY8 Verified in PY9 Savings	11	0.0013

(1) Total may not match sum of rows due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.
(3) Cadmus assumed there is no free ridership in this low-income program. Therefore, no net savings analyses were conducted.

12.6 Process Evaluation

12.6.1 Research Objectives

Cadmus conducted the PY9 process evaluation with a focus on program delivery and participation and addressed the following research objectives:

- Identify areas of program success
- Identify areas that may benefit from program improvements
- Assess satisfaction with trade allies: program contractors
- Assess satisfaction with market actors: multifamily building property managers and manufactured home park property managers
- Assess satisfaction with overall customer experience and installed products
- Assess the potential effect on participation in other PPL Electric Utilities programs (specifically low-income assistance programs), which is a program objective.

12.6.2 Evaluation Activities

The PY9 process evaluation for the WRAP included these activities:

- Interviews with PPL Electric Utilities and ICSP program managers
- Telephone participant surveys
- Interviews with contractors
- Logic model review
- Interviews with master-metered multifamily building property managers and manufactured home park property managers
- Process flow map review

The research activities were consistent with the evaluation plan with one exception. Instead of a single wave of phone surveys at the end of PY9, Cadmus conducted two waves of phone surveys with a sample of participants—one wave was after the completion of PY9 Q2 (including Q1 and 2 participants) and another wave after the completion of PY9 Q4 (including Q3 and Q4 participants). Cadmus made this change at PPL Electric Utilities' request to identify any possible differences in participant satisfaction, realization rates, and program success between the first and second halves of PY9.

Table 12-9 lists the process evaluation sampling strategy.

12.6.2.1 Survey Methodology

Cadmus conducted telephone surveys with program participants (n=228) in two waves to assess program satisfaction. Cadmus administered the first wave of telephone surveys (n=139) in January 2018 and the second wave of telephone surveys (n=89) in July 2018. Both surveys asked identical questions to assess participants' experience and satisfaction with the program. Questions to verify product installation were updated for the second wave of surveys.

Completed participant surveys produced a measurement of program satisfaction with ±1% precision at 90% confidence. In PY9, Cadmus achieved a 4% response rate among 3,430 phone records attempted, which is slightly lower than PY8's 5% response rate among 1,650 phone records attempted (see *Appendix K.2.2 Survey Approach* for sampling cleaning and attrition).

Surveys employed the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of the response list in the telephone survey items to reduce order effects
- Employ stratified random sampling

Cadmus used the same questionnaire structure for the telephone surveys conducted in PY8, so survey data were collected consistently. The SWE team and PPL Electric Utilities reviewed and approved the surveys in PY8 before they were fielded in PY9.

Table 12-9. Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame (1)	Percent of Sample Frame Contacted to Achieve Sample (2)
PPL Electric Utilities Program and ICSP Staff	Key Individuals from PPL Electric Utilities and ICSP	Telephone In-depth Interview	3	N/A	3	3	Census	100%
Market Actor Interviews	Master-Metered Multifamily Property Managers	Telephone In-depth Interview	22(3)	N/A	4	4	18(4)	22%
	Manufactured Home Park Property Manager		52	N/A	3	3	25(5)	12%
Participants	Program Participants (Baseload, low cost, full cost & Manufactured Home Park Initiative)	Telephone survey	12,232(6)	0.5	90/10 in each of 2 surveys (mid-year and end year)	228	3,430	6.6%
Contractors	Participating (7)	Telephone In-depth Interview	5	N/A	3	3	Census	60%
Program Total			**12,295**			**241**		

(1) Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database. After selecting all unique records, Cadmus removed any records from the population if the customers had participated in a survey in the last three months, were selected for another program survey, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey.
(2) Percent contacted means the percentage of the sample frame called to complete surveys.
(3) 22 property managers managed all master-metered multifamily buildings participated in WRAP in PY9.
(4) Contact information for 18 out of 22 master-metered multifamily property managers managing all properties were provided by the ICSP.
(5) Contact information for 25 manufactured-home park property managers were provided by the ICSP.
(6) Cadmus did not have access to individual contact information of master-metered multifamily building tenants. Therefore, Cadmus assessed satisfaction for master-metered multifamily buildings through interviews with property managers.
(7) Contact information for all five contractors were provided by the ICSP.

12.6.2.2 Program Staff and ICSP Interviews

In February of 2018, Cadmus conducted three interviews with WRAP managers from PPL Electric Utilities and the ICSP. The interviews focused on assessing the changes made to the program from PY8, the planned changes in PY10, program successes, and program challenges.

12.6.2.3 Multifamily Building and Manufactured Home Park Property Managers Interviews

In PY9, Cadmus conducted interviews with four property managers of master-metered multifamily buildings and three property managers of manufactured home parks that participated in WRAP. The objectives of these interviews were to understand how PPL Electric Utilities delivered the program, assess resident awareness and interaction with PPL Electric Utilities program staff, ascertain the managers' satisfaction with PPL Electric Utilities and the program overall, and solicit suggestions for improvement.

12.6.2.4 Contractor Interviews

Cadmus conducted interviews with three out of five contractors who support delivery of WRAP. The objectives of these interviews were to understand how contractors assist in program implementation, their satisfaction with PPL Electric Utilities and the program overall, and where they see areas for improvement and to follow up on comments and recommendations made by contractors in PY8.

12.6.3 Process Evaluation Findings

12.6.3.1 Program Delivery

In PY8, WRAP had a slow start, and only 2,718 jobs were completed.[97] In PY9, a total of 14,028 jobs were completed,[98] and 26% of the Phase III savings was achieved in PY9 alone. PPL Electric Utilities and the ICSP reported that the program was delivered effectively in PY9, especially in the second half of the program year.

Program Changes and Improvements

In PY9 (late fall 2017), PPL Electric Utilities and the ICSP determined that the program needed major changes to provide a successful customer experience, help customers save money, and to meet regulatory requirements. Subsequently, they implemented a corrective action plan in delivery, marketing, and outreach. The plan addressed issues reported in PY8, such as scheduling, lack of knowledge about the service area, and communication, and was designed to increase the number of

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[97] A job completed in each tenant unit in a master-metered multifamily building counts as a single job.

[98] A job completed in each tenant unit in a master-metered multifamily building counts as a single job. Thirty-two master-metered multifamily buildings participated in WRAP in PY9 have 1,818 tenant units and therefore 1,818 jobs were added to the total number of jobs. There is a total of 12,242 WRAP participants in PY9. In PY9, 14,028 individual WRAP jobs were completed.

completed jobs, improve realization rates, and improve customer satisfaction. Overall, Cadmus found that the actions were successful in that many aspects of the program improved considerably compared to PY8 and are working well.

In PY8, contractors complained about the limitations of the tablet-based software implemented by the ICSP, especially concerning the tool's data review capability and suitability for full-cost jobs. The ICSP addressed these issues and no complaints were made by contractors in PY9. The ICSP found an issue in the tablet-based software that led to the wrong LED nightlight baseline information in the audit reports provided to Cadmus. In the second half of PY9, the ICSP resolved this issue, which made a positive impact on the LED nightlight measure realization rates.

As reported in PY8, Cadmus found that contractors often installed 1.5 GPM efficient kitchen faucet aerators and showerheads when the existing aerator or showerhead was already 1.5 GPM, resulting in no energy savings. Similarly, in PY8, contractors often installed LED nightlights where there were no baseline nightlights, resulting in negative energy savings equal to the consumption of an LED nightlight. Cadmus found that the ICSP had instructed contractors about these issues in PY9, positively affecting the overall program energy realization rate. (See *Appendix K.1.4 Records Review Findings* for the details of improvements verified in the audit records review.)

Cadmus also found that ISRs increased substantially for all products and services throughout PY9 because the WRAP ICSP followed recommendations made in the PY8 annual report; these improvements involved improving program delivery, providing better instructions to contractors, and increasing satisfaction of the participants. (See *Appendix K.1.4 Records Review Findings* for details.)

In PY8, the ICSP said scheduling was the main challenge for WRAP because of the high number of site visit cancellations. As the ICSP gained knowledge about the service area during PY8 and PY9, hired more auditors and customer service representatives, far fewer scheduling complaints were reported during the two waves of participant phone surveys and in contractor and property manager interviews.

In PY9, at PPL Electric Utilities' request, the ICSP started completing each job in a shorter time than in PY8 to prevent possible participant dissatisfaction stemming from a long waiting time between enrollment and job completion.

Reported savings for full cost jobs represent 1.8% of total reported savings. Full cost jobs represent 3.1% of the total verified savings in PY9. PPL Electric Utilities decided to stop offering full-cost jobs to WRAP participants starting PY10; these homes will be treated within another PPL Electric Utilities program (LIURP). WRAP will continue to deliver programmable thermostats (typically a full cost job measure).

Marketing

The marketing initiative did not obtain a strong response in the beginning of PY8, so PPL Electric Utilities and the ICSP improved the design and language of the marketing materials used for PY9. PPL Electric Utilities also increased the number of postcards sent to customers and diversified the marketing methods to increase leads, and accepted applications over the phone which made the application process easier. These improvements had a major effect in PY9—the total number of jobs completed increased 516% compared to PY8.

Outreach

Cadmus' telephone surveys asked program participants' opinion about the best way for PPL Electric Utilities to inform them about energy efficiency programs and rebates. Fifty-eight percent said bill insert or newsletter, 22% said email from PPL Electric Utilities, 6% said from an auditor, 5% said through the PPL Electric Utilities website, and 3% said through social media such as Twitter, Facebook, or Instagram.

Cadmus also interviewed property managers of master-metered multifamily buildings and manufactured home parks. Two of the four master-metered multifamily property managers found out about WRAP from the ICSP program staff, one from a PPL Electric Utilities employee, and one from the property's executive director. Two property managers preferred to be informed about PPL Electric Utilities' programs through presentations at professional or industry associations, one preferred personal outreach, and another preferred an email.

Two of the four master-metered multifamily property managers notified tenants about WRAP by leaving a flyer on their door, and one of these also sent emails to tenants. The third property manager used direct emails, and the fourth sent emails, held resident meetings, and made announcements to inform tenants about WRAP. Similarly, the three manufactured home park property managers posted flyers on tenants' doors and sent emails to notify them about WRAP.

Property managers were asked who made the decision to participate in WRAP. Three out of four master-metered multifamily property managers said they made the decision along with the property owner, showing that outreach to key individuals in property management can be an effective method to increase program participation. One property manager made the decision with both the property manager and the executive director.

In contrast, two out of three manufactured home park property managers said residents could choose to participate. One respondent said that the park manager gave permission to treat the manufactured homes under WRAP because they wanted to ensure the validity of the program.

Challenges

Although many aspects of the program improved considerably in PY9, Cadmus found challenges that could be addressed. These revolve around energy education and communication.

Energy Education

Cadmus found that achieving energy savings attributable to energy education was a major challenge. During the participant phone surveys, 65% of those surveyed (n=227) said the home energy auditor provided recommendations about ways to save electricity and reduce energy costs while visiting the participant's home. This finding was consistent over the last three participant phone surveys: 62% in PY8, 64% in the first half of PY9, and 67% in the second half of PY9. Of the phone survey participants, 57% said they had followed some of the home energy auditor 's energy-saving recommendations. This is much higher than PY8, when 39% followed recommendations. It is important to note that more participants followed energy-saving recommendations in the second half of PY9 (87%) than the first half (42%).

The participant phone survey from the second half of PY9 found that 75% of participants remembered some of the recommendations given them during the home energy auditor's visit. Most could name only a few recommendations even though home energy auditors provided a long list of energy-saving recommendations. The following are the major recommendations with the percentage of people who remembered it:

- Turn off lights when not in use or not home (30%)
- Manage water usage and cut back (22%)
- Unplug appliances and/or electronics when not in use (15%)
- Use a surge protector or power strip for electronics (9%)
- Apply weatherstripping around windows and doors (7%)
- Wash clothes in cold water (4%)
- Other (13%)

Communication

Phone survey participants were satisfied with the overall communication. Three participants mentioned communications issues during the first wave of phone surveys and said the ICSP had not followed up with them consistently. Three phone survey respondents said language was a barrier and a translator would have been beneficial to resolve the issue. (PPL Electric Utilities has a dedicated bi-lingual representative and other representatives who can step in if needed.)

Contractors and property managers provided positive feedback for the overall communication.

Suggested Program Improvements

Cadmus asked WRAP participants if they could provide recommendations to improve the program. Cadmus observed the following improvements suggested by the phone survey respondents, mostly after the first half of PY9, as listed below:

- Provide a more comprehensive education and explain energy saving opportunities better (n=12)
- Provide better and a wide variety of products (n=9)
- Expand program eligible items and/or replacements for weatherized equipment (n=7)
- Follow up on installed equipment to ensure quality and functionality (n=7)
- Increased and advanced marketing for the program (n=7)
- Ensure auditors provide a professional service and they are friendlier (n=6)
- Remove limit on number of products (n=4)
- Provide detailed instructions for power strips (n=4)

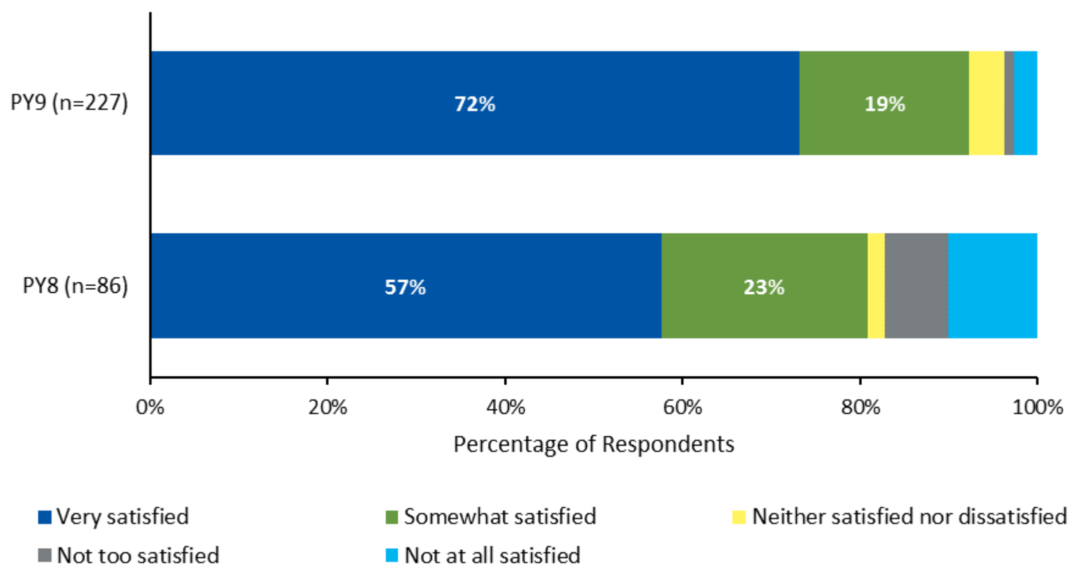
During the interviews, three property managers made suggestions to improve the program. One recommended increased advertising, and another requested that program representatives and/or contractors speak Spanish. The third asked that contractors leave behind some of the replaced equipment, such as showerheads and sink aerators, in case the tenant wanted to switch back to the old equipment. This property manager also said that a more in-depth training session about the power strips would have been helpful.

Contractors also made recommendations for program improvements during the interviews. They said customer feedback was generally good except for issues with the energy-efficient appliances, such as that refrigerators were not as big as the previous models. Another contractor said some customers found smart power strips confusing to use. Contractors also requested that insulation and major appliances such as ovens, washers, dryers, and heat pump water heaters be added to WRAP.

12.6.3.2 Satisfaction

Overall, Cadmus found that survey respondents are generally satisfied with WRAP and that the ICSP performed very well in PY9. As shown in Figure 12-1, when asked about their satisfaction with WRAP, 91% of customers (n=227) said they were either *very satisfied* (72%) or *somewhat satisfied* (19%). The program satisfaction increased substantially in PY9 in comparison to PY8. In PY8, 80% of customers (n=86) said they were either *very satisfied* (57%) or *somewhat satisfied* (23%).

Figure 12-1. Participant Satisfaction with WRAP



Source: "Thinking about your overall experience with the PPL Electric Utilities WRAP program, how would you rate your satisfaction?"

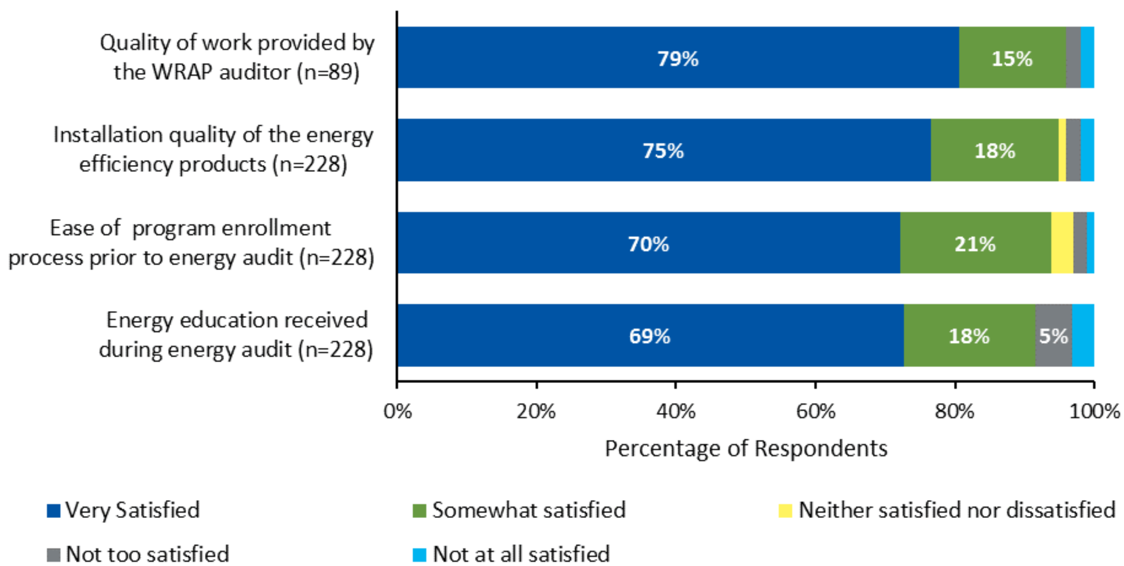
Responses were consistent from the first half of PY9, during which 91% of customers (n=139) said they were either *very satisfied* (72%) or *somewhat satisfied* (19%), compared to the second half of PY9, during which 92% of customers (n=89) said they were either *very satisfied* (73%) or *somewhat satisfied* (19%).

Cadmus found that respondents were generally satisfied with various program components in PY9. As shown in Figure 12-2, participants were most satisfied with the quality of the work provided by the home energy auditor,[99] followed by the installation quality of the energy efficiency products, the ease of program enrollment, and the energy education received during the audit.

Contractor Satisfaction

Contractors were asked about their satisfaction with WRAP overall and with specific elements of the program. Of three contractors Cadmus interviewed, one was *very satisfied* and two were *somewhat satisfied*. This was an increase from PY8, where two out of four contractors were *neither satisfied nor dissatisfied*.[100]

Figure 12-2. Participant Satisfaction with Different Program Components



Source: Survey Question "Please indicate how satisfied you are with each of the following components…"

Property Manager Satisfaction

Master-metered multifamily and manufactured home park property managers were asked about their satisfaction with WRAP overall and with specific elements of the program. Of the seven property managers, six were *very satisfied* with the program and one was *somewhat satisfied*. Of the four property managers in PY8, two were *very satisfied* with WRAP, and two were *somewhat satisfied*.

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99 Cadmus added this question to participant phone survey guide for the second wave of participant surveys and it was not asked during the first wave of participant surveys.

100 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Submitted to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

Property managers were generally satisfied with the various program elements. All four master-metered multifamily property managers interviewed were either *very* or *somewhat satisfied* with the WRAP contractors' interaction with tenants in their building, the overall quality of the work, the home energy audits, and the performance of the products installed in the tenant apartments. Three manufactured home park property managers Cadmus interviewed were also *very* or *somewhat satisfied* with the contractor's interactions with their residents.

Energy Education

Participants were asked how useful they thought the energy education provided by the WRAP energy educator was in helping them understand ways to save energy in their home. In PY9, 83% (n=198) said they thought it either *very useful* (59%) or *somewhat useful* (24%). More participants found the energy education useful in the second half of PY9. In the first half of PY9, 54% found it *very useful* and 26% found it *somewhat useful* (n=138), whereas in the second half of PY9, 72% found it *very useful* and 18% found it *somewhat useful* (n=68).

Two out of four multifamily building property managers organized an energy education seminar for their building residents. One property had 30% and the other had 50% resident attendance. One property manager said that offering free food could improve resident attendance. Cadmus asked the property managers their opinion of the energy education provided by the ICSP's subcontractor. Both property managers attended the event and said all aspects of the presentation were useful to the tenants. One said the presenters could have gone over the products and how to use them in greater detail as a large number of their residents had issues with sink aerators and showerheads.

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means "not at all likely" and 10 means "extremely likely." Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors. The passives are excluded from the calculation. An excellent NPS is 50 and above.

As shown in Table 12-10, WRAP achieved an excellent NPS of 70 in PY9, indicating there are more promoters than detractors among the survey respondents. NPS substantially improved in PY9 compared to PY8 (NPS of 48). Among the respondents, promoters increased to 78% in PY9 from 65% in PY8.

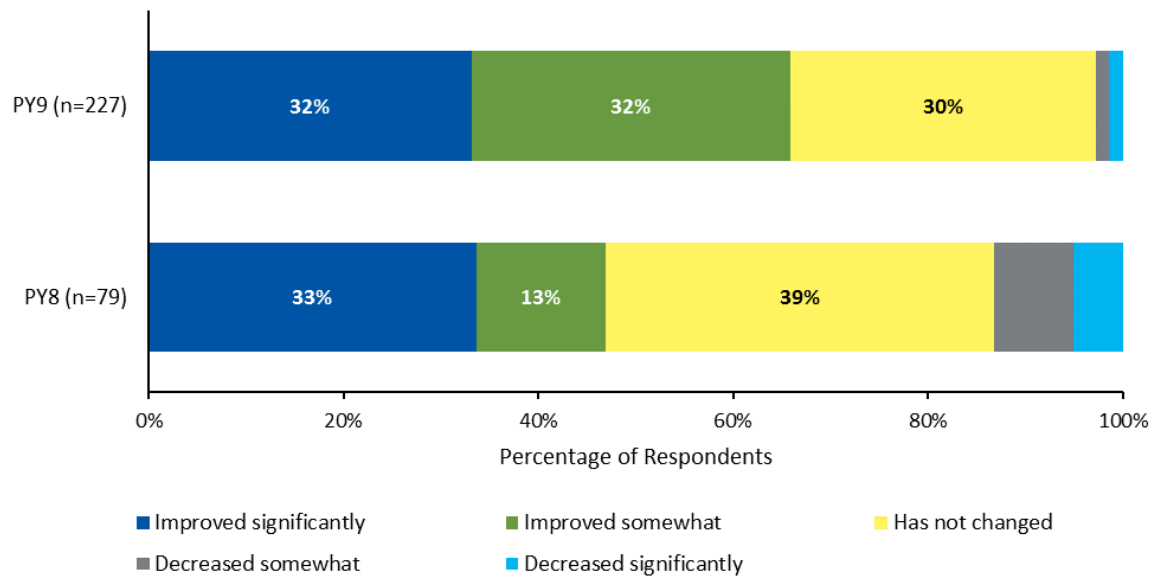
Table 12-10. Net Promoter Score Likelihood to Recommend the Program

Rating Classification	PY8 Percentage of Respondents (n=81)	PY9 Percentage of Respondents (n=219)
Promoters (9-10)	65%	78%
Passives (7-8)	17%	14%
Detractors (0-6)	17%	8%
NPS	**48**	**70**

Opinion of PPL Electric Utilities

Survey respondents were asked if their opinion of PPL Electric Utilities had changed since participating in the WRAP Program. As shown in Figure 12-3, 64% of respondents (n=227) said their opinion of PPL Electric Utilities improved after participating (32% said *improved significantly* and 32% said *improved somewhat)*. This is an increase from PY8, where 46% of respondents (n=79) said their opinion of PPL Electric Utilities improved after participating (33% said *improved significantly* and 13% said *improved somewhat)*. In PY9, two respondents said their opinion had *decreased somewhat* (2%), with one saying major appliances should have been replaced.

Figure 12-3. Opinion Shifts of PPL Electric Utilities Due to Program



Source: Survey Question "After participating in the PPL Electric Utilties WRAP Program, has your opinion of PPL Electric Utilities…"

12.7 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 12-11. TRC benefits were calculated using gross verified impacts. NPV PYTD costs and benefits are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). NPV costs and benefits for P3TD financials are expressed in PY8 dollars.

Table 12-11. Summary of WRAP Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	-		-	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$178	-	$453	-
7	Marketing [4]	-	$338	-	$601
8	Program Delivery [5]	-	$8,855	-	$11,665
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$9,371**		**$12,719**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**-**		**-**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	**$9,371**		**$12,719**	
14	Total NPV Lifetime Electric Energy Benefits	$2,927		$3,235	
15	Total NPV Lifetime Electric Capacity Benefits	$592		$654	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$1,232		$1,429	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$1,722		$1,600	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	**$6,473**		**$6,918**	
19	**TRC Benefit-Cost Ratio [9]**	**0.69**		**0.54**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 12-12 presents program financials and cost-effectiveness on a net savings basis. In this program, there is no free ridership; therefore, net verified savings are equal to gross verified savings.

Table 12-12. Summary of WRAP Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	-		-	
		EDC	**EDC**	**CSP**	**EDC**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$178	-	$453	-
7	Marketing [4]	-	$338	-	$601
8	Program Delivery [5]	-	$8,855	-	$11,665
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11 [6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$9,371**		**$12,719**	
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[1] May not sum to total due to rounding.
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[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs
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[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[101] A summary of the methodologies Cadmus used to calculate the non-energy benefits of saved water, natural gas therms, and lighting interactive effects can be found in *Appendix P Non-Energy Benefits*.

Non-Energy Benefits of Water Saving Products

WRAP offers these water-saving products: efficient showerheads, faucet aerators, thermostatic shower restriction valves, and energy education (in the form of taking shorter showers). Cadmus used data available in PPL Electric Utilities' tracking database to apply water savings to participants who received water-saving products and results from the participant surveys to apply water savings for the taking shorter showers. Table 12-13 summarizes the data used to determine the non-energy benefits for water-saving products for the WRAP.

Table 12-13. PY9 WRAP Non-Energy Benefits for Water-Saving Products

Measure	Home Type	TRM #	Gallons of Water Saved per Unit	Reported Installations	Average Realization Rate from Records Review (1)	Gallons of Water Saved
			A	B	C	A × B × C
Bathroom Aerators	Multifamily	2.3.8	705	2,204	119%	1,851,043
Bathroom Aerators	Single-Family		505	2,529	132%	1,678,182
Kitchen Aerators	Multifamily		1,638	2,739	94%	4,201,637
Kitchen Aerators	Single-Family		2,070	1,758	84%	3,047,922
Low-Flow Showerheads – Handheld	Multifamily	2.3.9	2,951	1,112	96%	3,157,399
Low-Flow Showerheads – Handheld	Single-Family		3,154	731	90%	2,073,412
Low-Flow Showerheads	Multifamily		2,951	1,116	97%	3,187,528
Low-Flow Showerheads	Single-Family		3,154	1,738	87%	4,771,318
Thermostatic Restriction Valve	Multifamily	2.3.10	621	1,009	118%	736,803
Thermostatic Restriction Valve	Single-Family		663	705	100%	467,896
Energy Education - Q1-Q2	All	2.3.9	59	5,019	100% (2)	296,422
Energy Education - Q3-Q4	All		75	9,029	100% (2)	679,432
Total (3)		-	-	-	-	**26,148,995**

(1) Cadmus used the realization rates found in the records reviews and applied them to each measure in each stratum.
(2) For the energy education products, the realization rate adjustments are built into the unit savings, so the adjustment is set to 100%.
(3) May not match due to rounding.

101 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

Non-Energy Benefits of Natural Gas Savings

WRAP had four categories of therms savings:[102]

- HVAC products
- Water-heating products
- Energy education (which comprises HVAC and water-heating products)
- Envelope improvements

The HVAC products with therms savings were furnace whistles (where homes with cooling were eligible to receive this measure) or from the small number of homes that received a programmable or smart thermostat when they did not have electric heating. Likewise, the water-heating products with therms savings come from the small number of homes that received these products but had a fossil fuel water heater. Energy education improvements applied to all participants, and the unit savings reflect the distribution of those who took action and those with fossil fuel space heat or water heat. Envelope improvements applied only to the manufactured homes stratum, as all full-cost jobs had both electric heating and water heating.

Table 12-14 shows the total therms savings for water-heating products and HVAC products. Therms savings from the energy education improvements and the limited air sealing improvements are shown in Table 12-15 and Table 12-16, respectively.

[102] There was also a therm penalty due to lighting interactive effects, which is covered in the next section.

Table 12-14. WRAP Non-Energy Benefits for Natural Gas Savings—HVAC and Water Heating

Improvement	Home Type	TRM #	Therms Saved per Unit	Reported Installations in Homes with Fossil Fuel Space Heat or Water Heat	Average Realization Rate from Records Review (1)	Total Therms Saved	Source and Assumptions (2)
			A	B	C	A × B × C	
Bathroom Aerators	Multifamily	2.3.8	2.71	5	126%	17	5.4.4
Bathroom Aerators	Single-Family		1.66	114	125%	236	
Kitchen Aerators	Multifamily		7.71	8	91%	56	
Kitchen Aerators	Single-Family		8.37	54	84%	380	
Low-flow Showerheads - Handheld	Multifamily	2.3.9	16.81	4	92%	62	5.4.5
Low-flow Showerheads - Handheld	Single-Family		15.44	7	91%	99	
Low-flow Showerheads	Multifamily		16.81	3	93%	47	
Low-flow Showerheads	Single-Family		15.44	68	86%	907	
Thermostatic Restriction Valve	Multifamily	2.3.10	3.77	5	121%	23	5.4.8
Thermostatic Restriction Valve	Single-Family		3.46	5	100%	17	
Water Heater Pipe Insulation	All	2.3.7	1.10	28	100%	31	5.4.1
Water Heater Temperature Setback	All	2.3.6	2.56	2	100%	5	5.4.6
Furnace Whistle	All	2.2.7	1.24	133	18%	29	PA TRM 2.2.7 and 2.2.2
Heat Pump Water Heater	All	2.3.1	-4.76	24	100%	-114	5.4.3
Programmable Thermostat	All	IMP (3)	40.92	1	100%	41	5.3.7, 2012 PA Res End-Use Study (4)
Smart Thermostat	All	IMP (3)	219.56	2	175%	768	5.3.7, 2012 PA Res End-Use Study (4)
Total (5)	-	-	-	-	-	**2,603**	-

(1) Cadmus used the realization rates found in the records reviews and applied them to each measure in each stratum. These are slightly different than the realization rates in Table 11-15 because the distribution of improvements in each stratum are different.
(2) The section numbers in this column (unless otherwise stated) refer to the algorithms for gas savings, which came from the IL TRM V6. Cadmus used the algorithms listed in the IL TRM and the inputs from the PA TRM.
(3) Pennsylvania Public Utility Commission. *Residential Thermostats IMP.* February 26, 2018.
(4) Data set from the 2012 Pennsylvania Residential End-Use and Saturation Study submitted to Pennsylvania PUC by GDS Associates, Nexant, and Mondre. Cadmus used these data to calculate capacities of fossil fuel heating systems of income-qualified homes, which were smaller than the default assumptions.
(5) May not match due to rounding.

Table 12-15 shows the therms savings from the energy education measure. All participants received the energy education improvement, and unit savings include the distribution of those who took action and those who had fossil fuel heat or water heat.

Table 12-15. WRAP Non-Energy Benefits—Therms Savings due to Energy Education

Improvement	TRM #	Therms Saved per Unit	Reported Installations	Total Therms Saved	Source and Assumptions (1)
		A	B	A × B	
Energy Education - Q1-Q2	2.3.9, 2.3.6, 2.2.8	6.75	5,019	33,878	5.4.5, 5.3.7
Energy Education - Q3-Q4		9.36	9,029	84,511	
Total (2)	-	-	-	**118,390**	-

(1) The section numbers in this column (unless otherwise stated) refer to the algorithms for gas savings, which came from the IL TRM V6. Cadmus used the algorithms listed in the IL TRM and the inputs from the PA TRM.
(2) May not match due to rounding.

Table 12-16 shows the therms savings from limited air sealing improvements. Cadmus shows the therms per unit (usually length) by heating degree day (HDD), the number of homes that received any of these improvements and had fossil fuel space heat, and total therms saved.

Table 12-16. WRAP Non-Energy Benefits—Therms Savings due to Limited Air Sealing

Improvement	TRM #	Therms per Unit per HDD	Homes with Natural Gas Space Heat that Received Improvement(1)	Total Therms Saved	Source and Assumptions
Closed Cell Foam	IMP (2)	0.00001	49	4	IMP (2)
Door Caddie		0.00050	73	222	
V-Strip		0.00001	159	12	
Window Kits		0.00000	9	0	
Total (3)	-	-	-	**238**	-

(1) Cadmus limited this measure to gas heat only following SWE's Guidance Memo and the Weather Stripping IMP which is based on natural gas impacts and converted to electric impacts. Weather Stripping IMP is sensitive to correlation factors and using the algorithm for all fossil fuel types could give an overestimate of savings.
(2) Pennsylvania Public Utility Commission. *Weather Stripping, Caulking and Outlet Gaskets*. February 28, 2018.
(3) May not match due to rounding.

Lighting Interactive Effects

Cadmus included heating penalties as a negative benefit in the TRC test for efficient lighting, per the Guidance memo.

Table 12-17. WRAP Lighting Gas Heating Penalties Calculations

Product	Gas Heat Fuel Share	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therm per kWh/yr)
LEDs	29%	90%	66%	20%	0.8	0.00586

Per the Guidance Memo, Cadmus assumed that there is a natural gas therms penalty. The results are shown in Table 12-18. Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Table 12-18. WRAP Lighting Gas Heating Penalties for LEDs

Product	Total Ex Post kWh/yr Savings	Total Natural Gas Therms Penalty
LEDs	7,520,465	-44,071
Total Gas Savings (adding savings from Table 12-14, Table 12-15, and Table 12-16)		**77,160**

12.8 Recommendations

Overall, the Winter Relief Assistance Program has performed as expected according to the program design and has exceeded both its estimated participation and estimated savings, especially in the second half of PY9. Recommendations are provided in Table 12-19, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Participation and Program Delivery

Finding: In PY9, the ICSP delivered services to a total of 12,242 participants for the WRAP and exceeded the planning estimates of 7,000 WRAP participants per year. This a substantial increase compared to PY8 in which a total of 2,718 participants received services. By the end of PY8, WRAP had achieved 5% of the Phase III planned savings due to low number of jobs completed. WRAP achieved 26% of the Phase III savings in PY9 alone. Taken together, WRAP achieved 31% of the Phase III projected savings by the end of PY9. (See section *12.1 Progress Toward Phase III Projected Savings*)

Finding: WRAP realized 82% of its reported savings, an improvement upon the PY8 realization rate of 76%. Cadmus found that the ICSP addressed the major issues identified in PY8, which positively affected the overall program energy realization rate. (See *Appendix K.1.4 Records Review Findings* for the details of improvements verified via audit records review).

Finding: The participants responding to surveys are more satisfied with WRAP in PY9 (91%) than in PY8 (80%). Participants were satisfied with all components of the program. Issues with scheduling, expectations, and communication identified in PY8 were mentioned less frequently in PY9, especially in the second half of the year. WRAP achieved an excellent net promoter score of 70. Satisfaction among contractors and master-metered multifamily and manufactured home park participants was also high in PY9. (See section *12.6.3.2 Satisfaction*)

Finding: The ICSP acted on recommendations made in PY8, and ISRs increased substantially for all measures throughout PY9: about 2% for showerheads, 5% for LEDs, 12% for bathroom aerators, 13% for kitchen aerators, 20% for LED nightlights, and 33% for Tier 2 advanced power strips. (See *Appendix K.1.4 Records Review Findings* for details).

Finding: A limitation in the tablet-based software used to record data during site visits led to incorrect information about the LED nightlight baseline in the audit reports. In the second half of PY9, the ICSP resolved this issue. (See section *12.6.3.1 Program Delivery*)

Conclusion: Currently, the recruiting and program delivery methods that the ICSP is implementing are working well. The ICSP has made substantial improvements in program delivery, especially evident in the second half of the program year. The ICSP has also achieved improvements in guidance provided to contractors, energy education provided to participants, its tablet-based software used by contractors, and overall quality control as recommended by Cadmus in PY8 annual report and throughout PY9. These changes resulted in substantially higher numbers of completed jobs, energy savings and realization rates, and satisfaction. The ICSP needs to keep the same pace it achieved in the second half of PY9 and complete a high number of jobs each year to achieve the Phase III energy savings projection of 55,546 MWh/yr.

Recommendation #1:
To achieve the energy savings projected for Phase III, the ICSP should maintain the high-quality program delivery achieved in the second half of PY9 and continue to deliver services to more than the planning estimates of 7,000 participants per year. Continue to complete WRAP jobs within a short timeframe; provide enhanced communication among program participants, contractors, and master-metered multifamily and manufactured home park property managers; provide detailed instructions to contractors; and conduct detailed quality control to achieve high ISRs, hence savings.

Communication

Finding: Cadmus found that a greater number of postcards sent to customers, diversified marketing methods, and accepting applications over the phone made the application process easier and increased leads substantially in PY9. (See section *12.6.3.1 Program Delivery*)

Finding: Fewer issues were reported through the phone surveys in PY9 compared to PY8. Most of the issues reported in PY8 about scheduling have been addressed. Although the overall communications improved substantially in PY9, a few program participants reported concerns about products installed and follow-up visits (see *Suggested Program Improvements* section in *12.6.3.1 Program Delivery* for details).

Conclusion
In PY9, the ICSP made substantial improvements in overall communication with program participants, contractors, and master-metered multifamily and manufactured home park property managers. These improvements resolved many issues reported in PY8, especially in the second half of PY9.

Energy Education

Finding: Cadmus estimated the energy education savings via participant telephone surveys in two waves in PY9. Cadmus found an increase in e*x post* energy savings in the second half of PY9 (81 kWh/yr) compared to the first half (27 kWh/yr). The percentage of residents who adjusted their thermostat in the winter increased from 17% in the first half of PY9 to 40% in the second half of PY9, which in turn caused an increase in energy education savings in the second half of PY9. However, e*x post* per-unit savings were still low compared to *ex ante* savings reported as 160 kWh/yr. (See *Appendix K.1.4 Records Review Findings.*)

Finding: In PY8, 39% of WRAP participants surveyed reported acting on at least one energy-savings recommendation following the energy education. In PY9, this percentage increased to 57%; however, this is still lower than the desired impact, as discussed in the section *12.6.3 Process Evaluation Findings*. Many respondents reported they had already been implementing some of the energy-savings actions recommended by the WRAP contractors prior to WRAP.

Finding: Energy education for WRAP participants in master-metered multifamily buildings is provided through a group session; however, building managers confirmed that the participation in these group sessions was typically low. (See section *12.6.3.1 Program Delivery*)

Finding: Estimating the energy education savings through participant telephone surveys has certain limitations because the phone survey respondent might not be the same person who directly received the energy education or might have trouble remembering the energy education recommendations while on the phone. (See section *12.6.3.1 Program Delivery*)

Conclusion: The improvements made in delivery of energy education increased the savings in PY9; however, low participation still drives down the energy savings realized. Moreover, providing a more comprehensive education and explaining energy saving opportunities better could further reduce complaints on the energy education provided.

Recommendation #2: Consider revising reported energy education savings to 54 kWh/yr instead of using reported savings of 160 kWh/yr. The energy education savings of 54 kWh/yr is the straight average of estimated energy education savings for the first half of PY9 (27 kWh/yr) and for the second half of PY9 (81 kWh/yr). The reported savings used in PY8 and PY9 is based on a billing analysis conducted in Phase II with a specific mix of fuel sources that is different than Phase III. Consider taking steps to increase the impacts of energy education:

- Put emphasis on prompts, such as magnets or stickers, as reminders of the recommendations (similar to the Energy Efficiency Kits and Education Program) and encourage participants to use them. Because participating households typically receive one education session persistence in energy savings recommendations may be limited.
- Consider ways to increase participation to energy education group sessions provided in master-metered multifamily buildings by offering free food or drinks or other giveaways.
- Consider leaving behind surveys (postcards) to remind participants to take actions and to collect data about actions taken. The leave-behind postcards may be easier for participants to report on their energy saving activities and behaviors.

- Consider providing an actual shower timer to encourage participants to take shorter showers.[103]

Tier 2 Advance Power Strips

Finding: The ISRs of Tier 2 advanced power strips increased to 88% in the second half of PY9 (44% in PY8 and 66% in the first half of PY9). Although complaints about Tier 2 advanced power strips decreased and ISRs increased substantially, there is still an opportunity to further improve ISRs because some program participants and contractors reported confusion or lack of understanding about using this product appropriately (see *Suggested Program Improvements* section in *12.6.3.1 Program Delivery* for details).

Finding: Tier 2 advanced power strips are being installed with one or two devices plugged into them (43% and 20% of the time, respectively). This reduces the full potential for energy savings (see *Appendix K.1.4 Records Review Findings* for details). The 2016 PA TRM assumes that power strips control more devices, that is, five devices are plugged into an entertainment center and three devices are plugged into a computer workstation (or an unspecified use).

Conclusion: Installing Tier 2 advanced power strips in entertainment centers or other places with only one or two devices plugged into them, and assigning savings per the TRM, has the potential to overstate savings. The PA TRM does not have specific requirements for the number of devices plugged into Tier 2 advanced power strips, but the source for the TRM references explicitly states this.

Recommendation #3: Consider improving the educational materials and provide additional explanation about installation and use of Tier 2 advanced power strips. Instruct contractors to install Tier 2 advanced power strips in places with at least three items plugged into them (preferably four or five) to better achieve the energy savings potential.

Reported Savings (*Ex Ante*) for Limited Air Sealing Improvements

Finding: Reported savings for limited air sealing in manufactured homes are being overstated. In PY9, reported savings are too large (129 kWh/yr) compared to the energy savings calculated using the weather-stripping IMP (40.6 kWh/yr) (see *Appendix K.1.4 Records Review Findings* for details).[104]

Conclusion: The current reported *ex ante* savings for limited air sealing improvements do not reflect the verified savings found by Cadmus. Revisions to the reported savings could improve the realization rates and allow for better planning.

Recommendation #4: Consider revising reported limited air sealing savings to 40.6 kWh/yr as calculated in PY9.

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[103] Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3: Residential Measures.* February 8, 2017. Section 5.4.9.

[104] 2016 TRM – Interim Measure Protocol: Residential Air Sealing. February 28, 2018.

12.8.1 Status of Recommendations

Table 12-19 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 12-19. Status of Recommendations for WRAP

Winter Relief Assistance Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	The ICSP should maintain the high-quality program delivery achieved in the second half of PY9 and continue to deliver services to higher number of participants than the anticipated 7,000 participants per year to achieve the annual energy savings planned for Phase III. Continue to complete WRAP jobs within a short timeframe; provide enhanced communication among program participants, contractors, and master-metered multifamily and manufactured home park property managers; provide detailed instructions to contractors; and conduct detailed quality control to achieve high ISRs, hence savings.	Implemented. The forecast provides the participant goals to achieve the planned Phase III savings. Communication elements have been added in PY9 that are continuing throughout the remainder of the Phase.
2	Consider revising reported energy education savings to 54 kWh/yr as *ex ante* savings of 160 kWh/yr savings is based on a billing analysis conducted in Phase 2 with a specific mix of fuel sources that is different than Phase 3. Consider taking steps to increase the impacts of energy education: • Put emphasis on prompts, such as magnets or stickers, as reminders of the recommendations (similar to the Energy Efficiency Kits and Education Program) and encourage participants to use them. Because participating households typically receive one education session persistence in energy savings recommendations may be limited. • Consider ways to increase participation to energy education group sessions provided in master-metered multifamily buildings by offering free food or drinks or other giveaways. • Consider leaving behind surveys (postcards) to remind participants to take actions and to collect data about actions taken. The leave-behind postcards may be easier for participants to report on their energy saving activities and behaviors. • Consider providing an actual shower timer to encourage them to take shorter showers.	Being considered. Many of the listed considerations are currently implemented. If 160 kWh/yr is to be adjusted we would request Cadmus provide the maximum achievable savings by fuel type and the program verified savings by fuel type. The recommendations may not be cost effective to implement if there is no significant room for improvement.
3	Consider improving the educational materials and provide additional explanation about installation and use of Tier 2 advanced power strips. Instruct contractors to install Tier 2 advanced power strips in places with at least three items plugged into them (preferably four or five) to better achieve the energy savings potential.	Being considered. The request to collect the number of plugged items is not considered in the PA TRM for savings calculations.
4	Consider revising reported limited air sealing savings to 40.6 kWh/yr as calculated in PY9.	Being considered. Also considering as a measure to remove as it is no longer cost effective.

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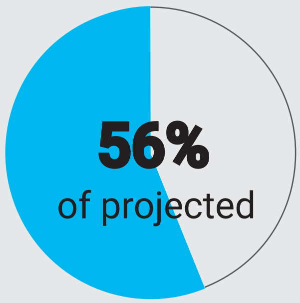
ENERGY EFFICIENCY KITS AND EDUCATION PROGRAM

The program delivers energy education and kits with energy-saving products to income-qualified customers at or below 150% of the federal poverty income guidelines.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **21,049 MWh/yr**



154% of projected

PY9 saved **11,829 MWh/yr**

PROGRAM SATISFACTION

98% Satisfied with overall program

90% *strongly agree* that they are **motivated to install** products in the kit because they want to **save money**

60% *strongly agree* that installing items from their kits helps them **lower their electricity bill**

58% *strongly agree* that they **knew how to install** all the products in the kit

PY9 PARTICIPATION

A total of **13,203** participants:

2,519 agency

10,684 direct mail

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$3,926**

57% of projected

144% of projected

PY9 expenditures **$2,032**

13 Energy Efficiency Kits and Education Program

Through the Energy Efficiency Kits and Education Program, PPL Electric Utilities delivers energy education and kits with energy-saving products to income-qualified customers at or below 150% of the federal poverty income guidelines. 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 two channels to recruit participants and deliver the program:

- **Direct mail kits.** CMC Energy, the low-income ICSP, conducted targeted mail outreach to invite qualified customers to participate in the Energy Efficiency Kits and Education Program. To receive a kit in the mail, recipients had to return the business reply card attached to the mailing. To generate the list of targeted outreach recipients, PPL Electric Utilities identified customers who had received Low-Income Home Energy Assistance Program (LIHEAP) benefits, were enrolled in PPL Electric Utilities' OnTrack Program, or were low-income-qualified and had been identified by the ICSP through market research, data mining, or other means.
- **Agency delivery.** Through their day-to-day interactions with clients, agencies (community-based organizations, or CBOs) assisted the ICSP's subcontractor (Resource Action Programs, or RAP) in recruiting qualified customers to participate in a one-hour energy-education workshop or a one-on-one session with agency staff at the agency's office. RAP conducted train-the-trainer webinar sessions to help agency staff understand key elements of the workshops and provide them with the tools they needed to introduce energy education and low-cost/no-cost energy efficiency products to their low-income clients. To maximize attendance, the agencies offered the workshops at various times during the day, evening, and weekend. During the workshops and one-to-one sessions, agency staff introduced customers to the energy-saving products and educational materials in the kits.

In PY9, the program distributed two kits, depending on the customer's fuel source for water heating, because PPL Electric Utilities can claim savings only for water-saving products installed in homes with an electric water heater.

Both kits contained self-installed products, energy education literature, and surveys to gather participation information for the program. Kits for customers with electric water heaters also included faucet aerators and low-flow showerheads. Kits for customers with a water heater fuel type other than electricity did not contain aerators or showerheads.

Each kit also included a paper survey, along with a self-addressed, stamped envelope. Cadmus used the survey-collected data to determine ISRs and satisfaction with the program. Table 13-1 lists the items included in each kit.

Table 13-1. Products Included in PY9 Energy Efficiency Kits

Energy-Efficiency Product	Non-Electric Water Heater Kit	Electric Water Heater Kit
Six 9W LED Bulbs	✓	✓
One LED Night Light	✓	✓
One Tier 2 Advanced Power Strips	✓	✓
One Furnace Whistle	✓	✓
One Low-Flow Showerhead		✓
One Kitchen Aerator		✓
Tips on Energy-Efficiency Behavior	✓	✓
Paper Survey	✓	✓

The objectives of the Energy Efficiency Kits and Education Program are these:[105]

- Provide low-income customers with a no-cost energy efficiency kit and education to help them conserve energy and reduce their energy costs
- Maintain partnerships with local agencies so customers receive maximum and timely customer assistance
- Achieve high satisfaction with customers and participating agencies, through quality service and an impactful program offering
- Promote other PPL Electric Utilities energy efficiency programs, specifically other low-income assistance programs
- Achieve a total approximate reduction in energy use of 38,000 MWh/year gross verified savings

13.1 Progress Toward Phase III Projected Savings

The Energy Efficiency Kits and Education Program's verified savings are 154% of the projected MWh/yr savings for PY9. The program has achieved 56% of the projected Phase III total planned savings and is making progress toward the Phase III projected savings.

Table 13-2 shows the program's verified gross savings and progress toward its Phase III projected energy savings, as filed in the EE&C Plan.

Table 13-2. Energy Efficiency Kits and Education Program Projected Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified	Projected (1)	Verified	Percentage of Projected	Projected (1)	Verified	Percentage of Projected
MWh/yr (2)	9,219	7,696	11,829	154%	37,601	21,049	56%

(1) Projected savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.
(2) Totals may not sum due to rounding.

105 Program objectives are listed in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

The following factor affects the program's progress toward the projected savings for PY9:

- The ICSP distributed more than 13,000 kits in PY9, many more than the 8,000 kits projected in the EE&C Plan for PY9. PPL Electric Utilities and the ICSP made the decision to send more kits to boost the savings achieved in the low-income sector and will phase out kits all together in PY12.

13.2 Participation and Reported Savings by Customer Segment

13.2.1 Definition of a Participant

A participant in the program is defined as an income-eligible customer who received an energy-savings kit through the agency or the direct-mail delivery channel. For recordkeeping purposes, each kit is assigned a unique job number. Customers who receive more than one kit are assigned multiple job numbers, one per unique kit.

Any kits returned to the ICSP receive two unique job numbers: one to indicate the distributed kit, and one to indicate the returned kit. For recordkeeping purposes, returned kits appear as separate records with negative reported savings in PPL Electric Utilities' tracking database.

13.2.2 Program Participation and Reported Impacts

Table 13-3 presents the number of records in PPL Electric Utilities' tracking database, the participation counts (distributed kits that were not returned) and reported energy and demand savings for the Energy Efficiency Kits and Education Program by customer segment in PY9. There are no incentive payments for this program. Income qualified customers receive the kit for free. See *Appendix L.1.2 Database Review Findings* for details about the count of kits.

Table 13-3. Energy Efficiency Kits and Education Program Participation and Reported Impacts

Parameter	Low-Income	Total[1]
PYTD # Participants [2]	13,406	**13,406**
PYTD Number of Participants Receiving Kits [3]	13,203	**13,203**
PYRTD MWh/yr	12,205	**12,205**
PYRTD MW/yr	0.90	**0.90**
PYVTD MWh/yr	11,829	**11,829**
PYVTD MW/yr	1.10	**1.10**
PY9 Incentives ($1000)	$0	**$0**

[1] Total may not match sum of columns due to rounding.
[2] The number of records is determined by the unique job numbers. Returned kits are assigned two unique job numbers: one for the distributed kit, and one for the returned kit. Note that this is just for recordkeeping purposes.
[3] In PY9, the ICSP distributed 13,203 unique kits that were not returned. A total of 114 kits were returned, represented as 203 unique rows in PPL Electric Utilities' tracking database. In some cases, a kit distributed in PY8 was returned in PY9, and thus only had one record in the tracking database.

13.3 Gross Impact Evaluation

13.3.1 Data Collection

Cadmus collected data to verify energy savings through the ICSP-administered participant surveys (paper surveys included in each kit). It also conducted a phone survey with a sample of program participants who did not return a paper kit survey. Cadmus also collected enrollment information from the ICSP's subcontractor to confirm the records in PPL Electric Utilities' tracking database.

13.3.2 Sample Design

Each energy-savings kit included a paper survey for participants to complete and return to the ICSP. The survey asked questions about installing the products and about the participant's experiences with the products and program. Participants returned the surveys to the ICSP throughout the year. When the program year ended in May 2018, the ICSP sent the survey data to Cadmus. Cadmus used the data to estimate the program's energy savings in PY9.

Cadmus also conducted a follow-up phone survey with a sample of program participants who did not return the survey from the kit (these participants are referred to as non-responders). Cadmus used these phone survey responses to estimate the program's energy savings in PY9 and to investigate any bias in in-service rates (ISRs) between responders and non-responders. Cadmus did not include customers who returned kits in its sample frame for the phone surveys.

The impact evaluation sampling strategy is listed in Table 13-4. Additional details about methodology are in *Appendix L.1 Gross Impact Evaluation*.

Table 13-4. Energy Efficiency Kits and Education Gross Impact Sample Design for PY9

Stratum	Population Size [1]	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size [2]	Impact Evaluation Activity
Agency	2,519	N/A [3]	All available	166	ICSP-collected paper kit survey
		0.5	70	70	Non-responder phone survey
Direct Mail	10,684	N/A [3]	All available	1,181	ICSP-collected paper kit survey
		0.5	70	70	Non-responder phone survey
Program Total	**13,203**			**1,487**	

[1] Number of unique kits that were distributed and not returned to the ICSP (not the number of unique records in PPL Electric Utilities' tracking database, which includes returned kits). (See *Appendix L.1.2 Database Review Findings* for details about the count of kits.)

[2] Number includes partially completed surveys. Respondents could skip questions.

[3] Cadmus used survey responses collected by the ICSP from all participants who returned their surveys. Therefore, Cadmus did not have an assumed proportion of Cv.

13.3.3 Gross Impact Evaluation Activities

Cadmus performed the following activities to evaluate the gross impacts of the Energy Efficiency Kits and Education Program. Refer to *Appendix L.1 Gross Impact Evaluation* for detail on these activities.

- **Records review.** Cadmus reviewed the records in PPL Electric Utilities' tracking database and compared these to the records in the enrollment data provided by the ICSP, verifying discrepancies with the ICSP prior to conducting any analyses.
- **Participant kit survey.** Cadmus collected the kit surveys returned by mail to the ICSP and used the collected data in the *ex post* savings analysis. Cadmus also reviewed the records in the survey data and verified all discrepancies between the survey records and PPL Electric Utilities' tracking database with the ICSP.
- **Participant phone survey.** Cadmus conducted phone surveys of a sample of participants who did not return a kit survey and used the collected data in the *ex post* savings analysis to investigate any impact-related bias of participants who returned the kit survey.

13.3.4 Gross Impact Evaluation Results

In PY9, the Energy Efficiency Kits and Education Program reported energy savings of 12,205 MWh/yr, as shown in Table 13-5, and demand reduction of 0.90 MW/yr, as shown in Table 13-6.

Table 13-5. Energy Efficiency Kits and Education Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Agency	2,105	94%	0.44	3.97%
Direct Mail	10,100	98%	0.43	1.66%
Program Total (1)	**12,205**	**97%**	**N/A**	**1.53%**
(1) Total may not match sum of rows due to rounding.				

Table 13-6. Energy Efficiency Kits and Education Program Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Agency	0.15	132%	0.57	5.09%
Direct Mail	0.75	120%	0.58	2.23%
Program Total (1)	**0.90**	**122%**	**N/A**	**2.05%**
(1) Rows may not sum to program total due to rounding.				

Differences in reported and evaluated ISRs primarily drove the differences in reported and verified savings for most products (shown in Table 13-7 in the next section):

- Differences in reported and evaluated ISRs drove the differences in reported and verified savings for many products, primarily **furnace whistles** and **LEDs**. See *Section 13.3.5 In-Service Rates* for details.

- For **Tier 2 advanced power strips**, the ICSP calculated reported savings in the PPL Electric Utilities tracking database under the assumption that all participants' use of advanced power strip was unspecified. However, Cadmus' analysis of survey data found that participants most frequently used their advanced power strips for entertainment centers, which produce higher savings than other uses and drive up the realization rate for this product.
- For **energy education,** the ICSP reported savings of 253 kWh/yr for every participant, regardless of stratum and kit type. Cadmus, however, found that customers who received kits with water-saving products more frequently had electric water heating, electric space heating, and central cooling systems and therefore higher savings than customers who did not receive water-saving products. Cadmus estimated energy education savings for recipients of water-savings kits as 252.63 kWh/yr for agency and 355.15 kWh/yr for direct mail, similar to the ICSP's reported savings of 253 kWh/yr. This similarity is because of the high correlation between having electric water heating (required to receive water-saving products) and having electric space heating (required to achieve a large portion of the energy education savings).

  However, Cadmus estimated far less energy education savings for recipients of kits with no water-savings products (20.96 kWh/yr for agency and 86.19 kWh/yr for direct mail participants). The ICSP's assumption for per-kit savings for energy education does not apply as well to kits with no water-saving products, and therefore the composition of kit types distributed to customers each year is the primary driver of the realization rates.
- The ICSP reported 0 kW/yr for **energy education**, and Cadmus found 0.0183 kW/yr on average across strata, which increased the overall demand realization rates to 132% for the agency stratum and 120% for the direct mail stratum.

A notable observation is that in PY9 the Energy Efficiency Kits and Education Program improved its realization rate to 97%, compared to 88% in PY8. However, the ICSP did not update its reported ISRs or other assumptions between program years, and the increase in realization rate is entirely driven by the kit type (including or not including water-saving products), particularly in the direct mail stratum. Specifically, in PY9 the direct mail stratum distributed many more kits with water products (70% of total kits) than in PY8 (55% of total).

See *Appendix L.1 Gross Impact Evaluation* for additional details.

13.3.5 In-Service Rates

Table 13-7 shows reported and evaluated ISRs by product and strata for PY9. Overall, reported ISRs are reasonable and matched well to the ISRs Cadmus estimated using survey data. The reported ISRs for furnace whistles continue to be low compared to the evaluated ISRs. On the other hand, LED bulbs continue to achieve lower evaluated ISRs than reported, probably because of the additional bulbs included in the Phase III kits. Cadmus observed that LED ISRs remained relatively high until after the fourth bulb, when installations dropped off dramatically, ranging from 72% to 66% for the fifth and sixth bulbs. See *Appendix L.1.3 Survey Findings* for details.

Table 13-7. PY9 Reported vs. Evaluated ISRs

Product	Agency		Direct Mail	
	Reported ISR	Evaluated ISR	Reported ISR	Evaluated ISR
Energy Education (1)	100%	45%	100%	55%
Tier 2 Advanced Power Strip	77%	69%	83%	62%
Furnace Whistle	17%	35%	20%	31%
LED Bulbs	96%	84%	98%	84%
Nightlight	87%	92%	92%	91%
Kitchen Faucet Aerator	63%	65%	75%	59%
Low-Flow Showerhead	64%	64%	72%	60%
(1) The ISR for energy education is based on the number of actions participants took out of four possible choices; see *Appendix L.1.4 Behavior Savings Methodology* for details on actions.				

Cadmus conducted phone surveys with participants who did not respond to the paper survey in the kits (non-responders) to gather more information about product installation. Table 13-8 shows the ISRs by stratum for responders and non-responders. Cadmus derived responder ISRs from the returned paper kit surveys and non-responder ISRs from the phone surveys. Except for direct mail furnace whistles, responder ISRs for all products in both strata are higher than non-responder ISRs, consistent with findings from PY8. Many of the differences in ISRs for agency participants are insignificant at the 10% level; only LED and furnace whistles are significantly different from each other. This is opposite from direct mail findings, where differences in ISRs are significant for all products *except* LED bulbs and furnace whistles.[106]

Table 13-8. ISR Comparison Between Responders and Non-Responders

Product	Agency			Direct Mail		
	Responder ISR	Non-Responder ISR	Significant at 10% (p-value)	Responder ISR	Non-Responder ISR	Significant at 10% (p-value)
Kitchen Faucet Aerator	68%	58%	No (0.1398)	60%	42%	Yes (0.0120)
Energy Education	47%	42%	No (0.1750)	55%	39%	Yes (0.0017)
Furnace Whistle	42%	19%	Yes (0.0007)	31%	32%	No (0.5953)
LED Bulbs	87%	78%	Yes (0.0137)	84%	82%	No (0.2966)
Nightlight	93%	89%	No (0.1025)	91%	80%	Yes (0.0011)
Low-Flow Showerhead	65%	60%	No (0.3039)	61%	52%	No (0.1416)
Tier 2 Advanced Power Strip	71%	67%	No (0.3102)	63%	51%	Yes (0.0332)

To help explain these results, Cadmus asked both responders and non-responders in phone surveys about their attitudes toward energy efficiency and any barriers to achieving energy savings. The *Responder and Non-Responder Comparison* discussion in *Section 13.6.3.2 Program Satisfaction* provides the results from the additional questions.

106 Cadmus used two-sample t-tests to determine differences in responder and non-responder ISRs.

13.4 Net Impact Evaluation

Energy Efficiency Kits and Education Program is offered to income-eligible customers in the low-income community. No free riders are anticipated among the population receiving the energy-savings kits because income-constrained customers are not likely to purchase the items in these kits on their own. The program assumes an NTG ratio of 1.0.

13.5 Verified Savings Estimates

In Table 13-9, Cadmus applied the realization rates to the reported energy and demand savings estimates to calculate the verified savings estimates for the Energy Efficiency Kits and Education Program in PY9. These totals are added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 13-9. PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) [1]	Total Demand (MW/yr) [1]
PYRTD Gross	12,205	0.90
PYVTD Gross	11,829	1.10
PYVTD Net[2] [3]	11,829	1.10
P3RTD Gross	22,625	1.65
P3VTD Gross	21,049	1.98
P3VTD Net [2] [3]	21,049	1.98

(1) Total may not match due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy savings compliance target.
(3) Net savings are not computed because program is assumed to have a NTG ratio of 1.0.

13.6 Process Evaluation

13.6.1 Research Objectives

Cadmus conducted the PY9 process evaluation with a focus on program delivery and participation and addressed the following research objectives:

- Identify areas of program successes and challenges
- Identify areas that may benefit from program improvements
- Assess satisfaction of customers receiving the kits

13.6.2 Evaluation Activities

The PY9 process activities included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Benchmarking
- Logic model review
- Analysis of postcard participant surveys
- Telephone participant surveys and analysis

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

- Cadmus did not conduct community-based organizations (CBO) interviews in PY9 because responses to interview questions have remained consistent throughout the program, including during the transition from Phase II to Phase III.
- Cadmus conducted follow-up phone surveys with a sample of participants who responded to the paper kit survey to gather information about why responders and non-responders may achieve different ISRs.

Table 13-10 lists the process evaluation sampling strategy. Additional details about Cadmus' approach to contacting customers and the sample attrition are presented in *Appendix L.2.2*.

Table 13-10. PY9 Energy Efficiency Kits and Education Program Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame [1]	Percent of Sample Frame Contacted to Achieve Sample [2]
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone In-depth Interview	3	N/A	3	3	3	100%
Participants	Agency responders	Paper kit survey	13,203 [3]	N/A	N/A	166	N/A	N/A
		Telephone survey		0.5	70	20 [4]	6,990	57% [5]
	Agency non-responders	Telephone survey		0.5	70	70		
	Direct mail non-responders	Telephone survey		0.5	70	70		
	Direct mail responders	Telephone survey		0.5	70	70		
		Paper kit survey		N/A	N/A	1,181	N/A	N/A
Program Total	**N/A**	**N/A**	**13,206**	**N/A**	**283**	**1,580**	**6,993**	**N/A**

(1) Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database. After selecting all unique records, Cadmus removed any records from the population of customers who had participated in a survey in the last three months, had been selected for another program survey, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey.
(2) Percent contacted means the percentage of the sample frame contacted to complete surveys.
(3) Number of unique kits verified and not returned to the ICSP, not unique jobs.
(4) Due to the low number of agency responders in the population, Cadmus was unable to reach the targeted number of telephone surveys after exhausting the sample frame of agency responders.
(5) Cadmus provided the survey firm with 6,990 records, but only 3,970 records were needed to reach the survey target.

13.6.2.1 Survey Methodology

Cadmus collected most participant data from the paper surveys included in the kits and returned to the ICSP. Cadmus collected additional responses from participants who did not return the paper survey (230 non-responders) through telephone surveys. Both surveys asked identical questions to assess experience and satisfaction with the program and to verify product installation. Cadmus also conducted follow-up surveys with a stratified random sample of participants who returned the paper survey to assess differences in program engagement between responders and non-responders.

Completed participant surveys produced a measurement of program satisfaction with ±1% precision at 90% confidence. Of 13,203 kits distributed (and not sent back or returned to the agency), 1,347 participants returned the paper survey, a response rate of 10%. This response rate is lower than the 16% achieved in PY8.[107] Altogether, Cadmus collected 1,487 participant responses,[108] providing data to determine energy and demand *ex post* verified savings estimates that exceeded the 90% confidence and 10% precision (90/10) by stratum (agency and direct mail) and for the program overall.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of the response list in the telephone survey items to reduce order effects
- Employ stratified random sampling

Cadmus used the same questionnaire for the telephone and paper surveys conducted in PY9 so survey data were collected consistently, although, unlike the paper surveys, the telephone surveys employed randomization of the response lists. The SWE team and PPL Electric Utilities reviewed and approved the surveys in PY8 before they were fielded in PY9.

13.6.2.2 Program Staff and ICSP Interviews

In February of 2018, Cadmus conducted three interviews with the Energy Efficiency Kits and Education Program managers from PPL Electric Utilities and the ICSPs. The interviews focused on assessing the changes made to the program from PY8, the planned changes in PY10, program successes, and program challenges.

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[107] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Submitted to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

[108] Although Cadmus collected a total of 1,577 paper and telephone survey responses, only 1,487 surveys included questions for use in the impact evaluation. The rest of the surveys were conducted with responders to the paper survey (already counted in the 1,487) and included questions for process purposes only.

13.6.3 Process Evaluation Findings

13.6.3.1 Program Delivery

Overall, Cadmus found that the ICSP continued to deliver the Energy Efficiency Kits and Education Program well in PY9. Both PPL Electric Utilities and the ICSP reported that the program was delivered effectively through the two delivery channels (direct mail and agency). Of the 22 CBOs, the ICSP said that 12 or 13 had relatively consistent kit delivery. The ICSP considered recruiting additional agencies in PY9 but did not find any that cover underserved areas.

In the PY8 evaluation, PPL Electric Utilities and the ICSP reported challenges in managing an inventory for two types of kits (with and without the water heating products) and delivering the right type of kit to customers. But in PY9, they said they did not have these same challenges because they determined the correct shipping frequency and volume of kits appropriate for each agency. The ICSP received some comments from agencies that their clients are confused about the two kit types; in response to this, PPL Electric Utilities and the ICSP have considered conducting additional training for agencies on why a customer receives a specific kit type.

Marketing and Outreach

Cadmus analyzed the returned paper and telephone surveys conducted with a random sample of non-responders (participants who did not respond to the paper survey). The surveys asked participants how they learned about the program. Of agency participants (n=166), 64% learned about the program through an agency or community-based organization, and 13% learned through word of mouth. These results are almost identical to the PY8 results (64% and 15%, respectively, n=335). Of direct mail participants, 67% (n=1,172) found out about the program through a mailer and 14% through the PPL Electric Utilities website. The PY9 results for the mailer and PPL Electric Utilities website are almost identical to the PY8 results (64% and 10%, respectively).

The surveys also asked participants if they knew that PPL Electric Utilities provided funding for the energy savings kits before their participation. Nineteen percent of agency participants (n=167) and 14% of direct mail participants (n=1,171) said that, before participating, they knew PPL Electric Utilities was the program sponsor. The PY9 results are slightly lower than the PY8 results, where 25% of agency participants (n=339) and 20% of direct mail participants (n=1,767) said that, before participating, they knew PPL Electric Utilities was the program sponsor.

Program Changes

In PY9, program stakeholders made three primary changes to the program:

- **Program marketing approach.** PPL Electric Utilities and the ICSP modified the timing of the program's marketing to reduce the number of kits delivered at one time. Instead of three large marketing efforts per year, they moved to smaller, more consistent marketing efforts throughout the year.

- **Program outreach.** PPL Electric Utilities added new program outreach materials, including flyers in the kits that provided more information about other programs, including WRAP. Additionally, PPL Electric Utilities sent postcards that reminded customers to return the kit surveys as well as second mailers with educational information on other actions customers can take (taking shorter showers, washing clothes in cold water, etc.).
- **Program delivery.** In PY8, agencies reported that some customers had issues with transporting the kit home with them. In response, PPL Electric Utilities conducted a pilot at the end of PY9 with some agencies by offering straps that can be added to kits as handles.

Areas Working Well

Overall, Cadmus found that many aspects of the program are working well. Both of the delivery channels (direct mail and agency) are efficiently distributing kits to eligible customers. The ICSP saw particular success with a mailer it sent to solicit participants into the direct mail channel, which generated a return rate of around 20%. The ICSP targeted the mailer using data from PPL Electric Utilities' OnTrack Program; 67% of direct mail customers learned about the program from a mailer. Of participants who received their kits through an agency, 64% learned about the program from an agency or community-based organization.

In addition to these program successes, customers are satisfied with the program—98% of customers said they were either *very satisfied* (86%) or *somewhat satisfied* (12%) with the program. PPL Electric Utilities and the ICSP thought that the kits were well received by customers for the following reasons:

- The kits allowed low-income renters to make some energy efficiency improvements in their home even if their landlord did not participate in another PPL Electric Utilities program.
- The kits created a positive customer experience.
- The kits increased customer awareness of other PPL Electric Utilities programs through the information included in the kit and by introducing customers to energy efficiency.

Challenges

PPL Electric Utilities and the ICSP reported a few areas that were not working well in PY9, including agency delivery issues. Just under half of the agencies delivered fewer kits than PPL Electric Utilities and ICSP expected, a trend continuing from PY8. The ICSP thinks the issue may be for one of several reasons, such as agency staffing, other priorities, or the seasonality of their work. Some of these issues were confirmed anecdotally in interviews with low-distributing agencies in PY8: one agency said that due to downsizing, it could not conduct as many one-on-one trainings. However, the size of the kits was also a problem for this agency since the kits were larger than in prior years, both in terms of storing them at the agency and finding places big enough to hold workshops. Additionally, both interviewed low-distributing agencies claimed to largely serve senior citizens and said it was often difficult for these clients to come into the agencies. Overall, PPL Electric Utilities and the ICSP also think the agency delivery channel could deliver more kits—in PY9, agencies constituted only about 20% of all kit deliveries.

The ICSP received a lot of questions from agencies and program participants about the advanced power strip, specifically because this item has a more complex installation process than other products in the kit. Similar to the agency delivery issues, this is a continuing trend from PY8, and a concern expressed by both low- and high-distributing agencies during Cadmus' agency interviews in PY8.

Suggested Program Improvements

PPL Electric Utilities and the ICSP suggested improvements for PY10 to increase agency engagement, extend messaging, deliver kits more consistently across the year, raise realization rates, and enhance kit portability.

- **Agency engagement.** The ICSP thinks it would be beneficial to conduct follow-up training on program operations and requirements with the agencies midway through the program year. The ICSP and PPL Electric Utilities view increasing agency engagement as an avenue to broadening customer participation in the program.
- **Messaging.** The ICSP plans to make small changes to program messaging, based on customer feedback in PY9.
- **Consistent delivery.** The ICSP would like to deliver kits consistently across the program year. They recognize that distributing the majority of direct mail kits in a short amount of time is difficult and would rather see a more even flow of around 2,000 kits per month. Their first step toward this improvement was to change the timing of program marketing in PY9, from three major efforts to more consistent marketing throughout the year.
- **Increase realization rates.** The ICSP and PPL Electric Utilities are re-evaluating the products to include in the kits. They decided to include one more LED nightlight and one more low-flow showerhead to the PY10 kits.[109]
- **Kit portability.** Assuming the pilot goes well, PPL Electric Utilities plans to make the tape handles to ease kit transport a program-wide feature.

13.6.3.2 Program Satisfaction

Participant Satisfaction

As shown in Figure 13-1, customers are generally satisfied with the energy efficiency kit they received as part of the program; 98% of customers said they were either *very satisfied* (86%) or *somewhat satisfied* (12%). Although overall satisfaction (top two categories) is consistent with PY8, the percentage of respondents saying they are *very satisfied* is significantly lower.[110]

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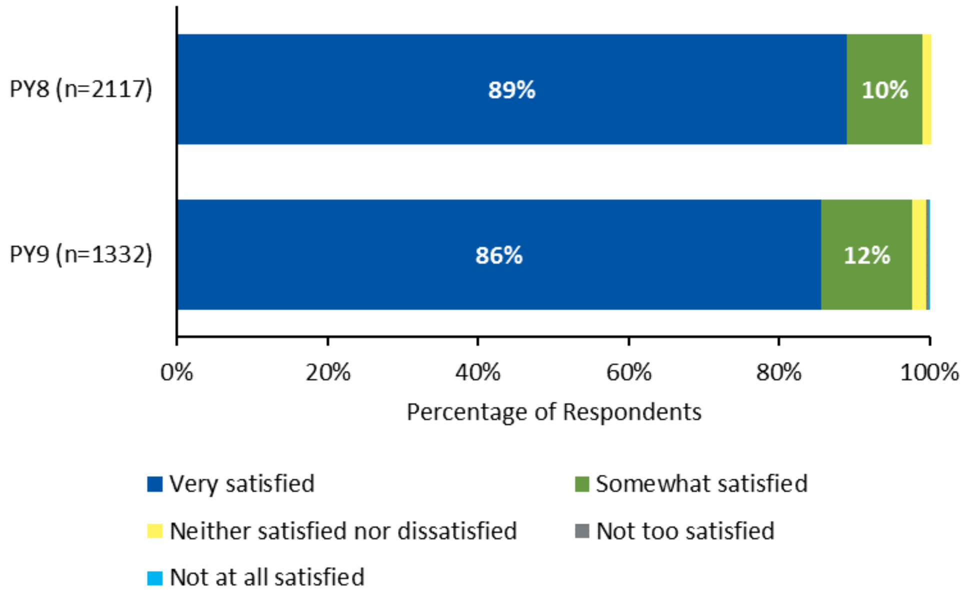
[109] Only kits sent to homes with electric water heating will receive low-flow showerheads.

[110] Cadmus used a two-tailed t-test to test for statistical significance. The p-value is 0.0039.

Figure 13-1. Participant Satisfaction with Energy Efficiency Kit



Source: Non-responder survey question, "Thinking about your overall experience with the Energy Efficiency Kit, how would you rate your satisfaction? Would you say you are…" Does not total 100% because of rounding.

Cadmus asked participants who received a kit from an agency if they had any specific issues with the education provided by agencies. Although the majority had no issues, a small percentage of participants responded they did:

- Agency did not help the customer understand the potential energy savings (7%; n=160)
- Customers did not have everything they needed from the kit to install the products (5%, n=162)
- Agency did not answer questions about the purpose of products in the kit (4%; n=157)

These values are only two to three percentage points higher than in PY8, and the differences are not statistically significant.

Responder and Non-Responder Comparison

Cadmus included the same questions in the telephone surveys conducted with non-responders and in the follow-up surveys with a random sample of participants who had returned a paper survey (responders). The questions asked participants about their attitudes toward the energy efficiency kits and barriers they experienced installing the products. The purpose of these questions was to identify any key differences in ISRs (discussed in greater detail in *Section 13.3.5 In-Service Rates*) and whether differences could be explained, in part, by differences in program engagement between participants who responded to the paper survey and those who did not. Cadmus compared responses overall and by delivery channel and found the following.

More non-responders than responders and more agency participants than direct mail participants reported being focused on saving money and that the kit helped them do that.

- 64% of non-responders (n=128) and 54% of responders (n=81) *strongly agree* that installing items from their kits helps them lower their electricity bill (combined 60% *strongly agree*, n=209).
- 94% of non-responders (n=137) and 84% of responders (n=90) *strongly agree* that they are motivated to install products in the kit because they want to save money (combined 90% *strongly agree*, n=227).
- 69% of agency participants (n=80) and 55% of direct mail participants (n=129) *strongly agree* that installing items from their kits helps them lower their electricity bills.

Fewer non-responders than responders and fewer direct mail participants than agency participants knew how to install all or most of the products from the kits, were able to install all the products themselves, and found the installations difficult or time-consuming.

- 55% of non-responders (n=136) and 62% of responders (n=90) *strongly agreed* that they knew how to install all the products in the kit (combined 58% *strong agree*, n=226).
- Of participants who did not install all products in their kits, 27% of non-responders (n=113) and 15% of responders (n=72) said they were not able to install all the products themselves. Additionally, 16 % of non-responders and 7% of responders could not figure out how to install all the products (including furnace whistles, power strips and other products). More responders (21%) than non-responders (7%) said they did not want to install all of the products.
- 58% of agency participants (n=86) *strongly disagreed* that "installing items from the kit is difficult or time-consuming," compared to only 42% of direct mail participants (n=136).

Agency participants indicated they had a better understanding of where to get information about the products in the kits than did the direct mail participants.

- 51% of agency participants (n=88) and 35% of direct mail participants (n=130) *strongly disagreed* with the statement "I don't know where to get information about the items in the kit."

13.6.3.3 Benchmarking

Act 129 Programs

Three Pennsylvania utilities offer kit programs under Act 129. PECO distributes kits as part of its low-income home energy audits but did not offer the program in PY8. FirstEnergy has an energy efficiency kits program, but it is not specifically for low-income customers. Duquesne Light offers a low-income program. Cadmus benchmarked the three PA programs.

Table 13-11 shows the target populations, delivery methods, number of kit types, products included, number of kits distributed, and per-kit electricity savings reported in PY8. PPL Electric Utilities is the only Act 129 utility to deliver kits through two separate channels, and the only utility to deliver kits through agencies. However, its mix of products and savings per kit align closely with both Duquesne Light and FirstEnergy Companies. PPL Electric Utilities distributed more kits than the other EDCs.

Table 13-11. Act 129 Kit Program Comparison

<table>
<tr><th>Metric</th><th>PPL Electric Utilities Energy Efficiency Kits and Education (1)</th><th colspan="2">Duquesne Light Low-Income Kits</th><th>First Energy Companies Low-Income Energy Efficiency Kits Initiative</th></tr>
<tr><td>Target Population</td><td>Low-income</td><td colspan="2">Low-income</td><td>Residential (with a low-income component)</td></tr>
<tr><td>Delivery Method</td><td>Agencies, mail</td><td colspan="2">Targeted community events</td><td>Mail</td></tr>
<tr><td>Number of Kit Types</td><td>2</td><td colspan="2">3</td><td>2</td></tr>
<tr><td>Products</td><td>LED Lamps
LED Nightlights
Showerhead (2)
Kitchen Aerator (2)
Furnace Whistle
Tier 2 Advanced Power Strip</td><td>LED EE Kit:
LED Lamps
LED Nightlights</td><td>CFL EE Kit
CFL Lamps
Electroluminescent Nightlights
Advanced Power Strip</td><td>LED Lamps
CFLs
LED Nightlights
Showerhead (2)
Aerator (2)
Furnace Whistle</td></tr>
<tr><td>Kits Distributed</td><td>12,058</td><td colspan="2">-</td><td>11,130</td></tr>
<tr><td>Evaluated Savings per Kit (kWh/yr) (3)</td><td>593</td><td colspan="2">410 (LED EE kit)
288 (CFL EE kit)</td><td>542 (Electric kit)
331 (Standard kit)</td></tr>
<tr><td colspan="5">(1) Values from PY8 evaluation of the Energy Efficiency Kits and Education program to align with timing of comparison programs.
(2) Products only included in kits distributed to customers with electric water heating.
(3) On average across kit types unless otherwise specified.</td></tr>
</table>

Expanded Benchmarking

Cadmus benchmarked the Energy Efficiency Kits and Education Program against four similar programs by analyzing each program's design, products, delivery, marketing, and performance, when available. Cadmus sought to include a mix of programs from different parts of the country and not only from Pennsylvania/the Northeast.

- Iowa's Energy Wise Program
- Duquesne Light's Low-Income Energy Efficiency Program (also an Act 129 program)
- Focus on Energy's Simple Energy Efficiency Program
- PacifiCorp's Wattsmart Starter Kits Program

Two of the programs that Cadmus selected, Focus on Energy and PacifiCorp's programs, are not specifically for low-income customers. Cadmus selected these programs because, while they are not low-income programs, they offer similar products and have a similar design to the Energy Efficiency Kits and Education program. The Iowa and Duquesne Light programs target only low-income customers.

Cadmus investigated two components of these programs to compare to the Energy Efficiency Kits and Education Program: how program administrators deliver kits to their customers and the types of kits provided. Cadmus focused on these program aspects in part because PPL Electric Utilities and ICSP program staff indicated that these are program components of particular interest.

Kit Delivery

As in the Energy Efficiency Kits and Education Program, three of the four program administrators deliver kits to their customers through either partnering agencies or through the mail. Duquesne Light's Low-Income Energy Efficiency Program delivers kits to customers at targeted low-income community events hosted by agencies. Through these events, Duquesne Light delivered 4,029 kits during its 2016-2017 program year. The low-income Iowa Energy Wise Program partnered with 19 agencies that delivered 4,500 kits in 2017, requiring customers to attend a one-hour energy education session or a one-on-one training with agency staff. This program's initiative focused heavily on behavior change as a means of reducing energy consumption. Similar to the Energy Efficiency Kits and Education Program, these programs rely on agencies for the majority of marketing support.

Focus on Energy's Simple Energy Efficiency Program and PacifiCorp's Wattsmart Starter Kits Program both deliver kits to customers through the mail, requiring customers to sign up for kits through a website (Focus on Energy also allows customers to sign up for the program through a call center). As these programs are not targeting low-income customers, both offer low-cost kits in addition to no-cost options: Focus on Energy low-cost kits cost customers between $3.00 and $8.95, while PacifiCorp's low-cost kits cost $4.99 each. Both of these programs reported using bill inserts as a primary means of promoting their kit program, while the Energy Efficiency Kits and Education Program relies heavily on direct mailers.

Unlike the Energy Efficiency Kits and Education Program delivery, none of these programs delivered their kits through multiple channels. Another important distinction is that only the programs that delivered kits through the mail (requiring customers to enroll online or over the phone at a call center) offer multiple kit types based on customers' electric water heating. Duquesne Light's low-income kit program offers two types of kits, but all low-income customers are eligible for either kit as they do not include water-saving products. As noted in the *Challenges* section in *13.6.3.1 Program Delivery*, the Energy Efficiency Kits and Education Program's agency delivery is heavily dependent on about half of the partnered agencies, while the others have continued delivering fewer kits than expected. One low-distributing agency staff member commented that although it used to hold workshops to deliver kits, it did not hold any in PY8 out of fear that clients would blame it when the kits lacked some of the products. It may be asking too much of some of the agencies to deliver two different types of kits to their clients.

Types of Kits

Cadmus found a variety of products included in the kits offered by the four programs, shown in Table 13-12. Although all included lighting products, only some included water-saving products, advanced power strips, or insulation products. The Iowa Energy Wise Program only offered one kit, but it included the largest variety of products, such as lighting, water-saving, weather-stripping, and window insulation. Only Iowa and Focus on Energy kit programs included insulation products. The products included in the Energy Efficiency Kits and Education Program are well-aligned with the types of products included in the majority of the kits.

Table 13-12. Energy-Efficiency Kits and Education Program Product Comparisons

Products		PPL Electric Utilities Energy Efficiency Kits and Education	Iowa Energy Wise	Duquesne Light Low-Income Kits	Focus on Energy Simple Energy Efficiency (1)	PacifiCorp WattSmart Starter Kits
		Two Kits	One Kit	Three Kits (2)	Eight Kits (3)	Eight Kits (3)
Lighting	CFL	-	-	(CFL EE kit only) Two 13 W One 20 W One 23 W	Up to two (one 13 W; one 23 W)	Up to four A19s
	LED	Six 9 W	Three 9 W	(LED EE kit only) Two 9 W Two 11 W Two 15 W	Up to three A19s Up to four 10 W Flood Up to three 5 W Globe Up to three 5 W Candle	Up to four A19s
	Nightlight	One	-	Two	-	-
Other Products	Advanced Power Strip	One (Tier 2)	-	Up to one (4)	Up to one (Tier 1)	-
	Furnace whistle	One	One	-	-	-
	Digital Room Thermometer	-	One	-	-	-
Water-Saving Products	Showerhead	One (5)	One	-	Up to one	Up to two (5)
	Faucet Aerator	One (5)	Two	-	Up to two	Up to three (5)
	Water Flow Bag	-	One	-	-	-
Insulation Products	Rope Caulk	-	One	-	-	-
	Pipe Insulation	-	-	-	Up to one	-

(1) Focus on Energy has eight different kits with different products in each kit.
(2) The third kit contains between one to four LED or CFL bulbs and no nightlight or power strip.
(3) Three of the eight kits are offered at no cost to customers.
(4) Did not specify Tier 1 or Tier 2.
(5) These products are only included in electric hot water kits.

Only one of the programs, Iowa's Energy Wise Program, incorporated behavior changes into total savings calculations. The evaluator for that program used a survey to ask customers about their energy efficiency behaviors, specifically temperature changes for water heating and space heating and cooling, changes in shower length, and unplugging electronics. The Energy Efficiency Kits and Education Program also includes behavior change savings for water heating and space heating and cooling.

Across all benchmarked programs, the evaluated savings per kit ranges from 123 kWh/yr for PacifiCorp's CFL-only kit to 410 kWh/yr for Duquesne Light's LED kit. The Energy Efficiency Kits and Education Program obtained the highest per-kit savings with 593 kWh/yr. Table 13-13 shows the number of kits distributed and evaluated savings by program.

Table 13-13. Energy-Efficiency Kits and Education Program Benchmarks

Metric	Unit	Program				
		PPL Electric Utilities Energy Efficiency Kits and Education	Iowa Energy Wise	Duquesne Light Low-Income Kits	Focus on Energy Simple Energy Efficiency	PacifiCorp Wattsmart Starter Kits
Kits Distributed	Kits	13,203	4,500	- [1] [2]	70,978	34,013
Evaluated Savings per Kit [3]	kWh/yr	593	379	410 for LED kit 288 for CFL kit	159	123
	Therms	17.4	21.1	- [1]	9.7	- [1]
	Gallons	2,144	3,682	- [1]	- [1]	- [1]

[1] Throughout the table, "- "denotes when a given metric is either unavailable or not calculated.
[2] Duquesne Light gives away kits but does not track low-income participation.
[3] On average across kit types unless otherwise specified.

13.7 Cost-Effectiveness Reporting

Details of program finances and cost-effectiveness are presented in Table 13-14. Cadmus calculated TRC benefits using gross verified impacts. The net present value program year-to-date (NPV PYTD) benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). Net present value costs and benefits for P3TD financials are expressed in PY8 dollars.

Table 13-14. Summary of Energy Efficiency Kits and Education Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	-		-	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$40	-	$100	-
7	Marketing [4]	-	$150	-	$250
8	Program Delivery [5]	-	$1,842	-	$3,432
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	$2,032		$3,782	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	$2,032		$3,782	
14	Total NPV Lifetime Electric Energy Benefits	$2,342		$3,844	
15	Total NPV Lifetime Electric Capacity Benefits	$443		$746	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$415		$763	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$2,426		$2,254	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	$5,626		$7,607	
19	**TRC Benefit-Cost Ratio [9]**	**2.77**		**2.01**	

[1] May not sum to total due to rounding.
[2] All costs for plan design and development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 13-15 presents program financials and cost-effectiveness on a net savings basis. Net verified savings are equal to gross verified savings because the program is assumed to have a NTG ratio of 1.0

Table 13-15. Summary of Energy Efficiency Kits and Education Program Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	-		-	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$40	-	$100	-
7	Marketing [4]	-	$150	-	$250
8	Program Delivery [5]	-	$1,842	-	$3,432
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	$2,032		$3,782	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	$2,032		$3,782	
14	Total NPV Lifetime Electric Energy Benefits	$2,342		$3,844	
15	Total NPV Lifetime Electric Capacity Benefits	$443		$746	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$415		$763	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$2,426		$2,254	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	$5,626		$7,607	
19	**TRC Benefit-Cost Ratio [9]**	**2.77**		**2.01**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as “Program Delivery” costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[111] A summary of the methodologies Cadmus used to calculate the non-energy benefits of saved water, natural gas therms, and lighting interactive effects can be found in *Appendix P Non-Energy Benefits*.

Non-Energy Benefits of Water Saving Products

This program offers two water-saving products: low-flow showerheads and faucet aerators. Table 11-15 summarizes the data used to determine non-energy benefits for water-saving products for this program.

Table 13-16. Energy Efficiency Kits and Education Non-Energy Benefits for Water Saving Products

Products	Stratum	TRM #	Gallons of Water Saved per Unit (1)	Number of Units Distributed	ISR (2)	Gallons of Water Saved
Faucet Aerators	Agency	2.3.8	1,989	1,409	65%	1,815,338
	Direct Mail	2.3.8	2,171	7,543	58%	9,574,398
Showerheads	Agency	2.3.9	3,572	1,409	64%	3,203,057
	Direct Mail	2.3.9	3,085	7,543	60%	13,911,738

(1) Unit savings were calculated using average household size and number of showers estimated from enrollment surveys
(2) Direct mail ISRs are adjusted to reflect the share of direct mail kits returned (1.86%)

Non-Energy Benefits of Natural Gas Savings

Water-saving products were distributed to homes with electrically heated water. However, some homes may have either been miscategorized or changed water-heating configuration after the beginning of the program. Surveys indicated that 1.7% of homes that received water-saving products heated water with fossil fuel. This program offers these fossil fuel-saving products: temperature setback (thermostat and water heater), furnace whistles, low flow showerheads, and faucet aerators.

Table 13-17 summarizes the savings estimates for each product and fuel type.

Table 13-17. PY9 Energy Efficiency Kits and Education Non-Energy Benefits for Fossil Fuel Saving Products

Stratum	TRM #	Unit Therms Savings (1)	Number of Units Distributed	ISR (2)	% Fossil Fuel	Therms Savings (Total)
Faucet Aerators (homes with fossil fuel water heaters receiving kits with water products)						
Agency	2.3.8	9.3	1,409	65%	2%	170
Direct Mail	2.3.8	8.3	7,543	58%	0.3%	85
Showerheads (homes with fossil fuel water heaters receiving kits with water products)						
Agency	2.3.9	18.4	1,409	64%	2%	332
Direct Mail	2.3.9	15.4	7,543	60%	0.2%	157
Thermostat Setback (energy education component)						
Agency	2.2.8	52	2,519	69%	67%	60,310
Direct mail	2.2.8	55.9	10,778	70%	42%	175,565

111 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

Stratum	TRM #	Unit Therms Savings (1)	Number of Units Distributed	ISR (2)	% Fossil Fuel	Therms Savings (Total)
Water Heater Setback (energy education component)						
Agency	2.3.6	3.7	2,519	26%	44%	1,050
Direct Mail	2.3.6	3.4	10,778	36%	28%	3,648
Furnace Whistles						
Agency	2.2.7, 2.2.2	2.4	2,519	40%	67%	1,605
Direct Mail	2.2.7, 2.2.2	2.4	10,778	32%	42%	3,430

(1) Unit savings were calculated using average household size, number of showers, water heater recovery efficiency, and EFLH estimated from enrollment surveys.
(2) Direct mail ISRs are adjusted to reflect the share of direct mail kits returned (1.86%)

Lighting Interactive Effects

Cadmus included heating penalties as a negative benefit in the TRC test for efficient lighting, according to the Guidance Memo.

Table 13-18. PY9 Energy Efficiency Kits and Education Lighting Gas Heating Penalties Inputs

Product	Gas Heat Fuel Share	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therms per kWh/yr)
LED A-9	29%	90.48%	65.5%	20%	0.8	0.00586

According to the Guidance Memo, Cadmus assumed only that there was a natural gas therms penalty. The results, by stratum, are shown in Table 13-19. Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Table 13-19. PY9 Energy Efficiency Kits and Education Lighting Gas Penalties

Product	Number of LEDs Distributed	*Ex Post* Total (kWh/yr)	Heating Penalty (Therms per kWh/yr)	Total Heating Penalty (Therms)
LED A-9	79,218	2,621,186	0.00586	15,360

13.8 Recommendations

Overall, the Energy Efficiency Kits and Education Program has performed as expected according to the program design and has exceeded both its projected participation and projected savings. Recommendations are provided in Table 13-20, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Energy Education Savings

Finding: The Energy Efficiency Kits and Education Program achieved 97% of its reported savings, an improvement upon the PY8 realization rate of 88%. This increase was driven by the direct mail delivery channel, specifically because average verified energy education savings per kit are more closely aligned with the ICSP's reported energy education savings per kit (253 kWh/yr). In PY9, Cadmus found average per-kit energy education savings of 287.21 kWh/year in the direct mail channel, compared to 172.65

kWh/yr in PY8. This increase was only because kits with water-saving products constituted more of the total number of direct mail kits distributed (70% in PY9, compared to 55% in PY8). The average per-kit savings in the agency stratum remained similar (161.34 kWh/yr) as its distribution of kit types did not change drastically. (See *Section 13.3.4 Gross Impact Evaluation Results* for details on this finding.)

Conclusion: The ICSP reported the same energy education savings for every participant, regardless of stratum and kit type. Differentiating energy education savings for kits without water-saving products could increase the accuracy of reported savings and improve realization rates.

Recommendation #1: Consider reporting separate per-kit energy education (*ex ante*) savings for kits with and without water-saving products. Use the savings verified in the prior year's evaluation (for example, use the PY9 verified savings for PY10 reported *ex ante* savings), which are provided in *Appendix L.1.3 Survey Findings*.

In-Service Rates

Finding: For some products, Cadmus found significantly different ISRs between responders (those who returned the paper surveys from the kit) and non-responders (those who did not return the paper survey). Specifically, for the agency delivery channel, non-responders installed LED bulbs and furnace whistles at significantly lower rates than responders. For the direct mail delivery channel, non-responders installed kitchen faucet aerators, Tier 2 advanced power strips, and LED nightlights at significantly lower rates, and conducted fewer energy education activities, than responders. Agency participants tended to install products at higher rates than direct mail participants. (See *Section 13.3.5 In-Service Rates* for further discussion on these results.)

Finding: Responders and agency participants more frequently *strongly agreed* that they knew how to install all or most of the products in the kits compared to non-responders and participants who received their kits in the mail. (See the *Responder and Non-Responder Comparison* discussion in *Section 13.6.3.2 Program Satisfaction* for further details on these findings).

Finding: Agency participants more frequently *strongly agreed* that they knew where to get information about the products in the kits than did the direct mail participants. (See the *Responder and Non-Responder Comparison* discussion in *Section 13.6.3.2 Program Satisfaction* for further details on these findings.)

Conclusion: Responders and non-responders, as well as agency and direct mail participants, differed in their attitudes and knowledge about energy efficiency and barriers to installing products or implementing energy efficiency (based on information gathered in follow-up phone surveys with participants). These differences may lead to differences in ISRs between groups. Although non-responders appeared to be more motivated to save money by installing products from the kit, they faced certain barriers to installing these products more often than responders. Direct mail participants faced similar barriers more often than agency participants.

Recommendation #2: Consider ways to increase program engagement and ISRs, especially in the direct mail stratum, by adding or clarifying installation instructions and highlighting the call center phone number and website in the installation instructions for participants who seek help installing products.

Products included in Kits

Finding: Iowa's Energy Wise Program incorporates behavior change into its savings calculations, specifically temperature changes for water heating and space heating/cooling, changes in shower length, and unplugging electronics. (See *Section 13.6.3.3 Benchmarking* for details on this finding.)

Finding: The products in the Energy Efficiency Kits and Education Program kits are generally consistent with the lighting and water products that benchmarked utilities have in their kits, except that PPL Electric Utilities' kit does not contain insulation products. (See *Section 13.6.3.3 Benchmarking* for details on this finding.)

Conclusion: The products in the Energy Efficiency Kits and Education Program compare well with other Act 129 kit programs and other kit programs in the country. All programs offer some form of lighting (usually LEDs) and usually offer water-saving products, such as showerheads and aerators, to customers with electric water heating.

Recommendation #3: Consider adding an insulation product, such as rope caulk or weatherstripping, to increase the number and types of energy efficiency upgrades customers can make.

Finding: The ICSP received reports from agencies that many customers were confused about how to install the advanced power strips. However, the ICSP is not including advanced power strips in the PY10 kits. (See *Section 13.6.3.1 Program Delivery* for details on this finding.)

Finding: Three of seven programs (PPL Electric Utilities, Focus on Energy, and Duquesne Light) included an advanced power strip in program kits. Focus on Energy includes a Tier 1 smart strip in some of its kits. Duquesne Light also includes a power strip in its low-income kits but did not specify whether it was a Tier 1 or a Tier 2. (See *Section 13.6.3.3 Benchmarking* for details on products provided in other kit programs.)

Kit Distribution Channels

Finding: The direct mail channel delivered the vast majority of program kits in PY9 (10,684 kits, or 81% of kits distributed and not returned in PY9). (See *Section 13.3.2 Sample Design* for details on this finding.)

Finding: According to the ICSP, nine or 10 of the participating agencies (almost half) had not distributed as many kits as anticipated. Program stakeholders (PPL Electric Utilities and the ICSPs) believe this may be because the agencies lacked the staffing resources necessary to implement the program and had other priorities or because their work may be seasonal. (See *Section 13.6.3.1 Program Delivery* for details on this finding.)

Finding: The ICSP said efforts to recruit additional agencies to the program in PY9 were unsuccessful because the ICSP did not find any agencies that covered underserved areas. (See *Section 13.6.3.1 Program Delivery* for details on this finding.)

Finding: Similar to the Energy Efficiency Kits and Education Program, Duquesne Light's Low-Income Energy Efficiency Program and Iowa's Energy Wise Program rely on agencies to distribute a significant number of kits. Neither program offers different kits by type of home water heating. (See *Section 13.6.3.3 Benchmarking* for details on this finding.)

Finding: Focus on Energy's Simple Energy Education Program and PacifiCorp's Wattsmart Starter Kit Program rely solely on the website and call centers to enroll participants and kits are distributed by mail. Both programs offer eight kit types, and several are specifically for electric water heating. (See *Section 13.6.3.3 Benchmarking* for details on this finding.)

Conclusion: Although the Energy Efficiency Kits and Education Program and other similar programs successfully offer different types of kits through the mail, agencies have more difficulty because some customers are not eligible to receive water-savings products, making group workshops difficult and increasing time to distribute kits to their clients. Following up on this, in the beginning of PY10, the ICSP provided agencies with the option to ship kits to participants' homes instead of requiring them to carry the kits home from the agency. This alleviates the struggle of agencies to store kits at their facilities and allows agencies to supply all their clients with kits in either a one-on-one or group workshop setting.

Recommendation #4: Consider adjusting kit-delivery projections for agencies based on the volume they have been able to distribute so far in Phase III and continue to rely heavily on the direct mail delivery channel to reach projected numbers of kit distributions for the program. This will allow PPL Electric Utilities to deliver a sufficient number of kits without changing the program design to accommodate low-distribution agencies and changes in kit delivery options.

13.8.1 Status of Recommendations

Table 13-20 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 13-20. Status of Recommendations Energy Efficient Kits and Education

Energy Efficiency Kits and Education Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Consider reporting separate per-kit energy education (*ex ante*) savings for kits with and without water-saving products. Use the savings verified in the prior year's evaluation (for example, use the PY9 verified savings for PY10 reported *ex ante* savings).	Being considered. The current low income workbook will need adjustments to capture the data. We currently use a blended number to account for this.
2	Consider ways to increase program engagement and ISRs, especially in the direct mail stratum, by adding or clarifying installation instructions and highlighting the call center phone number and website in the installation instructions for participants who seek help installing products.	Being considered. The PPL Electric Utilities logo is on the cover of the instructions, the phone number will be considered. The website already contains the phone number with the ability to watch videos and print instructions for each measure.
3	Consider adding an insulation product, such as rope caulk or weather stripping, to increase the number and types of energy efficiency upgrades customers can make.	Rejected. We believe the measure would not be cost effective to provide and would require a re-design of the kit box. There is also a safety component as well with a professional not installing the measures.
4	Consider adjusting kit-delivery projections for agencies based on the volume they have been able to distribute so far in Phase III and continue to rely heavily on the direct mail delivery channel to reach projected kit distributions for the program. This will allow PPL Electric Utilities to deliver a sufficient number of kits without changing the program design to accommodate low-distribution agencies and changes in kit delivery options.	Implemented. The current low income workbook will be adjusted to reflect the historical mix of agency and direct mail kits. We currently use a historical average for projections.

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APPLIANCE RECYCLING PROGRAM

The program offers an incentive to customers who turn in eligible appliances and provides free pick-up and environmentally sound recycling services.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **22,575 MWh/yr**

34% of projected

84% of projected

PY9 saved **10,731 MWh/yr**

PROGRAM SATISFACTION

98% Satisfied with overall program

98% satisfied with the **clarity of application** requirements

96% satisfied with **PPL Electric Utilities rebates** for qualifying equipment and services

92% satisfied with the **information learned online from PPL Electric Utilities**

PY9 PARTICIPATION

A total of **12,852** participants recycled:

8,692 refrigerators

2,167 freezers

1,327 room air conditioners

666 dehumidifiers

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$4,019**

34% of projected

98% of projected

PY9 expenditures **$2,074**

14 Appliance Recycling Program

In this downstream program, the Appliance Recycling Program, PPL Electric Utilities offers an incentive to customers who turn in eligible appliances and provides free pick-up and environmentally sound recycling services. Refrigerators must measure between 10 and 30 cubic feet to qualify for the program, and both primary and secondary refrigerators and freezers are eligible. Eligible appliances must be plugged in and functioning when picked up. If customers recycle an inefficient refrigerator or freezer, they can also turn in room air conditioners and dehumidifiers; however, these are not picked up as a stand-alone service.

Table 14-1 shows the appliance eligibility parameters and incentives.

Table 14-1. Eligible Equipment and Incentives

Equipment	Eligibility Rating	Incentive Range
Refrigerator	Working unit; > 10 cubic feet and ≤ 30 cubic feet	Between $20 and $75
Freezer	Working unit; > 10 cubic feet and ≤ 30 cubic feet	Between $20 and $75
Room Air Conditioner	Working unit removed from mounting	Between $10 and $25
Dehumidifiers	Working unit	Between $10 and $25

PPL Electric Utilities' energy efficiency programs staff provides overall strategic direction and program management. Its EM&V staff oversees evaluation activities and coordinates with the programs delivery staff.

In PY9, CLEAResult, the ICSP, delivered the Appliance Recycling Program to customers and was responsible for marketing and managing the call center services, online and telephone scheduling of appliance pick-ups, processing applications and rebates, tracking program data, and providing customer and transaction information to PPL Electric Utilities. Recleim, the ICSP's subcontractor, managed the pick-up, decommissioning, and recycling of appliances.

The objectives of the Appliance Recycling Program are these: [112]

- Encourage customers to dispose of their existing, inefficient refrigerators, freezers, air-conditioning units, and dehumidifier units in an environmentally responsible manner
- Reduce the use of secondary, inefficient refrigerators, freezers, and air-conditioning units
- Decommission appliances on the site to prevent resale in a secondary market
- Promote other PPL Electric Utilities' energy efficiency programs
- Achieve a total energy reduction of approximately 65,000 MWh/yr gross verified savings

[112] Program objectives are stipulated in PPL Electric Utilities revised *Energy Efficiency and Conservation Plan Act 129 Phase III.* Docket No. M-2015-2515642. December 2017.

- Achieve high customer satisfaction with the program
- Enhance relationships with box stores and independent retailers to encourage participation in the "buy new and recycle" component

14.1 Progress Toward Phase III Projected Savings

The Appliance Recycling Program's verified savings are within 84% of the projected MWh/yr savings projected for PY9. The program has achieved 34% of the projected Phase III total planned savings and is making progress toward the Phase III projected savings.

Table 14-2 shows the program's verified gross program savings and progress toward its Phase III projected energy savings, as filed in the EE&C plan.

Table 14-2. Appliance Recycling Program Savings

	PY8 Only	PY9 Only			Phase III: PY8–PY12		
	Verified	Projected [1]	Verified	Percentage of Projected	Projected [1]	Verified	Percentage of Projected
MWh/yr	11,844	12,734	10,731	84%	65,522	22,575	34%

[1] Projected savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642), December 2017.

The program did not meet the projected savings for PY9 for these reasons:

- The number of recycled refrigerators and freezers were both less than planned (8,692 refrigerators were recycled compared to 8,798 planned, and 2,167 freezers were recycled compared to 2,200 planned).
- The overall number of recycled units for PY9 was higher than planned because more room air conditioner and dehumidifier units were recycled than anticipated (1,327 room air conditioners were recycled compared to 917 planned, and 666 dehumidifiers were recycled that were not initially included in the projected savings).
- The larger number of recycled room air conditioners and dehumidifiers resulted in lower program savings because their per-unit savings are lower than refrigerators and freezers.
- Per-unit savings for recycled refrigerators and freezers decreased in PY9 because the open variable inputs for the unit energy consumption (UEC) equation differed from the TRM defaults. Part-use factors also differed from the TRM default values.

As recommended by the Phase III Evaluation Framework, in PY9 Cadmus verified all of the open variables, rather than relying on TRM default values, using two data sources: PY9 tracking data for physical appliance characteristics and PY8 survey data to determine primary or secondary status and the rooms in which appliances were used prior to recycling.[113]

[113] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Section 2.3.4.2 Using the TRM to Determine *Ex Post* Savings.

Additionally, Cadmus calculated and applied verified part-use factors for refrigerators and freezers using PY8 participant survey responses rather than applying the TRM default part-use values.

14.2 Participation and Reported Savings by Customer Segment

14.2.1 Definition of a Participant

Cadmus defined participants as unique appliances that were decommissioned through the Appliance Recycling Program during the program year. The program is targeted primarily to residential customers but is available to all PPL Electric Utilities customers with a working, residential-grade refrigerator, freezer, room air conditioner, or dehumidifier.

Table 14-3 presents the participation counts, reported and verified energy and demand savings, and incentive payments for the Appliance Recycling Program in PY9 by customer segment.

Table 14-3. PY9 Appliance Recycling Participation and Reported Impacts

Parameter	GNE	Large C&I (Non-GNE)	Residential	Small C&I (Non-GNE)	Total[1]
PYTD Number Participants	66	5	12,693	88	**12,852**
PYRTD MWh/yr	68	4	13,286	96	**13,454**
PYRTD MW/yr	0.01	0.00	1.87	0.01	**1.89**
PYVTD MWh/yr	53	3	10,598	76	**10,731**
PYVTD MW/yr	0.01	0.00	1.57	0.01	**1.59**
PY9 Incentives ($1000)	$2	$0	$361	$0	**$363**
[1]Total may not match sum of columns due to rounding.					

14.3 Gross Impact Evaluation

Cadmus calculated gross verified savings by gathering data from the PPL Electric Utilities tracking database and from surveys of program participants and used this information as inputs to the savings algorithms specified in the PA TRM. The impact evaluation sampling strategy is listed in Table 14-4.

Table 14-4. PY9 Appliance Recycling Gross Impact Evaluation Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	Impact Evaluation Activity
Appliance Recycling	12,852	N/A [1]	12,852	Database review
Program Total	12,852	N/A	12,852	
[1] Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.				

Table 14-5 shows the Appliance Recycling Program reported energy savings of 13,454 MWh/yr for PY9.

Table 14-5. PY9 Appliance Recycling Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Appliance Recycling	13,454	80%	0.06	7.63%
Program Total (1)	**13,454**	**80%**	**N/A**	**7.63%**
(1)Total may not match sum of rows due to rounding.				

Table 14-6 shows the number of verified units recycled in PY9 and the verified energy savings by product.

Table 14-6. PY9 Gross Energy Results by Product Recycled

Product	PYVTD MWh/yr	Product Count
Refrigerator	8,513	8,692
Freezer	1,486	2,167
Room air conditioner	175	1,327
Dehumidifiers	557	666
Program Total (1)	**10,731**	**12,852**
(1) May not match due to rounding.		

Table 14-7 shows a reported demand reduction of 1.89 MW in PY9.

Table 14-7. PY9 Appliance Recycling Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Appliance Recycling	1.89	84%	0.06	5.78%
Program Total(1)	**1.89**	**84%**	**N/A**	**5.78%**
(1)Total may not match sum of rows due to rounding.				

The ICSP reports the quantity of each recycled appliance (refrigerators, freezers, window air conditioners, and dehumidifiers) using information it uploads to PPL Electric Utilities tracking database. PPL Electric Utilities reports gross savings per appliance using the default inputs for the regression equation provided in the PA TRM,[114] with the exception of the proportion of units manufactured prior to 1990, which were forecasted based on previous year program tracking data.

In PY9, Cadmus populated the open variables in the TRM regression equation using inputs from a census of records from the PY9 tracking data and PY8 participant survey data. PPL Electric Utilities' tracking database tracks the configuration of each refrigerator and freezer recycled,[115] the year of manufacture, and the size of the appliance (in cubic feet). The PY8 participant surveys asked participants whether the appliance they recycled was a primary or secondary appliance as well as in which room the appliance

[114] Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards. February 2017. Available online: http://www.puc.state.pa.us/Electric/docs/Act129/TRM-2016_Errata_Feb2017.docx

[115] Refrigerator configurations include top or bottom freezer, single-door, and side-by-side. Freezer configurations include chest and upright.

was used prior to being recycled. This room determined which appliances were used in unconditioned spaces and were therefore subject to weather conditions.

The following factors led to variation between the reported and verified savings and to the observed realization rate:

- The average refrigerator age was five years younger than the TRM default value (24.3 years rather than 29.4 years).
- The average freezer age was seven years younger than the TRM default (30.2 years rather than 37.5 years).
- The proportion of recycled refrigerators used as the primary refrigerator was 54% rather than the 65% TRM default value.
- Refrigerator UECs were 6% lower with the verified open variable inputs compared to the TRM default values. Freezer UECs were 12% lower.
- The verified part-use factor for refrigerators was 84.4% compared to the TRM default value of 96.9%, and the verified part-use factor for freezers was 72.8% compared to the TRM default value of 98.5%.
- For a complete list of calculated variables used to populate the TRM regression equations, refer to Table M-4 in *Appendix M.1.2*.
- Part-use, that is, the amount of time the appliance is in use, is an adjustment factor specific to appliance recycling that is used to convert the UEC into average per-unit gross savings. The UEC itself is not equal to gross savings, because the UEC model yields an estimate of annual consumption. Not all recycled refrigerators would have operated year-round had they not been decommissioned through the program. As with the open variables for the TRM savings equation, Cadmus estimated a verified part-use factor using PY8 participant survey responses rather than the TRM default value. The part-use factors for both refrigerators and freezers were considerably lower than the TRM default values. This is somewhat expected, because the source of the TRM default values was last updated in PY3. More information about Cadmus' methodology for calculating part-use is contained in *Appendix M.1*.

14.4 Net Impact Evaluation

Cadmus applied the NTG ratio calculated in PY8 for the program in PY9. In PY8, Cadmus followed the methodology described in the Common Methods for Appliance Recycling programs specified by the SWE (Phase III Evaluation Framework, Appendix B).[116] This is consistent with the Uniform Methods Project

[116] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by the Statewide Evaluation Team (NMR Group Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC). Contracted under the Pennsylvania Public Utility Commission's RFP 2015-3 for the Statewide Evaluator. Final version August 25, 2016.

(UMP) appliance recycling protocol to determine program net savings.[117] The NTG ratio determined in PY8 and applied to PY9 is 0.66. Cadmus maintained the PY8 NTG ratio because the delivery of the Appliance Recycling Program did not change in a substantial way, therefore, the NTG ratio is expected to be similar to PY8.

Table 14-8 shows that historical and current NTG ratios, determined using primary data, remained stable over the life of the program, between 0.60 and 0.70, with the exception of a temporary uptick in PY5.[118] PY7 is not included in the table because Cadmus applied the PY6 NTG ratio that year.[119] PY9 is not included in the table because Cadmus applied the PY8 NTG ratio.[120]

Table 14-8. Current and Historical Net-to-Gross Ratios

Program Year	Net-to-Gross Ratio
PY8	0.66
PY6	0.60
PY5	0.74
PY4	0.68
PY3	0.63
PY2	0.61

14.5 Verified Savings Estimates

Table 14-9 shows the reported energy savings (PYRTD) and the verified gross and net energy savings estimates calculated by Cadmus for the Appliance Recycling Program in PY9. These program year totals are added to the savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts for reported, gross verified, and net savings.

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117 National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. "Chapter 7: Refrigerator Recycling Evaluation Protocol." March 2013. Available online: http://energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf

118 PPL Electric Utilities. *Annual Report Program Year 5: June 1, 2013–May 31, 2014.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2014.

119 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.

120 PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2014–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

Table 14-9. PYTD and P3TD Savings Summary

Savings Type	Energy (MWh/yr) [1]	Demand (MW/yr) [1]
PYRTD Gross	13,454	1.89
PYVTD Gross	10,731	1.59
PYVTD Net [2]	7,082	1.05
P3RTD Gross	25,489	3.54
P3VTD Gross	22,575	3.21
P3VTD Net [2]	14,900	2.12

[1] May not match due to rounding.
[2] Net savings are not used to meet PPL Electric Utilities' energy savings compliance target.

14.6 Process Evaluation

14.6.1 Research Objectives

The purpose of the process evaluation was to assess and provide recommendations for improving the Appliance Recycling Program's effectiveness in achieving its objectives. The main research objectives focused on these areas:

- Document program performance
- Evaluate customer satisfaction with the program
- Determine possible program enhancements

14.6.2 Evaluation Activities

The PY9 process evaluation activities for the Appliance Recycling Program included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Online participant surveys

The evaluation activities were consistent with the evaluation plan except Cadmus interviewed PPL Electric Utilities and ICSP program managers to assess program changes between PY8 and PY9.

Table 14-10 lists the process evaluation sampling strategy. Additional details about Cadmus' approach to contacting customers and the sample attrition are presented in *Appendix M.2.1*.

Table 14-10. Appliance Recycling Program Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size [1]	Number of Records Selected for Sample Frame [2]	Percent of Sample Frame Contacted to Achieve Sample [3]
Program Staff and ICSP	PPL Electric Utilities and CLEAResult staff	Phone and Email	3	N/A	2	3	3	All
Participants (Q1-Q3)	Appliance Recycling	Online survey	9,071 [4]	-	As many as possible	612	4,355	100%

[1] Number includes only completed surveys. Respondents could skip questions.
[2] Sample frame is a list of participants with email contact information drawn from the PPL Electric Utilities' database. After selecting all unique records, Cadmus removed any records from the population if the customers had participated in a survey in the last three months, were selected for another program survey, did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey.
[3] Percent contacted means the percentage of the sample frame contacted to complete surveys.
[4] Number of rebates for refrigerators and freezers available in PPL Electric Utilities' tracking database through the third quarter of PY9 at the time of the final survey effort. PPL Electric Utilities received additional data after the final sample, leading to a total number of records for Q1-Q3 in the tracking database of 10,785.

14.6.2.1 Survey Methodology

Cadmus completed 612 online surveys with Appliance Recycling Program participants, as shown in Table 14-10, to assess program satisfaction. Cadmus administered the online survey three times throughout PY9—during Q1, Q2, and Q3—to capture respondent feedback and to facilitate more timely feedback to PPL Electric Utilities and the ICSP. Cadmus contacted a census of eligible participants. Completed participant surveys produced a measurement of program satisfaction with ±1% precision at 90% confidence.

Surveys employ the self-report method, which can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus designed the surveys to minimize such issues and biases using these best practices:

- Avoid questions that are leading, ambiguous, or contain more than one topic
- Employ randomization of list-based survey items to reduce order effects

Cadmus used the same online questionnaire for all three surveys distributed in PY9, so survey data were collected consistently. The SWE team and PPL Electric Utilities reviewed and approved the survey before fielding.

14.6.2.2 Program Staff and ICSP Interviews

In February 2018, Cadmus conducted interviews with Appliance Recycling Program managers from PPL Electric Utilities (n=2) and the ICSP (n=1). The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and understanding potential challenges and areas that are working well. In July 2018, Cadmus also followed up with the ICSP to check on the status of recommendations made in PY8.

14.6.3 Process Evaluation Findings

14.6.3.1 Program Delivery

The Appliance Recycling Program was delivered effectively in PY9. The program continues to be on track to meet savings planned for Phase III and maintains high levels of customer satisfaction with the program overall and with individual program components.

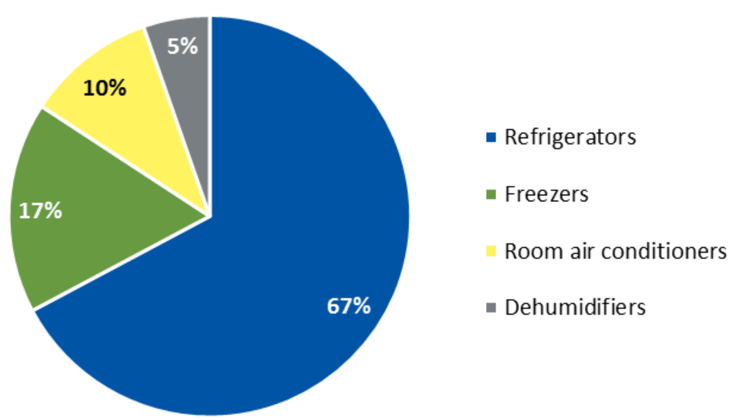
Program Changes

The ICSP delivered the PY9 program similar to PY8. One addition to the program was a new offer to recycle dehumidifier units for a rebate of $10. Like air conditioner units, dehumidifiers were not eligible to be picked up as a stand-alone equipment type, only as an add-on equipment type for customers who also recycled a refrigerator or freezer. Dehumidifier recycling was approved in the EE&C plan for PY8 but was begun by the ICSP only in PY9. The ICSP made no other changes to the program delivery.

Participation

Figure 14-1 shows the percentages of equipment recycled in PY9.

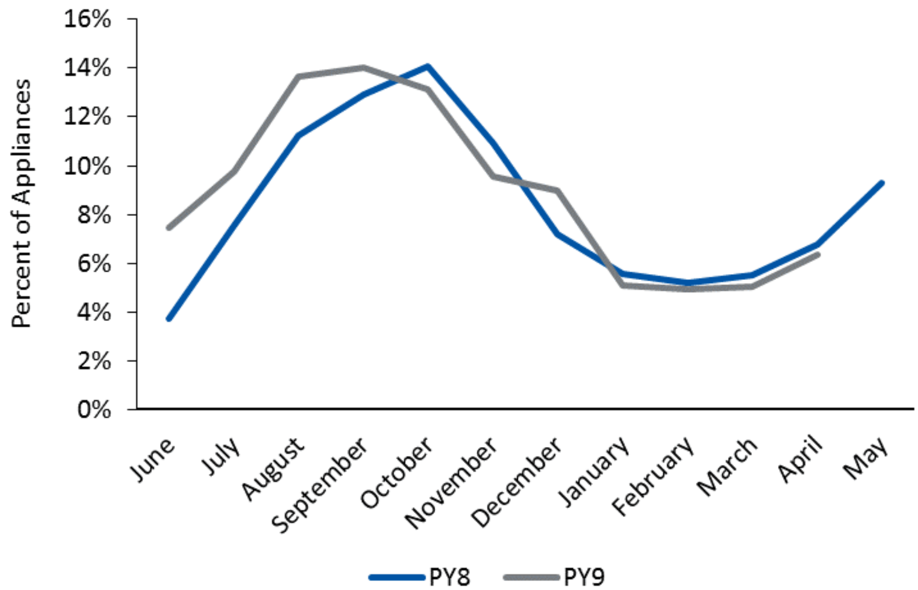
Figure 14-1. Proportion of Equipment Recycled in PY9 (Percentage of Total Units)



Source: PPL Electric Utilities Tracking Database

The Appliance Recycling Program showed the same seasonal participation trends, by quarter, in PY9 as in PY8 (Figure 14-2). Similar to PY8, participation in PY9 ramped up in the summer months, peaked in the fall, declined during the winter, then began to climb again during the spring.[121] The Q1 ramp-up in PY8 was a new observation compared to previous years but has now been observed in PY9 as well.

Figure 14-2. PY8 and PY9 Program Participation Trends



Source: PPL Electric Utilities Tracking Database

Program Marketing

Compared to PY8, the ICSP expanded marketing efforts for the Appliance Recycling Program in PY9 including a focus on new online channels. New forms of digital marketing outreach included a feature on the PPL Electric Utilities website sidebar and Facebook page. In September 2017, the ICSP held a dedicated event for the Appliance Recycling Program called the Recycling Roundup, which was promoted through social media and radio spots, including a live broadcast from the event. The marketing efforts for this dedicated event resulted in September being the peak month for PY9 program participation.

In previous program years, the Appliance Recycling Program has been well communicated to customers through bill inserts, and this remained an important marketing channel in PY9. Similar to PY8, the ICSP's tracking data for PY9 (n=12,852) has confirmed that the most common way customers learned about the program was through bill inserts from PPL Electric Utilities.

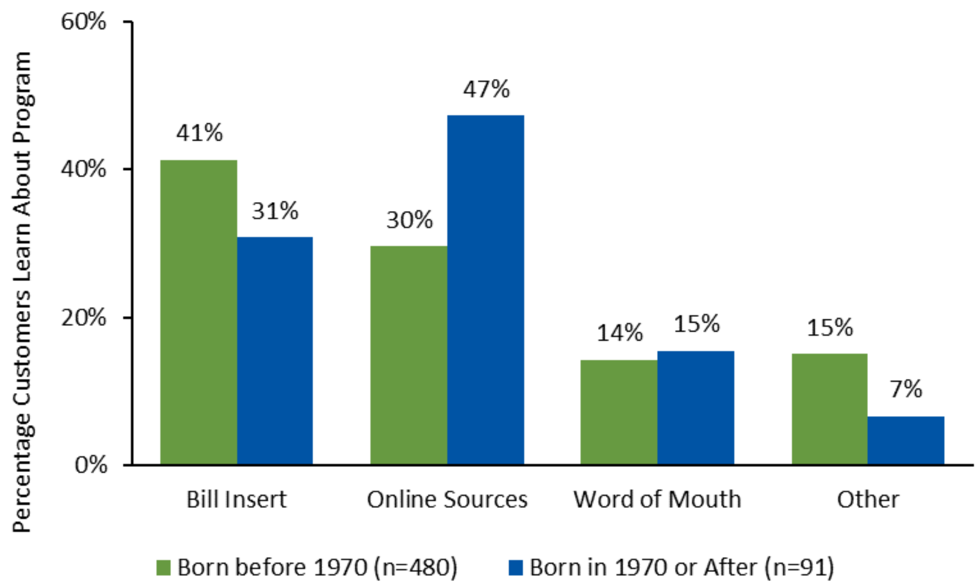
In PY9, Cadmus compared the survey data for participants' age (n=572) with data on program awareness from the ICSP's tracking data. As shown in Figure 14-3, older participants (born before 1970) heard about the program mainly through bill inserts (41%, n=480), while younger participants (born in or after

121 PPL Electric Utilities' tracking database for PY9 Q4 did not include a complete dataset for pick-ups in May 2018, which is typical because of a lag in incentive processing. The remaining data for May 2018 will be reported in PY10 Q1.

1970) heard about the program mainly through online sources (47%, n=91). This shows that older participants were 10% more likely than younger participants to have heard of the program through a bill insert. These data are similar to PY8; even so, from PY8 to PY9, more program participants in both age categories learned about the program through online sources, indicating an upward trend in this channel as a means to promote program awareness. Cadmus also compared the distribution of age for all survey respondents across PY8 and PY9 and found a very similar distribution.

Table 14-11 shows additional details about changes in how participants learned about the program between PY8 and PY9. *Appendix M* contains more information on survey participant demographics.

Figure 14-3. Ways Participants Learned About the Program in PY9 vs. Participant Age



Source: ICSP tracking data and participant survey question, "What year were you born?"

Table 14-11. Change in the Ways Participants Learned about the Program Between PY8 and PY9 by Participant Age

How Customer Learned About the Program	Born before 1970			Born in 1970 or after		
	PY8 (n=423)	PY9 (n=480)	Percent Change	PY8 (n=77)	PY9 (n=91)	Percent Change
Bill Insert	46%	41%	-5%	22%	31%	9%
Online Sources	25%	30%	5%	34%	47%	13%
Word of Mouth	17%	14%	-3%	22%	15%	-7%
Other	12%	15%	3%	22%	7%	-15%
Source: ICSP tracking data and participant survey question, "What year were you born?"						

Table 14-12 lists the digital channels that survey participants reported as their source for learning about the program in PY9.

Table 14-12. Digital Sources For How Survey Participants Learned About the Program in PY9

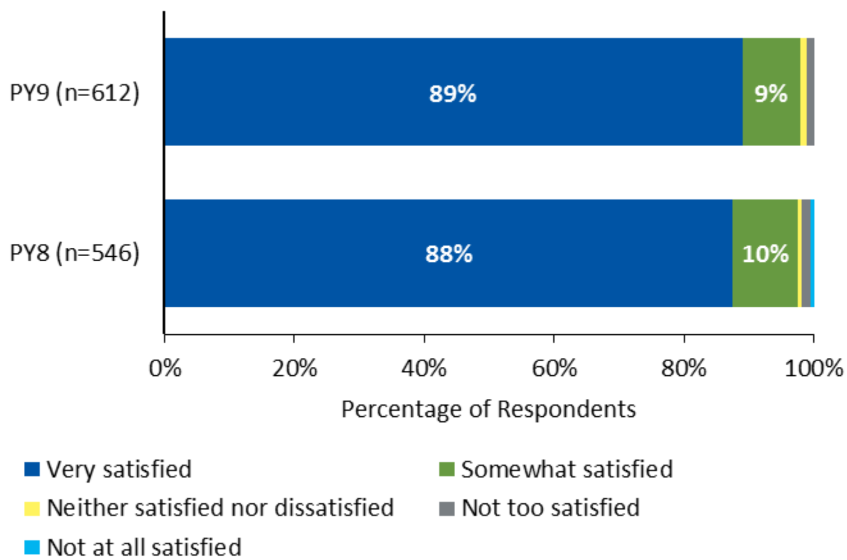
How Customer Learned About Program	Born before 1970 (n=142)	Born in 1970 or after (n=43)
Digital Banner	0%	0%
Email	45%	26%
Internet Search	14%	30%
PPL Website	41%	44%
Social Media	0%	0%
Source: ICSP tracking data and participant survey question, "What year were you born?"		

14.6.3.2 Program Satisfaction

Program participants showed similarly high levels of satisfaction with the Appliance Recycling Program in PY9 as they did in PY8 (Figure 14-4). In PY9, when asked about their overall satisfaction with the program, 98% of participants (n=612) said they were satisfied, which was also 98% in PY8 (n=546).

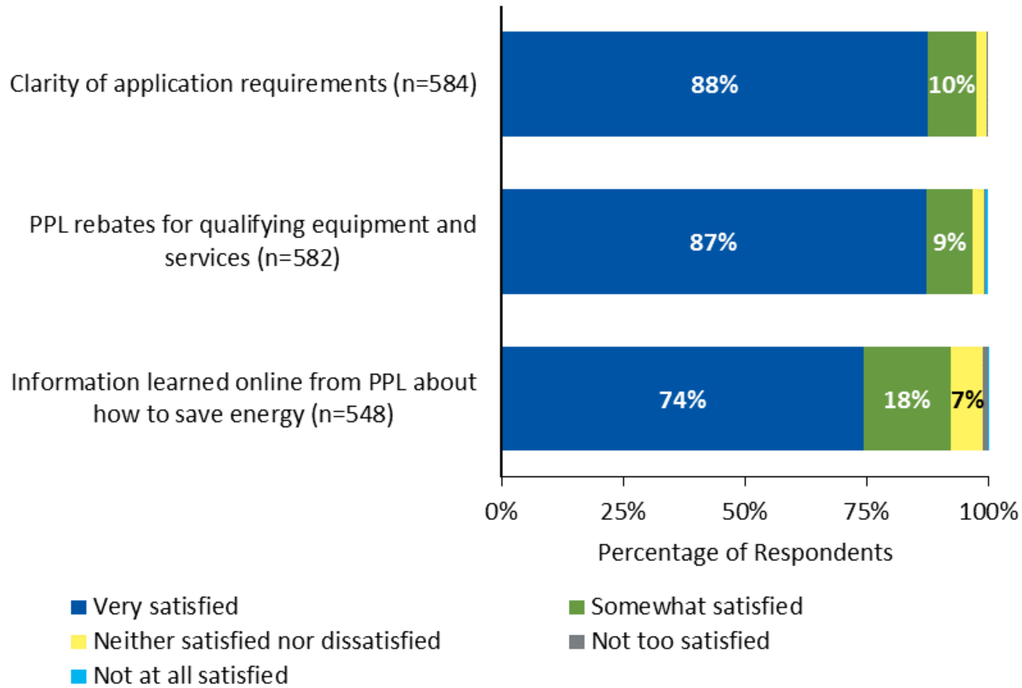
Participants also showed high levels of satisfaction for individual program components (Figure 14-5). Participants were asked about their satisfaction with the rebates, clarity of application requirements, and online information about ways to save energy.

Figure 14-4. Participant Overall Satisfaction



Source: Participant survey question, "Now, thinking about your overall experience with PPL Electric Utilities Appliance Recycling program, how would you rate your satisfaction?"

Figure 14-5. PY9 Participant Satisfaction With Program Components



Source: Participant survey question, "Please indicate how satisfied you are with each of the following program components."

Net Promoter Score

The net promoter score (NPS) is a metric of brand loyalty specifically measuring how likely customers are to recommend the program to others. Respondents rate their likelihood to recommend the program on a 10-point scale where 0 means *not at all likely* and 10 means *extremely likely*. Respondents giving a rating of 9 or 10 are known as promoters, respondents giving a rating of 7 or 8 are known as passives, and respondents giving a 0 to 6 rating are known as detractors. The NPS is expressed as a number between -100 and +100 that represents the difference between the percentage of promoters and detractors.

As shown in Table 14-13, the Appliance Recycling Program achieved an NPS of +89%, indicating that there are more promoters than detractors among the respondents and that participants are highly likely to recommend the program to others. The passives are excluded from the calculation. An excellent NPS is 50 and above.[122]

[122] Net Promoter, NPS, and Net Promoter Score are trademarks of Satmetrix Systems, Inc., Bain & Company, and Fred Reichheld.

Table 14-13. Net Promoter Score Likelihood to Recommend the Appliance Recycling Program

Rating Classification	PY8 Percentage of Respondents (n=548)	PY9 Percentage of Respondents (n=603)
Promoters (9-10)	90%	92%
Passives (7-8)	7%	5%
Detractors (0-6)	3%	3%
NPS	**+87**	**+89**

Cadmus reviewed suggestions for improvement noted by respondents. In total, 25 respondents categorized as passives or detractors provided suggestions for improving the program. Suggestions were to improve customer service, increase the rebate amount, allow recycling of additional appliance types, have more availability in the pick-up schedule, have a more specific pick-up time, and send the rebate check more quickly. Each category of suggestion had two to four responses.

Eleven of the 22 respondents who suggested expanding eligible appliances under the program offered specifics that included adding more refrigerator and freezer sizes, including electronics, and allowing room air conditioners and dehumidifiers to be recycled as stand-alone appliances.

Promoters (n=137) suggested increasing the rebate amount, allowing recycling of additional appliance types, and having shorter pick-up times.

Both promoters and detractors suggested improving customer service based on a variety of concerns that primarily focused on the schedulers and the appliance pick-up crews. One promoter wrote, “Need to leave message with call back number.” One detractor wrote, “They had to cancel and I had to call to find out they weren’t coming.”

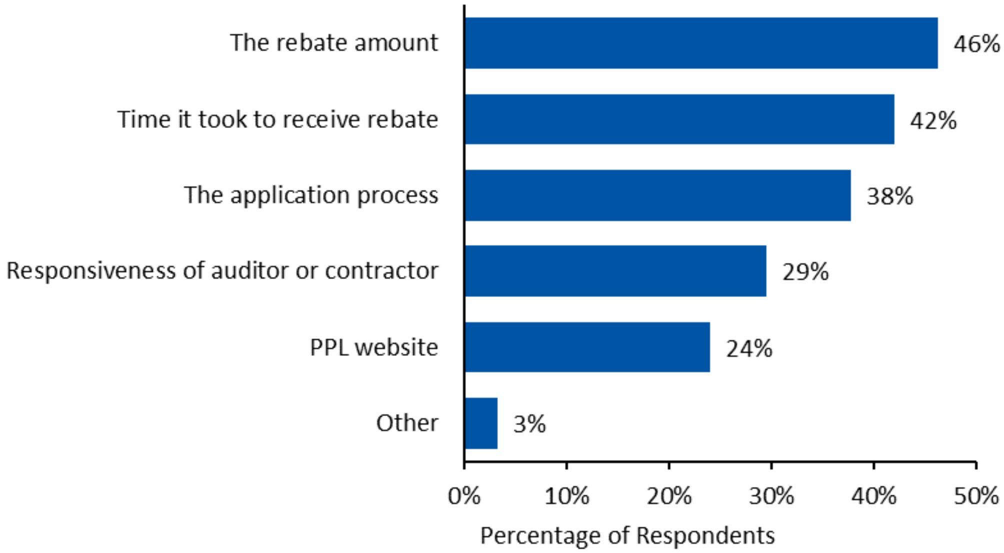
Opinion of PPL Electric Utilities

When asked how their opinion of PPL Electric Utilities had changed after participating in the Appliance Recycling Program, 32% of respondents (n=602) said that their opinion *improved somewhat,* 24% said their opinion *improved significantly,* and 43% said their opinion *had not changed* (n=608). Of the four respondents who said their opinion had *decreased* after participating, two said it was because of the long time it took to schedule a pick-up date, one said it was because a rebate check was never received, and one said the price of home heating had increased.

Areas Working Well

When asked what aspects of the program worked well, 46% of respondents said the rebate amount and 42% said the time it took to receive the rebate (n=607), as shown in Figure 14-6.

Figure 14-6. Program Components That Worked Best or Next Best for Participants



Source: Participant survey question, "Thinking about what worked well with the program, what one item worked best? What worked next best?" (n=607). Multiple responses allowed.

14.7 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 14-14. Cadmus calculated the TRC benefits using gross verified impacts. The net present value program year to date (NPV PYTD) benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). Net present value costs and benefits for P3TD financials are expressed in PY8 dollars.

Table 14-14. Summary of Appliance Recycling Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) (10)	
1	EDC Incentives to Participants	$363		$678	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		($341)	
4	**Incremental Measure Costs (Sum of rows 1 through 3) (1)**	**$363**		**$337**	
5	Design & Development (2)	-	-	-	-
6	Administration, Management, and Technical Assistance (3)	$40	-	$75	-
7	Marketing (4)	-	$202	-	$350
8	Program Delivery (5)	-	$1,470	-	$2,770
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11(6)	**Program Overhead Costs (Sum of rows 5 through 10) (1)**	**$1,711**		**$3,194**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		**$341**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) (7)**	**$2,074**		**$3,872**	
14	Total NPV Lifetime Electric Energy Benefits	$3,161		$6,346	
15	Total NPV Lifetime Electric Capacity Benefits	$619		$1,198	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	-		-	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	-		-	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) (8)**	**$3,780**		**$7,544**	
19	**TRC Benefit-Cost Ratio (9)**	**1.82**		**1.95**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 14-15 presents program financials and cost-effectiveness on a net savings basis.

Table 14-15. Summary of Appliance Recycling Program Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	$ 363		$678	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	**$363**		**$ 678**	
		EDC	**CSP**	**EDC**	**EDC**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$40	-	$75	-
7	Marketing [4]	-	$202	-	$350
8	Program Delivery [5]	-	$1,470	-	$2,770
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$1,711**		**$3,194**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	**$ 2,074**		**$3,872**	
14	Total NPV Lifetime Electric Energy Benefits	$2,086		$4,175	
15	Total NPV Lifetime Electric Capacity Benefits	$409		$788	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	-		-	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	-		-	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	**$2,495**		**$4,963**	
19	**TRC Benefit-Cost Ratio [9]**	1.20		1.28	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

14.8 Recommendations

Overall, the program has run smoothly over the course of PY9, showing high levels of customer satisfaction. Recommendations are provided in Table 14-16, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: A comparison of customer data from the PY9 and PY8 ICSP tracking databases shows that there is a shift in how customers are learning about the Appliance Recycling Program toward more online sources. In PY9, 30% of survey respondents born before 1970 (n=480) and 47% of survey respondents born in 1970 or after (n=91) learned about the program through an online source. By comparison, in PY8, 25% of survey respondents born before 1970 (n=423) and 34% of survey respondents born in 1970 or after (n=77) learned about the program through an online source. This represents a 5% increase in survey respondents born before 1970 who learned about the program from online sources and a 13% increase for survey respondents born in 1970 or after. Online sources represent a number of different response options that included email, internet search, and PPL website. No survey respondents reported learning about the program through a digital banner or social media. (See *Program Marketing* in section *14.6.3.1.*)

Finding: The makeup of survey respondents by age changed very little between PY8 and PY9. In PY9, 78% of those surveyed (n=572) were born between 1940 and 1969, while 16% were born in 1970 or after. In PY8, 77% of those surveyed (n=507) were born between 1940 and 1969, while 17% were born in 1970 or after. (See *Program Marketing* in *section 14.6.3.1.*)

Finding: Despite the gradual shift to online content, older demographics (who make up the majority of the program's participants) still rely heavily on bill inserts as the primary source of information about the program. (See *Program Marketing* in section *14.6.3.1.*)

Conclusion: A review of demographic data over PY8 and PY9 show that the participant age distribution remains approximately the same. A breakdown by age group shows an increase in the number of customers learning about the program through online sources from PY8 to PY9. This trend is especially pronounced in the age group born in 1970 or after. These findings reflect the ICSP's marketing strategy in PY9 that included an expansion of online marketing efforts. The digital marketing is effective, although it has the most impact in generating awareness about the program among younger customers.

Recommendation #1: Survey data show the majority of customers hear about the program through bill inserts, and the percentage who hear about the program through digital channels is steadily increasing, yet there are differences—by age group—in how customers hear about the program. Therefore, Cadmus recommends that PPL Electric Utilities continue its multichannel marketing approach, including bill inserts, online marketing strategies, and web content, to promote the program. Cadmus also recommends that, if participation slows, the program continue to explore new marketing strategies, such as advertising through Instagram, YouTube video ads, and mobile ads, to further expand its reach to the younger demographic.

Finding: The realization rate for energy savings was 80%, while the realization rate for demand savings was 84%. Verified savings were lower than reported because of lower actual average appliance ages for both refrigerators and freezers and a lower proportion of primary refrigerators than TRM defaults. Additionally, the verified part-use factor was substantially lower than the TRM defaults for both refrigerators and freezers. (See *Gross Impact Evaluation* in section *14.3.*)

Finding: Verified gross energy savings were 84% of projected savings for PY9. The lower than expected savings were because Cadmus applied updated inputs to the PA TRM savings formulas as described above. Another factor contributing to the shortfall in savings was the lower than expected numbers of recycled refrigerators and freezers. (See *Progress Toward Phase III Projected Savings* in section *14.1.*)

Conclusion: TRM default values for the open variables in the UEC equation do not reflect the current population of recycled refrigerators and freezers. Additionally, the default part-use factors for refrigerators and freezers are not representative of the current population of recycled appliances.

Recommendation #2: PPL Electric Utilities and the ICSP should consider updating the inputs used to calculate the reported savings for refrigerators and freezers based on evaluation findings. Savings should be adjusted by applying the open variables calculated by Cadmus in PY9 to the PA TRM savings formulas instead of the default TRM variables. Additionally, the program should update the part-use factor assumptions for reported savings using the verified part-use factor applied in PY9. Updating the *ex ante* per-unit energy savings will bring reported savings more in line with verified savings for the remainder of Phase III.

14.8.1 Status of Recommendations

Table 14-16 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 14-16. Status of Recommendations for the Appliance Recycling Program

Appliance Recycling Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Survey data show the majority of customers hear about the program through bill inserts, and the percentage who hear about the program through digital channels is steadily increasing, yet there are differences—by age group—in how customers hear about the program. Therefore, Cadmus recommends that PPL Electric Utilities continue its multichannel marketing approach including bill inserts, online marketing strategies, and web content to promote the program. Cadmus also recommends that, if participation slows, PPL Electric Utilities continue to explore new marketing strategies, such as advertising through Instagram, YouTube video ads, and mobile ads, to further expand its reach to the younger demographic.	Being considered.
2	Cadmus recommends that PPL Electric Utilities update annually the unit energy consumption values used to calculate the gross reported savings for recycled refrigerators and freezers. Savings should be adjusted by applying the open variables calculated by Cadmus in PY9 to the PA TRM savings formulas instead of the default TRM variables. Additionally, PPL Electric Utilities should update the part-use factor assumptions for reported savings using the verified part-use factor applied in PY9. Updating the unit energy consumption values and part-use factors will bring reported savings more in line with verified savings for the remainder of Phase III.	Being considered.

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CADMUS

STUDENT ENERGY EFFICIENT EDUCATION PROGRAM

This program offers THINK!ENERGY, an energy-efficiency education curriculum with classroom presentations, materials for teachers, and a take-home energy conservation kit for students.

VERIFIED ENERGY SAVINGS

Phase III has so far saved **10,562 MWh/yr**

44% of projected

116% of projected

PY9 saved **6,024 MWh/yr**

PROGRAM SATISFACTION

85% Satisfied with overall program

90%	Bright Kids (2nd – 3rd grades)
83%	Take Action (5th – 7th grades)
81%	Take Action pilot (5th – 7th grades)
85%	Innovation (9th – 12th grades)
81%	Innovation Pilot (9th – 12th grades)

PY9 PARTICIPATION

A total of **24,214** participants:

5,003	Bright Kids (2nd – 3rd grades)
12,422	Take Action (5th – 7th grades)
1,658	Take Action Pilot (5th – 7th grades)
4,109	Innovation (9th – 12th grades)
1,022	Innovation Pilot (9th – 12th grades)

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$2,007**

29% of projected

87% of projected

PY9 expenditures **$1,103**

15 Student Energy Efficient Education Program

The Student Energy Efficient Education (SEEE) Program provides THINK! ENERGY, a school-based energy efficiency education curriculum, through classroom presentations to students and classroom materials for teachers. THINK! ENERGY is offered once during the school year, typically in the fall.

Students receive educational materials and a take-home energy-savings kit of low-cost products to install at home. Each kit delivered to a student is counted as a program participant. The energy-savings kits are tailored to each grade level participating in the program and contain items such as LED bulbs, low-flow showerheads, faucet aerators, and smart power strips. Each kit includes a Home Energy Worksheet (HEW) that asks questions to track kit product installation rates as well as participant demographics and program satisfaction.

PPL Electric Utilities' residential ICSP, CLEAResult, identified National Energy Foundation (NEF) as the subcontractor to the ICSP. The ICSP undertakes a broad spectrum of responsibilities that includes marketing to and recruiting potential schools and teachers, creating curricula correlated with Pennsylvania academic standards, securing support of the program components by the Pennsylvania Department of Education, and assembling and shipping the energy-savings kits. PPL Electric Utilities collaborates with the ICSP on the program's strategic direction while maintaining the overarching Act 129 administrative, program support, evaluation, and data management systems. The ICSP provides oversight and direction to its subcontractor.

The objectives of the Student Energy Efficient Education Program are these:[123]

- Expand and promote energy efficiency literacy through education outreach programs
- Provide energy efficiency education to students offered through school assemblies and classroom curriculum
- Confirm energy efficiency education correlates to Pennsylvania Department of Education academic standards
- Provide students and teachers with a take-home kit of energy efficiency products that can be installed at home
- Provide teachers with energy efficiency information, lesson plans, activities, training, materials, and support for classroom use
- Obtain participation of approximately 115,000 students and teachers through 2021 and achieve approximately 24,000 MWh/yr gross verified savings
- Achieve high customer (students and teachers) satisfaction with the program

[123] Program objectives are listed in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.

15.1 Progress Toward Phase III Projected Savings

The Student Energy Efficient Education Program's verified savings are 116% of the projected MWh/yr savings for PY9. The program has achieved 44% of the projected Phase III total savings and is making progress toward the Phase III projected savings.

Table 15-1 shows the program's verified gross program savings and progress toward Phase III projected energy savings, as filed in the EE&C Plan.

Table 15-1. Student Energy Efficient Education Program Projected Savings

	PY8 Only Verified	PY9			Phase III: PY8-PY12		
		Projected (1)	Verified	Percentage of Projected	Projected (1)	Verified	Percentage of Projected
MWh/yr (2)	4,539	5,180	6,024	116%	23,993	10,562	44%

(1)Estimated savings are based on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642), December 2017.
(2) Totals may not sum due to rounding.

These are the factors affecting the program's progress toward the savings projected for PY9:

- Greater participation in PY9 (24,214 participants) than planned (24,000 participants).
- Differences between the reported in-service rates (ISRs) and other PA TRM algorithm inputs used by the ICSP and found by Cadmus through the survey analysis.[124]

15.2 Participation and Reported Savings by Customer Segment

15.2.1 Definition of a Participant

The Student Energy Efficient Education Program provides energy-savings kits to students in three cohorts:

- Bright Kids (2nd – 3rd grades)
- Take Action (5th – 7th grades)
- Innovation (9th – 12th grades)

In PY9, the ICSP and the ICSP's subcontractor also rolled out two pilots, which Cadmus evaluated as separate cohorts:

- Take Action Pilot (5th – 7th grades) provided a subset of classrooms in the Take Action cohort with an "augmented reality" application for smartphones and tablets to engage students and their parents with products in the energy efficiency kit at home.

[124] Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards. June 2016, errata update February 2017. Available online: http://www.puc.state.pa.us/Electric/docs/Act129/TRM-2016_Errata_Feb2017.docx

- Innovation Pilot (9th – 12th grades) provided Tier 2 advanced power strips in place of Tier 1 smart strips for a subset of Innovation cohort classrooms.

Each energy-savings kit distributed is counted as a participant and is recorded in the ICSP's database and PPL Electric Utilities' tracking database with a school, classroom, and teacher identifier. This identifier represents one classroom and is recorded with the number of kits distributed in that specific classroom. The number of kits distributed per classroom is collected on the teacher evaluation form and recorded in the ICSP and PPL Electric Utilities' tracking databases. PPL Electric Utilities did not collect or record utility account numbers of classroom students who received a kit.

15.2.2 Program Participation and Reported Impacts

Table 15-2 presents the participation counts, reported energy and demand savings for the Student Energy Efficient Education Program in PY9 by customer segment (residential). The program does not offer incentives; the kits are offered free of charge.

Table 15-2. PY9 Student Energy Efficient Education Participation and Reported Impacts

Parameter	Residential	Total[1]
PYTD # Participants	24,214	**24,214**
PYRTD MWh/yr	5,597	**5,597**
PYRTD MW/yr	0.56	**0.56**
PYVTD MWh/yr	6,024	**6,024**
PYVTD MW/yr	0.63	**0.63**
PY9 Incentives ($1000)	$0	**$0**

[1]Total may not match sum of columns due to rounding.

15.3 Gross Impact Evaluation

Cadmus conducted the following activities to evaluate the Student Energy Efficient Education Program's gross impacts. Refer to Appendix N for details on these activities:

- **Database review.** A review of PPL Electric Utilities' tracking database to ensure the accuracy of the database records compared to the ICSP's records.
- **HEW survey analysis.** An analysis of all online and paper HEWs returned by students who received a kit. The HEWs provided inputs, such as ISRs, for calculating energy savings. Students were not required to complete an HEW as part of the program. Cadmus analyzed all returned HEWs to provide data for the process and impact evaluations.

The impact evaluation's sampling strategy is summarized in Table 15-3. Of 24,214 energy-savings kits distributed, 17,223 students returned HEWs (71%).

Table 15-3. PY9 Student Energy Efficient Education Program Gross Impact Evaluation Sample Design

Stratum	Population Size	Assumed Proportion or Cv in Sample Design (1)	Achieved Sample Size	Impact Evaluation Data Source
Bright Kids 2nd – 3rd grades	5,003	N/A	3,796	Paper and online HEWs
Take Action 5th – 7th grades	12,422	N/A	8,663	Paper and online HEWs
Take Action Pilot 5th – 7th grades	1,658	N/A	1,353	Paper and online HEWs
Innovation 9th – 12th grades	4,109	N/A	2,646	Paper and online HEWs
Innovation Pilot 9th – 12th grades	1,022	N/A	765	Paper and online HEWs
Program Total	**24,214**	**N/A (1)**	**17,223**	
(1) Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.				

In PY9, the Student Energy Efficient Education Program reported energy savings of 5,597 MWh/yr, as shown in Table 15-4, and demand reduction of 0.56 MW/yr, as shown in Table 15-5.

Table 15-4. PY9 Student Energy Efficient Education Program Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Bright Kids	575	91%	0.10	1.03%
Take Action	3,154	109%	0.20	1.46%
Take Action Pilot	421	100%	0.15	2.83%
Innovation	1,115	107%	0.13	2.22%
Innovation Pilot	332	137%	0.19	4.80%
Program Total(1)	**5,597**	**108%**	**N/A**	**1.03%**
(1)Total may not match sum of rows due to rounding.				

Table 15-5. PY9 Student Energy Efficient Education Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate	Sample Cv or Error Ratio	Relative Precision at 85% C.L.
Bright Kids	0.07	92%	0.10	1.02%
Take Action	0.31	114%	0.19	1.39%
Take Action Pilot	0.04	106%	0.14	2.69%
Innovation	0.11	108%	0.11	1.84%
Innovation Pilot	0.03	135%	0.16	4.18%
Program Total(1)	**0.56**	**111%**	**N/A**	**0.94%**
(1)Total may not match sum of rows due to rounding.				

The following factors led to variation between the reported and verified savings and to the observed realization rates:

- The ICSP claimed savings for Innovation Pilot power strips only for students who returned an HEW, rather than for all kits distributed to this population. Furthermore, the ICSP applied an ISR (72%) to the claimed savings for this subset of the population, essentially applying an ISR twice in its calculations. Cadmus applied verified savings to all kits regardless of whether a survey was returned, which led to a substantially higher realization rate for the Innovation Pilot.
- Cadmus found higher ISRs than reported for showerheads for the Take Action, Take Action Pilot, Innovation, and Innovation Pilot participants and higher ISRs for Tier 1 smart strips for Innovation participants, which led to higher realization rates in these cohorts.
- ISRs for LEDs were slightly lower in PY9 than in PY8; the ICSP used PY8 ISRs to calculate *ex ante* savings. This difference was partially because of the addition of a fourth LED in PY9 (from three provided in PY8). The difference in ISRs resulted in lower *ex post* savings for all cohorts.
- The percentage of homes with electric water heating was higher than planned for both Innovation and Innovation Pilot cohorts, leading to higher water savings and realization rates for both cohorts.
- There were differences between the PA TRM algorithm inputs the ICSP used for its planned savings calculations and the inputs Cadmus used for its evaluated savings calculations:
  - The ICSP used the PA TRM default values for number of showers in the home (lower than the value Cadmus identified through data gathered from the HEWs) and number of people in the home for faucet aerators (lower than the value Cadmus identified through data gathered from the HEWs). This caused the ICSP to underestimate savings for faucet aerators and slightly overestimate showerhead savings, when not factoring installation rates.
  - The average water heater setback temperature change Cadmus identified through data gathering was lower for Innovation, Innovation Pilot, Take Action, and Take Action Pilot cohorts, leading to lower savings than planned for this improvement.

15.3.1.1 In-Service Rates

Table 15-6 shows the verified ISR for each of the items in the energy-savings kit from PY5 through PY9. Consistent with prior years, ISRs were higher for plug-in products (LED bulbs and smart strips) than for the water-saving products (showerheads and faucet aerators). Since PY7, survey-gathered ISRs for LEDs have decreased steadily, as anticipated in PY9 when a fourth bulb was added to all kits.

The ISR for Tier 1 smart strips, provided only in Innovation kits, increased from PY8. The ISR for its replacement in the Innovation Pilot kits, the Tier 2 advanced power strip, is much lower and does not reflect the actual ISR for these participants; Cadmus could verify installations only for Tier 2 advanced power strips used in entertainment centers because of the phrasing of the survey question on the ICSP-administered HEW.

To increase installation rates for water-saving devices in PY9, the ICSP updated the classroom presenter's training and materials to cover more information about the importance of saving water. ISRs remained the same from PY8 to PY9 for kitchen aerators and increased for showerheads.

Table 15-6. Verified Student Energy Efficient Education In-Service Rates for Products by Year

Kit Product	Stratum	PY5[1]	PY6[2]	PY7[3]	PY8	PY9
LED (4 bulbs) [4][5]	Bright Kids	73%	77%	90%	82%	75% [7]
	Take Action	60%	67%	89%	79%	75% [8]
	Take Action Pilot	-	-	-	-	74% [9]
	Innovation	67%	65%	89%	80%	77% [10]
	Innovation Pilot	-	-	-	-	78% [11]
Kitchen Aerator [6]	Take Action	35%	34%	32%	29%	29%
	Take Action Pilot	-	-	-	-	24%
Showerhead [6]	Take Action	31%	30%	25%	25%	32%
	Take Action Pilot	-	-	-	-	33%
	Innovation	34%	32%	31%	27%	35%
	Innovation Pilot	-	-	-	-	41%
Power Strip [12]	Innovation	80%	74%	74%	72%	77%
	Innovation Pilot	-	-	-	-	58%

(1) PPL Electric Utilities. *Annual Report Program Year 5: June 1, 2013–May 31, 2014.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2014.

(2) 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.

(3) PPL Electric Utilities. *Annual Report Program Year 7: June 1, 2015–May 31, 2016.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2016.

(4) ISR reflects average of all three bulbs per kit through PY8 and all four bulbs in PY9.

(5) For LED bulbs in PY7, PY8, and PY9, Cadmus based the ISR on the ISRs reported on the survey and 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). (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 four years of purchase. Discounting the future savings back to the current program year reduces the ISR from 97%. The PY9 evaluation used a weighted average nominal discount rate of 8.14% for all electric distribution companies (EDCs).

(6) Cadmus calculated water product ISRs by dividing respondents who installed the product in an electric water heat home by respondents who answered the question and have electric water heat.

(7) Individual Trajectory PY9 LED ISR for Bright Kids – LED1 83%, LED2 77%, LED3 72%, LED4 69% (ISRs calculated from surveys without "trajectory" calculation were LED1 64%, LED2 51%, LED3 40%, LED4 34%).

(8) Individual Trajectory PY9 LED ISR for Take Action – LED1 82%, LED2 77%, LED3 72%, LED4 69% (ISRs calculated from surveys without "trajectory" calculation were LED1 62%, LED2 48%, LED3 41%, LED4 37%).

(9) Individual Trajectory PY9 LED ISR for Take Action Pilot – LED1 79%, LED2 75%, LED3 72%, LED4 70% (ISRs calculated from surveys without "trajectory" calculation were LED1 62%, LED2 48%, LED3 41%, LED4 37%).

(10) Individual Trajectory PY9 LED ISR for Innovation – LED1 85%, LED2 79%, LED3 74%, LED4 71% (ISRs calculated from surveys without "trajectory" calculation were LED1 68%, LED2 57%, LED3 45%, LED4 39%).

(11) Individual Trajectory PY9 LED ISR for Innovation Pilot – LED1 84%, LED2 80%, LED3 76%, LED4 73% (ISRs calculated from surveys without "trajectory" calculation were LED1 67%, LED2 58%, LED3 49%, LED4 42%).

(12) The Innovation kit included a Tier 1 smart strip, while the Innovation Pilot kit included a Tier 2 advanced power strip.

15.4 Net Impact Evaluation

The Student Energy Efficient Education Program is a select offering to schools, and kits are provided free of charge to teachers, who in turn provide the kits to their students. No free riders are anticipated among the population receiving the energy-savings kit. That is, Cadmus does not expect teachers to voluntarily purchase and provide kits to students in the absence of the program. Likewise, because the kits are sent home with children as part of the school's curriculum and households do not purchase the kit, Cadmus assumes there is no free ridership. In addition, no spillover is measured.

The program is assumed to have an NTG ratio of 1.0.

15.5 Verified Savings Estimates

In Table 15-7, the realization rates determined by Cadmus are applied to the reported energy and demand savings estimates to calculate the verified savings estimates for the Student Energy Efficient Education Program in PY9. These totals are added to the verified savings achieved in previous program years to calculate the Phase III to date (P3VTD) program impacts.

Table 15-7. PYRTD and P3RTD Savings Summary

Savings Type	Energy (MWh/yr) (1)	Total Demand (MW/yr) (1)
PYRTD	5,597	0.56
PYVTD Gross	6,024	0.63
PYVTD Net(2)(3)	6,024	0.63
P3RTD	10,715	1.02
P3VTD Gross	10,562	1.11
P3VTD Net(2)(3)	10,562	1.11

(1) Total may not match sum of rows due to rounding.
(2) Net savings are not used to meet PPL Electric Utilities' energy saving compliance target.
(3) Net savings are the same as verified savings.

15.6 Process Evaluation

15.6.1 Research Objectives

The evaluation of the Student Energy Efficient Education Program involves these research objectives:

- Assess teachers' experiences with the current program offering
- Understand teachers' motivations for participating, as well as reasons for not participating
- Identify the optimal direction for the program in future years
- Assess student participant satisfaction with the program

15.6.2 Evaluation Activities

The PY9 process evaluation activities for the Student Energy Efficient Education Program included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Analysis of satisfaction questions on student-returned HEWs
- Online focus groups with participating teachers
- Interviews with nonparticipant teachers

The research activities were consistent with the evaluation plan for the Student Energy Efficient Education Program, with one modification. In the PY9 evaluation plan, Cadmus proposed conducting three focus groups—one group with teachers representing each student cohort (Bright Kids, Take Action, and Innovation)—and initially chose to segment by cohort. However, PPL Electric Utilities identified nonparticipant research as important for understanding why the program saw lower enrollment in PY9, so Cadmus substituted the Bright Kids cohort focus group with phone interviews with teachers who participated in PY8 but decided not to in PY9. Because of budget constraints, Cadmus could not conduct three online focus groups and phone interviews. Therefore, PPL Electric Utilities and Cadmus prioritized the Take Action and Innovation cohorts for the online focus groups because both are associated with higher savings, have a greater number of products, include water-saving products with declining ISRs, and have historically had more student engagement activities (e.g., poster contests).

Table 15-8 lists the process evaluation sampling strategy.

15.6.2.1 Program Staff and ICSP Interviews

In February 2018, Cadmus conducted interviews with Student Energy Efficient Education Program managers from PPL Electric Utilities (n=2) and the ICSP (n=1). The interviews focused on identifying and assessing changes to program design and delivery from PY8 to PY9 and understanding potential challenges and areas that are working well.

15.6.2.2 Teacher Focus Groups

In May 2018, Cadmus conducted two online focus groups with teachers who were part of the Take Action and Innovation cohorts. Cadmus segmented the groups by cohort type, conducting one focus group for each cohort.

Cadmus worked with the ICSP's subcontractor to gather a list of all teachers who participated in PY9. Cadmus then sent email invitations to all teachers with valid contact information who were part of either the Take Action or Innovation cohorts. Teachers who responded to these emails received a follow-up phone call to confirm their student cohort and their participation in the Student Energy Efficient Education Program in PY9.

Table 15-8 shows the total number of recruited and actual participants per focus group. Cadmus hosted these groups through FocusVision's InterVu platform. Each focus group lasted for approximately 90 minutes during the evening of May 30, 2018. Cadmus sent a $125 incentive to each teacher who participated in a group.

Table 15-8. Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame [1]	Percent of Sample Frame Contacted to Achieve Sample [2]
PPL Electric Utilities, ICSP, and ICSP subcontractor program stakeholders	N/A	Telephone in-depth interview	2	N/A [3]	2	2	N/A	100%
Teachers	All 2017–2018 participating teachers for Take Action and Take Action Pilot cohorts	Online focus group	556	N/A [3]	6	7	All eligible (535)	100%
	All 2017–2018 participating teachers for Innovation and Innovation Pilot cohorts	Online focus group	136	N/A [3]	6	8	All eligible (134)	100%
	All teachers who participated in 2016–2017 but not 2017–2018	Telephone in-depth interview	483	N/A [3]	6	6	All eligible (466)	100%
Students	Bright Kids, Take Action, Take Action Pilot, Innovation, Innovation Pilot	ICSP subcontractor-administered paper and online HEWs	24,214	N/A [3]	All returned surveys	17,223	All eligible	100%
Program Total			**25,391**	**N/A**	**20+**	**17,246**	**N/A**	**N/A**

[1] Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database. After selecting all unique records, Cadmus removed any records from the population if the customers did not have valid contact information (email or telephone number), were on the do not call list, or opted out of the online survey.
[2] Percent contacted means the percentage of the sample frame contacted to complete surveys.
[3] Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.

15.6.2.3 In-Depth Interviews with Prior Year Teachers

To understand more about barriers to participation, Cadmus conducted six in-depth phone interviews with teachers who participated in PY8 but decided not to in PY9. To qualify, these teachers must have had an opportunity to participate in PY9 but declined the invitation.

Cadmus worked with the ICSP's subcontractor to gather a list of all teachers who participated in PY8 and not in PY9. During the recruitment process, Cadmus confirmed the teacher's cohort and that the teacher was a participant in PY8 but chose not to participate in PY9 even though invited. Cadmus sent an email to all teachers with a valid email address asking if they were interested in participating and followed up with a phone call to supplement email recruitment. Cadmus conducted six interviews by phone, three with Bright Kids cohort teachers and three with Innovation cohort teachers.

15.6.2.4 Home Energy Worksheets (Participant Student Surveys)

Student participants completed HEWs, which were developed and administered by the ICSP's subcontractor, either online or on the paper forms included in the energy-savings kits. The HEWs asked questions to provide data for the impact evaluation as well as the process evaluation—questions included whether student participants had installed each product in the kit and about household characteristics and satisfaction with the program. The number of completed surveys produced a measurement of program satisfaction with ±0.18% precision at 90% confidence.

15.6.3 Process Evaluation Findings

This section summarizes findings about program experience, the impact of the night light recall on teacher's decisions to participate, and desired future program directions. This section is organized by these topics:

- Program delivery
- Student satisfaction
- Teacher experience and feedback

15.6.3.1 Program Delivery

The Student Energy Efficient Education Program provides energy efficiency education through classroom presentations to students and classroom materials for teachers. The program offers the curriculum once per school year, typically in the fall. Students receive educational materials and a free energy-savings kit of low-cost products to install at home. The kits contain LED bulbs, low-flow showerheads, faucet aerators, and/or smart power strips, depending on the student cohort.

Each kit includes an HEW that asks questions to track product installation rates as well as participant demographics and program satisfaction. The ICSP's subcontractor includes paper HEWs in the kits and manages an online HEW portal for students and parents to record the energy-saving products they install in their homes. To provide an incentive for teachers to encourage their students to fill out their HEWs, the ICSP's subcontractor offers mini-grants ($50 for Bright Kids, Take Action, and Take Action

Pilot, and $75 for Innovation and Innovation Pilot cohorts) in the form of prepaid gift cards to classrooms that achieve 80% HEW completion rates.

In PY9, the ICSP and the ICSP's subcontractor rolled out two pilot offerings:

- **Take Action Pilot.** The ICSP's subcontractor developed an "augmented reality" application (app) for smartphones and tablets, referred to as the Energy Sidekick app, which it piloted in the spring of PY9 to a subset of classrooms in the Take Action cohort. The intent of the app was to further engage students and their parents with the kit's products at home.
- **Innovation Pilot.** For a subset of 37 Innovation cohort classrooms, the ICSP's subcontractor substituted Tier 2 advaned power strips in place of the Tier 1 smart strips.[125]

The ICSP and ICSP's subcontractor also made two changes to the kit products from PY8:

- **Removed electroluminescent nightlight.** In PY9, the ICSP removed the electroluminescent nightlights from the Bright Kids and Take Action kits because of perceived concerns about the manufacturer recall (due to safety concerns) of these nightlights in PY8. The model of the nightlights in the Student Energy Efficient Education Program kits in PY8 was not part of the manufacturer recall in that year. However, at the time the recall was announced, PPL Electric Utilities did not know which models were affected and therefore instructed all kit recipients across all programs to stop using electroluminescent nightlights.
- **Added one additional LED light bulb.** The ICSP added an additional LED light bulb to the kits for all cohorts, for a total of four LED bulbs per kit.

In addition, the ICSP added questions to the HEW for Innovation, Innovation Pilot, and Take Action cohorts to gather data on and claim savings for water heater temperature setback behavior.

To help increase installation rates for the products in the kit (for which prior evaluations had found a declining trend in installation rates), the ICSP's subcontractor specifically trained presenters on how to review product installation during presentations to students. They created new, more detailed and up-to-date videos that were posted on the program website to instruct students and their families with installations. Presenter training and materials provided more information on the importance of saving water, with the intent to increase the installation rates for the water devices.

15.6.3.2 Student Satisfaction

Seventy-one percent of participants completed HEWs, a slight decrease from 73% in PY8. Figure 15-1 shows student satisfaction with the program overall. Of the 17,223 students who returned a HEW, 16,867 responded to the satisfaction question; of these, 85% said they were *very satisfied* (64%) or *somewhat satisfied* (21%) with the program overall. In line with prior program year findings, the cohort

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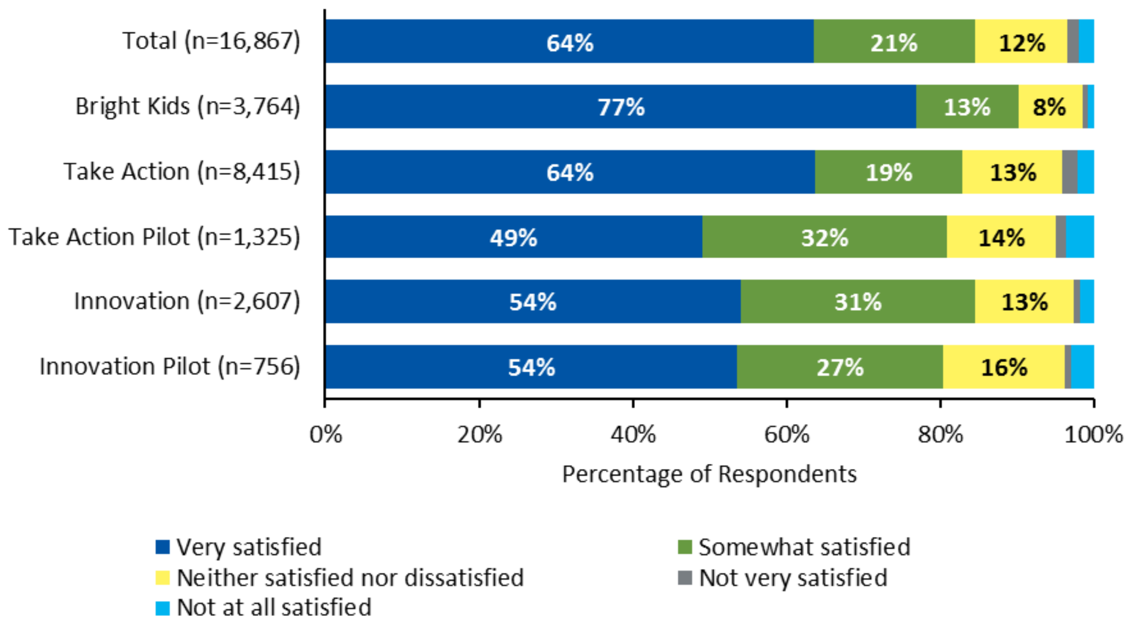
[125] Of the 37 teachers participating in the Innovation pilot, only 33 received a Tier 2 smart strip according to PPL Electric Utilities' tracking database. The remaining four teachers did not receive a smart strip (Tier 1 or Tier 2) according to the tracking database, even though they received a Secondary Energy Kit. See *Appendix N.1.2 Database Review Findings* for additional details.

most frequently *very satisfied* was Bright Kids (77%) and least frequently *very satisfied* was Take Action Pilot (49%) and the Innovation and Innovation Pilot (54% each).

Figure 15-1. Participant Satisfaction with Student Energy Efficient Education Program Overall by Cohort



Home Energy Worksheet Q11 (*Bright Kids*), Q24 (*Take Action*), Q25 (*Innovation*):
"Please rate your overall satisfaction with the Think! Energy program."

15.6.3.3 Teacher Experience and Feedback

During the focus groups, Cadmus asked teachers about their experience in the program and for feedback about how to improve it in the future.

Motivations for Participation

Teachers cited several reasons for participating in the SEEE Program, including these:

- **Complementary to existing curriculum.** Nearly all teachers said they participated because the subject matter fit well with their curriculum. One Innovation cohort teacher said it fits well because "we have an electrical unit at the beginning of the year. They come in right at the end of that unit [to give the presentation] and it works out perfect." A teacher who did not participate in PY9 gave another perspective on how the subject matter fits: "I teach a unit on energy and agricultural ecology, so [the THINK! Energy program] helps give kids a fresh perspective on how to conserve energy."
- **Exciting and different teaching approach.** Another commonly cited reason was that the approach to teaching the material is exciting and different than a normal teaching day. One Take Action cohort teacher said that "Every part of the program is high quality, such as the posters and the lesson folder. It's very informative and great for the students."

- **Free energy-saving products.** A small number of teachers, specifically those who said they were from lower-income districts, mentioned that the free energy efficiency products received by the students are a big benefit because these families may have limited disposable income to make energy efficiency improvements.
- **Teacher mini-grants.** Some teachers also discussed the mini-grants for returned HEWs as a motivating factor. The teachers have limited budgets and believe the mini-grant gives them some additional flexibility for what they can do in their classroom.
- **Prizes for students.** A couple of teachers said the free prizes (in addition to the kits) were a big draw for their students.[126] Teachers from the Take Action and Bright Kids cohorts specifically mentioned that the heat-activated pencils were popular among their students. An Innovation teacher said the Beats headphones were a big motivator for his students to complete the surveys.

Program Experience

Overall, teachers said the Student Energy Efficient Education Program effectively educated students about energy efficiency. Respondents in the focus groups and interviews attributed this success to numerous factors, such as the energy efficiency kits, the presentation by NEF (the ICSP's subcontractor), and the teaching methods. One teacher explained that "The program is really effective, especially when my students received their boxes and had something to take home. It got them to think about how they use energy at home and how they can save." In general, Take Action cohort teachers were more satisfied with all aspects of the program than were Innovation cohort teachers. The Bright Kids cohort teachers who were interviewed for the nonparticipating teacher research were also more satisfied with the program than were Innovation cohort teachers.

NEF Presentation

When asked what they thought about the classroom presentation conducted by NEF, teachers generally gave positive feedback, with 14 out of 15 teachers stating they found the presentation helpful. The majority of teachers thought the presenters did a good job of engaging the students in the presentation. Most of these teachers also thought the presentations effectively introduced the topics of energy and energy efficiency. A few teachers also specifically commented that the dual presenters helped improve the energy of the presentation, with one teacher saying that "the presenters really did a great job involving the students and getting them excited [about energy efficiency]. They were better than the average presenter we have in our school."

However, Innovation cohort teachers were generally less satisfied with the presentation than the other cohorts. One of the areas mentioned was the level of academic rigor, which respondents said was not advanced enough for their students. Specifically, these teachers would like to have seen greater detail

[126] As part of the program, students in different cohorts received or could win different types of prizes. Students in the Bright Kids and Take Action cohorts received heat-activated pencils at the NEF presentation. Students in the Innovation cohort were eligible to win a pair of Beats headphones by completing the home energy worksheet, or a solar backpack for participating in the Student Innovation Challenge.

on energy generation and the inclusion of mathematical exercises on calculating energy usage costs. Innovation cohort teachers were also less satisfied with the level of engagement. They suggested incorporating a trivia game such as Kahoot!, where students engage with the presentation through their cell phone or on a computer. These teachers have found success incorporating Kahoot! into their lesson plans and like that it gives students a break from traditional classroom activities. Another Innovation teacher thought the presenters struggled to engage their students, specifically that "they were good presenters, just not good teachers."

Supplemental Materials

Teachers liked the supplemental materials packet they received but thought that PPL Electric Utilities could provide more. Teachers mentioned liking a variety of items from the packet, such as the graphs and charts, worksheets for calculating energy cost, games, and the booklet that came with the materials. However, some teachers said they did not use the program handouts or activities because these materials were not relevant, or they did not understand how to incorporate them into their classroom. The most popular item was the electricity usage meter, which PPL Electric Utilities had provided to teachers in a previous program year and that many teachers were continuing to use to create a more hands-on activity for their students.

Energy Efficiency Kits

Almost all teachers needed to have parents sign permission slips before allowing students to take the kits home. Each teacher approached the kits differently. Some said they did not discuss the kits much at all with students. One teacher stated "we only have time for the presentation and don't bring kits out while [NEF is] there. The students go home with kits and come back with questions about how smart power strips work. I think it would be useful for [the presenters] to go through how the smart power strip works during the presentation." Other teachers went into great detail about each item in the kit, how to use it, and the benefits of installing it. One teacher said this "breaks up the conversation in class because I am showing each item in the kit. Showing students a smart power strip is like showing cavemen fire—it just amazes them."

The majority of teachers agreed that the take-home kit of free energy-efficient products was most appealing to the students. One teacher said "I think kits make it super motivating for kids. Our district is a lower economic district, so anything like that is beneficial to the families. They appreciate all that they get." Teachers like the kits because they both get students excited and help them to retain the lessons learned in class by practicing the skills at home.

Nevertheless, teachers mentioned several challenges with the kit, specifically, getting parents to agree to receive it, students and their families not finding some products useful, and issues explaining the smart power strip.

Energy Sidekick App

Cadmus recruited two teachers whose students used the Energy Sidekick app to ask for their feedback on the app. These teachers were satisfied with the app and thought it helped increase engagement and understanding of the material outside of school. One teacher had some issues with student phone compatibility but said this impacted only two or three students.

Barriers to Participation

During interviews with six teachers who participated in the 2016–2017 (PY8) school year but not the 2017–2018 school year (PY9), Cadmus asked questions to understand why these teachers chose not to participate. They provided the following reasons for not participating in the 2017–2018 school year:

- **Lack of value.** Three teachers declined to participate because they did not see the value in the program. Each teacher had a slightly different interpretation of value: one thought it was too introductory and did not provide the education her students needed, another preferred to wait for new students to come in so they do not see the same material twice, and the third switched to teaching biology so she did not think the material relevant to her subject.
- **Did not see invitation.** Two teachers said that they did not remember seeing an invitation to participate during the 2017–2018 school year. They said they may have been invited but the email had probably been lost in their inbox.
- **Night light recall.** The sixth teacher did not participate because of the night light recall in PY8. The administration in her school was very worried when it received notice of the recall and acted promptly to send out a notice to all parents. Because of the hassle of the recall, the school chose not to participate in the 2017–2018 school year.

Cadmus asked the nonparticipating teachers about their perceptions of the night light recall in PY8. Five of the six teachers said PPL Electric Utilities handled the recall appropriately, but one teacher reported issues about getting information about the recall from PPL Electric Utilities, such as who was affected and where to send the recalled night lights.

Future Program Direction

Cadmus asked participating and nonparticipating teachers if they would participate in the Student Energy Efficient Education Program in the future. Of 21 teachers, 19 said they would *definitely* participate again. Two teachers, both part of the Innovation cohort, said they might participate again; one was part of the PY9 program and one was part of the PY8 program. These two teachers thought the subject matter and engagement methods could be improved, specifically, that the material presented by NEF was not age-appropriate and would need to be improved to be useful for their students.

Teachers also provided feedback on how they would like to see the program change in the future. Teachers requested additional resources, specifically, interactive elements, such as videos and games; additional instructions for teachers on how to use the materials, such as videos of teachers presenting the classroom material; and more digital tools and resources.

Teachers offered several suggestions for new topics that would improve the program, including these:

- **Sources of energy.** The most commonly cited suggestion was for more information about sources of energy, specifically renewables. One teacher said, “kids need to understand how the energy grid works—they need to understand the big picture.” Another said some students expressed interest in putting wind turbines at their school and thought ideas like this could be incorporated into the program.
- **Energy use and cost calculation.** Teachers would also like to see discussion and exercises to calculate energy use and costs. Some Innovation cohort teachers said the material was not advanced enough for students. One Innovation cohort teacher said “it could be elevated mathematically to push the kids a little harder to think about the material. It seems more geared towards a middle school student.”
- **Careers in the energy field.** A couple of teachers said they wanted more information to make students aware of careers in energy, specifically for Innovation cohort students. One of these teachers said that “PPL would be an awesome resource to bring in people from energy-specific careers. [The utility] is a massive resource for employment.” A couple of teachers even suggested a reward for a select number of classes to visit a power plant or to undertake some sort of job shadowing.
- **Connection to the environment.** One teacher wanted to see more of a connection to the environment. Specifically, “we refer to things in our ecology unit regarding recycling and relating it to energy savings. This should be incorporated more into THINK! Energy.”
- **Updated products.** Finally, teachers thought the kits could be updated to include products like a safe night light, flashlight, rechargeable batteries, and smart/connected home technology.

15.7 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 15-9. The TRC benefits were calculated using gross verified impacts. NPV PYTD benefits and costs are expressed in PY9 dollars (PY9 includes months in both 2017 and 2018). NPV benefits and costs for P3TD financials are expressed in PY8 dollars.

Table 15-9. Summary of Student Energy Efficient Education Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3)** [1]	**-**		**-**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$31	-	$124	-
7	Marketing [4]	-	$165	-	$289
8	Program Delivery [5]	-	$906	-	$1,516
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10)** [1]	**$1,103**		**$1,929**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**-**		**$1,024**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12)** [7]	**$1,103**		**$1,929**	
14	Total NPV Lifetime Electric Energy Benefits	$1,408		$2,496	
15	Total NPV Lifetime Electric Capacity Benefits	$240		$419	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$508		$852	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$75		$69	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17)** [8]	**$2,230**		**$3,837**	
19	**TRC Benefit-Cost Ratio** [9]	**2.02**		**1.99**	

[1] May not sum to total due to rounding.
[2] All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes the marketing ICSP and marketing costs by program ICSPs
[5] Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as “Program Delivery” costs.
[6] Rows 1-11 are presented in nominal dollars.
[7] Total TRC Costs includes Total EDC Costs and Participant Costs.
[8] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
[9] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[10] All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Table 15-10 presents program financials and cost-effectiveness on a net-savings basis. In this program, the NTG ratio is equal to 1.0; therefore, the net verified savings are equal to the gross verified savings.

Table 15-10. Summary of Student Energy Efficient Education Program Finances–Net Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) [10]	
1	EDC Incentives to Participants	-		-	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	-		-	
4	**Incremental Measure Costs (Sum of rows 1 through 3) [1]**	**-**		**-**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development [2]	-	-	-	-
6	Administration, Management, and Technical Assistance [3]	$31	-	$124	-
7	Marketing [4]	-	$165	-	$289
8	Program Delivery [5]	-	$906	-	$1,516
9	EDC Evaluation Costs	**-**		**-**	
10	SWE Audit Costs	-		-	
11[6]	**Program Overhead Costs (Sum of rows 5 through 10) [1]**	**$1,103**		**$1,929**	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**-**		**$1,024**	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) [7]**	**$1,103**		**$1,929**	
14	Total NPV Lifetime Electric Energy Benefits	$1,408		$2,496	
15	Total NPV Lifetime Electric Capacity Benefits	$240		$419	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$508		$852	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$75		$69	
18	**Total NPV TRC Benefits (Sum of rows 14 through 17) [8]**	**$2,230**		**$3,837**	
19	**TRC Benefit-Cost Ratio [9]**	**2.02**		**1.99**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as “Program Delivery” costs.
(6) Rows 1-11 are presented in nominal dollars.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) All program year (PYTD) expenditures and benefits are discounted to PY8 dollars for the Phase (P3TD) total.

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[127] A summary of the methodologies Cadmus used to calculate the non-energy benefits of saved water, natural gas therms, and lighting interactive effects can be found in *Appendix P Non-Energy Benefits.*

Non-Energy Benefits of Water-Saving Products

The Student Energy Efficient Education Program offers two water-saving measures—low-flow showerheads and faucet aerators. Table 15-11 presents the data used to determine the program's non-energy benefits for water-saving measures.

Table 15-11. Student Energy Efficient Education Non-Energy Benefits for Water-Saving Products

Measures	Stratum	TRM #	Gallons of Water Saved per Unit [1]	Reported Installations	ISR	Gallons of Water Saved	Number of Homes with Fossil Fuel Water Heat that Installed Measure
Faucet Aerators	Take Action	2.3.8	1,984	475	28%	266,666	63
Faucet Aerators	Take Action Pilot		1,986	64	24%	29,875	7
Showerhead - 1	Take Action	2.3.9	3,120	475	31%	465,316	70
Showerhead - 1	Take Action Pilot		3,122	64	32%	63,942	9
Showerheads - 2	Innovation		3,128	93	33%	96,589	12
Showerheads - 2	Innovation Pilot		3,125	37	39%	45,447	5
Total Gallons of Water Saved			-	-	-	**967,834**	-

[1] The unit savings include the weighted average distributions of home type for each stratum.

Non-Energy Benefits of Natural Gas Savings

Student Energy Efficient Education had fossil fuel savings due to the installation of water heating in measures in homes with natural gas water heaters. Table 15-12 gives the summary of natural gas and other fossil fuel therms savings.

Cadmus used the results from the student HEW to calculate the ISR and the proportion of homes with fossil fuel water heaters by measure and by stratum.

127 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018

Table 15-12. Student Energy Efficient Education Natural Gas and Other Fossil Fuel Therms Savings

Measures	Stratum	TRM #	Unit Therms Savings [1]	Number of Reported Installations	ISR or RR[2]	Fossil Fuel Water Heat Distribution	Total Therms Saved	Algorithm Source [3]
			A	B	C	D	A*B*C*D	
Water Heater Temperature Setback	Take Action	2.3.7	2.56	475	60%	45%	328	IL TRM 5.4.6
Water Heater Temperature Setback	Take Action Pilot		2.56	64	78%	44%	57	
Water Heater Temperature Setback	Innovation		2.56	93	95%	42%	94	
Water Heater Temperature Setback	Innovation Pilot		2.56	37	80%	38%	29	
Faucet Aerators	Take Action	2.3.8	9.90	475	28%	47%	619	IL TRM 5.4.4
Faucet Aerators	Take Action Pilot		9.91	64	24%	45%	67	
Showerhead - 1	Take Action	2.3.9	15.69	475	31%	47%	1,098	IL TRM 5.4.5
Showerhead - 1	Take Action Pilot		15.68	64	32%	46%	146	
Showerheads - 2	Innovation		15.63	93	33%	39%	190	
Showerheads - 2	Innovation Pilot		15.65	37	39%	35%	79	
Total Thems Saved			-	-	-	-	**2,706**	-

[1] The unit savings include the weighted average distributions of home type for each stratum, where applicable.
[2] For the water heater temperature setback measure, Cadmus multiplied the unit therms savings by the realization rate because the survey fielded found that the change in temperature reduction was lower than the PA TRM default. Every other value in this column in the ISR.
[3] The section numbers in this column refer to the algorithms for gas savings, which came from:
Illinois Energy Efficiency Stakeholder Advisory Group. Illinois *Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3: Residential Measures.* February 8, 2017. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_3_Res_020817_Final.pdf.
Cadmus used the *algorithms* listed in the IL TRM but the *inputs* from the PA TRM. Although the algorithms for gas savings are known, Cadmus included the reference here to explicitly state where the algorithms came from (as they are not listed in the PA TRM).

Lighting Interactive Effects

Cadmus included heating penalties as a negative benefit in the TRC test for efficient lighting, per the Guidance Memo.

Table 15-13. Student Energy Efficient Education Program Lighting Gas Heating Penalties Calculations

Product	Gas Heat Fuel Share	% Lamps Interior	Lighting Savings in Heating Season	Waste Heat Escape	Furnace AFUE	Heating Penalty (Therms per kWh)
LED 9-W Bulbs	29%	90%	66%	20%	0.8	0.00586

Per the Guidance Memo, Cadmus only assumed that there was a natural gas therms penalty. The results, by stratum are shown in Table 15-14. Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Table 15-14. Student Energy Efficient Education Program Lighting Gas Heating Penalties for LEDs by Stratum

Product	Stratum	Number of LEDs Distributed	Total Ex Post kWh Savings	Total Natural Gas Therms Penalty
LED 9-W Bulbs	Take Action	49,688	1,493,483	-8,752
	Take Action Pilot	6,632	184,099	-1,079
	Bright Kids	20,012	524,715	-3,075
	Innovation	16,436	494,058	-2,895
	Innovation Pilot	4,088	156,616	-918
Subtotal			**2,852,970**	**-16,718**
Total Gas Therms Savings (adding gas therms from Table 15-12)				**-14,012**

15.8 Recommendations

Overall, the Student Energy Efficient Education Program performed well in PY9, distributing more kits than projected and exceeding the program's planned savings. Furthermore, satisfaction with the program was high, with 85% of students reporting they were *very* or *somewhat satisfied* with the program.

The impact and process evaluation activities in PY9 led to the following findings and recommendations from Cadmus to PPL Electric Utilities. Recommendations are provided in Table 15-15, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Findings. Some teachers in the Innovation cohort thought the subject matter of the program was not sufficiently challenging for their students. These teachers thought the program should incorporate additional math exercises to challenge students beyond what is currently provided (see *15.6.3.3 Teacher Experience and Feedback*). Of all materials provided through the program, teachers said the energy usage meter they received in prior program years was most useful because it helped students engage with and better understand energy-saving concepts (see *15.6.3.3 Teacher Experience and Feedback*). In

PY9, students who participated in the Innovation and Innovation Pilot cohorts indicated they were less satisfied with the program than those in the Bright Kids or Take Actions cohorts (see *15.6.3.2 Student Satisfaction)*. These student satisfaction results are consistent with the qualitative experiences of participating teachers, with Innovation cohort teachers citing concerns about the rigorousness of the content for their students (see *15.6.3.3 Teacher Experience and Feedback*).

Conclusion: Providing the Innovation cohort with program content of a more advanced level may help to effectively engage these students and improve teacher retention and satisfaction.

Recommendation #1: Consider asking NEF to update the presentation and teacher materials given to Innovation cohort students to be more challenging for this grade level. For example, consider providing energy usage meters to teachers again in future years and include additional exercises on calculating energy costs using this tool. Consider providing extra worksheets and challenging math exercises to teachers so that they have additional material available to use at their discretion.

Findings: Nearly all teachers found the NEF presentation helpful, with 14 out of 15 teachers rating it *very helpful* or *somewhat helpful*, specifically because the presenters engaged the students (see *15.6.3.3 Teacher Experience and Feedback*). When discussing what would help to make the classroom material more engaging, teachers requested additional interactive and digital elements, such as videos and games (see *15.6.3.3 Teacher Experience and Feedback*). In response, the program will roll out the Energy Sidekick app for all Take Action participants in PY10. Some teachers wanted additional instructions from PPL Electric Utilities on how to deliver the program, such as a short video showing other teachers using the material in a classroom or a training session from PPL Electric Utilities or NEF (see *15.6.3.3 Teacher Experience and Feedback*). In line with this, in PY10, the ICSP's subcontractor updated the installation videos provided to teachers by the program. Additionally, two teachers whose students used the Energy Sidekick app thought the app did a good job of helping students stay engaged with the program (see *15.6.3.3 Teacher Experience and Feedback*). However, students in the Take Action Pilot indicated lower satisfaction than those in the Take Action cohort (*see 15.6.3.2 Student Satisfaction*).

Conclusion: The highly engaging presentations are one of the strongest aspects of the program, but teachers wanted more support to maintain student engagement in the classroom. Digitizing resources and materials is already a teacher request and will be increasingly more relevant moving forward.

Recommendation #2: Consider providing teachers with additional digital resources as part of the teacher packet, such as videos, games, and links to online articles.

Recommendation #3: Follow up with teachers who were provided with additional instructions in PY10 and determine whether teachers continue to want demonstrations on how to incorporate program materials into their curriculum, such as video demonstrations of other teachers presenting the material in class.

Findings: Of all aspects of the program, students liked the energy efficiency kits most. However, they were less likely to install the water-saving products, such as showerheads, because, as they told teachers, some students and parents do not like them (see *15.6.3.3 Teacher Experience and Feedback*).

To increase installation rates for water-saving devices in PY9, the ICSP updated the presenter training and materials to cover more information on the importance of saving water. In PY9, Cadmus found that the installation rate for showerheads in the Take Action cohort rose to 32% in PY9 (from 25% in PY8) and in the Innovation cohort to 35% in PY9 (from 27% in PY8).

Teachers value the kits because the energy-savings products connect their students' home lives to what they learn in school. Some teachers said they did not have time to review the products in the kit with their class. According to teachers Cadmus interviewed, most of the questions they get about the kit regard the smart power strip (see *15.6.3.3 Teacher Experience and Feedback*). In line with this, in PY10, the ICSP's contractor has included additional information in the presentation on smart power strips with step-by-step instructions.

Conclusion: The kits are an important aspect of the program but required some additional instruction, especially around using the smart power strips and how showerheads save energy. In PY9, the increased focus on water-saving products in presentations and program materials may have supported the increase in installation rates for showerheads.

Recommendation #4: After PY10 changes are in place, consider following up with teachers to determine whether additional support is needed about how to use smart power strips and continue to focus on the importance and the energy-saving benefits of water-saving products. If needed, additional support could be added to the presentation, or as part of the supplemental materials, or both.

Findings: The ICSP substantially underreported savings for the Tier 2 advanced power strips in the Innovation Pilot (see *15.3 Gross Impact Evaluation*). For the Innovation Pilot, Tier 2 advanced power strips savings were not claimed for the entire population of distributed kits. Instead, the ICSP claimed savings only for the number of power strips confirmed as installed from the returned surveys and not for any students who did not return a HEW. Furthermore, the ICSP included an ISR, which, if claiming savings only for power strips confirmed as installed from the surveys, means it applied the ISR twice. Altogether, these discrepancies understated savings for Tier 2 advanced power strips. Cadmus calculated *ex post* savings based on the number of power strips distributed and not the number used by the ICSP to claim *ex ante* savings. This led to substantially higher verified savings than reported savings for the Innovation Pilot.

Conclusion: Calculating *ex ante* savings for Tier 2 advanced power strips based on the number of power strips distributed (as the ICSP does for all kit products) would increase the accuracy of reported savings and improve realization rates.

Recommendation #5: The ICSP should calculate *ex ante* savings for Tier 2 advanced power strips based on the number of power strips distributed.

Findings: Differences between the assumptions used by Cadmus and the ICSP affected the program's realization rate (see *15.3 Gross Impact Evaluation*). Specifically, the ICSP used the PA TRM default values for number of showers in the home (lower than the value Cadmus identified through data gathered from the HEWs) for showerheads and number of people in the home for faucet aerators (lower than the value Cadmus identified through data gathered from the HEWs). This caused the ICSP to underestimate savings for faucet aerators and slightly overestimate showerhead savings, when not factoring in the installation rates. The average water heater setback temperature change identified through data gathering was lower than the default value, leading to lower savings than planned for this improvement.

Conclusion: The ICSP could increase the accuracy of reported savings and improve realization rates if it used data available from the HEWs or used the prior year's verified ISR in the *ex ante* calculations.

Recommendation #6: The ICSP should consider using PY9 survey-verified results for ISRs, average water heater setback temperatures, and home characteristics (i.e., number of persons in the home and number of showers in home) to estimate PY10 *ex ante* energy savings.

15.8.1 Status of Recommendations

Table 15-15 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 15-15. Status of Recommendations for the Student Energy Efficient Education Program

Student Energy Efficient Education Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	Consider asking NEF to update the presentation and teacher materials given to Innovation cohort students to be more challenging for this grade level.	Being considered. NEF will work on adding more information on these items to their website for teachers to use in their energy lessons.
2	Consider providing teachers with additional digital resources as part of the teacher packet, such as videos, games, and links to online articles.	Implemented. Created a closed Facebook group for our Innovation teachers. It's a group that will be monitoring and using to interact with teachers and encourage them to share what they're doing in their classroom before, during and after the presentation. This will help determine whether any additional materials are needed to add to the curriculum, as well as allow teacher input on what else they'd like to see offered.
3	Follow up with teachers who were provided with additional instructions in PY10 and determine whether teachers continue to want demonstrations on how to incorporate program materials into their curriculum, such as video demonstrations of other teachers presenting the material in class.	Being considered. NEF will work on adding more information on these items to their website for teachers to use within their energy lessons.
4	After PY10 changes are in place, consider following up with teachers to determine whether additional support is needed about how to use smart power strips and continue to focus on the importance and the energy-saving benefits of water-saving products. If needed, additional support could be added to the presentation, or as part of the supplemental materials, or both.	Implemented. This year NEF has added more detail in the presentations. Also, NEF has changed the "Cost of Looking Your Best" activity which we believe will help with the importance of the shower devices.
5	The ICSP should calculate *ex ante* savings for Tier 2 advanced power vstrips based on the number of power strips distributed.	Being considered.
6	The ICSP should consider using PY9 survey-verified results for ISRs, average water heater setback temperatures, and home characteristics (i.e., number of persons in the home and number of showers in home) to estimate PY10 *ex ante* energy savings.	Being considered.

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CADMUS

DEMAND RESPONSE

The Demand Response Program is for commercial and industrial (C&I) customers and for government, nonprofit, and education (GNE) customers to voluntarily reduce electricity demand during Act 129 demand response events.

VERIFIED DEMAND REDUCTION

Phase III has so far saved **126.7 MW**

110% of projected

110% of projected

PY9 saved **126.7 MW**

PROGRAM SATISFACTION

80% Satisfied with overall program

100% satisfied with **communication with ICSP**

100% said **timing of event notifications** was adequate

90% likely to **participate in program in 2018**

PY9 PARTICIPATION

A total of **3** events with **93** unique particpants:

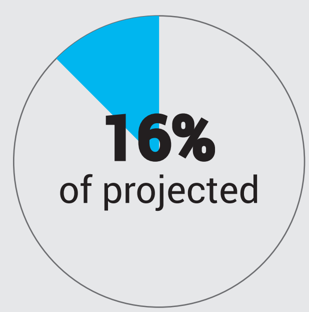
90 participants curtailed 120.29 MW in June 13, 2017 event

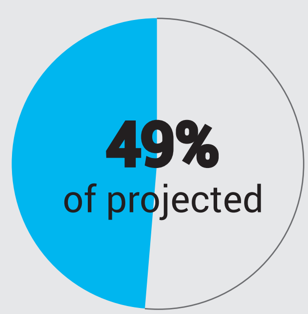
29 participants curtailed 131.81 MW in July 20, 2017 event

28 participants curtailed 127.93 MW in July 21, 2017 event

ACTUAL EXPENDITURES ($1,000)

Phase III expenditures so far **$2,383**





PY9 expenditures **$1,736**

16 Demand Response Program

During Phase III, PPL Electric Utilities operated the Demand Response Program for commercial and industrial (C&I) customers and for government, nonprofit, and education (GNE) customers. Participating customers entered into contracts with CPower, the program's ICSP, to voluntarily reduce electricity demand during Act 129 demand response events. A total of 93 customers participated in Act 129 demand response events during PY9.

PPL Electric Utilities managed the ICSP and provided overall strategic direction for the program. The ICSP enrolled and contracted with customers, initiated events during the summer (June through September 2017) of PY9, and made performance-based payments to participants.

In PY9, PPL Electric Utilities initiated three load curtailment events, which occurred on June 13, July 20, and July 21 of 2017. Each event occurred on non-holiday, weekdays between 2:00 p.m. and 6:00 p.m. PPL Electric Utilities initiated each event in accordance with Act 129 demand response rules, which require a four-hour event on the following day when at least one hour of the PJM RTO day-ahead forecast exceeded 96% of the PJM's forecast of summer peak demand. Per Act 129 demand response rules, there can be a maximum of six events per program year, and there were three events in PY9.

The ICSP notified participants between 10:00 a.m. and 6:00 p.m. on the day before the event, and most participants received notification in the morning or early afternoon. Before the start of each event, the ICSP received a commitment from these notified customers to participate in the event for specific hours. To enroll in an event, participants selected specific hours on the ICSP's online platform, which served as the primary enrollment and feedback channel for the program. Participants had the option of participating for all or a subset of event hours. Across all events and customers, only four times did a customer participate for a subset of hours.

To comply with the PaPUC's Act 129 Phase III demand response compliance targets, PPL Electric Utilities' Demand Response Program must reduce its system load by an average of 92 MW (measured at the generator level) over all demand response events during the last four years of Phase III (PY9–PY12).[128] In addition, PPL Electric Utilities is required to achieve a minimum of 85% of the 92 MW compliance target, or 78.2 MW, during each event.

Compliance targets for demand response programs were established at the generator level, which means the load reductions measured at the customer meter must be increased to reflect transmission and distribution losses (line losses). The peak demand impact estimates presented in this report have been adjusted for these line losses. PPL Electric Utilities uses the following line loss percentages/ multipliers by sector:

- Small C&I = [8.75% or 1.0875]
- Large C&I = [4.2% or 1.0420]

[128] Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2015-2515642) filed with the Pennsylvania PUC on June 6, 2017.

16.1 Progress Toward Phase III Projected Savings

PPL Electric Utilities designed the Demand Response Program for approximately 115 MW, to exceed its 92 MW Act 129 demand response compliance target to account for various operational and evaluation uncertainties. In PY9, PPL Electric Utilities achieved verified peak demand reductions that averaged 126.7 MW over all event hours, which are 11.7 MW (approximately 10%) greater than estimated in the EE&C Plan and approximately 38% greater than the 92 MW target for Phase III.

Table 16-1 shows the program's verified gross peak demand reductions and progress toward its Phase III totals, as filed in the EE&C plan.

Table 16-1. PY9 Demand Response Program Projected and Verified Savings

Event	PY9 Only			Phase III: PY8–PY12 [1]		
	Projected [2] (MW)	Verified [3] (MW)	Percentage of Projected	Projected [2] (MW)	Verified (MW)	Percentage of Projected
Demand response capacity	115	126.7	110.2%	115	126.7	110.2%

[1] All demand reductions are averages across all events. The planned reductions are not summed across years, since the sum of demand reductions across years is not a meaningful concept. There were no demand response events in PY8. The first demand response events occurred in PY9.
[2] Planned savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642) filed with the Pennsylvania PUC December, 2017. Estimated demand reduction is shown per event hour.
[3] Verified savings are the average demand response savings per event during the June 13, July 20, and July 21 Act 129 events.

16.2 Participation and Reported Savings by Customer Segment

16.2.1 Definition of a Participant

A participant in Demand Response Program in PY9 is defined as customer (unique account number) that participated in at least one of PPL Electric Utilities' Act 129 demand response events.

16.2.2 Program Participation and Reported Impacts

Table 16-2 presents the participation counts, reported demand reduction, and incentive payments for the Demand Response Program in PY9 by customer segment and Act 129 event.

The program reported demand savings of approximately 101 MW on June 13, 2017, 125 MW on July 20, 2017, and 121 MW on July 21, 2017. Large C&I customers accounted for between 96% and nearly 100% of the reported demand savings for these events.

Table 16-2. PY9 Demand Response Program Participation and Reported Impacts

Parameter	Small C&I (Non-GNE)	Large C&I (Non-GNE)	GNE	Total [(1)]
PYTD # Participants	60	23	10	**93**
June 13, 2017, Reported MW	(0.74)	101.27	0.34	**100.87**
July 20, 2017, Reported MW	0.11	121.23	3.92	**125.26**
July 21, 2017, Reported MW	-	116.69	4.11	**120.80**
Total Average Reported MW	**(0.31)**	**113.06**	**2.79**	**115.6**
PY9 Incentives ($1000)	$0.35	$956	$23	**$980**
Note: The load impacts reported in this table have been grossed up to reflect transmission and distribution losses. [(1)] Total may not equal total of row due to rounding.				

Table 16-3 reports the number of dual participants in the PPL Electric Utilities' demand response program and the incentives paid to dual participants. A dual participant was a facility that participated in PPL Electric Utilities' demand response program and a PJM demand response program in PY9. In PY9, all PPL Electric Utilities demand response program participants were dual participants.

Table 16-3. Dual Participants

Number of Dual-Enrolled Customers	Number of Act 129-Only Customers	Incentives paid to Dual-Enrolled Customers ($1000)	Incentives Paid to Act 129-Only Customers ($1000)
93	0	$980	$0
Note: Dual enrolled customers were enrolled in PPL Electric Utilities' Act 129 Demand Response Program and PJM demand response programs in PY9.			

16.3 Gross Impact Evaluation

The impact evaluation sampling strategy is summarized in Table 16-4. Cadmus analyzed consumption data to estimate Act 129 load impacts for the population of participants. There was no sampling. The number and composition of participants varied between events, because the ICSP called upon different sets of customers for each event.

Before the start of PY9, Cadmus collected 15-minute advanced metering infrastructure (AMI) interval consumption data from 2016 for recruited facilities and conducted an individual facility analysis to identify the most accurate baseline calculation method for Cadmus' determination of verified peak reductions for each participant. Cadmus evaluated the predictive accuracy of a range of day-matching methods such as the "three previous non-holiday, non-event weekdays" or "seven days of previous 10 non-holiday, non-event weekdays with the highest loads" and a variety of regression model specifications. Cadmus then used the most accurate baseline model to determine the verified peak load reductions during three Act 129 demand response events in summer 2017. Cadmus determined the verified peak load reductions for each customer during each event hour and the average load reduction for each event. Additional details about the evaluation methodology are in *Appendix O.1.1 Methodology*.

Table 16-4. PY9 Demand Response Program Gross Impact Sample Design

Stratum	Event	Population Size	Assumed Proportion or Cv in Sample Design	Achieved Sample Size	PYRTD MW	Impact Evaluation Activity
Small C&I	June 13, 2017	59	N/A (Census)	59	(0.74)	An individual customer impact analysis was conducted for each participant in each event
	July 20, 2017	1	N/A (Census)	1	0.11	
	July 21, 2017	0	N/A (Census)	0	-	
Large C&I	June 13, 2017	22	N/A (Census)	22	101.27	
	July 20, 2017	18	N/A (Census)	18	121.23	
	July 21, 2017	18	N/A (Census)	18	116.69	
GNE	June 13, 2017	9	N/A (Census)	9	0.34	
	July 20, 2017	10	N/A (Census)	10	3.92	
	July 21, 2017	10	N/A (Census)	10	4.11	
Program Total	**June 13, 2017**	**90**	**N/A (Census)**	**90**	**100.87**	
	July 20, 2017	**29**	**N/A (Census)**	**29**	**125.26**	
	July 21, 2017	**28**	**N/A (Census)**	**28**	**120.80**	

Note: The load impacts reported in this table have been grossed up to reflect transmission and distribution losses.

The research activities in PY9 were consistent with the evaluation plan except that Cadmus determined that, for small C&I or GNE facilities, day-matching produced event hour consumption baselines that were too low. Day-matching did not account for the positive correlation between Act 129 event days and facility electricity demand for air conditioning. Instead of day-matching, Cadmus used regression to estimate baselines for all GNE and small C&I facilities.

Table 16-5 shows that in PY9 the Demand Response Program verified average demand reduction is 126.7 MW. This yields a realization rate of 110% relative to the reported (*ex ante*) load reduction. The verified average demand savings exceeded by 34.7 MW PPL Electric Utilities' Act 129 target for Phase III.

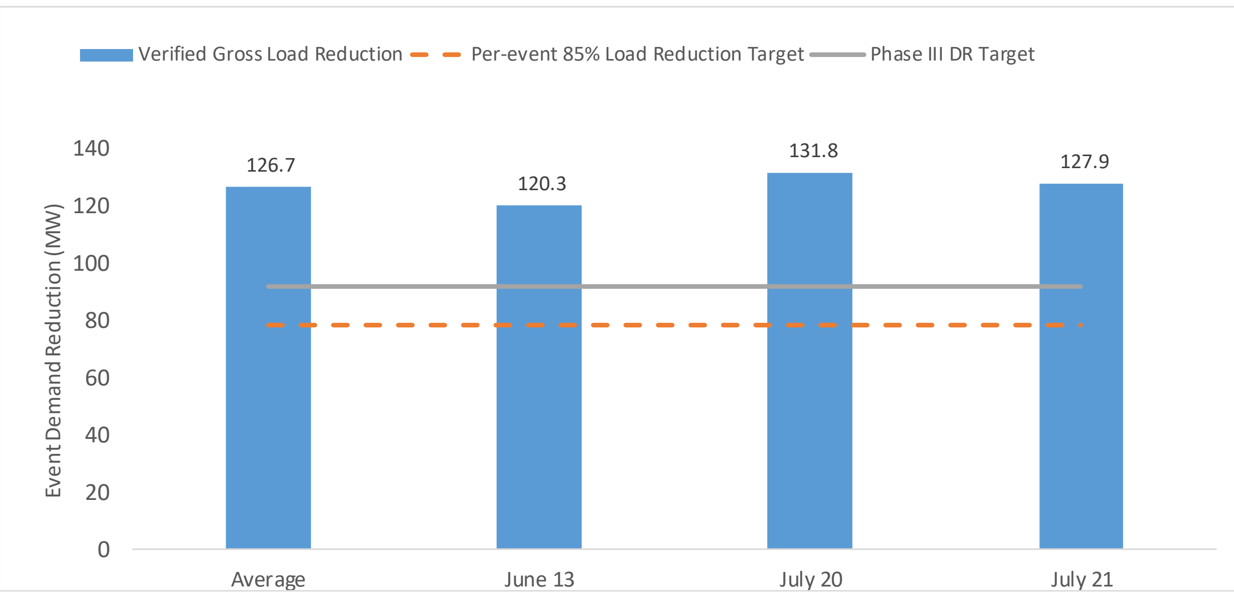
Table 16-5. PY9 Demand Response Program Gross Impact Results for Demand

Stratum	Event	PYRTD MW	Demand Realization Rate	PYVTD MW [1]	Sample C_v or Error Ratio	Relative Precision at 90% C.L. [2]
Small C&I	June 13, 2017	(0.74)	-404%	2.97	N/A	17%
	July 20, 2017	0.11	162%	0.17	N/A	13%
	July 21, 2017	-	0%	-	N/A	N/A
Large C&I	June 13, 2017	101.27	112%	113.86	N/A	6%
	July 20, 2017	121.23	105%	126.99	N/A	5%
	July 21, 2017	116.69	105%	123.01	N/A	5%
GNE	June 13, 2017	0.34	1022%	3.46	N/A	16%
	July 20, 2017	3.92	119%	4.65	N/A	18%
	July 21, 2017	4.11	120%	4.92	N/A	17%
Event	**June 13, 2017**	**100.87**	**119%**	**120.29**	**N/A**	6%
	July 20, 2017	**125.26**	**105%**	**131.81**	**N/A**	5%
	July 21, 2017	**120.80**	**106%**	**127.93**	**N/A**	5%
Average		**115.64**	**110%**	**126.68**	**N/A**	3%

[1] Based on Cadmus' analysis of participant AMI consumption data. MW were grossed up to reflect transmission and distribution losses.
[2] Precision accounts for covariances of savings across hours of each event but not between events.

Figure 16-1 shows PPL Electric Utilities is on track to meet the Phase III target of an average of 92 MW per event hour.

Figure 16-1. Gross Verified Savings in Comparison to Act 129 Targets



Note: The load impacts reported in this figure are based on Cadmus analysis of participant AMI consumption data and have been grossed up to reflect transmission and distribution losses.

PPL Electric Utilities achieved verified demand savings of 120.3 MW on June 13, 2017, 131.8 MW on July 20, 2017, and 127.9 MW on July 21, 2017, yielding realization rates of, respectively, 119%, 105%, and 106%.

The following factors may have led to differences between the reported and verified savings and realization rates that deviated from 100%:

- **Different treatment of estimated readings**. PPL Electric Utilities estimated about 2% of all hourly interval readings for participant facilities between April 1, 2017, and July 21, 2017. Cadmus replaced these estimated readings with missing values and did not include them in the analysis sample. It was not possible to estimate demand savings for one small C&I facility because all of its kWh readings for event hours were estimated.
- **Allowance of event notification days in basis window.** Cadmus excluded event notification days from consideration for the basis window when calculating customer baselines. This exclusion was justified because Cadmus' analysis of load impacts on notification days showed that many customers increased or decreased their loads in response to event notifications. (See *Appendix O Evaluation Detail – Demand Response Program*.) The ICSP did not exclude event notification days when calculating customer baselines.
- **Different methods for calculating customer baselines.** To the extent possible, the ICSP attempted to align its baseline calculation method with Cadmus' method. However, for all small C&I and GNE facilities and approximately half of large C&I facilities, Cadmus employed regression analysis to calculate the baseline while the ICSP employed day-matching. The ICSP reasoned that day-matching was easier for participants to understand than regression; Cadmus believed that regression yielded more accurate predictions of customer consumption.

The large C&I sector produced most of the program's demand savings. Large C&I participants provided average demand savings per hour of 113.9 MW on June 13, 2017, 127.0 MW on July 20, 2017, and 123.0 MW on July 21, 2017, or about 95% of the total verified savings.

16.4 Verified Savings Estimates

In Table 16-6, the realization rates determined by Cadmus are applied to the reported demand savings estimates to calculate the verified savings estimates for the Demand Response Program in PY9. In future years, these and future estimates of verified demand reductions will be averaged to calculate the Phase III (P3VTD) program impacts.

Table 16-6. PYTD and P3TD Demand Savings Summary

Savings Type	Demand (MW) [1] [2]
PYRTD	115.64
PYVTD Gross	126.68
PYVTD Net [3]	-
P3RTD	115.64
P3VTD Gross	126.68
P3VTD Net [3]	-

[1] Savings are presented as the average of the total demand response reductions per event across the June 13, July 20, and July 21 Act 129 events.
[2] Total may not match due to rounding.
[3] There are no net savings because neither free riders nor spillover apply to this program. C&I and GNE participants are not expected to curtail their loads without notification of PPL Electric Utilities system peaks and without compensation.

16.5 Process Evaluation

16.5.1 Research Objectives

The process evaluation assessed program implementation and customer satisfaction. The main research objectives focused on these areas:

- Customer recruitment and motivation
- Customer satisfaction and response to event notification
- Customer response to payment
- Program design and implementation
- Customer perspective about program benefits and costs
- Customer action to reduce loads

16.5.2 Evaluation Activities

The PY9 process evaluation activities for the Demand Response Program included these:

- Interviews with PPL Electric Utilities and ICSP program managers
- Telephone participant surveys
- Logic model review

Considering the smaller than expected participant sample frame, i.e., 26 unique companies managed the 93 participating facilities, Cadmus altered the target number of completed participant interviews from 70 to 10 and opted for telephone surveys instead of a mix of online and telephone surveys. Furthermore, because of the small sample size, Cadmus could not estimate population parameters with 90% confidence and ±10% precision.

The five largest participating companies in the Demand Response Program represent approximately 75% of the total enrolled peak reductions (MW). Despite multiple attempts to contact high-priority participants (ranked by enrolled MW load reduction) via email and phone calls, Cadmus completed interviews with three of the top 10 participants. Although Cadmus met the evaluation target of 10 participant interviews, none of the top five participants agreed to an interview, which limited the representative enrolled MW of interview respondents to 12.4% of the total enrolled MW in the program. Therefore, the responses are representative of small (by MW) participants.

Table 16-7 lists the process evaluation sampling strategy. Additional details about sampling methodology are included in *Appendix O.1.1 Methodology*.

Table 16-7. Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Number of Records Selected for Sample Frame [(1)]	Percent of Sample Frame Contacted to Achieve Sample [(2)]
PPL Electric Utilities Program and ICSP Staff	Staff	Telephone in-depth Interview	2	N/A	2	2	N/A	100%
Participant Surveys	Participating Companies [(3)]	Telephone in-depth interviews	26	N/A	10	10	26	100%
Program Total								

[(1)] Sample frame is a list of participants with contact information who have a chance to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database.
[(2)] Percent contacted means the percentage of the sample frame called to complete surveys.
[(3)] 26 unique companies managed the 93 participating facilities. See *Appendix A, Process Evaluation*, for additional discussion.

16.5.2.1 Survey Methodology

Cadmus conducted telephone interviews with participating customers between November and December of 2017.

To prepare the interview contact list, Cadmus included all 93 facilities participating in the PY9 Demand Response Program. Because seven participating companies managed multiple facilities, including 63 retail facilities managed by just three companies, Cadmus created a contact list of 26 unique participating companies.

16.5.2.2 Program Staff and ICSP Interview Methodology

In November of 2017, Cadmus conducted interviews with the program managers from PPL Electric Utilities and the ICSP.

16.5.3 Summary of Process Evaluation Findings

Overall, program managers and participants said the program is working well and as intended.[129] The program met the Act 129 demand reduction target and most customers are satisfied with the program, plan on participating in 2018, and said the program was worthwhile from a business standpoint. PPL Electric Utilities' and the ICSP's substantial upfront investment in a detailed operations manual and program design likely resulted in participant satisfaction with the program overall and with key design elements.

The program did encounter minor issues with customer enrollment and performance during the first event. These issues were properly addressed for the second and third events. In interviews with 10 program participants, representing roughly 12% of the total enrolled MW load reduction, respondents said payment timing is the primary challenge facing the program.

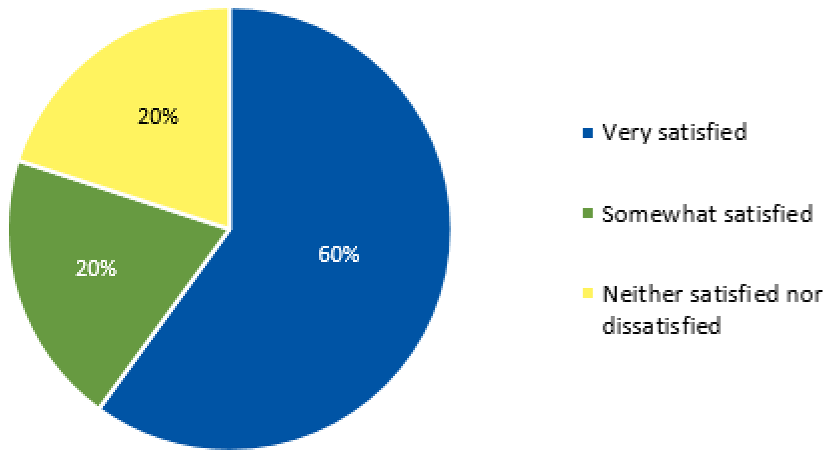
16.5.3.1 Participant Satisfaction

Overall, participants were satisfied with the PPL Electric Utilities Demand Response Program. Six of the 10 interview respondents said they were *very satisfied* with the program, and two said they were *somewhat satisfied* (Figure 16-2). None of the participants Cadmus interviewed said they were dissatisfied with the program overall.

Respondents were satisfied with their communications with ICSP – four respondents said that they were *very satisfied,* and four respondents said that they were *somewhat satisfied.* The remaining two respondents said they were *not too satisfied* with their communications with the ICSP.

[129] The five largest participating companies in the Demand Response Program represent approximately 75% of the total enrolled peak reductions (MW). However, none of the top five participating companies provided input to the process evaluation. Therefore, the findings are representative of the smaller participating companies that comprise approximately 12% of the MW for the Demand Response Program.

Figure 16-2. Overall Program Experience



Source: Interview question D1, "Thinking about your overall experience with the PPL Electric Utilities Demand Response Program, how would you rate your satisfaction" (n=10)

16.5.3.2 Program Benefits and Costs

Cadmus asked interview respondents whether it was worthwhile from a business standpoint to shut down or curtail operations in order to participate *in* the program. Eight of 10 respondents said the program benefits outweighed the costs and the program was worthwhile**.** The other two respondents had reduced their peak load by shifting to backup generators and had not yet compared the generator fuel costs to the expected incentive. One of these respondents said the benefits of PPL Electric Utilities' Demand Response Program were not good enough and compared poorly to PJM's program, which offered higher incentives.

Most respondents said the expected incentive amount was adequate. The ICSP waits for the annual evaluation to determine verified peak reductions before processing incentive payments. Since the program ICSP had not yet paid the incentive as of December 2017, two participants were anxious about recouping incurred operational costs. These two respondents said they were concerned by the delay in incentive payments and viewed the payment timing as inadequate compared to PJM's quarterly payment structure. The other respondents did not identify payment timing as a concern.

Nine of 10 respondents said that they will likely participate in the Demand Response Program in 2018. One respondent who was unlikely to participate said that generator fuel costs and the internal labor needed for participation outweighed the incentives.

16.5.3.3 Design and Implementation

All 10 respondents said that the timing of event notifications was adequate for them to prepare, and three respondents identified the 24-hour event notification as the primary strength of the program.

Also, respondents did not view the duration or frequency of events as major challenges, with all 10 reporting that the duration and frequency of the events did not affect their ability to participate.

Two respondents said they found the online platform difficult to use for the first event. Neither fully understood how to enroll for all hours of the event and how to interpret the performance reports on the online platform, and one did not fully understand how the final MW reduction was calculated for all four hours. In both instances, subsequent communication with the ICSP answered their questions and mitigated user difficulty for the second and third events.

16.6 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 16-8. Total resource cost (TRC) benefits were calculated using gross verified impacts. Per the TRC Order, 75% of the customer incentive payment is used as a proxy for the participant cost when calculating the TRC ratio for the program. PYTD values represent PY9 costs and benefits, and P3TD values represent phase costs and benefits up to PY9. Net present value (NPV) PYTD costs and benefits are expressed in PY9 dollars. NPV costs and benefits for P3TD financials are expressed in PY8 dollars.

Table 16-8. Summary of Demand Response Program Finances–Gross Verified

Row #	Cost Category	PYTD ($1,000)		P3TD ($1,000) (6)	
1	EDC Incentives to Participants	$980		$910	
2	EDC Incentives to Trade Allies	-		-	
3	Participant Costs (net of incentives/rebates paid by utilities)	($245)		($228)	
4	**Incremental Measure Costs (Sum of rows 1 through 3) (1)**	**$735**		**$683**	
		EDC	**CSP**	**EDC**	**CSP**
5	Design & Development (2)	-	-	-	-
6	Administration, Management, and Technical Assistance (3)	$53	-	$198	-
7	Marketing (4)	-	-	-	-
8	Program Delivery (5)	-	$703	-	$1,152
9	EDC Evaluation Costs	-		-	
10	SWE Audit Costs	-		-	
11(6)	**Program Overhead Costs (Sum of rows 5 through 10) (1), (6), (10)**	$756		$1,350	
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	-		-	
13	**Total NPV TRC Costs (Net present value of sum of rows 4, 11, and 12) (1), (7)**	**$1,491**		**$2,032**	
14	Total NPV Lifetime Electric Energy Benefits				
15	Total NPV Lifetime Electric Capacity Benefits	$6,188		$5,749	
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	-		-	
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	-		-	
18	**Total NPV TRC Benefits (8) (Sum of rows 14 through 17) (8), (1)**	**$6,188**		**$5,749**	
19	**TRC Benefit-Cost Ratio (9)**	**4.15**		**2.83**	

(1) May not sum to total due to rounding.
(2) All costs for Plan Design and Development are portfolio level costs and are assigned to customer sectors at the end of the phase. These portfolio costs are not assigned to specific programs.
(3) Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
(4) Includes the marketing ICSP and marketing costs by program ICSPs.
(5) Includes ICSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.
(6) P3TD amounts are discounted back to PY8.
(7) Total TRC Costs includes Total EDC Costs and Participant Costs.
(8) Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. 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.
(9) TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
(10) Total costs include those incurred for PY9 after the Semi-Annual Report filed January 15, 2018.

16.7 Recommendations

Overall, the Demand Response Program is on track to meet the Act 129 demand reduction target for Phase III. PPL Electric Utilities averaged 126.7 MW per event hour during PY9 and exceeded the required minimum demand savings for each event of 85% of 92 MW or 78.2 MW. The program is cost-effective, with P3TD TRC Benefit-Cost ratio of 3.6. Participants are predominantly satisfied with the program overall and with all program design and implementation aspects.

Recommendations are provided in Table 16-9, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Finding: Participants are satisfied with the program overall. Of the 10 respondents interviewed, six said they were *very satisfied* with the program, and two said they were *somewhat satisfied.* No participants said they were dissatisfied with the program overall (see section *16.5.3.1 Participant Satisfaction*). Interview respondents said the program is working as intended and that the notification timing is a main strength of the program. Respondents said the duration and frequency of events did not hinder their ability to participate.

Conclusion: Customer satisfaction with the program design and implementation are indicative of the upfront investment by PPL Electric Utilities and the ICSP to develop detailed operational plans. Participation in the program, once initial training is completed, is straightforward with well-defined protocols. The program is well designed to provide adequate flexibility and transparency to participants while also ensuring that minimum load reduction targets are met.

Finding: As of December 2017, participants have not yet received the incentive payment because the ICSP waits for the annual evaluation to determine verified peak reductions before processing incentive payments. Two interview respondents said the payment timing was inadequate, particularly in comparison to the quarterly incentive payments they receive through PJM's program (see section *16.5.3.2 Program Benefits and Costs*).

Conclusion: The lengthy period between event participation and incentive payment is a concern for some customers, particularly those that incur participation costs as higher production costs because of the curtailment of business operations or backup generator fuel costs.

Recommendation #1: The ICSP should clearly communicate to customers when they should expect to receive the incentive payment. The ICSP could consider paying the incentive earlier, in installments, or within a timeframe amenable to each customer's financial considerations.

Finding: Small C&I and GNE customers produced higher demand savings than the ICSP reported, as shown in Table 16-5.

Conclusion: Though each small C&I and GNE customer provided a relatively small amount of demand response capacity, together these customers performed as expected and contributed a small but significant share of the achieved savings.

Recommendation #2: The ICSP could consider enrolling more small C&I and GNE customers as a hedge against possible under-performance of large C&I customers with significant enrolled capacity.

Finding: Baselines for many small C&I and GNE facilities that the ICSP estimated by day-matching tended to be underestimated, as explained in *Appendix O*. Cadmus employed individual regressions to estimate baselines for all GNE and small C&I facilities and limited the baseline days to 30 non-holiday, non-event weekdays with the highest PJM day-ahead forecasts.

Conclusion: The *ex ante* savings reported by the ICSP underestimated the achieved demand savings.

Recommendation #3: In future evaluations, Cadmus plans to employ regression analysis to estimate baselines of small C&I and GNE customers or any customer with significant air conditioning loads. The ICSP could reconsider its baseline estimation approach for small C&I and GNE customers to better account for the impacts of weather on loads.

Finding: Some participants with large enrolled capacity appear to have adjusted their consumption of electricity on the day before an event in response to receiving advance notifications. *Appendix O* analyzes load impacts on notification days.

Conclusion: The Evaluation Framework for Pennsylvania Act 129 Phase III Programs gave evaluators discretion about whether to include notification days in the basis window. Since electricity consumption on notification days was outside the normal or expected range for many participant facilities, Cadmus concluded notification days should not be included in the customer baseline basis window. Cadmus excluded these days from the basis window when estimating baselines.

Finding: The savings realization rate was close to 100%, and, for large C&I participants, which supplied 95% of the demand savings, Cadmus' savings estimates were close to the ICSP's. This may be attributed to the alignment of baseline calculations methods, particularly for the largest savers, between the ICSP and Cadmus. *Appendix O* presents savings realization findings.

Conclusion: Alignment of the ICSP and Cadmus' baseline calculation methods for large C&I facilities using day-matching produced similar savings estimates, resulting in a realization rate near 100%.

16.7.1 Status of Recommendations

Table 16-9 contains the status of each PY9 recommendation made to PPL Electric Utilities.

Table 16-9. Status of Recommendations for the Demand Response Program

Demand Response Program		
Recommendation Number	**Recommendation**	**EDC Status of Recommendation (Implemented, Being Considered, Rejected and Explanation of Action Taken by EDC)**
1	The ICSP should clearly communicate to customers when they should expect to receive the incentive payment. The ICSP could consider paying the incentive earlier, in installments, or within a timeframe amenable to each customer's financial considerations	Implemented. The payment timing is specified in the individual customers contracts.
2	The ICSP could consider enrolling more small C&I and GNE customers as a hedge against possible under-performance of large C&I customers with significant enrolled capacity.	Implemented.
3	In future evaluations, Cadmus plans to employ regression analysis to estimate baselines of small C&I and GNE customers or any customer with significant air conditioning loads. The ICSP could reconsider its baseline estimation approach for small C&I and GNE customers to better account for the impacts of weather on loads.	Being considered

17 Cost Recovery

Act 129 allows Pennsylvania EDCs to recover EE&C plan costs through a cost-recovery mechanism. PPL Electric Utilities' cost-recovery charges are organized separately by customer sectors to ensure that the electric rate classes that finance the programs are the rate classes that receive the direct energy and conservation benefits. Cost-recovery is governed by tariffed rate class, so it is necessarily tied to the way customers are metered and charged for electric service.

Table 17-1. EE&C Plan Expenditures by Cost-Recovery Category(1) ($1,000)

Cost Recovery Sector	Rate Classes Included	PYTD Spending	P3TD Spending
Residential & Low-Income	Residential (primarily RS)	$31,051	$58,648
Small C&I	Small C&I (primarily GS1 & GS3)	$6,895	$13,354
Large C&I	Large C&I (primarily LP4 & LP5)	$7,497	$14,008
GNE	Residential, Small C&I, and Large C&I	$3,565	$7,995
Common (2)		$5,691	$11,292
Portfolio Total (3)		**$54,698**	**$105,298**

(1) Includes SWE costs.
(2) Includes costs not collected at the sector level. These costs are allocated to the sectors at the end of the phase.
(3) Totals may not sum due to rounding.

Appendix A. Upstream Lighting Cross-Sector Sales

Cadmus used PY8 cross-sector sales proportions, as described in the PY8 Annual Report.[130]

[130] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

Appendix B. Site Inspection Summary

Table B-1 summarizes programs receiving verification site visits by Cadmus or the ICSP (listed in column "Inspection Firm"). The table includes the numbers of inspections, and resolution of discrepancies.

Table B-1. Site Inspection Summary

Program	Inspection Firm	Inspections Conducted	Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
Non-Residential Sector				
Custom	Warren Energy Engineering, LLC (for Cadmus)	33	14	• Discrepancies only found on small sample sites (14 of 15 small sample site visits) though all equipment and quantities matched reported values
	CLEAResult (the ICSP)	89	89	• Contractor/customer estimate of original savings was not accurate • Actual metered data used in place of estimates • Project not modeled accurately originally compared to installed condition • Project scope deviation and possibly not understanding systems installed for Custom
Efficient Equipment Prescriptive Lighting	Warren Energy Engineering (for Cadmus)	32	23	Implementer reported incorrect building type (and associated TRM HOU and CF), pre- and post-install fixture quantities, pre- and post-install fixture types, pre- and post-install fixture controls, lamp type (and associated TRM HOU and CF).
	CLEAResult (the ICSP)	200	178	• Wrong HOU given on Appendix C form vs. what was found from customer interviews on site • Wrong number of lights submitted on application • Wrong amount of bulbs in the ballast/fixture submitted • Incorrect wattage selected for baseline fixtures
Efficient Equipment Direct Discount Lighting	Warren Energy Engineering (for Cadmus)	50	22	Implementer reported incorrect building type (and associated TRM HOU and CF), pre- and post-install fixture quantities, pre- and post-install fixture types, pre- and post-install fixture controls, lamp type (and associated TRM HOU and CF).
	CLEAResult (the ICSP)	67	30	• Wrong number of lights submitted on application • Wrong amount of bulbs in the ballast/fixture submitted • Projects started before receiving pre-approval • Integrated fixtures not used in application • Projects over 120,000 switched from prescriptive to customer provided HOU (or custom hours removed when not over 120,000)

Program	Inspection Firm	Inspections Conducted	Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
Efficient Equipment HVAC	Cadmus	8	2	Commercial CAC >5.4 tons IEER: AHRI capacity and performance are different from reported
			1	Water cooled EER: AHRI performance different from reported. Installed equipment was a water source heat pump.
			1	Guest room occupancy sensor: Reduced ISR and disabled occupancy-based controls during cooling season.
			1	Commercial ASHP <=5.4 Tons: Verified installed unit AHRI capacity and performance varied from reported
Efficient Equipment Motors	Cadmus	7	2	Variable Frequency Drive Improvements: Verified unit quantity, horsepower, or motor efficiency varied from reported
			1	Variable Frequency Drive Improvements: Verified baseline different from reported. Verified additional energy savings during overnight hours.
			1	Variable Frequency Drive Improvements: Verified installed drive set to manual, constant speed setting. Applied custom analysis approach.
			1	Kitchen Exhaust Fan VFDs: Reported savings incorrectly claimed savings for kitchen supply air fan VFDs in addition to the kitchen exhaust fan VFDs
Efficient Equipment Refrigeration	Cadmus	7	1	HE Cooler and Freezer Cases: Verified quantity less than reported (ICSP submitted a duplicate project)
			2	Anti-sweat heater controls low and medium temp: ISR varied from reported
			1	Add Door to Existing Ref Display Cases: Verified quantity less than reported; installed doors have anti-sweat heaters
Efficient Equipment Other	Cadmus	3	0	None
Efficient Equipment	CLEAResult (the ICSP)	21	4	• Project savings may have increased or decreased as a result of site visits which made the projects switch from prescriptive to customer submitted HOU • Ineligible equipment removed from applications • Project scope deviation and possibly not understanding systems installed for Custom

Program	Inspection Firm	Inspections Conducted	Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
Midstream Lighting	CLEAResult (the ICSP)	5	2	• Product not found ship to location and move to another facility
	Warren Energy Engineering (for Cadmus)	37 (110 projects)	37	• Verified quantities • Baseline equipment type • Building operating hours
Residential Sector				
Energy Efficient Home – New Homes Component	Performance Systems Development (PSD) (for the ICSP)	47	42	• Cooling Equipment (26) – Cooling Equipment discrepancies were most often caused by misreported efficiency ratings • Domestic Hot Water (17) – Domestic Hot Water discrepancies were most often caused by misreported efficiency ratings • Orientation (17) – Orientation discrepancies are caused by misreported building orientation • Lighting (10) – All lighting discrepancies involved an incorrectly reported percentage of energy-efficient bulbs. Raters often miscount or fail to identify all the existing fixtures in the home, causing inconsistencies in reporting
Low-Income Sector				
WRAP Manufactured Homes	CMC (the ICSP)	68	0	None
WRAP Baseload	CMC (the ICSP)	642	7	Reported quantity varied from in service quantity
WRAP Low Cost	CMC (the ICSP)	111	3	Reported quantity varied from in service quantity
WRAP Full Cost	CMC (the ICSP)	110	2	Reported quantity varied from in service quantity

Appendix C. Home Energy Report Impact Evaluation Detail

C.1 Methodology

C.1.1 Data Preparation

Cadmus worked with PPL Electric Utilities and the ICSP to acquire the data necessary for the Home Energy Education Program evaluation in PY9. Major data preparation steps included cleaning and compiling the program tracking data, billing consumption, and weather data and testing for significant differences in annual pretreatment consumption between treatment and control customers, by wave.

Cleaning and Compiling Final Data

Cadmus received program tracking data from the ICSP and billing consumption from PPL Electric Utilities. This section describes the steps Cadmus took to process the data and verify customers in the tracking and billing data.

Program Tracking Data

Cadmus received Home Energy Education Program tracking data from the ICSP at the close of PY9. These data included treatment group customers who received home energy reports in the current or a previous year and control group customers tracked since the program's inception. Because the Home Energy Education Program was implemented as a random control trial, Cadmus included all of the possible customers in its evaluation, adopting a "once in, always in" policy for customers originally randomized into either the treatment or control group prior to the launch of the home energy reports. Cadmus verified customer program data from the ICSP with the program tracking data it collected in previous program years to account for any customers not included in the ICSP's tracking data.

Table C-1 shows customer attrition through PY9, by treatment and control groups, by wave, and as originally randomized, active at the beginning of treatment, and treated in PY9. The attrition process captures customers whose accounts closed (became inactive) since the launch of the program and accounts who stopped receiving home energy reports. Differences in "Active at the Beginning of Treatment in PY9" and "Treated in PY9" reflect differences in counts of customers who were eligible to receive treatment in PY9 and customers who were actually treated in PY9.

Table C-1. PY9 Customer Attrition

Wave	Originally Randomized		Active at the Beginning of Treatment in PY9 [1]		Treated in PY9 [2]	
	Treatment	Control	Treatment	Control	Treatment	Control
Legacy Wave 1[4]	50,000	50,000	36,353	36,379	32,221	-
Legacy Wave 2[4]	55,040	25,003	42,146	19,077	37,058	-
Expansion Wave 1[4]	48,707	12,650	42,672	11,038	38,344	-
Low-Income Wave 1[3]	73,500	18,560	58,325	14,798	22,178	-
Low-Income Wave 2[3]	21,401	10,046	16,679	7,846	4,520	-
Phase III Expansion Wave 1	30,584	12,234	30,069	12,017	27,689	-
Total [5]	**279,232**	**128,493**	**226,244**	**101,155**	**162,010**	**-**

[1] Customers in Cadmus' full tracking and billing dataset who were active when PY9 treatment began.
[2] Customers in the ICSP's tracking data for whom Cadmus verified that the ICSP provided home energy reports in PY9 and were active when PY9 treatment began. These counts may not match PPL Electric Utilities' tracking database because a small number of accounts were randomized into two waves.
[3] Treatment for low-income customers began in May 2017.
[4] Treatment for low-propensity customers began in April and May 2018.
[5] May not match due to rounding

Billing Data

Cadmus collected customer billing data for each wave from PPL Electric Utilities to supplement the billing data it had collected and cleaned in previous program years. To clean the billing data, Cadmus followed these steps:

1. Dropped customers whose accounts went inactive before the delivery of the first energy reports
2. Cleaned and calendarized bills, including dropping bills that covered more than 65 days, dropping bills with negative consumption, dropping bills earlier than one year prior to the delivery of the first energy reports, and truing up bills with estimated reads
3. Dropped customers with less than 11 months of pre-treatment bills

Table C-2 provides the attrition in the PY9 analysis sample from data cleaning steps. The final modeling sample included customers in Cadmus' final tracking data who were not dropped during the billing data cleaning process and were included in the billing analysis. These customers were not necessarily active at the beginning of treatment in PY9.

Weather Data

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.

Table C-2. PY9 Sample Attrition from Data Cleaning

Step in Attrition	Legacy Wave 1		Legacy Wave 2		Expansion Wave 1	
	Treatment	Control	Treatment	Control	Treatment	Control
Originally Randomized Customers	50,000 (100%)	50,000 (100%)	55,040 (100%)	25,003 (100%)	48,707 (100%)	12,650 (100%)
Active at Program Launch	48,959 (98%)	48,955 (98%)	53,541 (97%)	24,325 (97%)	47,867 (98%)	12,435 (98%)
Calendarization	48,775 (98%)	48,771 (98%)	53,289 (97%)	24,190 (97%)	47,866 (98%)	12,435 (98%)
Less than 11 Months of Pre-Treatment Data	48,103 (96%)	48,122 (96%)	50,622 (92%)	22,930 (92%)	47,479 (97%)	12,342 (98%)
Final Modeling Sample	**48,103 (96%)**	**48,122 (96%)**	**50,622 (92%)**	**22,930 (92%)**	**47,479 (97%)**	**12,342 (98%)**
Step in Attrition	**Low-Income Wave 1**		**Low-Income Wave 2**		**Phase III Expansion Wave 1**	
	Treatment	**Control**	**Treatment**	**Control**	**Treatment**	**Control**
Originally Randomized Customers	73,500 (100%)	18,560 (100%)	21,401 (100%)	10,046 (100%)	30,584 (100%)	12,234 (100%)
Active at Program Launch	72,630 (99%)	18,344 (99%)	20,875 (98%)	9,765 (97%)	30,265 (99%)	12,101 (99%)
Calendarization	72,626 (99%)	18,344 (99%)	20,875 (98%)	9,765 (97%)	27,697 (91%)	11,096 (91%)
Less than 11 Months of Pre-Treatment Data	71,905 (98%)	18,151 (98%)	20,238 (95%)	9,482 (94%)	27,059 (88%)	10,849 (89%)
Final Modeling Sample	**71,905 (98%)**	**18,151 (98%)**	**20,238 (95%)**	**9,482 (94%)**	**27,059 (88%)**	**10,849 (89%)**

C.1.2 Verification of Balanced Treatment and Control Groups

Cadmus verified that subjects in the randomized treatment and control groups were equivalent in pre-treatment energy use. Cadmus conducted the random assignment of eligible customers to treatment or control groups for Legacy Wave 2 in Phase I, Expansion Wave 1 and both low-income waves in Phase II, and the Phase III Expansion Wave 1 in Phase III. The ICSP performed the randomization for Legacy Wave 1. Cadmus verified the equivalence of waves using the cleaned billing data, comparing preprogram average annual consumption from before the launch of the program.

Table C-3 provides the results of the tests for significant differences in treatment and control group pre-treatment consumption. Cadmus found that all waves were balanced. No statistically significant differences existed between the pre-treatment consumption of treatment and control groups in any wave.

Table C-3. Tests for Significant Differences in Annual Pre-Treatment Consumption

Wave	Customers		Average Annual Electricity Use per Customer (kWh/yr)			p-value (1)
	Treatment Group	Control Group	Treatment Group	Control Group	Difference	
Legacy Wave 1	48,103	48,122	18,535	18,467	67.93	0.1340
Legacy Wave 2	50,622	22,930	27,648	27,760	-111.30	0.1191
Expansion Wave 1	47,479	12,342	23,196	23,191	4.94	0.9276
Low-Income Wave 1	71,905	18,151	11,831	11,780	50.91	0.3678
Low-Income Wave 2	20,238	9,482	7,967	8,041	-74.13	0.4607
Phase III Expansion Wave 1	27,059	10,849	15,178	15,176	1.85	0.9700

(1) A p-value >0.05 indicates an insignificant difference at the 5% significance level.

C.1.3 Ex Post Verified Savings Methodology

Energy Savings Model Specification

Cadmus used regression analyses of monthly billing data from customers in the treatment and control groups to estimate the Home Energy Education Program's energy savings. The billing analysis conformed to IPMVP Option C, whole facility,[131] and the approach described in the Uniform Methods Project.[132,133] Methods also followed those described in the Phase III Evaluation Framework for behavioral programs.[134]

131 Efficiency Valuation Organization. *International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume 1.* January 2012. Page 25. (EVO 10000 – 1:2012) Available online: http://www.evo-world.org/

132 Agnew, K., and M. Goldberg. *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol.* U.S. Department of Energy, National Renewable Energy Laboratory. April 2013. (NREL/SR-7A30-53827) Available online: http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

133 Stewart, J., and A. Todd. *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. (NREL/SR-7A40-62497) Available online: http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

134 Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* August 25, 2016. See Behavior Section 6.1.1.

More specifically, Cadmus used a multivariate regression to analyze the energy use of customers who had been randomly assigned to treatment and control groups. Cadmus tested and compared two general model specifications to check the robustness of savings results:

- The ***post-only*** model regresses customer average daily consumption on a treatment indicator variable and includes as regressors customers' pre-treatment energy use, month-by-year fixed effects, and weather.[135] The model is estimated only with post-treatment customer bills.
- The ***difference-in-differences (D-in-D) fixed effects*** model regresses average daily consumption on a treatment indicator variable, month-by-year fixed effects, customer fixed effects, and weather. The model is estimated with pre-treatment and post-treatment customer bills.

Both models yielded savings estimates that were within each other's confidence intervals, meaning that their results were not statistically different (see this graphically in Figure C-1 and Figure C-2, presented later in this section). In PY9, Cadmus reported the results of the post-treatment only model, consistent with PY8.

The error term ε_{it} should be uncorrelated with program participation ($PART_i$) and other observable variables because of the random assignment of homes to treatment and control groups, and therefore ordinary least squares should result in an unbiased estimate of the average daily savings per customer. Cadmus clustered the standard errors on customers to account for arbitrary correlation in customer consumption over the analysis period.

The following sections provide additional details about each modeling approach.

Post-Only Model

The post-only model was specified assuming the average daily consumption (ADC_{it}) of electricity of home 'i' in month 't' as given by Equation C-1.

Equation C-1

$$ADC_{it} = \beta_1 PART_i * PY_t + \beta_2 Pre\text{–}Usage_i + \beta_3 Pre\text{–}Summer_i + \beta_4 Pre\text{–}Winter_i + \beta_5 Pre\text{–}Usage_i \times \tau_t + \beta_6 Pre\text{–}Summer_i \times \tau_t + \beta_7 Pre\text{–}Winter_i \times \tau_t + W'\gamma + \tau_t + \varepsilon_{it}$$

Where:

β_1	=	Coefficient representing the conditional average treatment effect of the program on electricity use (kWh per customer per day).
$PART_i$	=	Indicator variable for program participation (which equals 1 if customer 'i' was in the treatment group and 0 otherwise).
PY_t	=	Indicator variable for each program year (which equals 1 if the month 't' was in the program year and 0 otherwise).

135 Allcott, H., and T. Rogers. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review* 104 (10), 3003-3037. 2014.

β_2 = Coefficient representing the conditional average effect of pre-treatment electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{-}Usage_i$ = Mean household energy consumption of customer 'i' across all pre-treatment months.

β_3 = Coefficient representing the conditional average effect of pre-treatment summer electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{-}Summer_i$ = Mean household energy consumption of customer 'i' during June, July, August, and September of the pre-treatment period.

β_4 = Coefficient representing the conditional average effect of pre-treatment winter electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{-}Winter_i$ = Mean household energy consumption of home 'i' during December, January, February, and March of the pre-treatment period.

W = Vector using both HDD and CDD variables to control for the impacts of weather on energy use.

γ = Vector of coefficients representing the average impact of weather variables on energy use.

τ_t = Average energy use in month 't reflecting unobservable factors specific to the month. The analysis controls for these effects with month-by-year fixed effects.

β_5 = Coefficient representing the conditional average effect of pre-treatment electricity use, given month 't', on post-treatment average daily consumption (kWh per customer per day).

β_6 = Coefficient representing the conditional average effect of pre-treatment summer electricity use, given month 't', on post-treatment average daily consumption (kWh per customer per day).

β_7 = Coefficient representing the conditional average effect of pre-treatment winter electricity use, given month 't', on post-treatment average daily consumption (kWh per customer per day).

ε_{it} = Error term for customer 'i' in month 't.'

Difference-in-Differences Fixed Effects Model

The D-in-D fixed effects model was specified assuming the average daily consumption (ADC_{it}) of electricity of customer 'i' in month 't' as given by Equation C-2:

Equation C-2

$$ADC_{it} = \alpha_i + \tau_t + W'\gamma + \beta_1 PART_i \times POST_t + \epsilon_{it}$$

Where:

β_1	=	Coefficient representing the conditional average treatment effect of the program on electricity use (kWh per customer per day).
$PART_i$	=	Indicator variable for program participation (which equals 1 if customer 'i' was in the treatment group and 0 otherwise).
$POST_t$	=	Indicator variable for whether month 't' is pre- or post-treatment (which equals 1 if month 't' was in the treatment period and 0 otherwise).
W	=	Vector using both HDD and CDD variables to control for the impacts of weather on energy use.
γ	=	Vector of coefficients representing the average impact of weather variables on energy use.
α_i	=	Average energy use in customer 'i' reflecting unobservable, non-weather-sensitive, and time-invariant factors specific to the customer. The analysis controlled for these effects with customer fixed effects.
τ_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.
ϵ_{it}	=	Error term for customer 'i' in month 't'

Regression Analysis Estimates

Cadmus estimated separate treatment effects for each wave and program year. Table C-4 shows both the D-in-D fixed effects model and post-only model estimates of average daily savings per customer, by wave and program year. All of the models were estimated by ordinary least squares, and Huber-White robust standard errors were adjusted for correlation over time in a customer's consumption.

Note that the ICSP's subcontractor did not send home energy reports to low-propensity customers until late April 2018, near the end of PY9. Cadmus expected the effects of treatment to be different before and after low-propensity customers received their first Phase III reports. To measure the savings occurring after low-propensity customers received their first home energy reports, Cadmus included two program-year indicators for PY9:

- PY9a covers the period in PY9 in which only non-low-propensity customers received any home energy reports (June 2017 through April 2018)
- PY9b covers the period in PY9 in which all customers in these waves, including low-propensity customers, received a Phase III home energy report (May 2018)

In PY8, low-income wave customers did not receive their first reports until May 2017. Cadmus continued to include PY8a (covering June 2016 through April 2017) and PY8b (covering only May 2017) treatment effects in its models for both waves.

Table C-4. Treatment Effects for the Home Energy Education Program by Model Specifications

Treatment Year	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
PY1	0.236 (0.085)***	0.170(0.065)***	-	-	-	-
PY2	0.684(0.046)***	0.688(0.027)***	-	-	-	-
PY3	0.927(0.047)***	0.900(0.028)***	0.934(0.074)***	1.012(0.045)***	-	-
PY4	1.007(0.048)***	1.007(0.029)***	1.192(0.075)***	1.263(0.046)***	-	-
PY5	0.879(0.049)***	0.897(0.029)***	1.201(0.077)***	1.257(0.047)***	-	-
PY6	0.869(0.049)***	0.875(0.030)***	1.214(0.078)***	1.290(0.048)***	0.575(0.089)***	0.594(0.057)***
PY7	0.864(0.050)***	0.838(0.030)***	1.073(0.079)***	1.129(0.049)***	0.739(0.081)***	0.701(0.048)***
PY8	0.907(0.051)***	0.901(0.031)***	0.985(0.080)***	1.080(0.051)***	0.822(0.083)***	0.762(0.049)***
PY9a [(1)]	0.917(0.051)***	0.906(0.033)***	0.924(0.083)***	1.039(0.054)***	0.663(0.087)***	0.640(0.053)***
PY9b [(2)]	0.825(0.147)***	0.660(0.118)***	0.583(0.230)**	0.639(0.191)***	0.601(0.234)**	0.416(0.187)**

Treatment Year	Low-Income Wave 1		Low-Income Wave 2		Phase III Expansion Wave 1	
	D-in-D Fixed Effects	Post-Only	D-in-D Fixed Effects	Post-Only	D-in-D Fixed Effects	Post-Only
PY6	0.064(0.054)	0.101(0.033)***	-	-	-	-
PY7	0.407(0.051)***	0.412(0.029)***	0.145(0.064)**	0.152(0.031)***	-	-
PY8a [(3)]	0.371(0.054)***	0.383(0.032)***	0.164(0.071)**	0.153(0.035)***	0.129(0.070)*	0.123(0.038)***
PY8b [(4)]	0.341(0.142)**	0.340(0.109)***	0.014(0.188)	0.128(0.122)		
PY9	0.234(0.055)***	0.249(0.032)***	0.052(0.074)	0.036(0.037)	0.289(0.071)***	0.297(0.039)***

Note: Standard errors are presented below the estimated treatment effect in parentheses (*** Significant at 1%; ** Significant at 5%; * Significant at 10%). The treatment effects represent the average daily savings per treatment group customer.
[(1)] PY9a covers months June 2017 through April 2018 of PY9.
[(2)] PY9b covers May 2018 of PY9.
[(3)] PY8a covers months June 2016 through April 2017 of PY8.
[(4)] PY8b covers May 2017 of PY8.

The PY9 savings estimates from the D-in-D fixed effects and post-only models were statistically indistinguishable, suggesting that the estimated treatment effects do not depend on the modeling approach. Cadmus reported savings based on the post-only models for all waves because of the increased precision achieved with these models; this is seen in the smaller standard errors of post-only estimates compared to D-in-D fixed effects estimates.

Post-only treatment effects were significant across all waves and program years with two exceptions. Cadmus evaluated average daily savings per customer of 0.128 (p-value of 0.292) and 0.036 (p-value of 0.324) kWh for Low-Income Wave 2 in PY8b and PY9, respectively. A p-value less than 0.10 suggests that the estimate is not statistically different from 0.0 kWh/day, which may mean that either customers in this wave truly did not reduce their consumption compared to the control group or savings in these periods were too small to identify with the available sample size. Table C-2, provided earlier, shows that the counts of treatment and control customers in this wave are considerably smaller than in the other waves.

Table C-5 shows the estimated average daily savings as a percentage of control group consumption, by program year and wave. Consistent with previous year, Legacy Wave 1, Legacy Wave 2, and Expansion Wave 1 maintained consistent savings through PY9a (the majority of PY9) and continued to achieve the largest percentage savings ranges of all waves, with savings ranging between 1.1% (Expansion Wave 1) to 1.9% (Legacy Wave 1).

Encouragingly, the Phase III Expansion Wave 1 more than doubled its savings as a percentage of control group consumption from PY8 to PY9, a significant increase of 0.4%. However, savings remained lower than expected for this wave at 0.7%. Several factors may have contributed, including this wave's average annual pre-treatment usage (shown earlier in Table C-3), which is considerably lower than the usage by other residential waves.

Table C-5. Percentage Treatment Effects for the Home Energy Education Program by Model Specifications

Treatment Year	Legacy Wave 1		Legacy Wave 2		Expansion Wave 1	
	D-in-D Fixed Effects	Post-Only	D-in-D Fixed Effects	Post-Only	D-in-D Fixed Effects	Post-Only
PY1	0.5% (0.2%)***	0.3% (0.1%)***	-	-	-	-
PY2	1.3% (0.1%)***	1.3% (0.1%)***	-	-	-	-
PY3	1.9% (0.1%)***	1.9% (0.1%)***	1.4% (0.1%)***	1.5% (0.1%)***	-	-
PY4	2.0% (0.1%)***	2.0% (0.1%)***	1.7% (0.1%)***	1.8% (0.1%)***	-	-
PY5	1.7% (0.1%)***	1.7% (0.1%)***	1.6% (0.1%)***	1.7% (0.1%)***	-	-
PY6	1.8% (0.1%)***	1.8% (0.1%)***	1.7% (0.1%)***	1.8% (0.1%)***	0.9% (0.1%)***	1.0% (0.1%)***
PY7	1.9% (0.1%)***	1.8% (0.1%)***	1.7% (0.1%)***	1.8% (0.1%)***	1.4% (0.1%)***	1.3% (0.1%)***
PY8	1.9% (0.1%)***	1.9% (0.1%)***	1.5% (0.1%)***	1.6% (0.1%)***	1.5% (0.1%)***	1.4% (0.1%)***
PY9a (2)	1.9% (0.1%)***	1.9% (0.1%)***	1.4% (0.1%)***	1.5% (0.1%)***	1.2% (0.2%)***	1.1% (0.1%)***
PY9b (3)	2.2% (0.4%)***	1.8% (0.3%)***	1.2% (0.5%)**	1.3% (0.4%)***	1.5% (0.6%)**	1.0% (0.5%)**
Treatment Year	**Low-Income Wave 1**		**Low-Income Wave 2**		**Phase III Expansion Wave 1**	
	D-in-D Fixed Effects	**Post-Only**	**D-in-D Fixed Effects**	**Post-Only**	**D-in-D Fixed Effects**	**Post-Only**
PY6	0.2% (0.2%)	0.3% (0.1%)***	-	-	-	-
PY7	1.4% (0.2%)***	1.4% (0.1%)***	0.7% (0.3%)**	0.8% (0.2%)***		
PY8a (4)	1.2% (0.2%)***	1.3% (0.1%)***	0.8% (0.4%)**	0.8% (0.2%)***	0.3% (0.2%)*	0.3% (0.1%)***
PY8b (5)	1.6% (0.7%)**	1.6% (0.5%)***	0.1% (1.3%)	0.9% (0.9%)		
PY9	0.8% (0.2%)***	0.9% (0.1%)***	0.3% (0.4%)	0.2% (0.2%)	0.7% (0.2%)***	0.7% (0.1%)***

(1) Standard errors are presented below the estimated treatment effect in parenthesis (*** Significant at 1%; ** Significant at 5%; * Significant at 10%).
(2) PY9a covers months June 2017 through April 2018 of PY9.
(3) PY9b covers May 2018 of PY9.
(4) PY8a covers months June 2016 through April 2017 of PY8.
(5) PY8b covers May 2017 of PY8.

Annual Program Energy Savings

Cadmus estimated program savings in PY9 for each wave's population of treated customers as the product of average daily savings per participant and the number of days these customers were treated in PY9, shown in Equation C-3. Because home energy reports in Pennsylvania have a one-year measure life, PPL Electric Utilities can claim only the savings in PY9 that occurred within 12 months of customers receiving reports in Phase III. Therefore, for low-propensity waves treatment customers, Cadmus only counted the days since these customers received their first Phase III home energy reports in May 2018. Similarly, many low-income customers received Phase III print reports in May 2017, and Cadmus included their treatment days through April 2018 when calculating PY9 savings. In February and April of 2018, the home energy reports vendor sent electronic reports to a subset of low-income customers for whom it had email addresses, so Cadmus considered these customers treated for all of PY9.

Equation C-3

$$Savings_h = -\hat{\beta}_{1,h} * \sum_{i=1}^{N} Treatment\ Days_{i,h}$$

Where:

$\hat{\beta}_{1,h}$	=	Average daily savings (kWh) per treatment group customer in wave 'h', estimated from Equation C-1.
$Treatment\ Days_{i,h}$	=	The number of days customer 'i' in wave 'h'was treated in PY9.

Cadmus estimated realization rates for each wave as the ratio of verified program savings to reported program savings (estimated by the ICSP).

Table C-6 shows the estimate of PY9 total savings and average annual savings per customer with 85% confidence intervals for each wave. Except for the low-income waves, the reported savings fall within the 85% confidence intervals around *ex post* verified savings. However, the 85% confidence intervals do not contain the reported program total savings, suggesting the two estimates are significantly different.

Table C-6. PY9 Home Energy Education Program Savings Estimate

Wave	Point Estimate (MWh/yr)	85% Confidence Interval (Lower Bound)	85% Confidence Interval (Upper Bound)
Legacy Wave 1	9,092	8,613	9,571
Legacy Wave 2	11,615	10,742	12,487
Expansion Wave	8,152	7,187	9,118
Low-Income Wave 1	4,297	3,493	5,102
Low-Income Wave 2	164	-76	404
Phase III Expansion Wave	3,008	2,443	3,573
Total Program (1)	**36,328**	**34,612**	**38,045**

(1) May not match due to rounding.

Ex Post Verified Savings across Time

Figure C-1 through Figure C-7 provide the percentage daily savings across time for each pre- and post-treatment month through PY9. Cadmus calculated the percentage daily savings for each wave as the ratio of average daily savings to monthly average control group consumption. Because Cadmus reported the post-only results for each wave, it plotted the monthly percentage savings and confidence intervals (gray) resulting from the D-in-D fixed effects model (blue) to show pre-treatment consumption trends.

The green line in the figures shows the monthly savings resulting from the reported post-only model specifications. The post-only monthly savings trend closely to the D-in-D fixed effects monthly savings, and they remain within the D-in-D fixed effects confidence interval across months and waves; this suggests that the savings estimated by each model specification are not significantly different. It also suggests that savings are robust and not dependent on the model specification (pre-post versus D-in-D fixed effects). For every wave, the confidence interval in the pre-treatment period contains zero. This suggests that treatment and control groups had equivalent consumption prior to treatment.

Cadmus specified both the D-in-D fixed effects and post-only models with month and year fixed effects. To avoid linear dependency in the regressors, Cadmus dropped one month and year from each model specification. In the D-in-D fixed effects model specifications, Cadmus dropped the last month prior to treatment, which explains the gap in monthly savings in each figure for this month. Similarly, Cadmus dropped the first month of treatment in the post-only model specifications (since they did not include pre-treatment bills).

Figure C-1 and Figure C-2 show steady savings across months in PY9 for Legacy Wave 1 and Legacy Wave 2. A slight upward trend is observed for Legacy Wave 1 that began after the Phase II ICSP resumed treatment in October 2014 and that persisted throughout Phase II and now into Phase III. Legacy Wave 2 appears to have the opposite trend after resuming treatment in Phase II, with savings slightly decreasing throughout Phase II and more obviously in Phase III. Monthly savings reflect actual weather, so small changes in savings from year to year may not be program-related.

Figure C-1. Percentage Daily Savings across Time: Legacy Wave 1

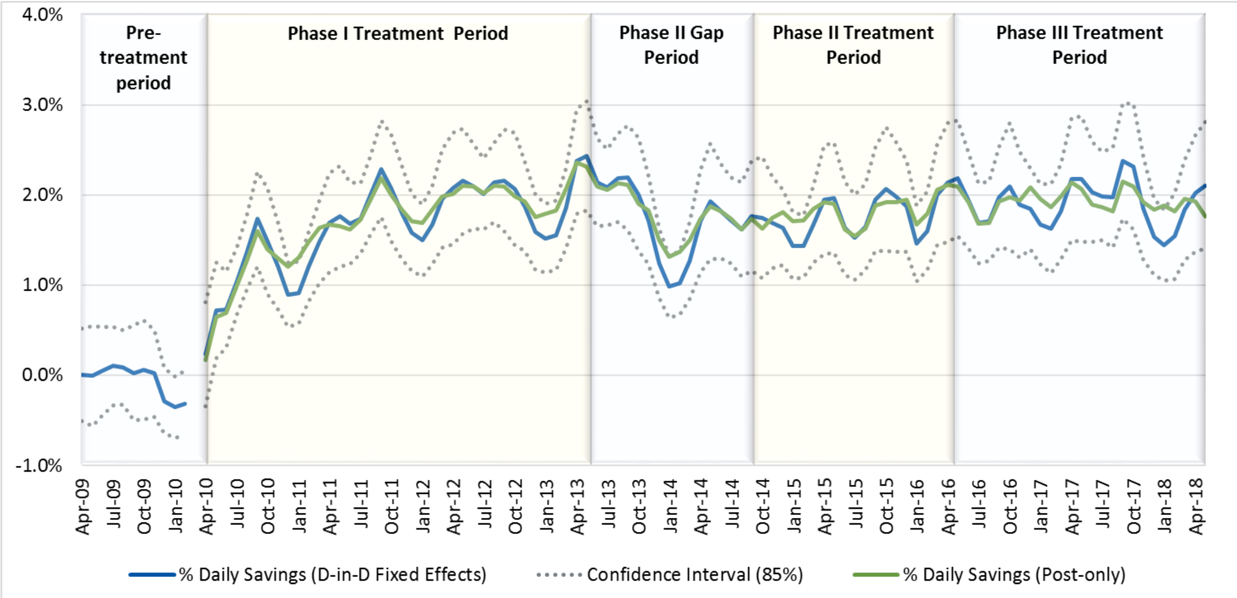


Figure C-2. Percentage Daily Savings across Time: Legacy Wave 2

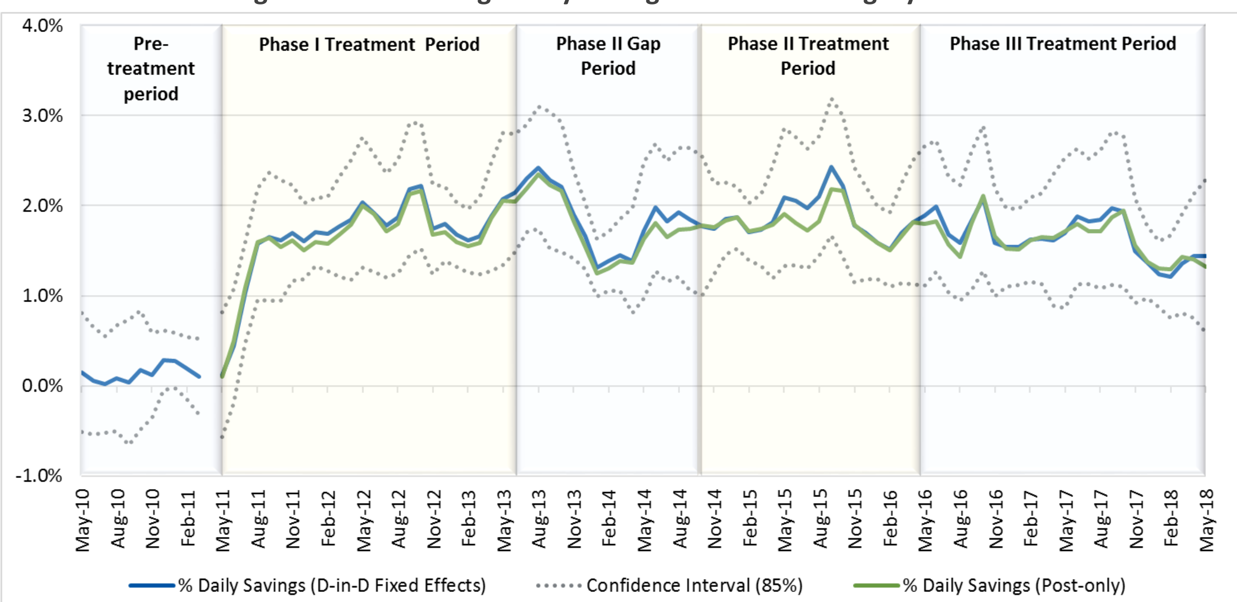


Figure C-3 shows savings for Expansion Wave 1 increased until the beginning of Phase III then in PY9 returned to the levels observed in the first six months of the program. This is consistent with the trends of Legacy Wave 2, where savings reached a steady state but have since slightly declined.

Figure C-3. Percentage Daily Savings across Time: Expansion Wave 1

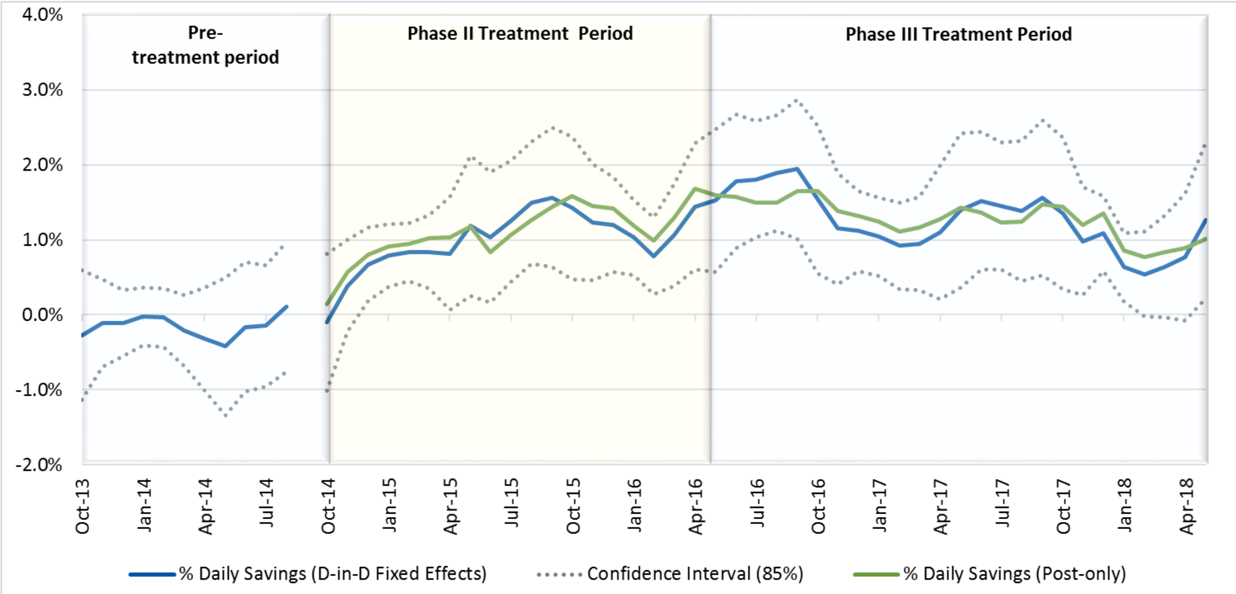


Figure C-4 shows that, after receiving treatment at the end of PY8, Low-Income Wave 1 savings peaked in May 2017. Although savings steadily declined afterwards, they appear to increase again after some customers in this wave received electronic reports in February 2018 and again in April 2018.

Figure C-4. Percentage Daily Savings across Time: Low-Income Wave 1

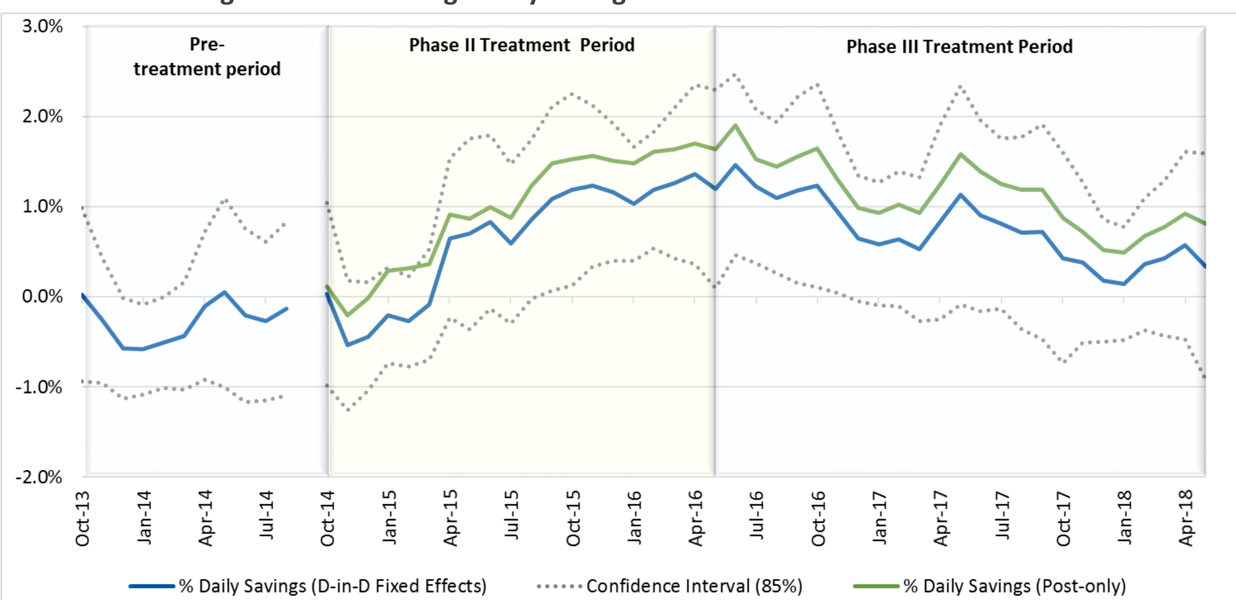


Figure C-5 shows the percentage daily savings by month for Low-Income Wave 2. The confidence intervals around monthly savings are wider for this wave than any other wave and include zero savings for most months, which is consistent with Cadmus' finding that savings in PY9 were statistically insignificant and imprecisely estimated.

Figure C-5. Percentage Daily Savings across Time: Low-Income Wave 2

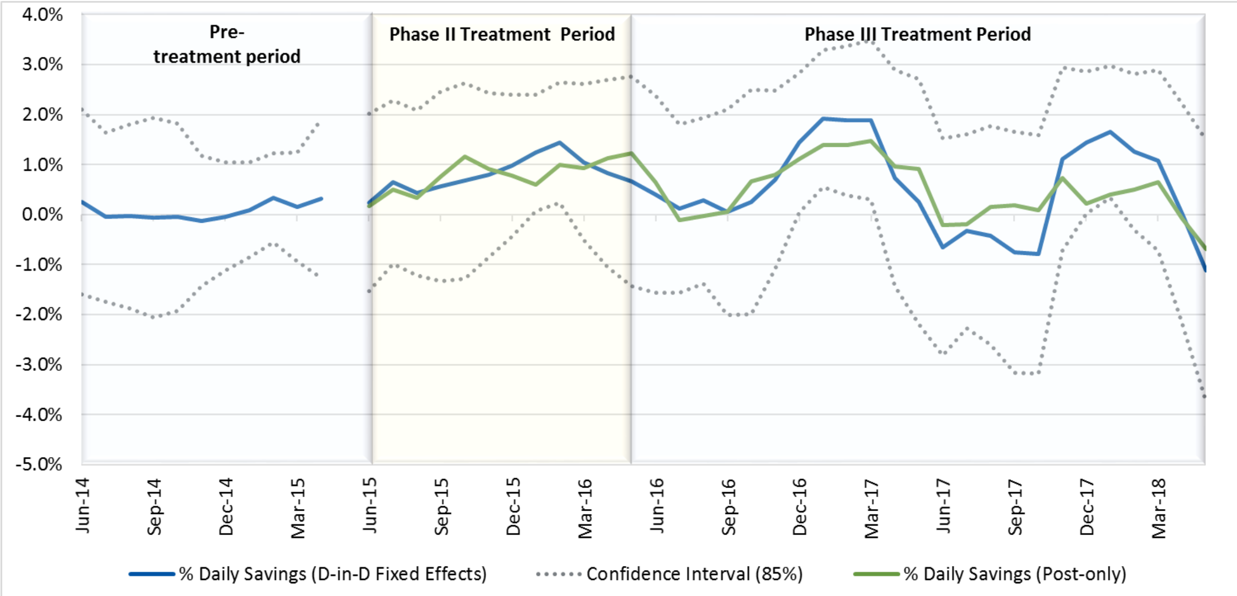
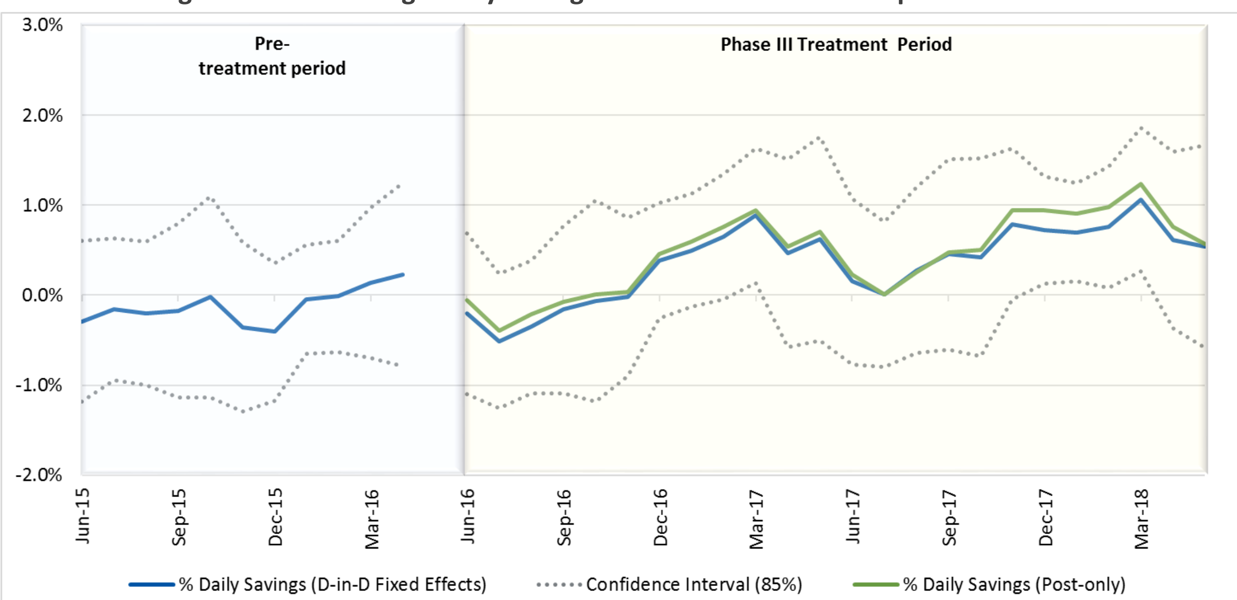


Figure C-6 shows the percentage daily savings by month for the Phase III Expansion Wave. The monthly percentage daily savings hovered near 0.0 kWh for the first six months of PY9 but steadily increased beginning in January 2017, reaching an average of 0.7% across the last six months of PY9.

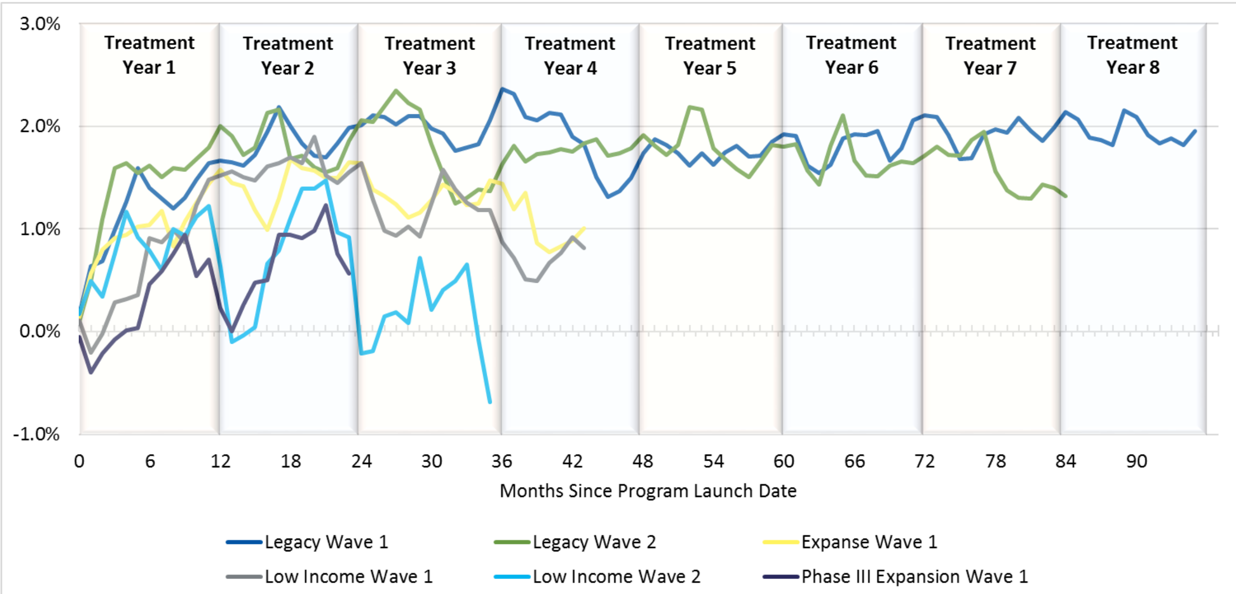
Figure C-6. Percentage Daily Savings across Time: Phase III Expansion Wave 1



To compare savings trends across waves, Cadmus provides Figure C-7, which shows percentage daily savings by the number of months since first treatment for each wave. Across all waves, savings increased from 0% to between 0.8% and 1.7% in the first year of treatment. Savings for the two longest-running waves (Legacy Wave 1 and Legacy Wave 2) appear to plateau after the second year of treatment, with some peaks in savings occurring in years three and four that stabilize afterwards.

Although Legacy Wave 1 remains flat through treatment year 8, it is clear that Legacy Wave 2's savings began to decline steadily beginning in its fifth treatment year, the end of Phase II.

Figure C-7. Percentage Average Daily Savings from First Month of Treatment



It is clear from Figure C-7 that each wave has a ramp-up period, and in the first year of treatment increases in percentage savings remained fairly consistent between waves. However, the Phase III Expansion Wave notably followed a different pattern from the others in its second year of treatment, returning almost to zero savings and repeating the ramp-up process in the second year, whereas the other waves largely retained the level of savings achieved in the first program year (note that Low Income Wave 2's second program year was PY8, when customers in the wave stopped receiving treatment completely). Again, savings reflect changes in weather, which can explain some differences in savings by months of treatment.

Demand Reduction Evaluation Methodology

As in PY8, Cadmus did not evaluate demand reductions using hourly data in PY9. Instead, it converted each wave's PY9 average energy savings into demand reductions using the evaluated PY4 ratio of peak demand reduction values to average per-customer energy savings per hour. Across Legacy Wave 1 and Legacy Wave 2, Cadmus estimated average per-customer demand reductions of 0.041 kWh/hr and 0.056 kWh/hr for each wave, or 193% and 108% of each wave's average per-customer energy savings per hour, respectively. Cadmus used the weighted average of these ratios (148%) to convert PY9 program energy savings into demand reductions, assuming ratios stayed constant through time, and allowing demand reductions to be scaled by energy savings observed in PY9.

Note that the definition of peak demand changed between PY4 and PY9. In PY4, peak demand was calculated for the top 100 hours of PPL Electric Utilities' system demand. In PY9, peak hours are defined as hours with day-ahead forecasts for the PJM market that are 95% or more of the PJM peak summer forecast.

C.1.4 Uplift Analysis Methodology

Savings from the Home Energy 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 PY9, 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 save energy into PY9. In these cases, the Home Energy Education Program billing analysis would capture the savings from these products, causing them to be counted in both the Home Energy Education Program and PPL Electric Utilities' other efficiency programs.

To avoid double-counting of cross-program savings caused by the home energy report program, Cadmus subtracted cross-participation savings from the residential portfolio savings. To do this, Cadmus conducted an uplift analysis to estimate the impacts of the Home Energy Education Program on participation in PPL Electric Utilities' residential and low-income efficiency programs and the energy savings from that participation. Cadmus refers to any difference in the rate of participation and savings as "participation uplift" and "savings uplift."

The following sections provide details on uplift results.

Cross-Participation in Downstream Residential Rebate Programs

Cadmus used the experimental design of the Home Energy Education Program to estimate home energy report savings from PPL Electric Utilities' efficiency program participation.

To illustrate, suppose that there is an equal number of customers in the treatment and control groups and that the utility markets the benefits of installing Product A to all residential customers. Customers in the treatment and control groups will receive the same marketing and be eligible for incentives from the utility for Product A. The impact of energy reports on adoption of Product A can then be estimated as the difference in adoption of Product A—and savings—between the randomized treatment and control groups. Any differences can be attributed to the home energy report program.

For products and services promoted by utility programs and tracked at the customer level (downstream programs), Cadmus estimated the participation and savings uplift by matching Home Energy Education Program treatment and control customers in each wave to the energy efficiency program participation tracking data in PPL Electric Utilities' tracking database, starting in the month when treatment began through to the end of PY9.[136]

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[136] Each product's record in PPL Electric Utilities' tracking database includes the program to which it belongs along with the date the product was installed. Cadmus' database records the evaluated *ex post* annual savings.

Home Energy Education Program treatment and control customers participated in 9 downstream PPL Electric Utilities rebate programs from PY2 through PY9. These were the Appliance Recycling Program, Energy Efficiency Kits and Education Program,[137] Energy Efficient Home Program, Low-Income WRAP, Non-Residential Energy Efficiency Program, Renewable Energy Program, Residential Energy Assessment and Weatherization Program, Residential Home Comfort Program, and Residential Retail Program (equipment component).

Participation Uplift

After matching tracking data to Home Energy Education Program customers, Cadmus calculated participation uplift. Cadmus defined participation uplift as the difference in the percentage of treatment group customers participating in at least one rebate program and the percentage of control group customers participating in at least one rebate program.

The control group's 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. This baseline participation rate is defined as the number of control group customers who participated in at least one other Act 129 program in PY9, divided by the total number of control group customers. The home energy reports had an additive effect on participation in the other programs if the cross-program participation rate was greater for treatment customers than it was for control customers.

Table C-7 shows the PY9 participation rate uplift results for each wave of the Home Energy Education, broken out by program. Cadmus first provides the differences in rates of cross-participation between treatment and control groups (uplift participation) then the percentage uplift participation relative to control group participation. The Appliance Recycling Program had the highest cross-program participation in PY9.

Table C-7. Participation Uplift by Program (Per 1,000 Customers)

Program	Participation Uplift per 1,000 Customers (Percentage Participation Uplift)					
	Legacy Wave 1	Legacy Wave 2	Expansion Wave 1	Low-Income Wave 1	Low-Income Wave 2	Phase III Expansion Wave 1
Appliance Recycling	2.4 (19%)	1.8 (14%)	1.5 (15%)	1.0 (15%)	-1.3 (-38%)	-0.2 (-2%)
Energy Efficiency Kits and Education	-0.8 (-10%)	0.9 (6%)	0.6 (6%)	-1.9 (-8%)	-1.0 (-7%)	0.1 (1%)
Energy Efficient Home	1.2 (6%)	-2.4 (-10%)	-2.9 (-14%)	-0.2 (-2%)	-0.7 (-12%)	0.4 (2%)
Low-Income WRAP	-0.6 (-35%)	0.1 (12%)	0.3 (38%)	-0.4 (-2%)	-3.3 (-12%)	-0.1 (-8%)
Non-Residential EE	0.1 (67%)	-0.1 (-58%)	0.1 (45%)	0.1 (100%)	-	-0.1 (-150%)

[137] Formerly named the E-Power Wise Program.

Savings Uplift

The savings uplift analysis followed a simple-differences approach. Similar to the approach suggested in the Behavior Section of the Phase III Evaluation Framework,[138] Cadmus followed these steps to estimate uplift savings from downstream programs:

1. Matched the program tracking data for each program year to the treatment and control customers by a unique identifier
2. Assigned each transaction to a month based on the participation date field in the tracking data
3. Excluded any installations that occurred prior to the customer being assigned to the treatment or control group
4. Calculated the average monthly electricity savings of each efficient product installed by a Home Energy Education customer, proportioned across months by the accrued heating and cooling degree days in each month for products sensitive to weather (Cadmus proportioned annual savings across months equally for products not sensitive to weather). Cadmus used the *ex post* gross verified savings for each product in PPL Electric Utilities' tracking database.
5. Summed the monthly average savings, by customer, for all products installed prior to a given month through the end of PY9. Cadmus incorporated customer inactive dates and measure lives of products when aggregating monthly savings
6. Calculated the average annual savings accrued per customer for the treatment and control groups during PY9
7. Calculated the incremental average annual savings per customer from other programs by taking the difference in annual per-customer savings for the treatment group and control group

Multiplying the incremental average annual savings per customer by the number of program customers treated in PY9 yielded the estimate of the total Home Energy Education Program savings from participation in other PPL Electric Utilities energy efficiency programs and counted by the other efficiency programs.

Table C-8 provides the results of the savings uplift analysis by program. The largest proportion of cross-program savings came from the Appliance Recycling Program, which saved across all waves except Low-Income Wave 2. Low-Income Wave 1 is the strongest cross-program saver.

[138] Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* August 25, 2016. See Behavior Section 6.1.1.8.

Table C-8. Savings Uplift by Program

Program	Total Uplift Savings (MWh/yr) (Percentage of Program Total Savings)					
	Legacy Wave 1	Legacy Wave 2	Expansion Wave 1	Low-Income Wave 1	Low-Income Wave 2	Phase III Expansion Wave 1
Appliance Recycling	444.49 4.89%	464.63 4.00%	95.42 1.17%	403.49 9.39%	-41.86 -25.46%	-29.19 -0.97%
Energy Efficiency Kits and Education	-48.07 -0.53%	21.02 0.18%	26.55 0.33%	338.71 7.88%	14.87 9.05%	-14.46 -0.48%
Energy Efficient Home	42.51 0.47%	240.76 2.07%	-217.03 -2.66%	79.46 1.85%	8.23 5.00%	130.99 4.36%
Low-Income WRAP	-41.00 -0.45%	-41.91 -0.36%	29.63 0.36%	442.40 10.29%	202.19 122.99%	8.61 0.29%
Non-Residential Energy Efficiency	203.97 2.24%	105.05 0.90%	43.51 0.53%	-35.45 -0.82%	-32.11 -19.53%	65.70 2.18%
Renewable Energy Program	-46.40 -0.51%	53.88 0.46%	-61.32 -0.75%	-15.54 -0.36%	-21.74 -13.22%	154.98 5.15%
Residential Energy Assessment & Weatherization	111.91 1.23%	230.54 1.98%	119.48 1.47%	-4.00 -0.09%	26.46 16.10%	176.36 5.86%
Residential Home Comfort	14.57 0.16%	-109.34 -0.94%	56.09 0.69%	57.83 1.35%	-14.86 -9.04%	190.68 6.34%
Residential Retail	38.62 0.42%	-19.35 -0.17%	-72.94 -0.89%	-14.12 -0.33%	-3.78 -2.30%	-68.95 -2.29%

Appendix D. Evaluation Detail – Efficient Equipment Program

D.1 Gross Impact Evaluation – Lighting

D.1.1 Methodology

Evaluation Sampling Approach

Prescriptive Lighting

Cadmus calculated an annual sample size for prescriptive lighting projects to meet the evaluation requirements described in the Phase III Evaluation Framework.[139] The PY9 evaluation sampling plan was designed to meet 90% confidence and 10% precision for the lighting stratum because lighting is a high-impact measure, contributing the majority of savings to the program and to the non-residential sector portfolio.

The sample plan was based on the number and characteristics of the non-residential lighting projects anticipated in PY9. The sample size calculation used an error ratio of 0.50 for MWh/yr. The Evaluation Framework requires evaluating all projects with *ex ante* annual savings greater than 750,000 kWh/yr. Cadmus evaluated all prescriptive lighting projects below the threshold with a basic level of rigor and all lighting projects at or above the threshold with an enhanced level of rigor.[140]

Table D-1 shows the PY9 sampling plan by quarter for a final sample size of 49 projects. Cadmus drew samples, conducted site visits, and reviewed records starting at the end of PY9 Q1.

Table D-1. Prescriptive Lighting Component Sampling Strategy

Quarter	Population Size (1)	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
Q1	210	N/A (2)	~10	32	Site visits, record review
Q2	223		~10	6	Site visits, record review
Q3	249		~10	8	Record review
Q4	137		~10	3	Record review
Total	**819**	**90/10**	**40**	**49**	

(1) Population size refers to the number of unique project job numbers.
(2) 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.

Cadmus used a stratified ratio estimation approach because it is more efficient than using a simple random sampling approach and results in smaller sample sizes. Cadmus further divided prescriptive lighting into four substrata—small, small-medium, medium-large, and large. These boundaries were

139 Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* October 21, 2016.

140 Table 1-2 in the PA TRM defines the thresholds for end-use categories that must be reviewed with enhanced levels of rigor.

established by the substratum's contribution to total gross reported kWh/yr savings, following the methods in Chapter 13: Sampling in The California Evaluation Framework.[141] Cadmus determined the number of sample points, where a point was a job, for each stratum using a Neyman allocation routine that accounts for the variance in each stratum.[142]

Table D-2 shows the substrata lighting boundaries for high and low energy savings by quarter. In all quarters, Cadmus defined census projects as those with *ex ante* energy savings greater than 750,000 kWh/yr, which require enhanced levels of rigor according to the PA TRM. In PY9, there were 22 threshold lighting participants.

Table D-2. PY9 Quarterly Prescriptive Lighting Component Substrata Boundaries

Substratum	Q1		Q2		Q3		Q4	
	kWh /yr High	kWh/yr Low	kWh/yr High	kWh/yr Low	kWh/yr High	kWh/yr Low	kWh/yr High	kWh/yr Low
Small	80,823	0	78,058	596	112,687	409	98,086	1,641
Medium	303,552	90,026	272,405	78,129	383,001	113,724	396,728	100,166
Large	607,538	343,103	1,221,931	283,735	749,000	443,813	611,076	398,609
Census	4,611,269	750,000	5,296,855	750,000	5,809,957	750,000	2,361,625	750,000

The PY9 prescriptive lighting projects were post-stratified at the end of PY9 into the final substrata below. A breakdown of total participants and reported savings by final substratum is shown in Table D-3. As can be seen, post-stratification conducted for the final analysis included all projects. Therefore, a project classified as, for example, Q1 when received in the first quarter could be reclassified in the post-stratification.

Table D-3. PY9 Prescriptive Lighting Component Post-Stratification

Substratum	kWh/yr High	kWh/yr Low	Reported Participants (1)	Reported Savings (MWh/yr)	Percentage Reported Savings
Small	49,985	0	563	9,657	9%
Medium	233,267	49,986	161	18,135	17%
Large	749,999	233,267	73	30,072	28%
Census	5,809,957	750,000	22	48,013	45%
Total			**819**	**105,878(2)**	**100%(2)**

(1) Defined by unique job number.
(2) Total does not match sum of rows due to rounding.

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

142 Neyman allocation is a sample allocation method that may be used with stratified samples. The purpose of the method is to maximize survey precision, given a fixed sample size.

Direct Discount Lighting

Cadmus followed the same sampling methodology for direct discount channel lighting projects as for prescriptive lighting projects. Table D-4 shows the PY9 sampling plan by quarter for a final sample size of 50 projects.

Table D-4. Direct Discount Lighting Component Sampling Strategy

Quarter	Population Size [1]	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
Q1	25	N/A [2]	~11	11	Site visits, record review
Q2	33		~11	10	Site visits, record review
Q3	63		~10	11	Site visits, record review
Q4	69		~10	18	Site visits, record review
Total	**190**	**90/10**	**42**	**50**	

(1) Population size refers to the number of unique project job numbers.
(2) Sample size was set at the program level then allocated to substrata according to Neyman routine. Each substratum does not have a target sample size.

Cadmus initially divided direct discount lighting into four substrata quarterly—small, small-medium, medium-large, and large. Table D-5 shows the substrata direct discount lighting boundaries for high and low energy savings by quarter.

Table D-5. PY9 Quarterly Direct Discount Lighting Component by Substratum

Substratum	Q1		Q2		Q3		Q4	
	kWh/yr High	kWh/yr Low	kWh/yr High	kWh/yr Low	kWh/yr High	kWh/yr Low	kWh /yr High	kWh/yr Low
Small	25,474	663	12,191	1,456	34,277	0	62,206	1,472
Small-Medium	42,841	29,821	25,912	13,237	72,494	37,782	106,801	63,486
Medium-Large	117,439	81,425	43,911	26,180	128,966	80,332	149,780	108,800
Large	154,823	135,573	104,570	51,777	249,583	131,628	732,567	155,971

Cadmus post-stratified the PY9 direct discount lighting projects at the end of PY9 into the final three substrata below. A breakdown of total participants and reported savings by final substratum is shown in Table D-6.

Table D-6. PY9 Direct Discount Lighting Component Post-Stratification

Substratum	kWh/yr High	kWh/yr Low	Reported Participants [1]	Reported Savings (MWh/yr)	Percentage Reported Savings
Small	32,558	0	124	1,302	16%
Medium	113,954	32,558	42	2,751	33%
Large	732,567	113,955	24	4,164	51%
Total			**190**	**8,216[2]**	**100%[2]**

(1) Defined by unique job number.
(2) Total does not match sum of rows due to rounding.

Ex Post *Verified Savings Methodology for Lighting*

The *ex post* savings incorporated installation rates, adjustments for nonqualifying equipment, and adjustments for equipment details determined through the sample of projects selected for records review and site visits. Cadmus verified installation and qualification rates for all sampled records.

D.1.2 Database Review Findings – Lighting

Cadmus conducted desk reviews for 99 lighting projects (49 prescriptive lighting and 50 direct discount channel). The purpose of the review was to check the database and project data for accuracy and compliance with the PA TRM requirements. Cadmus verified information recorded in PPL Electric Utilities' tracking database by comparing it to corresponding rebate applications, customer-submitted supporting documentation, and information recorded by the ICSP. Cadmus also reviewed logger data files from lighting hours of use measurement devices and the ICSP's logger data analysis if the ICSP determined hours of use using metering. Cadmus combined the results of its records review with the findings from site visits to determine the verified savings for each of the sampled projects.

D.1.3 Site Visit Findings – Lighting

Cadmus conducted site visits for 82 projects (32 prescriptive and all 50 direct discount lighting projects) in the impact evaluation sample to verify the as-built conditions for each project and identify any discrepancies reported by the ICSP in the project file. Site visits were not conducted for all of the prescriptive threshold lighting projects, since we conducted record reviews for the census of 22 projects. If we found the ICSP's project documentation and logged or metered data for lighting operating hours were complete and accurate, we did not conduct a site visit. If we could not fully verify the information in the project documentation, we conducted a site visit. Of the 22 threshold lighting projects, we conducted five site visits.

If a project had numerous records (approximately 20 or more) in the PA TRM Appendix C Lighting Audit and Design Tool for Commercial and Industrial Projects,[143] Cadmus selected and inspected a sample using 90/20 criteria for confidence and precision. according to the Phase III Evaluation Framework.[144] Cadmus also interviewed facility representatives to determine operating schedules and estimate lighting hours of use.

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[143] The PA TRM Appendix C Lighting Audit & Design Tool was designed to document the pre- and post-installation cases of the lighting retrofit and facilitate calculation of energy and demand reductions for large lighting installations.

[144] Sampling to meet 90/20 within a facility is based on Section 3.3.3.2.3 of the Phase III Evaluation Framework. Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* October 21, 2016.

Verified savings incorporated site-specific data. Reasons for adjustments to the ICSP's reported data included corrections to the following:

- Fixture type and quantity
- Annual lighting hours of use
- Building type and associated stipulated lighting hours of use and/or coincidence factor
- Space cooling type
- Fixture control type

Table D-7 and Table D-8 summarize results of the site visits for the prescriptive and direct discount lighting projects, respectively. Overall, the magnitude of these adjustments for lighting had a minimal impact on verified savings. The "discrepancy magnitude ratio" between the absolute value of the sum of the discrepancies between verified and reported energy savings, divided by the total reported energy savings was 1.5% and the demand reduction ratio was 3.2%.

By strata, the energy savings and demand reduction discrepancy magnitude ratios for prescriptive lighting were 1.1% and 3.1%, respectively. The energy savings and demand reduction discrepancy magnitude ratios for direct discount lighting were 6.0% and 4.7%, respectively.

Table D-7. Prescriptive Lighting Component Site Visits

Description of Discrepancy	Number of Sites with Discrepancy (1)	Impact on Realization Rates
Verified TRM facility type varied from reported TRM facility type	2	Affected TRM hours of use and peak demand coincidence factors
Verified baseline and/or installed lighting fixture controls varied from the reported controls	4	Affected TRM hours of use and peak demand coincidence factors
Verified baseline and/or installed lighting fixture quantities varied from the reported quantities	8	Affected total baseline and/or installed fixture wattage
Verified baseline and/or installed lighting fixture wattage varied from the reported wattage	5	Affected total baseline and/or installed fixture wattage
Verified space conditioning type (air conditioned, unconditioned, heated) varied from reported conditioning type	9	Affected energy savings and peak demand reduction
Reported custom hours of use not calculated correctly	4	Affected TRM hours of use and peak demand coincidence factors
(1) Nine of the 49 sampled projects had more than one discrepancy.		

Table D-8. Direct Discount Lighting Component Site Visits

Description of Discrepancy	Number of Sites with Discrepancy (1)	Impact on Realization Rates
Verified TRM facility type varied from reported TRM facility type	2	Affected TRM hours of use and peak demand coincidence factors
Verified baseline and/or installed lighting fixture controls varied from the reported controls	4	Affected TRM hours of use and peak demand coincidence factors
Verified baseline and/or installed lighting fixture quantities varied from the reported quantities	17	Affected total baseline and/or installed fixture wattage
Verified baseline and/or installed lighting fixture wattage varied from the reported wattage	4	Affected total baseline and/or installed fixture wattage
Reported TRM hours of use incorrect for installed fixture type (general service lamp hours of use were used instead of screw-in hours of use)	1	Affected TRM hours of use and peak demand coincidence factors
Reported TRM hours of use incorrect for exterior lighting fixtures (3,832.5 hours reported, TRM lists 3,833 hours)	7	Affected TRM hours of use
Verified space conditioning type (air conditioned, no cooling) varied from reported conditioning type	15	Affected peak demand reduction
Reported custom hours of use not calculated correctly	1	Affected TRM hours of use and peak demand coincidence factors

(1) Eighteen of the 50 sampled projects had more than one discrepancy.

Prescriptive and Direct Discount Lighting Medium Substrata

The post-stratified 'medium' substrata for prescriptive and direct discount lighting have the greatest variances between reported and verified energy savings and demand reductions, shown in Table 5-3. Cadmus sampled 11 prescriptive and 11 direct discount jobs in the medium substratum.

Of the sampled prescriptive lighting jobs, site verifications identified discrepancies at five sites. Two of the five had minor discrepancies related to fixture quantities and types. The remaining three had highly variable realization rates. The first job was reported as an exterior facility type, but the fixtures were verified to be installed inside a shooting range. This adjustment reduced the annual operating hours and verified energy savings. It also increased the peak coincidence factor from 0% to 100%. The second job had a calculation error in the coincidence factor calculation (verified coincidence factor was higher than reported). The third project had reported savings greater than 120,000 kWh and the reported hours of use and coincidence factor were based on a staff interview. During the verification site visit, Cadmus performed a similar interview and the verified hours of use and coincidence factor were reduced substantially (annual hours of use reduced by almost 50%).

Of the sampled direct discount lighting jobs, site verifications identified discrepancies at three sites. One of the three had a minor discrepancy related to installed fixture quantities. The second job had a substantial decrease in the number of installed fixtures. The third job was verified as a warehouse facility but was reported as an industrial facility and did not install occupancy sensors as reported. These adjustments decreased the operating hours, peak coincidence factor, and savings from occupancy sensors.

D.2 Gross Impact Evaluation – Equipment

D.2.1 Methodology

Evaluation Sampling Approach

In PY9, 104 unique customers (billing accounts) completed 116 equipment projects. PPL Electric Utilities issued rebates for 39 types of equipment. Cadmus evaluated all sampled equipment projects with a basic level of rigor, according to the Phase III Evaluation Framework.[145]

The PY9 evaluation sampling plan was designed to meet levels of 85% confidence and 15% precision (85/15) for the equipment stratum. Cadmus first selected the projects with the largest savings from each stratum to ensure that a large percentage of the total savings were represented. Cadmus then drew a simple random sample from each substratum to fill the remaining sample target. The sites where these sampled projects were implemented were reviewed to determine whether additional equipment had been implemented at the same location. These overlapping projects were added to the final sample.

Cadmus reviewed the sample of 26 project records (desk audit), which involved verifying information from PPL Electric Utilities' tracking database using rebate applications, customer-submitted supporting documentation, and information recorded by the ICSP.

In PY9, Cadmus conducted site visits to verify 25 of the 26 records sampled. One record was for office equipment and was verified with a record review only. Table D-9 presents the equipment description and database code by four substrata—HVAC, motors, other, and refrigeration—along with the number of projects sampled per substrata.

Table D-9. PY9 Efficient Equipment Component (Equipment) Types

Substratum	Equipment Description	Database Code	Sampled Projects
HVAC	Commercial DHP <5.4 Tons	COMMDHP	8
	Water Centrifugal Chiller	WCCHILL	
	Commercial CAC <= 5.4 Tons	CAC<5.4TONS	
	Commercial ASHP <= 5.4 Tons	ASHP<5.4TONS	
	Commercial CAC > 5.4 Tons IEER	CAC IEER	
	Guest Room Occupancy Sensors	GROOC SENSOR	
	Water Cooled Electric Chiller	WCECHILL	
	Water cooled EER	WEAC	
Motors	Variable Frequency Drive (VFD) Improvements	VFD	7
	Air Tanks for Load/No Load Compressors	AIRTANK	
	ECM Circulating Fan	ECMFAN	
	No-Loss Condensate Drains	CONDDRAIN	
	VSD on Kitchen Exhaust Fan	VSDKITCHENFAN	

[145] Levels of rigor are described in the Evaluation Framework for Pennsylvania Act 129 EE&C Programs, section 3.3.2.2., October 21, 2016.

Substratum	Equipment Description	Database Code	Sampled Projects
Other	Commercial Ice Machines	COMMICEMAKER	4
	PC Computer	COMPUTER	
	Multifunction (Printer, Copier, Scanner)	MULTIFNCTN	
	Copier	COPY	
	Printer	PRINT	
	Computer Monitor	MONITOR	
	Low Flow Pre-Rinse Sprayer Grocery Store	LFRINSESPRAYGROCERY	
	Electric Steam Cookers	COMMSTEAMCOOK	
	VSD Controller for Dairy Vacuum Pumps	VSDCNTRLDRYVACPMP	
Refrigeration	HE Cooler Cases	HECOOLCASE	7
	HE Freezer Cases	HEFRZCASE	
	Anti-Sweat Heater Controls Low Temp	ASHTRCNTRLLOW	
	Anti-Sweat Heater Controls Medium Temp	ASHTRCNTRLMED	
	High Efficiency Evaporator Fans-Reach in Cooler, SP <16W	HEEVAPFANRICOOLCASE1	
	High Efficiency Evaporator Fans-Reach in Freezer, SP <16W	HEEVAPFANRIFRZCASE1	
	High-Efficiency Evaporator Fans-Walk-In Cooler, SP 1/15 HP 49 Watt	HEEVAPFANWICOOLCASE4	
	High-Efficiency Evaporator Fans-Walk-In Freezer, PSC, 1/20 HP 37 Watt	HEEVAPFANWIFRZCASE7	
	High-Efficiency Evaporator Fans-Walk-In Freezer, SP, 1/15 HP 49 Watt	HEEVAPFANWIFRZCASE4	
	High Efficiency Evaporator Fans-Reach in Cooler, SP 16W-36W	HEEVAPFANRICOOLCASE2	
	High-Efficiency Evaporator Fans-Walk-In Cooler, SP 16W-23W	HEEVAPFANWICOOLCASE2	
	High Efficiency Evaporator Fans-Reach in Cooler, PSC <16W	HEEVAPFANRICOOLCASE4	
	High-Efficiency Evaporator Fans-Walk-In Cooler, PSC 1/15 HP 49 Watt	HEEVAPFANWICOOLCASE8	
	High-Efficiency Evaporator Fans-Walk-In Cooler, PSC 16W-23W	HEEVAPFANWICOOLCASE6	
	Add Door to Existing Ref Display Cases	ZEROSWEATDOOR	
	Variable Speed Ref Compressor Tons	VSREFCOMTON	
	High-Efficiency Evaporator Fans-Walk-In Freezer, PSC 1/15 HP 49 Watt	HEEVAPFANWIFRZCASE8	
Total Sampled Projects			**26**

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

Table D-10. Efficient Equipment Component (Equipment) Sampling Strategy

Substratum	Population Size (1)	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
HVAC	35	N/A (2)	N/A (2)	8	Site visits, record review
Motors	27			7	Site visits, record review
Other	19			4	Site visits, record review (3)
Refrigeration	35			7	Site visits, record review
Equipment Total	**116**	**85/15**	**20**	**26**	

(1) Population size refers to the number of unique project job numbers per equipment type.
(2) 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.
(3) One of the Other substratum projects was office equipment and was verified through a documentation review only. A site visit was not conducted.

Ex Post *Verified Savings Methodology for Equipment*

The *ex post* savings incorporated installation rates, adjustments for nonqualifying equipment, and adjustments for equipment details determined through the sample of projects selected for records review and site visits. Cadmus verified installation and qualification rates for all sampled records.

D.2.2 Database Review Findings – Equipment

Cadmus conducted a desk audit of a sample of 30 equipment projects; these projects were sampled and reviewed after Q2 and after Q4. Cadmus verified records in PPL Electric Utilities' tracking database and compared these with corresponding rebate applications, customer-submitted supporting documentation, and information recorded by the ICSP. The purpose of the review was to check the database and project data for accuracy and compliance with the PA TRM requirements.

D.2.3 Site Visit Findings – Equipment

Cadmus completed site visits for 20 unique customers who received rebates for 25 equipment projects to verify the as-built conditions for each project and to identify any discrepancies in the data reported by the ICSP in the project file. Table D-11 summarizes the results of the site visits.

Table D-11. Equipment Component Summary Site Visits

Substratum	Total Site Visits per Substratum [1]	Equipment Description	Discrepancy	Projects Affected
HVAC	8	Guest room occupancy sensors	Verified installed quantity differed from what was reported	1
		Commercial air conditioner and air source heat pump	Reported equipment specifications were different than the AHRI specifications	3
		Water source heat pump	Equipment type was different than what was reported	1
Motors	8	Variable frequency drive improvements	Verified motor efficiency or capacity differed from what was reported	2
			Verified quantity differed from what was reported	1
			Project did not fit TRM algorithm requirements and a custom calculation was used	2
		VFDs on kitchen exhaust fans and replacement air units	Removed replacement air unit fan motor VFD savings because savings already accounted for in kitchen exhaust fan VFD savings	1
Other	6	Low-flow pre-rinse sprayers	Rounding of savings in the PPL Electric Utilities tracking database	1
Refrigeration	7	Anti-sweat heater controls	Difference between reported and verified door quantities	2
			Rounding of savings in the PPL Electric Utilities tracking database	1
		Adding doors to existing refrigerated display cases	Difference between reported and verified feet of doors	1
			Doors were reported as zero-energy doors but found to have anti-sweat heaters	1
		High-efficiency evaporator fan motors	Rounding error in the 2016 PA TRM deemed savings tables	1
Total	**29**			

[1] Unique projects

One of the large evaluated equipment projects involving the installation of guest room occupancy sensors for a hotel had been submitted as complete and installed in December 2017. However, during the verification site visit, Cadmus found that the entire first floor of the hotel had not been retrofitted. Section 2.3.4.1 of the Phase III Evaluation Framework states: "For replacements and retrofits, ICSPs will use the applicable date to determine which TRM version to select to estimate EDC claimed savings. The 'in-service date' (ISD) or 'commercial date of operation' (CDO) should be the date at which the measure is installed and energized. For projects with commissioning, the CDO is the date commissioning is completed and equipment is installed and energized." [146]

[146] Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* October 21, 2016.

D.3 Net Impact Evaluation – Lighting and Equipment

D.3.1 Net-to-Gross Ratio Methodology

Cadmus used self-report surveys to assess net savings for the lighting and equipment projects in the Efficient Equipment Program. Cadmus also researched customer communications with PPL Electric Utilities and the ICSP to provide additional context about possible free ridership.

The self-report surveys collected data to assess net savings for the lighting (n=57) and equipment (n=8) strata, following the Evaluation Framework's recommended common method for assessing free ridership.[147] The SWE team and PPL Electric Utilities reviewed and approved the survey prior to fielding.

The assessment includes two components of free ridership—the *intention* of the customer to implement an energy-efficient project without a rebate and the *influence* of the program on the customer's decision to implement the energy-efficient project. When scored, each component has a value from zero to 50 and a combined total free ridership score from zero to 100.

Intention Score

Under the intention and influence method used to determine free ridership, Cadmus assessed intention by asking the following key questions to determine how the organization's project-related decisions would have differed in the absence of the Efficient Equipment Program:

- "Which of the following would have happened if you had not received the rebate for $[REBATE AMOUNT] from PPL Electric Utilities for the [MEASURE OR C_MEASURE] project?"
- "By how much would you have reduced the size, scope, or efficiency?"
- "How likely is it that your organization would have paid the full cost to install the same quantity and efficiency of that equipment at the same time you conducted this project?"

Cadmus used the responses to these questions to determine a respondent's final intention score, which was multiplied by the respective *ex post* kWh/yr savings to calculate intention-based free rider savings.

Influence Score

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 survey asked the following influence question:

> "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."

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[147] Pennsylvania Public Utility Commission. *Phase III Evaluation Framework.* October 21, 2016.

From responses to this question, Cadmus obtained data about the influence of PPL Electric Utilities rebates, information from PPL Electric Utilities about ways to save energy, any assistance from PPL Electric Utilities on planning the project, and any past participation in a PPL Electric Utilities program. Cadmus assessed influence from participants' ratings of how important various program elements were in their decision to purchase energy-efficient equipment.

D.3.2 Net-to-Gross Ratio Sampling

Table D-12 lists the sampling strategy for the lighting and equipment strata within the prescriptive delivery channel.

Table D-12. PY9 Efficient Equipment Program Lighting and Equipment Stratum Sampling Strategy for Net Savings 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	Achieved Sample Size	Percent of Sample Frame Contacted to Achieve Sample (2)
Equipment	Equipment projects	116	0.5	85/15	23	61	8(3)	100%
Lighting (4)	Lighting projects	1,009(5)	0.5	85/15	46	572	57(6)	100%

(1) Population refers to number of paid projects in PY9.
(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 surveys.
(3) One of the nine total respondents did not answer the NTG questions and is not included in the NTG analysis.
(4) Prescriptive lighting and direct discount lighting combined.
(5) Combined population of prescriptive lighting and direct discount lighting participants.
(6) Three of the 60 total lighting respondents did not answer the NTG questions and are not included in the analysis.

D.3.3 Net-to-Gross Ratio Findings

Free Ridership

Cadmus summed the intention and influence components to estimate the total intention/influence method free ridership average by stratum, weighted by *ex post* gross kWh/yr savings. Table D-13 summarizes the intention, influence, and free ridership scores for each stratum. The savings weighted influence score found 1% of the equipment savings and 1% of the lighting stratum savings could be classified as free ridership. The savings-weighted average intention scores showed 43% of the equipment stratum savings and 30% of the lighting stratum savings could be classified as free ridership.

Table D-13. Energy Equipment Program Intention, Influence, and Free Ridership Score by Stratum

Stratum	Number of Respondents	Intention Score	Influence Score	Free Ridership Score
Equipment	8	43%	1%	44%
Lighting	57	30%	1%	31%

Spillover

Following methods defined in the Phase III Evaluation Framework, Cadmus asked survey respondents if they had installed any additional energy-efficient equipment since participating in the Efficient Equipment component without receiving a PPL Electric Utilities rebate. The survey also asked if program participation influenced their decision to install the additional equipment. The data collected through the surveys did not provide enough information to reliably quantify spillover in commercial settings; therefore, spillover is reported qualitatively.

Of the lighting stratum respondents, six purchased additional energy-efficient lighting, three purchased refrigeration equipment, two purchased HVAC equipment, and one purchased thermostats after participating in the Efficient Equipment Program. All respondents credited factors related to PPL Electric Utilities as having some level of influence on their purchasing decisions.

Of the equipment stratum respondents, one purchased additional energy-efficient lighting and another purchased HVAC equipment after participating in the Efficient Equipment Program. Both respondents credited factors related to PPL Electric Utilities as having some level of influence on their purchasing decisions.

Table D-14 shows the NTG ratio results for the equipment and lighting strata of the Efficient Equipment Program.

Table D-14. PY9 Efficient Equipment Program NTG Findings Summary

Stratum	n	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 85% C.L.
Equipment	8	44%	0%	0.56	11%
Lighting	57	31%	0%	0.69	9%

Customer Communication Research

To explore whether there was any supporting documentation to show that the Efficient Equipment Program influenced the customer's decision to participate, Cadmus requested communication documents from PPL Electric Utilities and the ICSP for all participants who completed the self-report survey and had an unweighted free ridership score of 50% or higher (n=14 for lighting and n=5 for equipment).[148,149] Cadmus received and reviewed 29 lighting related communication documents and six equipment related documents that included email conversations, meeting notes, and ICSP communication summaries.

148 Fifteen lighting survey participants had a free ridership scored of 50% or higher but one did not have any additional documentation.

149 Six equipment survey participants had a free ridership scored of 50% or higher but one of them did not have additional documentation.

Although these documents provided anecdotal information about the involvement of PPL Electric Utilities, the ICSP, and the contractor in designing and implementing the projects, Cadmus found no additional information to support making any adjustment to the free ridership score determined through the self-report surveys.

D.4 Process Evaluation – Lighting and Equipment

D.4.1 Additional Findings

This section presents additional process evaluation findings for the Efficient Equipment Program.

Logic Model Review

Cadmus reviewed the Efficient Equipment Program's logic model and determined this program is operating as expected. Table D-15 lists the outcome of the logic model review.

Table D-15. Logic Model Review for Efficient Equipment Program

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
Program implementation, technology assistance, and education provided to customers and trade allies, marketing and outreach, applications processed, QA/QC and evaluation processes developed and implemented, and incentive payments processed	**Program Activities**	Delivered program activities as expected
Trade allies are active and informed, marketing materials distributed, incentives paid, and rebate application and processing/payment systems implemented and functioning	**Outputs Produced by Program Activities**	Delivered outputs as expected
Customer and trade ally awareness of the program and its energy-efficient opportunities increases, equipment is rebated, and immediate energy savings and demand reduction are achieved	**Short-Term Outcomes**	Produced short-term outcomes as expected
Experience and feedback will lead to program updates, additional marketing will occur, continued equipment installations and energy and demand savings will be achieved customer and trade ally awareness of PPL Electric Utilities programs will continue to increase, and the program will gain sufficient experience and data to add some custom products and services to the PA TRM, so they can be rebated as prescriptive equipment	**Intermediate Outcomes**	On track to produce intermediate outcomes
PPL Electric Utilities' will increase its knowledge and experience operating this type of program, long-term energy savings and demand reductions will be achieved, and environmental benefits accrue	**Long-Term Outcomes (end of Phase III)**	On track to produced long-term outcomes

Participant Profile

Cadmus reviewed PPL Electric Utilities' tracking database and developed a profile of the 1,120 unique Efficient Equipment Program prescriptive participants. In PY9, 116 participants received rebates for equipment, 819 received rebates for prescriptive lighting equipment, and 190 received rebates for direct discount lighting equipment.

Table D-16 shows the survey population and total participant population by sector. The majority (65%) of program participants were from the small C&I sector. Survey respondents (n=69) represented 8% of the total equipment participants and 6% of the total lighting participants.

Table D-16. Total and Survey Population by Sector

Sector	Total Population (n=1,009)	Survey Respondents (n=69)
Large C&I	10%	7%
Small C&I	65%	61%
GNE	23%	32%
Residential	2%	0%
Source: PPL Electric Utilities' tracking database; may not total 100% due to rounding		

More than half of the survey respondents (61%; n=57) had participated in the Efficient Equipment Program prior to PY9, and of these 7 respondents, 11% said they worked with an ESCO in a performance contract for their project. The difference in responses between equipment and lighting participants was not significant.

As shown in Table D-17, a majority of survey respondents (38 participants, 55%) represented facilities of less than 100,000 square feet, which is in line with the program participation by sector shown in Table D-16, where 61% of participants were from the small C&I sector.

Table D-17. Facility Size of Survey Respondents

Facility Size	Total Survey Respondents (n=69)
Below 100,000 sq. ft.	38
100,000 sq. ft. or larger	30
No answer	1
Source: Survey question "What is the total square footage of this facility?"	

D.4.2 Survey Approach

Contact Instructions

Cadmus attempted to contact a census of participants. Cadmus first contacted all participants with email addresses to complete an online survey then telephoned participants who did not have a valid email address or did not respond to the online survey. Giving participants two avenues to respond to the survey increased response rates in this limited population.

Cadmus coordinated with PPL Electric Utilities to screen the sample and remove the records of any customers who had been called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey) or requested not to be contacted again and any records with incomplete information.

This cleaning and survey sample preparation process reduced the available sample for each stratum. Cadmus sent online survey invitations to participants with email addresses and followed up with one reminder email invitations. If the participant did not complete an online survey, Cadmus contacted the participant by telephone. Cadmus attempted to reach participants up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

Survey Attrition

Table D-18 lists the total records used for surveys and the outcome (final disposition) of each record.

Table D-18. Efficient Equipment Program Participant Survey Sample Attrition Table

Description of Call Outcomes	Number of Records
Online	
Population (number of unique jobs)	**1,125**
Removed: inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on “do not contact” list	**381**
Removed: incomplete or invalid email address	**0**
Survey Sample Frame (email invitations sent)	**744**
Email was returned (bounce back)	44
Did not respond	667
Opt out	5
PPL Electric Utilities or market research employee	n/a
Cannot confirm project location	0
Did not complete survey	10
Completed Surveys	**18**
Online Response Rate	**3%**
Telephone	
Population (number of unique jobs)	**1,125**
Removed: inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on “do not contact” list	**381**
Removed: incomplete or invalid phone number	**0**
Removed completed online survey	**18**
Survey Sample Frame (used for telephone survey calls)	**726**
Not attempted [(1)]	**523**
Records Attempted	203
Not reached: No answer, answering machine, phone busy, refused	146
Screened out: Cannot confirm equipment/not aware of participation, employment, ESCO	3
Partial complete (not included in survey findings analysis)	4
Completed Surveys	**50**
Telephone Response Rate	**25%**
Total Completed Surveys (total for all modes)	**68**
Overall Response Rate	**11%**
[(1)] Not all records were needed to reach the targeted number of completed surveys.	

Appendix E. Evaluation Detail – Custom Program

E.1 Gross Impact Evaluation

E.1.1 Methodology

Evaluation Sampling Approach

Cadmus defined projects in four strata:

- **Large stratum.** 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 this stratum at the behest of the ICSP. Cadmus verified a census of eight projects in the large stratum.
- **Small stratum.** Projects with expected savings below 500,000 kWh/yr were assigned to the small stratum. Of the 91 small stratum projects reported in PY9, Cadmus verified savings for a sample of 15 projects.
- **Combined heat and power (CHP) stratum.** All CHP projects were assigned to this stratum, and Cadmus planned to evaluate all of these projects. Cadmus verified the one CHP project in PY9.
- **Unverified.** There were no unverified projects in the large stratum for PY9.

Three projects, all in the PY8 large stratum, claimed savings in PY8 even though savings were not verified until PY9. These projects were paid an initial incentive based on 60% of the reserved project savings, with a true-up payment made in PY9 after savings were verified (the initial payment plus final payment was based on the verified project savings). No additional savings were claimed in PY9, so the verified savings are not reported in PY9. The verified savings for these projects are reflected in the Phase III to-date total energy and demand savings.

No "high interest" substratum within the small strata was identified in PY9, but it may be identified in future program years. High-interest equipment and systems are expected to contribute a significant amount of savings while exhibiting high uncertainty, or are under consideration by PPL Electric Utilities and the ICSP for new offerings or approaches. Cadmus reviewed several projects with an agricultural equipment code that received incentives in PY9 to determine if any could be considered for a high-interest substratum. However, these projects represented less than 2% of savings, so no separate high-interest substratum was created.

Ex Post *Verified Savings Methodology*

Cadmus evaluated all sampled projects, verifying savings using a high level of rigor, using approaches described in the International Performance Measurement and Verification Protocol (IPMVP). The approach by stratum is discussed below.

Large Stratum

The ICSP calculated the initial savings (called reserved savings) to inform which projects fall into the large stratum.[150] The ICSP informed Cadmus about any projects likely to fall into the large stratum. Calculation methodologies and verification approaches vary by project. Cadmus prepared the site-specific measurement and verification plan (SSMVP), typically in coordination with the ICSP. Cadmus conducted pre-installation inspections to gather baseline data for all large stratum projects except new construction, for which there was no existing condition, and any projects that were not designated as large stratum until after the equipment was installed.

Cadmus conducted post-installation site visits and other customer outreach to verify installation and gather additional data to verify energy savings. For some large projects, Cadmus installed data logging equipment, collected data from a customer control system through trends or spot readings, or gathered equipment and operating information from customer interviews.

Cadmus verified savings for all large stratum projects prior to project savings being reported by PPL Electric Utilities and the ICSP.

Small Stratum

At the end of each quarter in PY9, Cadmus randomly selected projects to include in the evaluation of the small stratum. Cadmus did not conduct pre-installation inspections because small stratum projects cannot be sampled until after equipment is installed and the incentive is paid. Cadmus prepared the SSMVP for each project then conducted post-installation inspections and verified savings.

Cadmus calculated the realization rate for the selected sample as the ratio of *ex post* verified gross savings to *ex ante* savings then applied this realization rate to the entire small stratum population.

CHP Stratum

All CHP projects were sampled. Cadmus prepared the SSMVP in coordination with the ICSP, then conducted a post-installation site visit to verify equipment operated as designed. We collected data for CHP-generated electricity, parasitic loads, useful heat recovered from the CHP, and gas usage from the customer. We conducted a regression analysis comparing CHP electric generation, useful heat recovered, and natural gas usage, and then annualized the result using typical meteorological data to verify project savings.

[150] Reserved savings are based on early customer or contractor estimates of baseline and proposed equipment energy use and do not necessarily represent the reported or verified project savings.

E.1.2 Realization Rate Findings

Cadmus found various reasons for the differences between *ex ante* and *ex post* savings.

Large and CHP strata. Data entry errors in reporting demand savings for two projects caused differences between reported and verified demand savings. No such errors were found with usage (kWh) savings.

Small stratum. For projects in the small stratum, the ICSP's and Cadmus' savings methodologies differed depending on the information available, customer data trending capabilities, the ratio of estimated savings to overall customer usage, and Cadmus' ability to deploy logging equipment. Cadmus noted these sources for discrepancies in realization rates in small sample projects:

- For two projects, the ICSP used TRM calculation approaches and default values for operating hours, coincidence factor, or, in one case, equipment post-installation wattage. In one instance the ICSP used a TRM approach and default values from the Wisconsin TRM. In another instance, the ICSP used a PA TRM approach and default values for an agricultural measure and applied them to an industrial/manufacturing measure. Cadmus used site-specific values determined through customer interviews, on-site observations, or specifications for installed equipment to update the default values used in the ICSP approach. For one project, Cadmus' verification analysis used a site-specific load for a dishwasher that reduced the load on the equipment by 85% compared to the Wisconsin TRM default used by the ICSP.
- For one project, the reported savings did not account for an increase or decrease in production when normalizing baseline data to post-installation metering or trend data. The verified analysis accounted for production.
- For one project, the verified analysis used more post-installation operating data because the equipment was in service longer than estimated when the incentive was initially paid (note the ICSP's analysis was limited by the time period for post-installation data collection).
- For one project, the ICSP's analysis used different production metrics for normalizing baseline and post-installation equipment operation. For example, one regression model used pounds of product and another model used quantity of product. When these regression models with different independent variables (i.e., pounds or quantity) were applied to the same independent variable (i.e., annual pounds), the results were inherently inaccurate. Cadmus repeated the analysis using consistent units.
- For one project, an incorrect voltage was used when converting current (amps) to power (watts), and an incorrect load factor was used when converting nameplate horsepower to watts.
- For the last project, Cadmus removed negative savings from periods when a system returned to its pre-installation operation. For example, for hours when the incentivized equipment was not running, the ICSP assumed negative savings when in actuality the system would have returned only to the pre-installation operating condition.

E.2 Net Impact Evaluation

E.2.1 Net-to-Gross Ratio Methodology

Cadmus used self-report surveys to assess the net savings for the Custom Program and researched participant documents to provide additional context about free ridership. Cadmus followed the Evaluation Framework's recommended common method for self-report surveys. The SWE team reviewed and approved the surveys prior to fielding.[151]

An assessment of free ridership involves two components—the *intention* to implement an energy-efficient project without a rebate and the *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 free ridership score ranging from zero to 100.

Intention Score

Cadmus assessed intention by asking questions to determine how the organization's project-related decisions would have differed in the absence of the Custom Program. Cadmus used the responses to determine a participant's final intention score, which was multiplied by the participant's respective *ex post* kWh/yr savings to calculate intention-based free rider savings. The savings-weighted average intention score showed that 21% of savings could be classified as free ridership.

Influence Score

Influence is assessed by asking about how much influence—from 1 (no influence) to 5 (extremely influential)—various program elements had on the customer's decision to purchase energy-efficient equipment. The survey asked the following influence question:

> "**N8.** 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."

From responses to this question, Cadmus obtained data about the influence of PPL Electric Utilities rebates, information from PPL Electric Utilities about ways to save energy, and any assistance from the ICSP. Cadmus assessed influence from participants' ratings of how important various program elements were in their decision to purchase energy-efficient equipment. The average maximum influence rating was 4.2. The savings-weighted influence score found 6% of the savings could be classified as free ridership.

To estimate spillover, surveys included questions to determine whether participants installed specific additional high-efficiency products and, if so, whether participation in the Custom Program was important to their decision. Additional high-efficiency product purchases counted only toward spillover

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[151] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC October 21, 2016.

if the customer did not receive a rebate and the program had been important to the decision to purchase and install the products.

E.2.2 Net-to-Gross Ratio Findings

Cadmus summed the intention and influence components to estimate the total intention and influence method free ridership average, weighted by *ex post* gross program savings. Table E-1 summarizes the intention, influence, and free ridership score.

Table E-1. PY9 Custom Program Intention, Influence, and Free Ridership Scores

n	Intention Score	Influence Score	Free Ridership Score
25	21%	6%	27%

For the four largest projects (one large stratum and three small stratum) represented by survey respondents in PY9, the savings-weighted free ridership score was 15%. These four projects represented 59% of the analysis sample's verified savings,[152] and they accounted for nine percentage points of the program-level free ridership estimate of 27%. Table E-2 lists the sector for the four projects with the largest verified savings.

Table E-2. PY9 Custom Program Free Ridership for Four Top Saving Projects

Sector/Stratum of Four Largest Projects included in Free Ridership Surveys	Verified kWh/yr Savings	Percentage of Analysis Sample Verified Savings	Percentage of Program Population Verified Savings	Free Ridership
Large C&I/Large	2,678,074	32%	9%	0%
Small C&I/Small	911,925	11%	3%	25%
Large C&I/Small	851,617	10%	3%	62.5%
Large C&I /Small	522,065	6%	2%	0%
Total (1)	**1,240,920**	**59%**	**17%**	**15%(2)**

(1) Total may not match due to rounding.
(2) Weighted by verified kWh/yr savings. Relative precision at 85% C.L. is 30%.

Customer Communication Research

To explore other evidence of the Custom Program's influence on customers' decisions to participate, Cadmus requested communication documents from PPL Electric Utilities and the ICSP for all participants who completed the self-report survey and had an unweighted free ridership score of 50% or higher (n=17). Cadmus reviewed 39 communication documents that included email conversations, incentive reservation notices, meeting notes, and ICSP communication summaries.

Although these documents provided anecdotal information about the involvement of PPL Electric Utilities, the ICSP, and the contractor in the design and implementation of projects, Cadmus did not find

[152] The four largest projects in the analysis sample represented 17% of the verified savings for the Custom Program population.

any additional information to support changing the free ridership score determined through the self-report surveys.

E.3 Process Evaluation

E.3.1 Additional Findings

This section presents additional process evaluation findings for the Custom Program.

Logic Model Review

Cadmus reviewed the logic model and determined that the program is operating as expected. Table E-3 lists the outcome of the logic model review.

Table E-3. PY9 Custom Program Logic Model Review

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
Program implementation, technology assistance, and education provided to customers and trade allies, marketing and outreach, applications processed, QA/QC and evaluation processes developed and implemented, and incentive payments processed	**Program Activities**	Delivered program activities as expected
Trade allies are active and informed, marketing materials distributed, incentives paid, and rebate application and processing/payment systems implemented and functioning	**Outputs Produced by Program Activities**	Delivered outputs as expected
Customer and trade ally awareness of the program and its energy-efficient opportunities increases, equipment is rebated, and immediate energy savings and demand reduction are achieved	**Short-Term Outcomes**	Produced short-term outcomes as expected
Experience and feedback will lead to program updates; additional marketing will occur; continued equipment installations and energy and demand savings will be achieved; customer and trade ally awareness of PPL Electric Utilities programs will continue to increase; and the program will gain sufficient experience and data to add some custom products and services to the PA TRM so they can be rebated as prescriptive equipment	**Intermediate Outcomes**	On track to produce intermediate outcomes
PPL Electric Utilities' will increase its knowledge and experience operating this type of program, long-term energy savings and demand reductions will be achieved, and environmental benefits accrue	**Long-Term Outcomes (end of Phase III)**	On track to produced long-term outcomes

Participant Profile

This section provides a profile of all customers who participated in the Custom Program and summarizes the firmographics of survey respondents. Table E-4 shows the sectors represented in the survey population and in the full participant population.

Table E-4. PY9 Custom Program Sector Breakdown

Sector	Total Population (n=100)	Survey Respondents (n=26)
Large	35%	58%
Small	47%	35%
GNE	16%	8%
Residential	3%	0%
Source: PPL Electric Utilities' Tracking Database; may not total 100% due to rounding.		

More than half of the survey respondents (60%; n=20) had participated in the Custom component of the Non-Residential Energy Efficiency Program before PY9. Seven of the 11 who answered the question said their facilities were more than 100,000 square feet. Nine of the 16 who answered the question said their facility had more than 100 employees.

Table E-5 shows the types of facilities participating in the Custom Program and responses to the survey. The majority of total population and survey respondents were from the manufacturing segment.

Table E-5. PY9 Facility Types Responding to the Survey and Participating in the Custom Program

Facility Use	Total Population (n=100) (1)	Survey Respondents (n=26) (2)
Manufacturing	44%	65%
Education	8%	4%
Grocery – supermarket or convenience store	26%	8%
Hospital or healthcare	2%	0%
Office	2%	0%
Police/fire station	1%	0%
Warehouse	1%	4%
Agriculture	1%	0%
Other	16%	19%
(1) Source: PPL Electric Utilities' Tracking Database based on unique bill account numbers; may not total 100% because of rounding. (2) Source: Survey question, "What is the primary use of your facility?"; may not total 100% because of rounding.		

Table E-6 lists the types of projects completed in PY9.

Table E-6. PY9 Custom Program Project Types

Project Type	Number of Projects (n=100)	Percentage of Projects (n=100)	Percentage of Survey Respondents' Projects (n=26)
Agriculture	3	3%	0%
Motors	34	34%	31%
HVAC	18	18%	19%
Refrigeration	10	10%	4%
Combined heating and power (CHP)	1	2%	0%
Other	34	34%	46%
Source: PPL Electric Utilities' Tracking Database; may not total 100% because of rounding.			

E.3.2 Survey Approach

Contact Instructions

Cadmus attempted to contact all participants. Cadmus first contacted all participants with email addresses to complete an online survey, then telephoned participants who did not have a valid email address or did not respond to the online survey. Giving participants two avenues to respond to the survey increased response rates in this limited population.

Cadmus coordinated with PPL Electric Utilities to screen the sample and remove the records of any customers who had been called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey), had requested not to be contacted again, or whose records had incomplete information.

This cleaning and survey sample preparation process reduced the available sample from 100 to 70. Cadmus sent online survey invitations to the 70 participants with email addresses and followed up with one reminder email invitation. If the participant did not complete an online survey, Cadmus attempted to contact the participants by telephone up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

Sample Attrition

Table D-18 lists the total records used for surveys and the outcome (final disposition) of each record.

Table E-7. PY9 Custom Program Participant Survey Sample Attrition Table

Description of Call Outcomes	Number of Records
Online	
Population	**100**
Removed: duplicate inactive customer, completed survey in past 3 months, on "opt out" list, duplicate contact, on “do not contact” list, incomplete, or invalid email address	30
Survey Sample Frame (email invitations sent)	**70**
Email was returned (bounce back)	2
Did not respond	64
Opt out	0
PPL Electric Utilities or market research employee	0
Cannot confirm project location	0
Did not complete survey	3
Completed Surveys	**4**
Online Response Rate	**6%**
Telephone	
Population	**100**
Removed: duplicate, inactive customer, completed survey in past 3 months, on "opt out" list, duplicate contact, on “do not contact” list, incomplete or invalid phone number	30
Completed online survey	4
Survey Sample Frame (used for telephone survey calls)	**66**
Not attempted	**0**
Records Attempted	66
Not reached: No answer, answering machine, phone busy, refused	42
Screened out: Cannot confirm equipment/not aware of participation, employment, ESCO	1
Partial complete (not included in survey findings analysis)	1
Completed Surveys	**22**
Telephone Response Rate	**33%**
Total Completed Surveys (total for all modes)	**26**
Overall Response Rate (for both modes)	**37%**

Appendix F. Evaluation Detail – Midstream Lighting Program

F.1 Gross Impact Evaluation

F.1.1 Methodology

Ex Ante *Reported Savings Methodology*

The entity participating in the Midstream Lighting program is a distributor, typically an electric equipment supply outlet. A Midstream Lighting participant is reported as a unique job, that is, a participating distributor's sale of qualified products. To receive an incentive for a qualified lighting product, the distributor must report each sale and include information about the product, the product quantity, the purchaser, and the address of the intended installation.

The ICSP looked up the end-user facility (building) type in the PPL Electric Utilities database then uploaded this information to its database. The hours of use were assigned for the reported building type using the PA TRM.

In this midstream program, contractors or purchasers do not complete a PA TRM Appendix C lighting calculator to compute savings. *Ex ante* savings were computed by the ICSP using the IMP baseline and efficient products (and *ex ante* savings were confirmed by PPL Electric Utilities).

The ICSP assigned the *ex ante* baseline fixture types to qualified products as prescribed in the Lighting Improvements for Midstream Delivery Programs IMP.[153] The *ex ante* savings were computed assuming a 98% installation rate, according to the IMP.

Evaluation Sampling Approach

Savings from the Midstream Lighting component were unverified in PY8 because the evaluation was still in progress at year's end, as discussed in the PY8 Annual Report.[154] In PY9, savings for PY8 and PY9 were verified and reported jointly. The sampling methods and rigor for PY8 and PY9 were designed to meet a 90/10 level of confidence and precision using a coefficient of variation of 0.5. Cadmus selected this high level of rigor, at the requirement of the SWE, because Phase III was the first time that PPL Electric Utilities or any other EDC offered a midstream option, and there was a high level of uncertainty around performance and energy savings.

The primary sampling unit in the gross savings evaluation was a job, or a sale of a rebated lighting product associated with a specific site or facility. During the PY8 and PY9 evaluation period, Cadmus planned to allocate 68 sample points or jobs, subject to a finite population correction factor. The sample design used a stratified ratio method with four strata plus a certainty stratum. The certainty stratum

[153] 2016 TRM – Interim Measure Protocol: Lighting Improvements for Midstream Delivery Programs, version approved October 2017, effective June 1, 2017.

[154] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017.

includes all jobs with savings 750,000 kWh/year or more. This stratum requires metering hours of use, as specified in the Evaluation Framework for prescriptive commercial lighting programs, and required by the SWE for this midstream program. In PY8 and PY9, there were no jobs with savings of 750,000 kWh/year or more. The four remaining strata were defined by the savings reported for the sample points, where a point was a job (large, medium-large, medium-small, and small). The boundaries were selected using the algorithm defined in the California Evaluation Framework for stratified ratio estimation,[155] using the Neyman allocation method.[156]

In PY8, Cadmus drew random samples from the December 2016 and February, April, and May 2017 reports provided by the ICSP to ensure representation in the start-up and operations phases of the Midstream Lighting component. In PY9, Cadmus drew sample for each of the first three quarters. The verification efforts were conducted for the first quarter, and jointly for the second and third quarter.

To address the uncertainty about report timing and different stratum definitions for each verification period, Cadmus post-stratified PPL Electric Utilities' complete PY8 and PY9 Midstream Lighting database by kWh/year reported savings and assigned all records, including the previously drawn sample jobs and alternates, to the post-stratification bins. This last step allowed Cadmus to use ratio estimators in calculating the realization rates and their uncertainty with uniform strata definitions.

During post-stratification, an additional stratum was defined for T8 lighting. T8 products were assigned to a separate stratum because, as of third quarter of PY9, PPL Electric Utilities did not claim savings for reduced wattage T8s rebated under Midstream Lighting. Cadmus therefore classified this product as a separate stratum, and developed findings for projects of all sizes involving reduced wattage T8s.

For PY8 and PY9, Cadmus estimated a total of 5,881 products across 5,824 jobs (sales). Cadmus verified 99 jobs associated with 51 sample sites in PY8, and 110 jobs associated with 37 sample sites in PY9. The number of sampled sites and total verified jobs differs because Cadmus identified other jobs associated with the site address of the sampled job for that program year, and these sibling jobs were also included in the analysis.

The sibling jobs that were not part of the original sample were classified into the Convenience stratum. In developing program results, jobs in the Convenience sample stratum did not contribute to the precision calculations for the strata they belong to by size definition. An additional analysis was conducted where jobs within sites were clustered, which calculated a precision value that was similar to that calculated by the analysis reported here. Cadmus reported verified savings for jobs (which was the unit used in sample design) independently, instead of the site level analysis. The reported analysis classifies jobs into savings size strata where their *ex ante* savings determined the size strata.

[155] TecMarket Works. *The California Evaluation Framework.* June 2004.

[156] The Neyman allocation method maximizes precision, given a fixed sample size, by allocating sample points to each stratum according to the expected variance in each stratum.

The PY8 and PY9 Midstream lighting projects were post-stratified at the end of PY9 into the final substrata below. A breakdown of total participants in the population and sample by final substratum is shown in Table F-1. Table F-2 shows the sampling strategy, the target and achieved sample sizes, as well as the percentage of reported savings for the final sub-stratum that was included in the gross savings verification sample.

Table F-1. Midstream Lighting PY8 and PY9 Impact Evaluation Sample Thresholds

Stratum	kWh High	Population Size (2)	Sample Size
Midstream Lighting – Large	No designated upper bound	3	1
Midstream Lighting – Medium-Large	301,240	99	11
Midstream Lighting – Medium	24,425	506	19
Midstream Lighting – Small	8,142	5,009	51
Midstream Lighting – T8	N/A	140	4
Midstream Lighting – Convenience	N/A	123	123
Midstream Lighting Component Total (1)	**N/A**	**5,880**	**209**
(1) May not match due to rounding.			
(2) Population refers to the number of unique jobs(projects and products).			

Table F-2. Midstream Lighting PY8 and PY9 Impact Evaluation Sampling Strategy

Stratum	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Percent of Population Reported kWh Included in Sample	Evaluation Activity
Midstream Lighting – Large	N/A	2	1	24%	Record review and site visit
Midstream Lighting – Medium-Large	N/A	19	11	14%	
Midstream Lighting – Medium	N/A	9	19	4%	
Midstream Lighting – Small	N/A	40	51	2%	
Midstream Lighting – T8	N/A		4	15%	
Midstream Lighting – Convenience Sample	N/A		123	100%	
Midstream Lighting Component Total	**90/10**	**70**	**209**	**13%**	

Ex Post *Verified Savings Methodology*

Database Review

Cadmus conducted a quality control check of the following to verify the sample records in the PPL Electric Utilities tracking database. The savings algorithm was applied to reported inputs to compare with reported savings. For jobs included in the gross verification sample and additionally, for a random sample of records in PPL Electric Utilities' program database, Cadmus also checked the following:

- Baseline fixtures or lamps match the equipment prescribed in the IMP
- Hours of use for the given building and lamp types match the PA TRM, where lamp types could be either screw-based or general service lighting (GSL)

- Savings for each record match savings calculated by Cadmus using the IMP algorithms and lighting inputs

Cadmus did not identify any errors in the savings calculations reported in the PPL Electric Utilities tracking database for these sampled records, indicating that the database correctly calculated Midstream Lighting *ex ante* savings according to the IMP. The PPL Electric Utilities tracking database also selected the correct baseline equipment for each program-discounted product and correctly implemented the IMP for midstream programs.

Records Review

Cadmus conducted reviews of distributors' invoices submitted to PPL and the ICSP, as well as distributors' records of sales to the contractor or end-user, when available, for jobs within the savings verification sample. During the review of records, we reviewed the technical specification of the reported installed equipment, confirmed the correct application of the IMP's baseline and efficient lighting pairing and the building type.

Site Visits

To calculate *ex post* verified savings, Cadmus visited the site for each sampled job (sale, as reported by the ICSP) and prepared a modified PA TRM Appendix C during the verification site visit. At the site of each sampled job, Cadmus reviewed additional jobs (sales) associated with the site address for that program year. These additional jobs could be the same product as the sampled job, which could not be distinguished from the sampled record. The additional jobs could also be the same or different products at the site which could be distinguished from the sampled job. The list of jobs reviewed and verified were noted in the PA TRM Appendix C.

During the site visits, Cadmus verified the building type, and when physical conditions and customer acceptance allowed, confirmed the independent variables used in the savings algorithms included in the IMP. Cadmus used a modified Appendix C tool for the inspections that includes columns to record the observed *in-situ* baseline fixtures and their wattages; observed baseline and post-installation quantities; evaluated coincidence factors, hours of use, savings factors, interactive factors and post-install in service rates. *Ex post* savings were calculated using the observed and evaluated values for the independent variables listed in the Lighting Improvements for Midstream Delivery Programs IMP.

Baseline. Cadmus determined *in situ* baseline fixtures and lamps wattages through interviews with site contacts and examination of unchanged, removed or spare lighting equipment still at the site. In cases where the baseline could not be verified because the equipment had been removed or the facility managers did not know the baseline equipment type, or both, Cadmus used the IMP baseline product that was paired with the new product. If site specific data could be obtained, the baseline equipment that Cadmus recorded in the PA TRM Appendix C baseline equipment was the *in situ* equipment, not the IMP baseline.

In-service rate. During the site visits, Cadmus identified the program-qualified product that replaced the baseline equipment and verified the fixture or lamp counts, both installed and in storage. Using these counts, Cadmus calculated the ISR for each job and for the program. Often, at the time of site visit, end-use customers or their contractors were in the process of installing equipment. If, in Cadmus' judgment, the customer showed intention to complete the installation and as a result the probability of savings was high, Cadmus assumed project completion and calculated the ISR.

Building type. Cadmus compared the actual building type to the ICSP's reported building type to determine accuracy. This is important because hours of use are determined by the building type.

Hours of use. Hours of use were determined using the PA TRM building types for each sampled site. Cadmus and the ICSP used site-specific hours of use for records with savings greater than 120 MWh/yr.

Additional factors. The independent variables of coincidence factors, interactive energy and demand factors, and savings factors for lighting controls were based on PA TRM building types and verified by Cadmus. The presence or absence of any space cooling was determined during the site visit.

Realization rate. Cadmus calculated each site's realization rate as the ratio of the PA TRM Appendix C savings calculated with site-specific data to the *ex ante* savings reported in the PPL Electric Utilities database for both kWh/yr and kW/yr.

F.1.2 Site Visit Findings

Cadmus conducted 88 site visits across PY8 and PY9, for a combined verification of 209 jobs in PPL Electric Utilities' tracking database. Table F-3 summarize results of the site visits for the distributed discount projects. The reasons for site-specific realization rate adjustments are described below.

Table F-3. Prescriptive Lighting Component Site Visits

Description of Discrepancy	Number of Sites with Discrepancy
Verified installed lighting fixture quantities varied from the reported quantities (ISR smaller or greater than 100%)	36
Verified baseline lighting fixture types varied from the reported fixture types	150
Verified installed lighting fixture types varied from the reported fixture types	59
Verified installed lighting fixture quantities varied from the reported quantities (ISR smaller or greater than 100%)	36
Verified building type varied from the reported building type	81
(1) Total of the individual categories is greater than the number of sites In the sample as sites can have multiple adjustments to savings calculations	

In-service rate. Cadmus calculated an ISR of 88% across all equipment installed at sampled PY8 and PY9 jobs. The main driver of the ISRs were:

- 7 sampled jobs in PY9 were found to be duplicate records in the tracking system, accounting for 19% of the savings for jobs in the evaluation sample.
- 5 sampled jobs in PY9 were installed entirely, and 2 jobs partially at New Construction facilities which renders their savings from installations at these facilities, ineligible for the Midstream delivery channel. These jobs comprised 3% of the savings for jobs included in the sample.

- Where the installation of the reported quantity of rebated lighting equipment could not be verified, Cadmus adjusted the realization rate for an ISR that was different from 1.

Baseline. Cadmus revised the IMP baseline and efficient product pairing for sites in the combined PY8 and PY9 sample where site visit findings of baseline equipment type or wattage were found to vary from IMP assumptions.

- **T8 wattage.** An anomaly in the IMP prescribed full baseline lamp wattage when replaced by linear LED lamps but overstated the wattages in the installed demand. Therefore, when Cadmus created the PA TRM Appendix C for linear LED lamp replacements, the baseline was lower than in the IMP and in the PPL Electric Utilities database. For example, the IMP assumes that a 4-foot, 2-lamp fixture with 32 watts per lamp has a demand of 64 watts, but in the PA TRM Appendix C the same fixture draws 59 watts or 92% of the value provided in the IMP. The anomaly for T8 lamp baselines was addressed in the revised IMP approved by the SWE and other EDCs, and impacted two of the four sampled jobs in this stratum.
- **High/Low bay fixtures.** Total reported savings for jobs in the verification sample involving high/low bay products were reduced by 35%. A major factor was an adjustment to the baseline wattages for all but three of the 25 sampled jobs. The Midstream IMP assumed metal halide baselines with 400- or 750-watt lamps, based on the lumen output of the LED lighting. The verified baseline fixtures were found to be a mix of high output linear fluorescent or lower wattage metal halide.
- **Baseline equaled the replacement.** Cadmus site visits found two records for jobs where 25-watt T8 lamps and one job for LED floodlights that replaced the same type of fixture.

Installed fixture. The reported installed equipment types were verified for accuracy for all jobs in the sample. Cadmus adjusted discrepancies in the reported installed wattage for 59 jobs. A common source of discrepancy between reported and verified installed equipment was due to the verified DesignLights Consortium (DLC) wattage which was different than reported wattage.

Building type and hours of use. Cadmus adjusted the building type and therefore hours of use and demand coincidence factor for 81 jobs based on site visit findings. These jobs accounted for 44% of the sampled kWh/year savings. Cadmus used PA TRM building type hours of use for the sampled jobs. No jobs were large enough to require metering.

Miscellaneous. Cadmus made miscellaneous adjustments. to factors such as savings factor for existing lighting control, which was adjusted for 193 sampled jobs. The Midstream IMP assumes a savings factor of 1.44%. Cadmus adjusts this value to match the controls that are observed during the review site visit. Cadmus adjusted the HVAC interactive factors for jobs as the result of changes in building type, or from verifying that the air conditioning status differed from IMP assumptions.

Unverified Savings. Reported savings for one job in PY9 have been treated as unverified. Equipment rebated as part of this job were reported by the customer to have been returned to the distributor. Cadmus was unable to verify the return during the PY9 evaluation.

F.2 Net Impact Evaluation for Midstream Lighting

F.2.1 Net-to-Gross Ratio Methodology

Cadmus used self-report surveys to assess net savings for the Midstream Lighting component of the Efficient Equipment Program. Cadmus followed the Evaluation Framework's recommended common method for self-report surveys. The SWE team reviewed and approved the surveys prior to fielding.[157]

An assessment of free ridership involves two components—the *intention* to implement an energy-efficient project without a rebate and the *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 free ridership score ranging from zero to 100. A free rider for the Midstream Lighting program means that PPL had no influence on an end-user participant's purchasing decisions and the participant would have purchased the same equipment at the same time in absence of the Midstream Lighting discounts.

Intention Score

Cadmus assessed intention by asking the following key questions to determine how the end-user's project-related decisions would have differed in the absence of the Efficient Equipment Program:

- "According to our records, your project cost was discounted by about [insert dollars for the referenced project]. Which of the following would have happened if you had not received the instant discount from PPL Eclectic Utilities for the qualified lighting products?"
- "By how much would you have reduced the size or scope?"

Cadmus used the responses to determine a participant's final intention score, which was multiplied by the participant's respective verified gross program kWh savings to calculate intention-based free rider savings.

Influence Score

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. Cadmus assessed influence from participants' ratings of how important specific program elements were in their decision to purchase energy-efficient equipment.

The survey asked the following influence questions:

- "Please use a scale from 1, meaning no influence, to 5, meaning extremely influential, to rate how influential you think the instant discount was in your decision to purchase the ENERGY STAR- or DesignLights Consortium-certified lighting?"

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[157] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* October 21, 2016.

- "How influential was information or educational material provided by PPL Electric Utilities or distributor sales staff in your decision to purchase the ENERGY STAR- or DesignLights Consortium-certified lighting?"
- "How influential was your distributor's recommendation in your decision to purchase high efficiency equipment?"

F.2.2 Net-to-Gross Ratio Sampling

In PY9, Cadmus conducted a survey with end users (including contractors who purchased products from distributors and those for whom the contractors purchased products) through the Midstream Lighting component. In some instances, multiple projects were initiated or completed by the same customer. This required Cadmus to generate a sample of unique decision-makers to ensure that no customer was contacted more than once every three months (according to PPL Electric Utilities requirements) and that none had requested not to be contacted. 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

Table F-4 provides the sampling strategy for the Midstream Lighting stratum surveys.

Table F-4. PY9 Midstream Lighting Component Sampling Strategy

Stratum	Stratum Boundaries	Population Size	Assumed Cv or Proportion 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]
Midstream Lighting	End Users (Purchasers and Non-Purchasers)	1,581	N/A	90/10	30	1,581	27	17%

[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.

F.2.3 Net-to-Gross Ratio Findings

Cadmus summed the intention and influence components to estimate the total intention and influence method's free ridership average, weighted by verified gross program kWh/yr savings. Table F-5 summarizes the intention, influence, and free ridership score by the equipment and lighting program strata. One participant accounted for 29% of the analysis sample verified gross program kWh/yr savings and was estimated as a 0% free rider. No other participant in the analysis accounted for more than 8% of the analysis sample gross program kWh/yr savings.

The savings-weighted average intention scores showed 10% of the end-user's verified kWh savings could be classified as free ridership. The savings weighted influence score found 5% of the end user's verified kWh savings could be classified as free ridership.

Table F-5. PY9 Midstream Lighting Intention, Influence, and Free Ridership Scores

Stratum	n	Intention Score	Influence Score	Free Ridership Score
Midstream Lighting	27	10%	5%	15%

Table F-6 shows the NTG ratio results for Midstream Lighting.

Table F-6. PY9 Midstream Lighting Component NTG Ratio

Stratum	n	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision at 90% C.L.
Midstream Lighting	27	15%	0%	0.85	11%

F.3 Process Evaluation for Midstream Lighting

F.3.1 Additional Findings

This section presents additional process evaluation findings for the Midstream Lighting Program.

Logic Model

Cadmus reviewed the logic model developed in PY8, and determined the program is operating as expected. Table F-7 summarizes the logic model review.

Table F-7. Logic Model Review Midstream Lighting

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
Continue to recruit and educate distributors, provide distributors with marketing materials, determine eligibility verification processes, reimburse distributors for discounts, qualified product sales, and inform the end-use customer of the discount via a postcard.	**Program Activities**	Delivered program activities as expected; additional distributors reported significant sales in PY9.
Develop marketing materials, purchasers receive instant discounts, rebates paid to distributors, units installed.	**Outputs Produced by Program Activities**	Delivered outputs as expected.
Increase program awareness, increase customer and contractor awareness of energy-efficient lighting, and increase installations of energy-efficient lighting; immediate energy and demand savings.	**Short-Term Outcomes**	Distributors reported increased sales of efficient lighting attributable to Midstream Lighting, and reported sales increased from PY8. Awareness of this program among participants in the Custom and Prescriptive Lighting programs is still relatively low, similar to PY8.
Reduce annual energy consumption and peak load, and lower electric bills for program participants.	**Intermediate Outcomes**	On track to produce intermediate outcomes.
Continued energy savings; PPL Electric Utilities meets its goal to reduce energy consumption and peak demand.	**Long-Term Outcomes (end of Phase III)**	On track to produce long-term outcomes.

Participant Profile

Distributors

In PY9, 17 distributors participated in the Midstream Lighting component. Cadmus interviewed 12 of these distributors, all of whom said they were highly focused on the customer experience and frequently recommended products and provided information about incentives to help their customers make purchase decisions. Five distributors reported a multistate presence and estimated that between 6% and 75% of sales were to customers in PPL Electric Utilities' service territory.

- Most distributors said contractors or electricians made up approximately 70% of their total lighting sales, with business owners or managers and residential customers combined making up the remaining 30%.
- All distributors reported little to no energy service company (ESCO) sales.
- One distributor reported 10% of sales were to retailers.
- One distributor said residential customers made up 60% of its sales.
- One distributor said business owners or managers made up 60% of its sales.

Contractors

Cadmus interviewed 15 contractors who installed lighting purchased through Midstream Lighting. Six have companies of less than 10 employees, the other nine have companies with 10 or more employees. Eight contractors were the primary lighting supplier for the customers they serviced. Seven were either not the main supplier or worked for their customer on a one-time job.

End Users

End-users include those who purchased products for their own facilities (end-user purchasers) and those who had a third-party contractor purchase products (end-user non-purchasers). The facilities of both types of end-user respondents (n=27) ranged from small, single owner-operator businesses to corporations that employ 500 to more than 1,000 people.

- 13 end users purchased the discounted products for large-scale replacements.
- 12 end users conducted maintenance repair operations as lamps fail.
- 2 end users were not sure when products were purchased.

This is a change from PY8, when most end users conducted maintenance repair operations, and only three of 15 primarily conducted large-scale replacements.

As in PY8, most end users said they kept very little to no lighting in stock. In PY9, 10 kept none, 20 kept under 5%, three kept 10%, three kept 20%-30%, and one kept 50% of their lighting stock in storage.

Program Awareness

Table F-8 summarizes how respondents in each of the groups heard about Midstream Lighting. These findings indicate that distributors have been informing their customers (purchasers and contractors) about the Midstream Lighting discounted products—nearly all purchasers and end users heard about the program from the distributor. The distributors have also been telling these customers that the discounts are provided by PPL Electric Utilities. Of the end-users, only two purchasers and three non-purchasers were aware of the amount of the discount for their project. Notably, half or fewer of all groups knew about the prescriptive rebates for lighting in PPL Electric Utilities' Non-Residential Energy Efficiency Program. These findings are similar to those in PY8.

Table F-8. Midstream Lighting Awareness

Participant Group	Definition	How they learned about Midstream Lighting	Distributor said that PPL provided the discount	Knew the amount of the discount	Knew about prescriptive rebate program
Contractors (n=15)	Purchased qualified products for their customers	13 from distributors 1 direct from PPL 1 word of mouth	14 yes 1 no	N/A	7 yes 8 no
End-user purchasers (n=15)	Purchased products for their business directly from participating distributor	12 from distributors 2 direct from PPL 1 word of mouth	14 yes 1 don't know	2 yes 13 no	6 yes 9 no
End-user non-purchasers (n=12)	Received qualified discounted products from their contractor	6 from distributors 2 from contractors 2 word of mouth 2 from PPL website	N/A	3 yes 9 no	6 yes 6 no

Cadmus included questions in the participant surveys for other components (Prescriptive Lighting, Efficient Equipment, and Custom) of the Non-Residential Energy Efficiency Program regarding their awareness of Midstream Lighting. Overall, 34% of respondents in these downstream rebate programs were aware of Midstream Lighting.

Although the survey sample sizes for these other components are small, the findings shown in Table F-9 indicate that awareness of Midstream Lighting among customers who participated in the commercial rebate program is still relatively low.

Table F-9. Percentage of Commercial Rebate Customers Aware of Midstream Lighting

Program	PY8	PY9
Custom	38% (n=16)	50% (n=24)
Prescriptive Lighting	26% (n=61)	23% (n=56)
Prescriptive Equipment	2 of 7	5 of 8

Motivators for Participation

Most distributors participate to stay competitive. The incentive helps them drive sales, and participating in a utility program adds credibility to selling high-efficiency products. Most distributors agreed that without the Midstream Lighting incentives, sales of program-qualified products would be lower. Seven distributors (n=12) attributed increased sales of qualifying products to the program discounts, and two said a factor was increased customer demand for more efficient products.

When asked to compare Midstream Lighting with the prescriptive lighting component of the Non-Residential Energy Efficiency Program, most distributors preferred Midstream Lighting because its process is simpler for customers and has less paperwork. One also said being able to provide a rebate on the spot helps the distributor compete with big box stores like The Home Depot, which sells discounted screw-in bulbs through PPL Electric Utilities' Efficient Lighting Program.

Distributors' Stocking and Sales Patterns

Most distributors reported sourcing products by purchasing them directly from a manufacturer and said their stocking decisions were influenced by various factors, including customer demand, corporate policies, and relationships with long-term suppliers. Most distributors agreed that Midstream Lighting has not changed which lighting items they stock, but some said they were stocking larger quantities of program-qualifying products.

Distributors reported a shift in the lighting industry toward greater acceptance of LEDs and a small yet growing demand for lighting controls and smart lighting systems, which they predicted will increase over the next three years. They estimated that 50% to 85% of their dollar sales before Midstream Lighting started (in PY8) came from lighting products that are now program-eligible, and these sales have since increased slightly while sales of standard-efficiency products have declined. Most distributors reported they now sell more LEDs than standard-efficiency lighting, and some said LEDs were the only types of lights they sell. They attributed this trend to market changes, such as greater customer awareness of efficient product options, customer motivation to save energy and reduce maintenance costs, falling prices for lighting products in general, and utility program incentives. Distributors believe Midstream Lighting can play a role in the market's shift toward integrated lighting systems if the program provides discounts for system components such as controls or sensors.

Several distributors said they had started serving smaller customers, including end users, and they attributed this trend to Midstream Lighting.

Program Influence

Influence on Distributors' Customer Interactions and Promotion Practices

Most distributors *always* or *often* helped their clients with their lighting purchases, both prior to the launch of the program and currently. However, a few explained that their sales staff had a reactive approach with customers, in which they would answer questions about program-qualifying products but not actively promote these products. Three distributors said they helped customers choose qualifying products more often now than before participating in the program. Seven distributors *always* and three *often* tell customers about PPL Electric Utilities' Midstream Lighting discounts, but one *sometimes* skipped telling small customers about the discounts. Once they started participating, distributors said 10% to 60% of their sales were the result of their recommendations for program-eligible products.

Program Influence on Contractors' Promotional Practices and Business

Contractors (n=15) thought customers took three primary factors into account when deciding to install efficient or standard lighting: the cost of the products, the return on investment (ROI) in energy savings, and the ease of installation and maintenance of lighting products. Therefore, contractors also considered these primary factors when deciding which lighting products to promote to their clients. They said many contractors walked clients through multiple scenarios for their lighting upgrades, such as installing all new LED fixtures or retrofitting their old fixtures, and showed clients the lifetime cost for each scenario. Contractors' recommendations influenced their clients' decisions—of the 12 end-user non-purchasers interviewed, nine said their contractor was influential in their decision to purchase program-discounted products.

All but two contractors thought it was cost-effective for their clients to upgrade to LED in every situation; two said LED upgrades were cost-effective 80% to 90% of the time. As shown in Table F-10, nearly all contractors said they recommended high-efficiency lighting options in every situation, and about half said this had increased since Midstream Lighting became available. Nevertheless, contractors said their clients were not typically aware of the difference between ENERGY STAR- or DesignLights Consortium (DLC)-certified and noncertified products. Six contractors said none of their clients knew the difference, and five thought less than 10% knew the difference. Nor did clients tend to request qualified products prior to learning about the available discounts. Five contractors said their clients never asked for certified products, and five said their clients sometimes requested them.

Table F-10. Contractor Recommendations and Client Requests

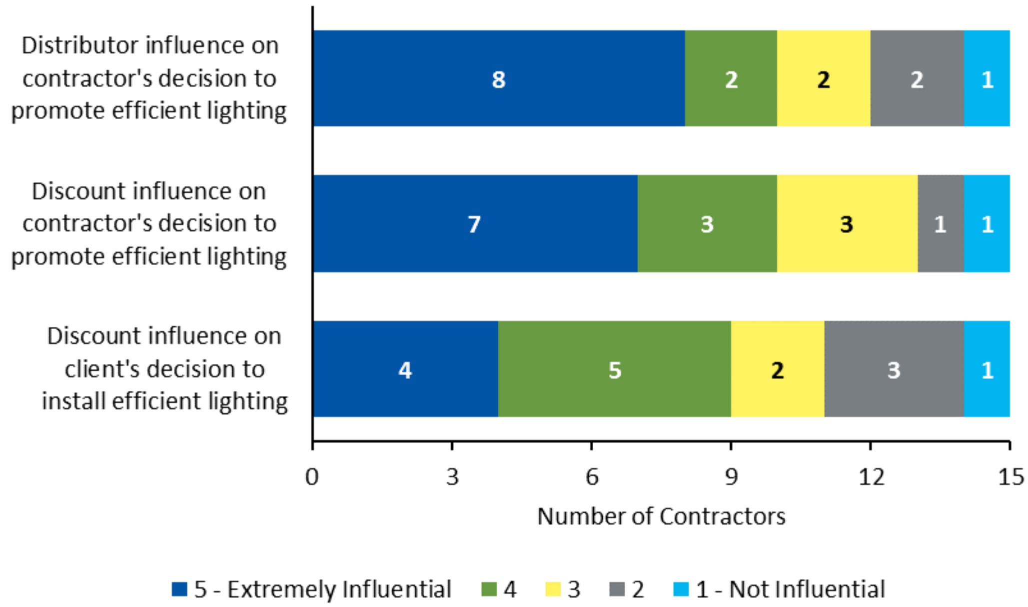
	How often contractors recommend high-efficiency lighting	Increase in recommendation of high efficiency lighting since start of Midstream Lighting	How often clients ask for ENERGY STAR or DesignLights Consortium (DLC) lighting
Contractors (n=15)	14 always 1 often	8 yes (4 large increase and 4 small increase) 7 no	1 always 3 often 5 sometimes 1 rarely 5 never

Midstream Lighting appears to have influenced contractors in making recommendations to their clients. As shown in Figure F-1, two-thirds of contractors (10 of 15) gave a 4 or 5 rating to the influence of their distributor and/or the program discounts in their decision to promote energy-efficient lighting products to their clients. Overall, these findings are similar to those in PY8.[158]

Contractors saw a slightly positive effect on their business because of the Midstream Lighting incentives. Nine of the 15 contractors interviewed thought the Midstream Lighting component had helped increase their revenue and sales volume—two said the impact was substantial and four said it was moderate. Four contractors said the discounts positively influenced their sales of non-program-eligible efficient products.

158 Contractors' rating of distributors and discounts is consistent with PY8; in PY8, five said the distributor was extremely influential, and six said the discounts were extremely influential.

Figure F-1. Influences on Contractor's and Client's Efficient Lighting Decisions



Source: Contractor survey questions: E6. How influential, using a scale from 1, meaning no influence, to 5, meaning extremely influential, would you say the instant discounts are in your decision to promote the ES and DesignLights Consortium (DLC) qualified lighting products to your customers?; E7. How influential was your distributor's recommendation in your decision to promote the ES and DesignLights Consortium (DLC) qualified lighting products?; E13. You rated the instant discounts as a [READ IN ANSWER TO E6] in terms of their influence on your decision to promote ES or DesignLights Consortium (DLC) products. Using this same scale, how influential do you think the instant discounts are to your clients' decisions to install high efficiency lighting?

Suggested Improvements

Respondents had multiple suggestions to improve the program. Of 42 end user and contractor respondents, 22 suggested changes. These were the most common program changes requested:

- Additional information about program-eligible products (3 purchasers, 2 non-purchasers)
- More tools and program support, such as resources on the website to identify eligible fixtures or a direct phone line to a program representative (3 contractors, 1 non-purchaser)
- More eligible products (1 contractor, 3 purchasers)
- More distributors to expand the scale of the program (1 contractor, 2 non-purchasers)
- Higher discounts (2 purchasers, 1 non-purchaser)

Eight of the 12 distributors offered these suggestions to improve the program:

- Expand product eligibility to more or all ENERGY STAR or DesignLights Consortium items, add other products, or eliminate need for new product preapproval (5 distributors)
- Reduce burden of fulfilling requirements by requiring fewer data and/or by creating an online portal where distributors can upload data to the ICSP and easily check, for example, if a customer's address is eligible for the program (3 distributors)

- Put invoice number on payments from the ICSP so distributors can match incentive payments to specific sales (2 distributors)
- Ask distributors more often about their opinions regarding optimal rebate levels (1 distributor)
- Provide clear program end date to avoid discovering the program has suddenly ended (1 distributor)

Three of 12 distributors noted that as prices for high-efficiency lighting decline so do prices of standard-efficiency lighting and recommended that the program adjust discount levels to reflect the decrease in the price of the equivalent standard-efficiency products. In particular, they said the following:

- Discounts for 4-foot and 2-foot linear currently too low because the price of their standard-efficiency options has dropped since the incentive level was set (1 distributor)
- An effective discount should cover approximately 50% of the incremental cost of high-efficiency versus standard-efficiency lighting (1 distributor)
- PY9 discounts “very aggressive” (1 distributor)
- Incentives for LED wall pack fixtures (exterior lights) should be increased by a small amount to make their price more competitive with standard-efficiency exterior lighting options (1 contractor)

When asked if any products should be added to the program, respondents requested a variety of items:

- Parking lot and area lighting, such as pole-mounted LEDs, flood lights, and wall packs (1 distributor, 1 contractor, 1 purchaser, 1 non-purchaser)
- General outdoor lighting (no specifics) (2distributors, 1 contractor, 1 non-purchaser)
- Plug-in CFL-LED replacements (2 distributors, 1 non-purchaser)
- 8-foot T8s (2 distributors, 1 contractor, 1 non-purchaser)
- LED panels, such as 2x2 and 2x4 flat panels (1 contractor, 1 purchaser)
- Lighting controls (1 distributor)
- Explosion-proof high-bay LEDs (1 purchaser)
- Additional fixtures (no specifics) (1 non-purchaser)
- 2-pin and 4-pin lamps

End-User Segmentation Analysis

The end-user segmentation analysis compared PY8 and PY9 Midstream participants with Phase II and Phase III Efficient Equipment Lighting participants based on their annual consumption and reported lighting savings. The following section includes tables and further detail supporting the discussion in *Section 6.5.4* demonstrating the shift of smaller customers and jobs to Midstream Lighting.

Table F-11 shows the population counts used in the analysis. As Midstream Lighting launched late in PY8, there are only 17 months of data over the first two years of Phase III. The Phase II prescriptive rebate lighting and the direct install program deliver channels referenced as a comparison were offered for three years.

Table F-11. Participant Counts by Analysis Group

Participant Group	Number of Customers (1)
Midstream Lighting (17 months)	2326
Phase III Lighting (prescriptive rebates, 2 years)	1386
Phase III Lighting (direct install, 2 years)	191
Phase II Lighting (prescriptive rebates, 3 years)	3,530
Phase II Lighting (direct install, 3 years)	2,163

(1) PPL Electric Utilities' tracking data from PY5-PY9; unique customer accounts.
(2) Phase II lighting participants span three years; for comparison purposes, in PY7, there were 1,560 commercial lighting jobs reported for this program.

The annual consumption quartiles in Table F-12 are based on the combination of all commercial customers (i.e., participants and non-participants). The Phase II and Phase III percentages show how lighting program participants fell into these quartiles. The differences in the distribution across phases is statistically significant and show that the Phase III participants are more concentrated in the first and fourth customer quartiles than Phase II participants.[159]

Table F-12. Lighting Participant Groups Across Customer Energy Consumption Quartiles

Commercial Customer Quartile	Annual Energy Consumption, kWh/yr	Phase II Participant Percentage	Phase III Participant Percentage	P Value
1	6,439	6%	10%	0.00000
2	16,802	13%	9%	0.00000
3	52,110	23%	20%	0.00009
4	331,799,000	57%	61%	0.00003

Table F-13 shows the distribution of Phase II and Phase III lighting participants across the Phase II and Phase III combined participant quartiles. Here, we see that both the prescriptive rebate and direct install participants are less concentrated in the first quartile in Phase III.

[159] Cadmus used a two sample t-test for the difference in proportions shown in these tables. The results presented are significant when $p < .05$.

Table F-13. Lighting Distribution Channels Across Participant Energy Consumption Quartiles

Participant Quartile	Annual Energy Consumption, kWh/yr	Phase II			Phase III			
		All Lighting Participants	Prescriptive Rebates	Direct Install	All Lighting Participants	Prescriptive Rebates	Direct Install	Midstream Lighting
1	26,075	27%	18%	42%	22%	10%	23%	30%
2	89,200	26%	21%	34%	23%	19%	32%	25%
3	416,910	25%	31%	17%	24%	30%	29%	20%
4	328,750,000	22%	30%	7%	30%	41%	19%	24%

When comparing the average energy savings by participant (distinct customer account) between Phase III and Phase II, the differences are not statistically significant, as shown in Table F-14.

Table F-14. Phase II vs. Phase III Lighting Participant Average Energy Savings

Phase (Duration of Data)	Average Energy Savings per Participating Customer (kWh/yr)	P Value
Phase II (3 years)	49,851	0.547
Phase III (2 years)	53,133	

However, both the prescriptive rebates and direct install customers' average savings were higher in Phase III, after Midstream Lighting was introduced, as shown in Table F-15.

Table F-15. Average Lighting Participant Energy Savings, by Phase and Path

Phase	Average Energy Savings per Participating Customer, kWh/yr
Phase II Prescriptive Rebates	62,871
Phase II Direct Install	28,627
Phase III Prescriptive Rebates	126,409
Phase III Direct Install	43,828
Midstream	9,801

Also, the proportion of participating customers in the first savings quartile increased in Phase III, even as the average project savings stayed consistent, as shown in Table F-16.

Table F-16. Phase II vs. Phase III Lighting Participants Across Energy Savings Quartiles

Savings Quartile(1)	Project Savings (kWh/yr)	Phase II Overall	Phase III Overall	P Value
Q1	3,347	17%	36%	6.26041E-98
Q2	10,034	27%	22%	2.50425E-07
Q3	29,504	29%	19%	2.43573E-27
Q4	12,508,597	27%	22%	6.86893E-07
(1)The quartiles in this table are based on the combined Phase II and Phase III participant data.				

Table F-17 shows just Phase III participants, and how they were distributed over the savings quartiles that were determined using the combined Phase II and Phase III participant data. This table shows the concentration of Midstream Lighting in the first quartile and those of both the prescriptive rebate and direct install delivery channels in the fourth quartile.

Table F-17. Phase III Lighting Participants Across Combined Phase Energy Savings Quartiles

Savings Quartile(1)	Project Savings (kWh/yr)	Midstream	Prescriptive Rebate	Direct Install
Q1	3,347	55%	8%	12%
Q2	10,034	24%	19%	26%
Q3	29,504	14%	27%	26%
Q4	12,508,597	7%	46%	36%
(1)The quartiles in this table are based on the combined Phase II and Phase III participant data.				

F.3.2 Survey Approach

Contact Instructions

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

Cadmus coordinated with the ICSP to screen the sample and removed the records of any customers called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey), had requested not to be contacted again, or had incomplete information.

Cadmus attempted to reach the contact by telephone up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

Sample Attrition

Table F-18 lists total numbers of records and the outcome (final disposition) of each record.

Table F-18. Midstream Lighting Component Sample Attrition Table

Description of Call Outcomes	Number of Records			
	Distributors	Contractors	Purchasers	End Users (Non-Purchasers)
Telephone Interview				
Population (number of contact names) [1]	17	1,203 [2]	1,999	1,203 [2]
Removed: inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on “do not contact” list	0	1,114	1,063	571
Removed: incomplete or invalid phone number	0	0	0	0
Interview Sample Frame (used for interview calls)	**17**	**89**	**936**	**632**
Not attempted	**0**	**47**	**857**	**448**
Records Attempted	**17**	**42**	**79**	**184**
Non-working number	0	1	4	1
Wrong number	0	0	3	0
Refusal	0	2	11	46
No answer/answering machine/phone busy	5	23	37	114
Non-specific or specific callback scheduled	0	1	6	10
Partial complete (not included in interview findings analysis)	0	0	0	1
Total Completed Surveys	**12**	**15**	**15**	**12**
Telephone response rate	**71%**	**36%**	**19%**	**7%**

[1] Number of contacts available at the time of the survey effort.
[2] Contractors and End User Non-Purchasers started from the same population list.

Appendix G. Evaluation Detail – Continuous Energy Improvement Program

G.1 Gross Impact Evaluation

G.1.1 Methodology

Background

Cadmus estimated the energy and demand savings at 16 of the 18 schools that participated in the Continuous Energy Improvement Program. These 16 schools were from four districts, as listed in Table G-1, and pilot schools are noted with an *. The ICSP and PPL Electric Utilities did not report savings for the pilot school from District 3. Another school in District 3 was excluded because a PV array was installed at the site, and no solar generation data were available; therefore, Cadmus could not apply the methodology described below without these data. All schools started participating in the Continuous Energy Improvement Program in February 2017, and Cadmus evaluated their first year of savings.

Table G-1. Evaluated Schools and Districts

District	School
District 1	School A
	School B*
	School C
	School D
	School E
District 2	School F*
	School G
	School H
	School I
District 3	School J
	School K
	School L
	School M
	School N
District 4	School O*
	School P
The * designates a pilot school.	

Cadmus developed savings estimates using facility-level energy consumption data measured from approximately one year before the schools participated in this program (the baseline period) through their first year of participation (the performance period). This approach empirically quantifies the impacts of the program and is consistent with the International Performance Measurement and Verification Protocol (IPMVP) Option C.[160]

Datasets

Participant Documentation

Participant documentation was provided by PPL Electric Utilities and the ICSP. The documentation contained information on the participating schools, including their names, addresses, account numbers, participation dates, school calendars, capital projects installed, and regression model specifications and resulting continuous energy improvement savings.

Advanced Metering Infrastructure (AMI) Data

PPL Electric Utilities provided hourly interval electricity consumption data (referred to as AMI data) for each account number at the 16 schools from approximately January 2016 through April 2018. In some cases, individual schools had multiple account numbers that Cadmus merged at the facility level. These data were also split into baseline and performance periods using the dates of each school's participation, all of which began in February 2017.

Local Climatological Data

Part of Cadmus' analysis involved correlating each school's energy consumption with weather data, such as outdoor air temperature and relative humidity. These data are available through the National Oceanic and Atmospheric Administration (NOAA) at weather stations across the country. Cadmus used the school addresses provided in the PPL Electric Utilities' tracking database to locate nearby weather stations and download datasets of hourly weather observations during the period concurrent with the AMI data.

Data Review

Cadmus visually inspected each set of time series data used in the analysis of the 16 schools. Where data were missing, Cadmus worked with PPL Electric Utilities to obtain a complete year of data for the baseline and performance periods. None of the AMI data contained values that were negative, exceedingly high, or otherwise appeared unreliable.

Examples of the plots Cadmus reviewed are shown in Figure G-1, Figure G-2, and Figure G-3; all of these figures show data from School G.

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[160] International Performance Measurement and Verification Committee. *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings*. May 2016. Available online: www.evo-world.org.

Figure G-1. AMI Data Review for School G

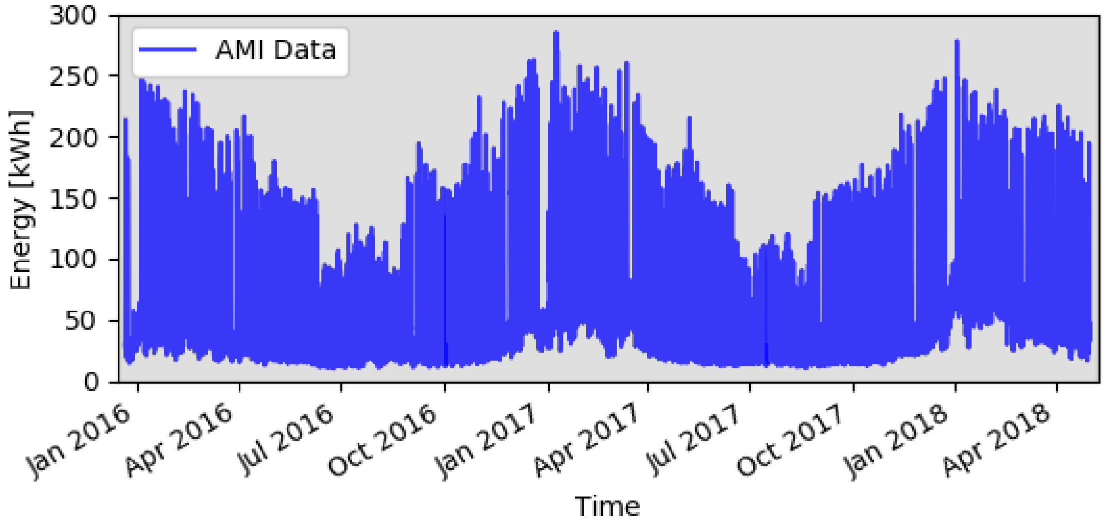


Figure G-2. Weather Data Review for School G

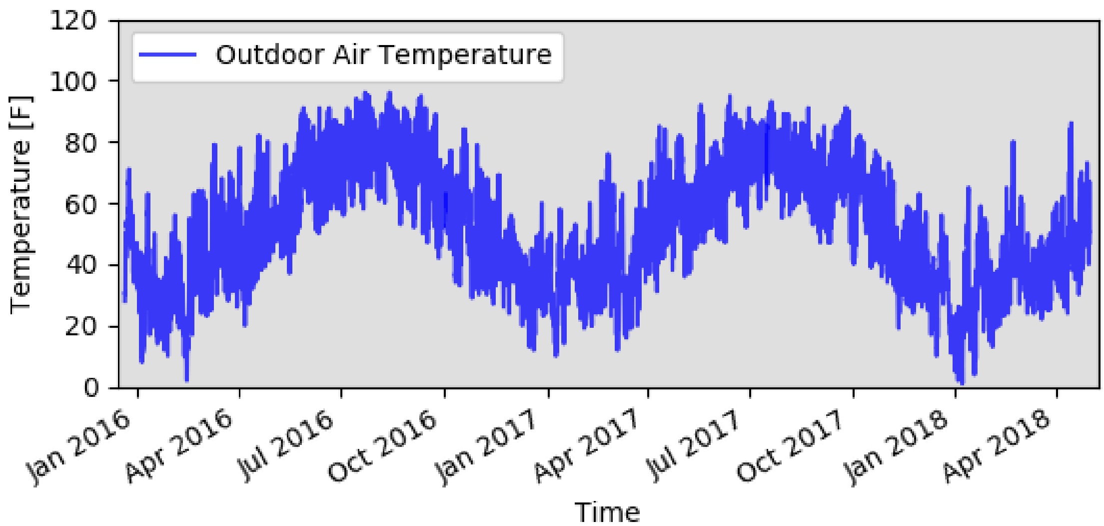
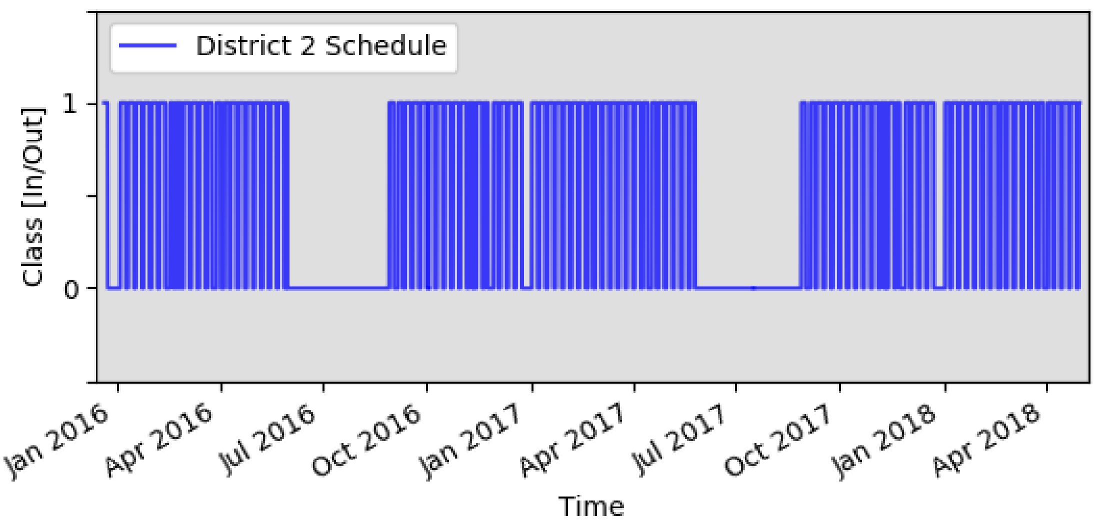


Figure G-3. District Schedule Review for School G



An indicator variable called "Class (In/Out)" was used to signify days that school was not in session (signified by a 0) and days school was in session (signified by a 1).

Dataset Preparation

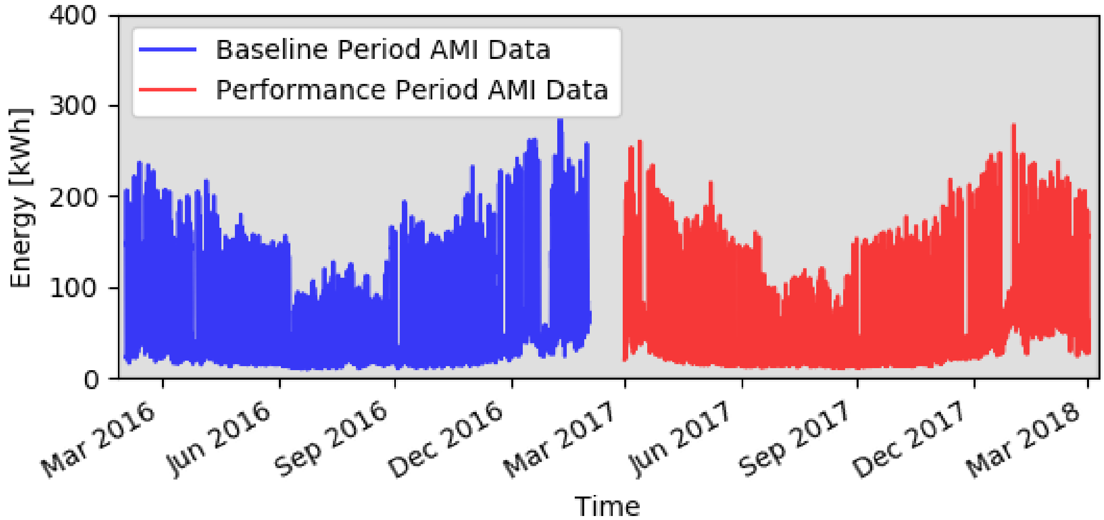
Cadmus prepared several datasets for each school prior to estimating savings. Each dataset contained electricity consumption, temperature, relative humidity (RH), and class schedule data, but at varying time intervals. These intervals were either hourly, daily, or monthly, and different sets of independent variables were available or calculated for each interval, as shown in Figure G-2. Cadmus used these datasets to test how savings and uncertainty varied with different techniques and inputs.

Table G-2. Independent Variables by Sampling Interval

Sampling Interval	Available Independent Variables
Hourly	Temperature, RH, Time of Day, Day of Week, Class (in/out)
Daily	HDDs, CDDs, Average RH, Day of Week, Class (in/out)
Monthly	HDDs, CDDs, Class (total class days in month)

Datasets were also split into baseline and performance periods. At this step, Cadmus removed the entire month of February 2017 to standardize the start dates. Therefore, the performance period for all schools was March 1, 2017, through February 28, 2018. This was consistent with the ICSP's approach, where monthly billing data from February 2017 were not included. Figure C-4 illustrates this process.

Figure G-4. Splitting Pre- and Post-Program AMI Data for School G



Also, for direct comparison with *ex ante* savings, Cadmus prepared datasets using monthly billing data, which varied slightly from AMI data when summed across the same interval.

Modeling

Cadmus used statistical modeling to estimate energy and demand savings for the Continuous Energy Improvement Program. These techniques empirically quantify savings, by regressing baseline period energy consumption as a response to local meteorological and temporal variables, and predict what a school's energy consumption would have been during the performance period had they not participated in the program. The model fit to the baseline period data is referred to as the baseline model.

Cadmus tested several baseline models for each school to understand the tradeoffs in modeling data sampled at varying intervals and in applying different modeling techniques. Cadmus first recreated the models that the ICSP had developed to obtain *ex ante* savings then used the AMI data to attempt to improve the precision of the reported savings.

Recreating the ICSP's Models

The ICSP provided Cadmus with the workbooks it used to estimate *ex ante* savings for each school. These estimates were developed from monthly billing data, heating and cooling degree days, and district class schedules. Again, using School G as the example, the raw data are shown in Figure G-5, Figure G-6, and Figure G-7.

Figure G-5. Monthly Billing Data for School G

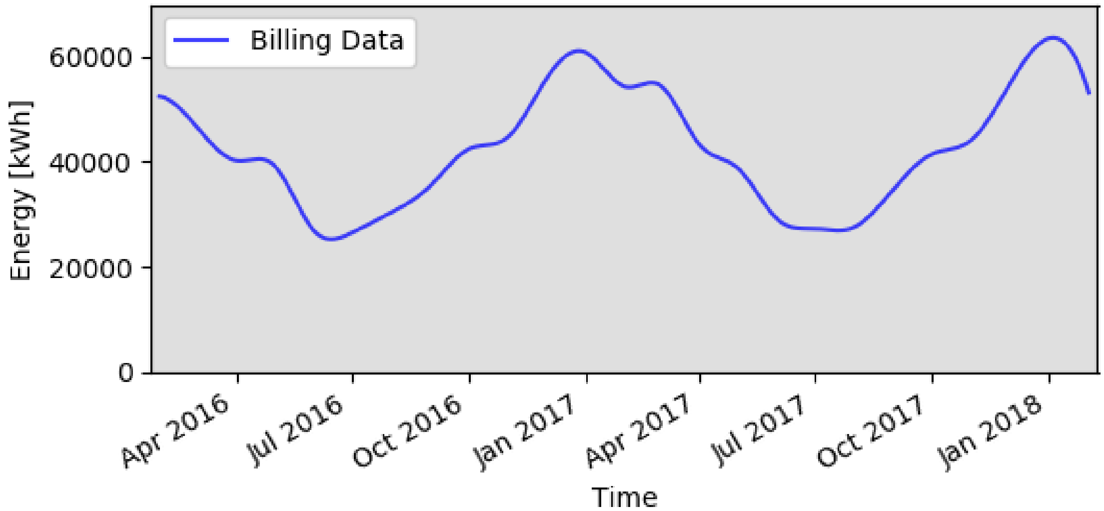


Figure G-6. Monthly Heating Degree Days for School G

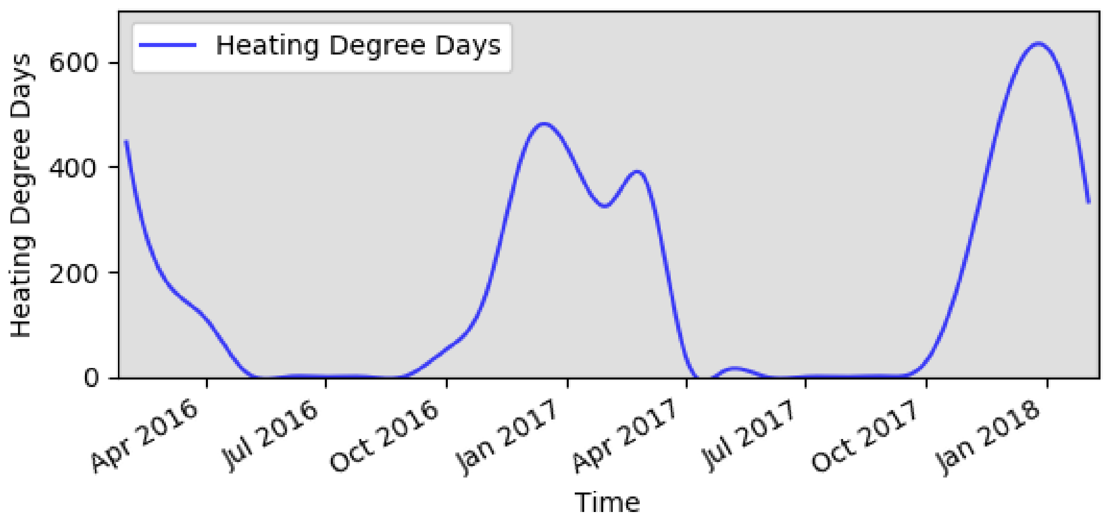
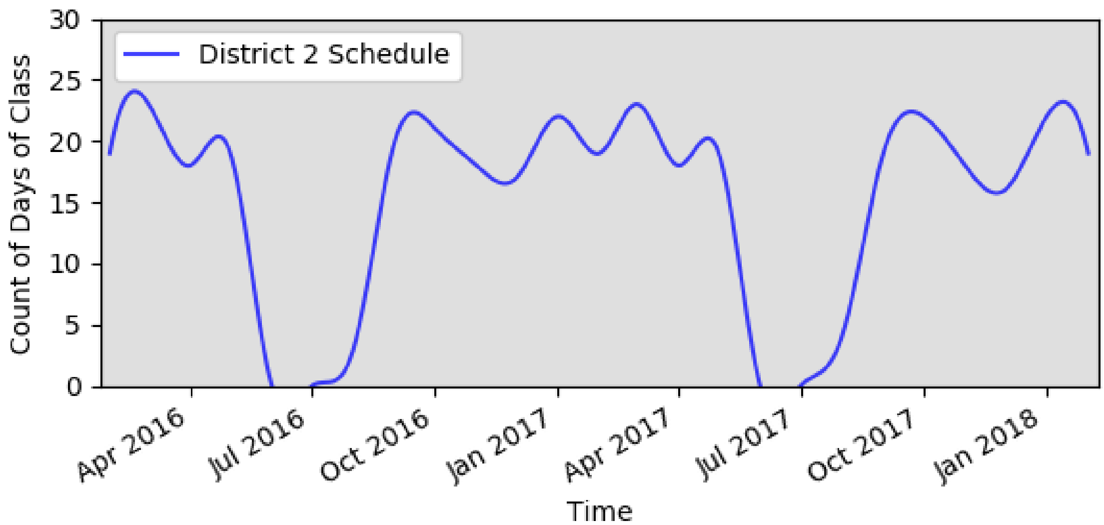


Figure G-7. Monthly Days of Class for School G



The positive relationship between monthly energy consumption, HDDs, and the number of class days can be seen in Figure G-8 and Figure G-9.

Figure G-8. Monthly Energy Consumption vs. Heating Degree Days for School G

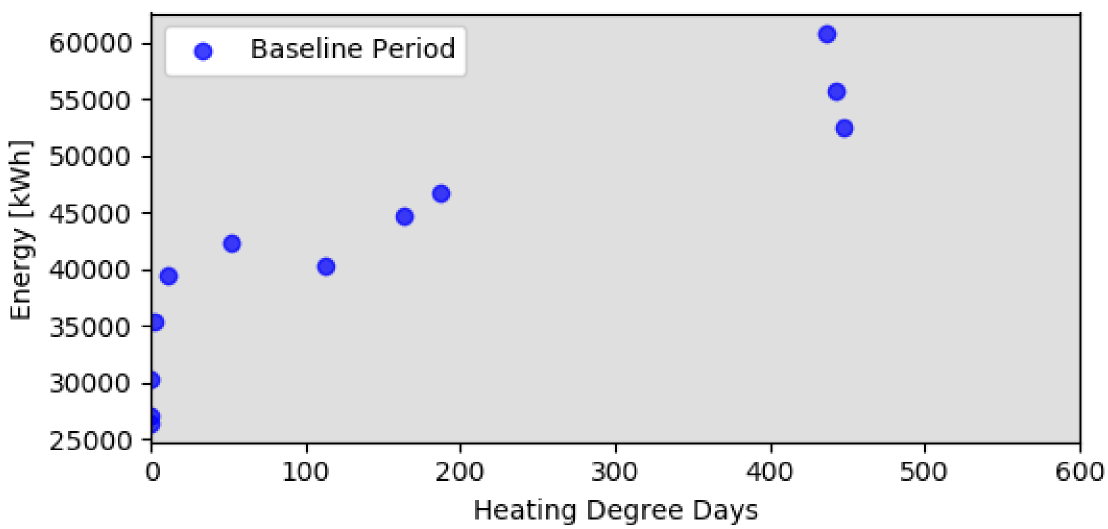
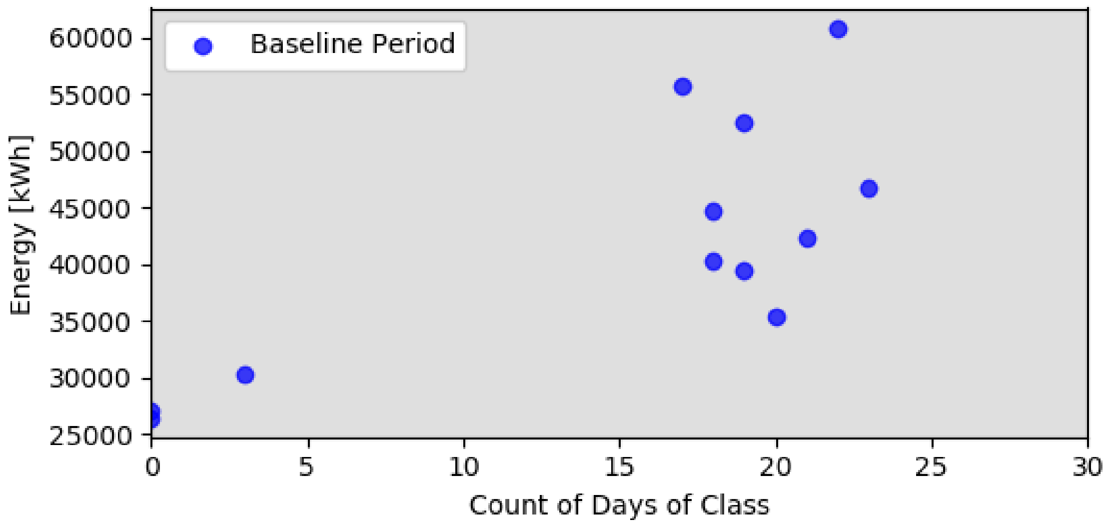
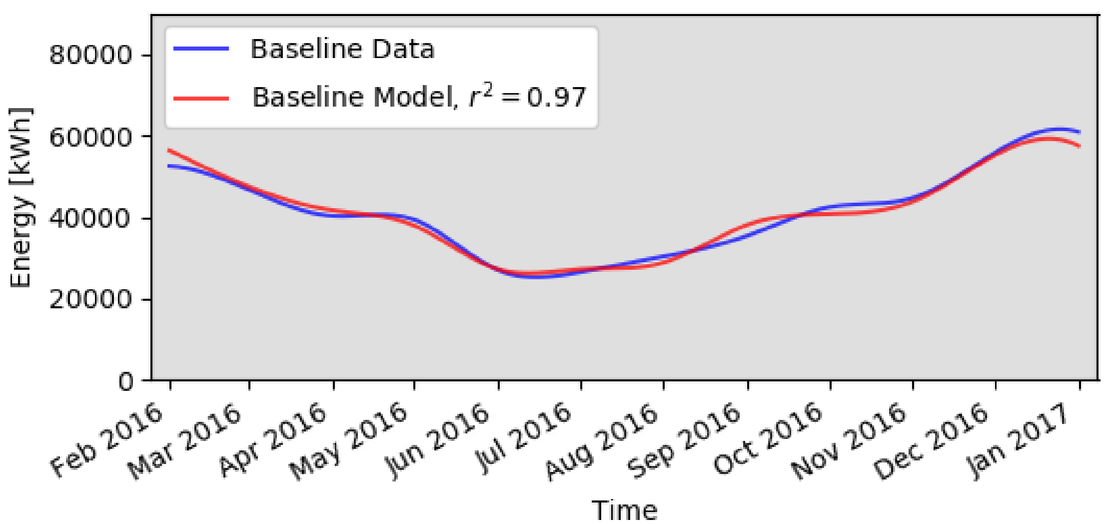


Figure G-9. Monthly Energy Consumption vs. Number of Class Days for School G



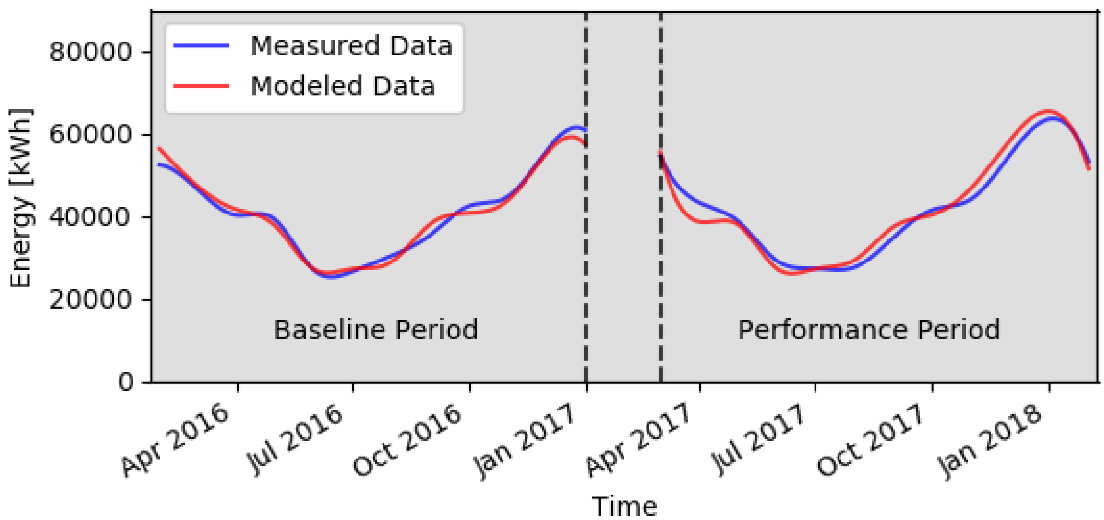
The ICSP used these two independent variables, HDDs and number of class days, to develop a baseline model. Cadmus recreated the ICSP's baseline model, as shown in Figure G-10.

Figure G-10. Baseline Modeling for School G



This particular baseline model, for School G, explains most of the variability in monthly energy consumption. After fitting the model coefficients, this model is used to make counterfactual predictions of energy consumption during the performance period, as shown in Figure G-11, and savings are estimated by taking the difference between the predicted consumption and the measured consumption.

Figure G-11. Estimating Savings During Performance Period for School G



The estimated savings for School G are small, amounting to 3,154 kWh, or less than 1%, of annual baseline consumption.

Cadmus applied the same methodology to all 16 schools using the same data as the ICSP and compared results.[161] The reported and recreated values for 11 schools matched exactly, and four were within 5%. One school, School L, did not match, with a result that was 99% different than reported. Cadmus was not able to determine the source of variation for School L but, in reviewing the results as a whole, determined that the ICSP had provided adequate data and documentation to reproduce the reported results.

Developing Models with AMI Data

Monthly billing data are often used in estimating energy savings, but when higher frequency data are available it may be possible to improve the precision of the results by applying additional inputs and alternative modeling techniques. Cadmus tested two modeling techniques, multiple linear regression and random-forest regression, on hourly, daily, and monthly datasets for each school. It is essential that the process of comparing these combinations of datasets and techniques is objective in the selection of independent variables and hyperparameters.

An additional step for monthly and daily datasets is choosing the base temperatures to calculate HDDs and CDDs. The fit of a baseline model depends on this choice, so Cadmus tested a range of base temperatures by fitting a linear model to each combination for HDD and CDD base temperatures and selected the pair yielding the highest r-squared. Figure G-12 illustrates this process for School G, and

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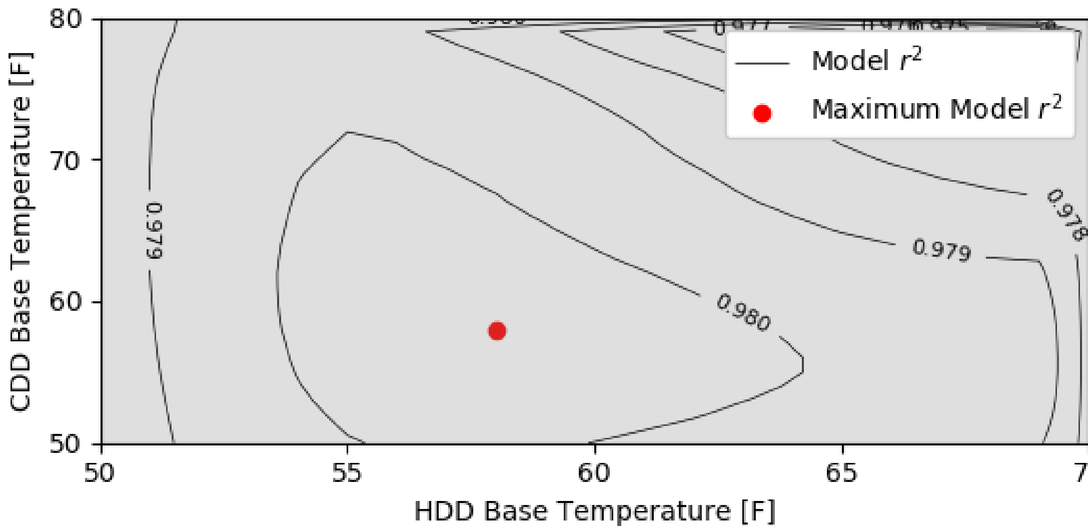
161 Some datasets had minor variations due to discrepancies between the reported HDD or CDD base temperatures and the bases used in the calculating these values.

although r-squared values do not fluctuate much with HDD and CDD base temperatures, this procedure is more objective than using engineering judgment.

Figure G-12. Optimizing HDD and CDD Base Temperatures for School G



Next, Cadmus selected the independent variables for each baseline model. It is best practice to exclude variables that do not correlate with the energy consumption, correlate highly with other variables, or do not predict well out of sample. Cadmus first plotted all candidate variables against energy consumption to confirm there was a correlation, then recursively tested combinations of independent variables using cross-validation. This process determined the final inputs for each school's baseline model. Additionally, if any capital equipment improvements were installed during the baseline period, Cadmus included an indicator variable in the model to signify the equipment installation date.

Many machine learning techniques, including random-forest regression, also allow for specification of hyperparameters, and the reliability of out-of-sample predictions can vary drastically with the choice of these inputs. An important hyperparameter for models using branching, tree-like structures is the number of observations in each end node or leaf. When leaf sizes are very small, models can appear to fit extremely well but fail to predict with similar accuracy. Cadmus used grid-search cross-validation over a range of hyperparameters to avoid over-fitting baseline models.

Cadmus scored baseline models using several metrics, including r-squared, coefficient of variation root-mean-square error (CVRMSE), and normalized mean bias error (NMBE), and bounded total estimated performance period consumption using prediction intervals. These metrics informed Cadmus' final choice in fitting baseline models using daily consumption data and random-forest regression.

The whole-facility savings were then determined by subtracting the actual consumption during the performance period from the predicted baseline consumption.

Five schools participated in other PPL Electric Utilities' rebate programs and installed energy-efficient equipment during their participation in the Continuous Energy Improvement Program. Cadmus subtracted the prorated *ex post* savings for these equipment upgrades from the whole-facility savings to determine the savings for the Continuous Energy Improvement Program.

The whole-facility, capital project, and Continuous Energy Improvement Program energy savings are shown in Table G-3.

Table G-3. Evaluated Energy Savings by School

School	Whole-Facility Savings (kWh)	Prorated Capital Project Savings (kWh)	CEI Program Savings (kWh)	85% Confidence Lower Bound (kWh)	85% Confidence Upper Bound (kWh)	Savings as a Percentage of Baseline Consumption
School A	-2,138	0	-2,138	-5,706	1,429	-0.3%
School B	34,602	0	34,602	26,268	42,937	4.7%
School C	91,298	0	91,298	72,435	110,162	3.6%
School D	74,113	0	74,113	63,751	84,475	4.1%
School E	66,569	0	66,569	58,105	75,033	8.5%
School F	22,333	0	22,333	9,135	35,531	2.5%
School G	-9,261	0	-9,261	-16,383	-2,138	-1.8%
School H	58,379	0	58,379	50,592	66,166	13.5%
School I	38,837	0	38,837	23,668	54,005	3.4%
School J	3,057	6,290	-3,233	-7,635	1,170	-0.8%
School K	9,815	63,453	-53,638	-60,172	-47,104	-12.5%
School L	-3,704	0	-3,704	-10,742	3,335	-0.4%
School M	479,576	55,341	424,235	376,875	471,595	7.5%
School N	8,878	0	8,878	2,871	14,884	2.4%
School O	-158,358	8,362	-166,720	-190,866	-142,575	-7.3%
School P	75,791	15,435	60,356	47,697	73,016	5.2%
Total	**789,787**	**148,881**	**640,906**	**572,062**	**709,751**	**3.1%**

Cadmus also used these models to estimate demand savings, by first fitting them to peak period hourly data during the baseline period,[162] then predicting hourly consumption during the performance period. Cadmus then calculated whole-facility demand savings by averaging the hourly savings during the peak period. To determine the Continuous Energy Improvement Program demand savings, Cadmus subtracted *ex post* capital project demand savings from the whole-facility demand savings.

The whole-facility, capital project, and the Continuous Energy Improvement Program demand savings are shown in Table G-4.

[162] Peak period is defined as June through August excluding weekends and holidays, 2:00 p.m. to 6:00 p.m., according to the 2016 PA TRM in Table 1-3.

Table G-4. Evaluated Average Demand Savings by School

School	Whole-Facility Savings (kW)	Capital Project Savings (kW)	CEI Savings (kW)	Savings Lower Bound (kW)	Savings Upper Bound (kW)	CEI Savings (%)
School A	16.03	0.00	16.03	14.27	17.78	27%
School B	9.30	0.00	9.30	6.23	12.38	14%
School C	49.38	0.00	49.38	38.09	60.66	15%
School D	43.95	0.00	43.95	38.68	49.21	25%
School E	6.88	0.00	6.88	1.52	12.24	6%
School F	12.44	0.00	12.44	9.62	15.26	15%
School G	20.98	0.00	20.98	18.64	23.32	40%
School H	15.79	0.00	15.79	14.04	17.55	41%
School I	31.92	0.00	31.92	27.48	36.37	31%
School J	8.05	0.12	7.93	5.71	10.15	13%
School K	12.48	10.78	1.70	-0.55	3.94	2%
School L	26.09	0.00	26.09	21.01	31.17	22%
School M	244.71	0.26	244.45	212.97	275.93	28%
School N	4.17	0.00	4.17	0.77	7.56	6%
School O	-49.73	2.56	-52.29	-59.24	-45.33	-21%
School P	-1.93	5.12	-7.05	-13.17	-0.93	-4%
Total	**450.51**	**18.84**	**431.67**	**392.85**	**470.49**	**16%**

Reported and evaluated the Continuous Energy Improvement Program demand savings, along with the confidence intervals by school, are shown in Table G-5. PPL Electric Utilities did not report demand savings. For eight of the 16 evaluated schools, the reported energy savings were within the 85% confidence interval of the evaluated savings, indicating evaluated and reported savings are not statistically different. The overall realization rate was 89%, and total reported savings were statistically different than the total evaluated savings.

Table G-5. Reported and Evaluated Continuous Energy Improvement Energy Savings by School

School	Reported Energy Savings (kWh)	Evaluated Energy Savings (kWh)	Savings Lower Bound (kWh)	Savings Upper Bound (kWh)	Reported Savings within the C.I. of Evaluated Savings
School A	6,101	-2,138	-5,706	1,429	No
School B	33,413	34,602	26,268	42,937	Yes
School C	93,900	91,298	72,435	110,162	Yes
School D	104,244	74,113	63,751	84,475	No
School E	78,007	66,569	58,105	75,033	No
School F	30,030	22,333	9,135	35,531	Yes
School G	3,154	-9,261	-16,383	-2,138	No
School H	62,405	58,379	50,592	66,166	Yes
School I	23,907	38,837	23,668	54,005	Yes
School J	5,681	-3,233	-7,635	1,170	No
School K	-21,806	-53,638	-60,172	-47,104	No
School L	2,991	-3,704	-10,742	3,335	Yes
School M	396,404	424,235	376,875	471,595	Yes
School N	11,746	8,878	2,871	14,884	Yes
School O	-141,883	-166,720	-190,866	-142,575	No
School P	35,104	60,356	47,697	73,016	No
Total	**723,398**	**640,906**	**572,062**	**709,751**	**No**

Savings Realization Rate Methodology

Cadmus calculated the program realization rate by dividing the *ex post* evaluated savings by the *ex ante* reported savings. Extrapolation of the realization rate to the population is not necessary for the Continuous Energy Improvement Program since the realization rate is based on a census of all schools. No realization rate was calculated for demand savings because there were no *ex ante* savings reported.

G.1.2 Database Review Findings

Cadmus reviewed whether the savings reported in the PPL Electric Utilities tracking database matched the savings documented in the ICSP's M&V Reports and found that all reported savings aligned.

G.1.3 Site Visit Findings

Cadmus did not conduct site visits. Savings were verified using a billing analysis.

G.1.4 Realization Rate Findings

Evaluated and reported continuoue energy improvement savings varied mainly due to the modeling methodology differences. The differences in capital project savings also contributed to the realization rate. Evaluated and reported savings for capital projects are shown in Table G-6 and differed for two main reasons. The first is that Cadmus' evaluation used the *ex post* capital project savings, while the ICSP used the *ex ante* capital project savings. The second is that Cadmus accounted for a capital project at

School J identified in PPL Electric Utilities' tracking database but that the ICSP did not account for. Overall the evaluated prorated capital project savings were 99% of the reported prorated capital project savings.

Table G-6. Evaluated and Reported Prorated Capital Energy Savings

School	Reported Capital Savings (kWh)	Evaluated Capital Savings (kWh)
School J	5,769	6,290
School K	56,147	63,453
School M	60,656	55,341
School O	10,221	8,362
School P	17,054	15,435
Total	**149,847**	**148,881**

G.2 Net Impact Evaluation

G.2.1 Net-to-Gross Ratio Methodology

Cadmus used self-report interviews, administered by phone, to assess the net-to-gross ratio. Cadmus followed the Evaluation Framework's recommended method for self-report surveys.[163] The SWE team reviewed and approved the interview guide prior to fielding.

Because the Continuous Energy Improvement Program is demanding and focuses on O&M and energy-saving behavior activities, very little free ridership is expected. It can also be difficult to measure. It would be time-intensive to ask energy managers the intention and influence questions for every activity implemented at every school and impossible to attribute savings to individual behavior and O&M activities. Therefore, Cadmus focused questions on the program's overall influence on capital, O&M, and behavioral projects at the pilot school and combined these responses with responses to other questions, such as about projects that were already planned and if the district already had an energy policy or energy goals before participating in Continuous Energy Improvement activities.

Cadmus calculates net savings only to inform future program planning. Energy savings and demand reduction compliance targets are met using verified gross savings.

G.2.2 Net-to-Gross Ratio Sampling

Cadmus conducted telephone self-report interviews between May and June 2018 with all four energy managers from the participating school districts. The sampling strategy is presented in Table G-7.

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163 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC. October 21, 2016.

Table G-7. PY9 Continuous Energy Improvement 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	Records Selected for Sample Frame	Achieved Sample Size	Percent of Sample Frame Contacted to Achieve Sample (2)
School District Pilot Schools	Pilot schools	4	N/A	N/A	4	4	4	100%

(1) Represents number of energy managers. The energy managers focused on one pilot school at each school district in PY9. Note that savings could not be estimated at one pilot school.
(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.

G.2.3 Net-to-Gross Ratio Findings

To assess net savings, Cadmus asked energy managers how influential the Continuous Energy Improvement Program was on the decision to implement O&M, behavioral, and capital projects, on a scale of 1 (*no influence*) to 5 (*extremely influential*). Table G-8 presents these results. One energy manager's responses were determined to be invalid and another did not respond for O&M and behavioral improvements. Therefore, Cadmus assessed other information relevant to calculating NTG, also presented in Table G-8, such as which activities were in place prior to participating in Continuous Energy Improvement. All schools had previously completed energy savings projects, two had previously set energy goals, three had previously tracked energy usage, and two had completed energy projects during Continuous Energy Improvement Program participation that were planned prior to participation.

Because of the small sample size, with responses only representing three of the 16 schools with reported savings, Cadmus determined it was not possible to compute the NTG ratio for PY9. In PY10, Cadmus will interview energy managers again and aim to collect information for a larger sample of participating schools.

Table G-8. PY9 Continuous Energy Improvement NTG Findings

District	Completed Energy Projects Prior to CEI?	Previous Goals?	Previously Tracking Energy?	Projects completed during CEI that were already planned	Program Influence (1) 1 (*no influence*) to 5 (*extremely influential*)		
					Capital Projects	O&M Projects	Behavioral Activities
1 School B	Yes	No	No	None	5	5	5
2 School F	Yes	No	Yes	None	Responses deemed invalid (2)		
3 (3)	Yes	Yes	Yes	Lighting, HVAC Controls	4	4	5
4 School O	Yes	Yes	Yes	Upgrade air handler motors	No response	No response	3

(1) The question was "Please rate how influential the CEI program was on [PILOT SCHOOL]'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."
(2) Respondent misinterpreted the question.
(3) It was not possible to estimate energy savings for this district's pilot school.

G.3 Process Evaluation

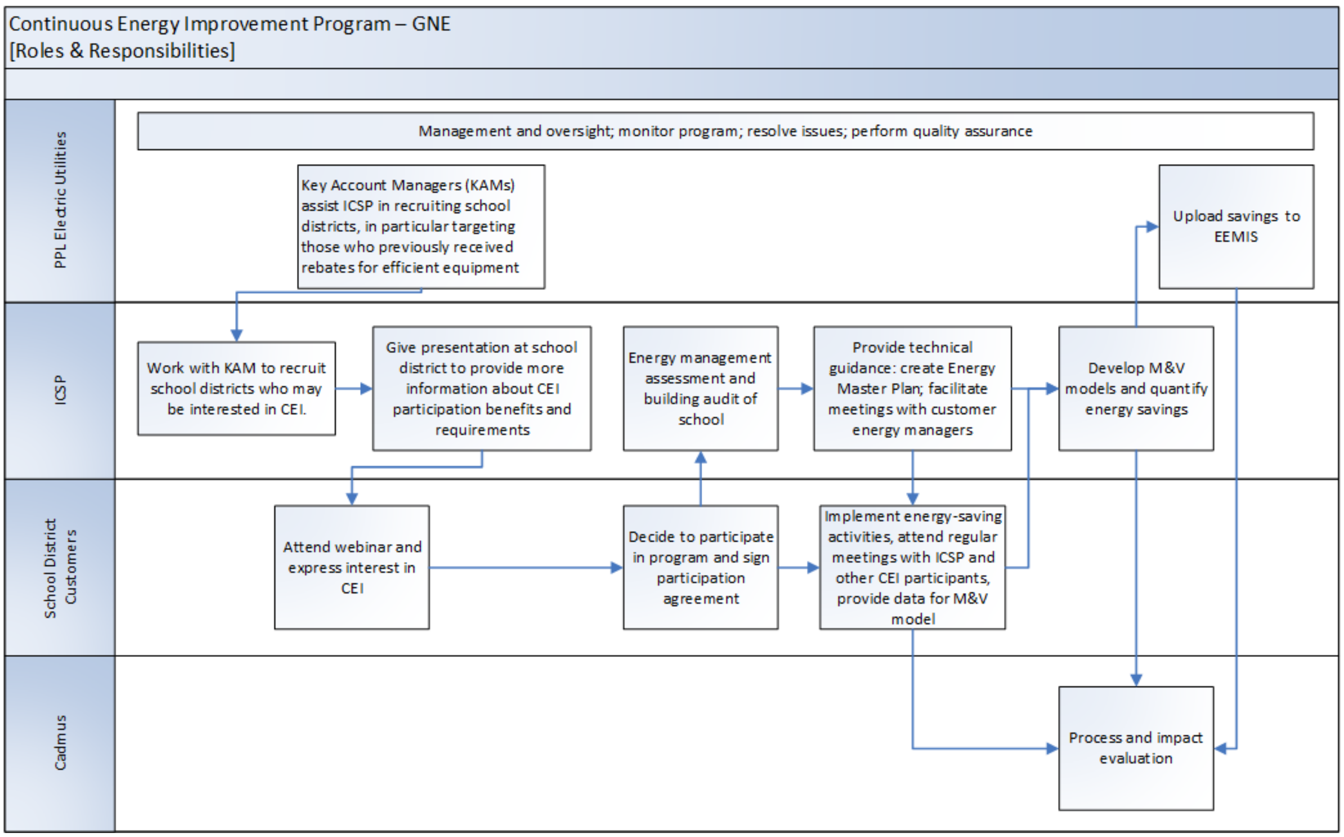
G.3.1 Additional Findings

This section includes additional process evaluation findings from the process map and logic model review.

Process Map

Based on interviews with PPL Electric Utilities and ICSP program managers, Cadmus developed a process map for the Phase III Continuous Energy Improvement Program, shown in Figure G-13.

Figure G-13. Process Map for the Continuous Energy Improvement Program



Logic Model Review

Cadmus reviewed the logic model and determined that the program is operating as expected. Table G-9 lists the outcome of the logic model review.

Table G-9. Logic Model Review for the Continuous Energy Improvement Program

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
Program implementation, audit, development of the Energy Master Plan, and other technical consulting and education provided to participating school districts, QA/QC and evaluation processes developed and implemented, and incentive payments processed	**Program Activities**	Delivered program activities as expected
The ICSP offers workshops and monthly meetings to increase school districts' knowledge about managing energy; the ICSP conducts an audit at the pilot school and develops an Energy Master Plan; school districts' implement activities to save energy; incentives paid	**Outputs Produced by Program Activities**	Delivered outputs as expected
Customer awareness of the program and its energy-efficient opportunities increases, school districts' knowledge about managing energy consumption increases; and immediate energy savings and demand reduction are achieved	**Short-Term Outcomes**	Produced short-term outcomes as expected
Experience and feedback will lead to program updates; continued energy and demand savings will be achieved; customer awareness of PPL Electric Utilities programs will continue to increase	**Intermediate Outcomes**	On track to produce intermediate outcomes
PPL Electric Utilities' will increase its knowledge and experience operating this type of program, long-term energy savings and demand reductions will be achieved, and environmental benefits accrue	**Long-Term Outcomes (end of Phase III)**	On track to produced long-term outcomes

Appendix H. Evaluation Detail – Efficient Lighting Program

H.1 Gross Impact Evaluation

H.1.1 Methodology

Evaluation Sampling Approach

Table H-1 lists the sampling for the impact evaluation of the Efficient Lighting Program. The impact evaluation activities produced results with ±4.26% precision at 85% confidence.

Table H-1. PY9 Efficient Lighting Program Impact Evaluation Sampling Strategy

Stratum	Population Size	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
Lighting Manufacturer Invoices	557	N/A	70	70	Strategic sample audit
Program Total	**N/A**		**N/A**		

H.1.2 Baseline Adjustments

Table H-2 lists the baseline adjustments described in section *9.3.1.2 Tracking Data Review*. Cadmus checked baseline wattages for each SKU against the baseline tables by bulb type in PA TRM tables 2-2, 2-3, and 2-4 and made adjustments for records that did not align with these tables.

Table H-2. PY9 Baseline Wattage Adjustments by PA TRM Bulb Category

TRM Bulb Category	Lumens	Reported Baseline Wattage	Evaluated Baseline Wattage	Quantity of Bulbs Adjusted
3-Way (Exempt)	1200	53	100	4,034
3-Way (Exempt)	1600	72	100	8,278
3-Way (Exempt)	1650	72	100	3,625
3-Way (Exempt)	800	43	100	151
Candelabra/Decorative	300	29	40	91,002
Candelabra/Decorative	315	29	40	692
Candelabra/Decorative	325	29	40	30,814
Candelabra/Decorative	330	29	40	34,799
Candelabra/Decorative	345	29	40	1,370
Candelabra/Decorative	350	29	40	14,953
Candelabra/Decorative	400	29	40	4
Candelabra/Decorative	500	43	60	33,185
Globe	350	29	40	11,987
Globe	450	29	40	39,217
Reflector	1000	120	65	1,211
Reflector	1021	60	65	36
Reflector	1079	120	65	10
Reflector	1100	75	65	671

TRM Bulb Category	Lumens	Reported Baseline Wattage	Evaluated Baseline Wattage	Quantity of Bulbs Adjusted
Reflector	1200	125	65	744
Reflector	1300	120	65	419
Reflector	1350	120	180	357
Reflector	1390	125	180	3,300
Reflector	1800	120	60	2,388
Reflector	182	77	80	145
Reflector	2206	200	360	922
Reflector	2400	150	250	1,249
Reflector	306	20	40	57
Reflector	405	78	40	213
Reflector	432	83	40	566
Reflector	461	45	40	1,455
Reflector	471	30	40	71
Reflector	520	50	40	202
Reflector	528	50	40	1,601
Reflector	534	60	40	578
Reflector	540	200	40	240
Reflector	540	125	40	106
Reflector	554	60	40	2,100
Reflector	586	79	40	201
Reflector	600	60	50	771
Reflector	600	65	50	4,868
Reflector	610	65	50	430
Reflector	622	60	50	86
Reflector	627	60	50	1,420
Reflector	635	60	50	2,195
Reflector	635	82	50	138
Reflector	636	65	50	205
Reflector	645	40	50	1,895
Reflector	650	76	50	558
Reflector	650	60	50	20,583
Reflector	650	40	50	2,400
Reflector	650	65	50	2,018
Reflector	667	40	50	816
Reflector	667	65	50	532
Reflector	669	60	50	470
Reflector	689	40	50	683
Reflector	690	65	50	5,629
Reflector	690	40	50	1,087
Reflector	692	65	50	557

TRM Bulb Category	Lumens	Reported Baseline Wattage	Evaluated Baseline Wattage	Quantity of Bulbs Adjusted
Reflector	700	65	50	834
Reflector	719	83	50	28
Reflector	721	65	50	1,241
Reflector	750	75	50	3,127
Reflector	750	65	50	1,296
Reflector	776	40	50	2,070
Reflector	778	60	50	93
Reflector	799	82	50	60
Reflector	800	75	50	1,437
Reflector	800	125	50	360
Reflector	800	40	50	328
Reflector	850	60	55	6,358
Reflector	850	75	55	5,928
Reflector	881	125	55	585
Reflector	900	75	55	11,904
Reflector	920	120	55	2,596
Reflector	925	75	55	1
Reflector	940	75	55	206
Reflector	990	120	55	1,406
Reflector	998	60	55	3,062
Total				**383,214**

Cadmus identified 21 SKUs with lumens ratings outside those in the PA TRM for specific reflector lamp types and researched the baseline wattages as reported on manufacturer and retailer websites. Cadmus confirmed for 12 SKUs that the baseline wattages specified in the PPL Electric Utilities tracking database matched those specified on manufacturer and retailer websites. Cadmus adjusted the baselines for the remaining SKUs as described in Table H-3.

Table H-3. PY9 Bulbs Incompatible with PA TRM Baseline Wattage Tables

Specialty Type	Lumens	Reported Baseline Wattage	Confirmed Baseline Wattage	Bulbs Adjusted	Source
LED Fixture	182	77	80	145	Online search
LED Fixture	1,350	120	180	1,786	Retailer website
LED Fixture	1,390	125	180	1,514	Retailer website
LED Fixture	1,390	125	180	357	Retailer website
LED Fixture	1,800	120	60	1,203	Retailer website
LED Fixture	1,800	120	60	1,185	Retailer website
LED Fixture	2,206	200	360	487	Retailer website
LED Fixture	2,206	200	360	435	Retailer website
LED Parabolic Aluminized Reflector	2,400	150	250	1,249	Retailer website
Total				**8,361**	

Appendix I. Evaluation Detail – Home Energy Education Program

I.1 Process Evaluation

I.1.1 Additional Findings

Logic Model Review

A logic model identifies the relationships between the program activities and expected results. Cadmus reviewed the Home Energy Education Program's logic model and determined that the program operated as expected in PY9. Table I-1 shows the program logic model's expected and actual outcomes.

Table I-1. Home Energy Education Program Logic Model Review

Logic Model Element	Expected PY9 Outcome	Actual PY9 Outcome
Program Activities	**Develop customer education and normative messaging about energy use**	Delivered program activities as expected
Outputs Produced by Program Activities	**Tailored print and electronic home energy reports; energy management portal**	Delivered outputs as expected
Short-Term Outcomes	**Residential customers become better informed about their energy use and more aware of energy efficiency**	Produced short-term outcomes as expected
Intermediate Outcomes	**Residential customers take actions to reduce their energy use through product and/or behavior change adoption**	Produced intermediate outcomes expected
Long-Term Outcomes	**Residential customers continue to take energy-saving actions, possibly with minimal encouragement (e.g., fewer home energy reports)**	To be determined at the end of Phase III

Treatment Group Customer Profile

The customer surveys also collected demographic details about the treatment group customers, as shown in Table I-2. The majority of treatment group customers (home energy report recipients) had the following characteristics:

- Lived in a single-family detached residence (83%)
- Had an average household size of 2.8 people
- Averaged 57 years of age
- Had completed some college education or more (77%)
- Had an annual household income of $60,000 or greater (60%)

Table I-2. Home Energy Education Program Customer Survey Demographics

What type of residence do you live in? Is it…	Treatment Group (n_w=414)
A single-family detached residence	83%
Attached house (townhouse, row house, or twin)	6%
Mobile or manufactured home	6%
Multifamily apartment or condo building with 4 or more units	2%
Something else	3%
What is the highest level of education that you have completed?	**Treatment Group (n_w=431)**
Less than high school diploma or equivalent	1%
High school diploma or equivalent	22%
Technical or business school certificate/two-year college degree/some college	30%
Four-year college degree/bachelor's degree	28%
Graduate or professional degree/masters or PhD	19%
What year were you born?	**Treatment Group (n_w=473)**
Mean birth year (age)	1961 (57 years old)
Standard deviation	13.02
Including yourself, how many people lived in your home full-time during the past 12 months? Full-time is considered more than 9 months in the past year.	**Treatment Group (n_w=507)**
Mean household size	2.8 people
Standard deviation	1.54
In 2017, what was your annual household income before taxes? Please stop me when I read your category. Was it…	**Treatment Group (n_w=368)**
Under $10,000	2%
$10,000 to under $15,000	4%
$15,000 to under $20,000	3%
$20,000 to under $25,000	3%
$25,000 to under $30,000	5%
$30,000 to under $35,000	3%
$35,000 to under $40,000	5%
$40,000 to under $45,000	2%
$45,000 to under $50,000	2%
$50,000 to under $60,000	11%
$60,000 to under $75,000	12%
$75,000 to under $100,000	18%
$100,000 to under $150,000	17%
$150,000 to under $200,000	5%
$200,000 or more	8%

I.1.2 Survey Approach

Survey Data Analysis

To analyze the survey data, Cadmus compiled frequency outputs, coded open-end survey responses, and ran statistical tests. To determine whether survey results significantly differed between waves and program years, Cadmus ran t-tests for differences in proportions and means set at the 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$) significance levels.

Cadmus reported survey results at the program level and applied statistical weights to the treatment group survey data at the wave level to reflect actual program population proportions. Table I-3 shows the wave-level statistical weights applied to the treatment group survey responses. Weighted survey data are indicated by the notation n_w.

Table I-3. Statistical Weights for Treatment Group Customer Survey Data

Wave Stratum	Population Count [1]	Proportion of Population	Survey Sample Achieved	Proportion of Total Survey Sample	Statistical Weight [2]
Phase I Legacy Waves	43,812	35.0%	115	21.6%	1.619
Phase II Expansion Wave	27,814	22.2%	111	20.9%	1.065
Phase III Expansion Wave	21,681	17.3%	100	18.8%	0.921
Phase II Low-Income Wave 1	26,676	21.3%	106	19.9%	1.069
Phase II Low-Income Wave 2	5,231	4.2%	100	18.8%	0.222
Total	**125,214**	**100.0%**	**532**	**100.0%**	**N/A**

(1) 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.
(2) The statistical weight is calculated by dividing the proportion of population by the proportion of total survey sample.

Contact Instructions

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

Cadmus coordinated with PPL Electric Utilities' contractor to screen the sample and remove the records of any customers called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey), had requested not to be contacted again, or had incomplete information.

For the telephone survey, Cadmus attempted to reach the contact by telephone up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

For the online survey, Cadmus sent out an initial email invitation followed by one reminder email.

Sample Attrition

Table I-4 list total number of records submitted and the outcome (final disposition) of each record for the online and telephone surveys.

Table I-4. Treatment Group Customer Survey Sample Attrition Table

Description of Call Outcomes	Number of Records
Population (Number of Unique Customers) [(1)]	**202,277**
Removed: inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list, missing or invalid email address, missing or invalid phone number	53,190
Online Survey	
Selected for survey sample frame (sent to subcontractor for online survey emails) [(2)]	29,490
Not attempted [(3)]	16,750
Records Attempted	12,740
Email was returned (bounce back or failed)	1,229
Did not respond	10,988
Opt out	2
PPL Electric Utilities or market research employee	12
Cannot confirm awareness of home energy reports	38
Did not complete survey after starting	193
Completed Surveys	**278**
Online Response rate	**2%**
Telephone Survey	
Selected for survey sample frame (sent to subcontractor for telephone survey calls) [(2)]	24,211
Not attempted [(3)]	18,619
Records Attempted	5,592
Non-working number	873
Wrong number, business	274
No answer/answering machine/phone busy	3,615
Language barrier	24
PPL Electric Utilities or market research employee	29
Cannot confirm equipment/not aware of participation	68
Refusal	106
Terminated survey	26
Non-specific or specific callback scheduled	323
Completed Surveys	**254**
Telephone Response Rate	**5%**
Total Completed Surveys (all modes)	**532**

[(1)] Number of records available in ICSP's database at the time of the final survey effort.
[(2)] Not selected for sample because of more records than were needed for the telephone survey.
[(3)] Selected for sample but target was reached before attempted.

Appendix J. Evaluation Detail – Energy Efficient Home Program

This appendix details the methodologies and results for the Energy Efficient Home Program evaluation activities.

J.1 Gross Impact Evaluation

J.1.1 *Ex Post* Verified Savings Methodology

Cadmus assessed savings for the sampled units, calculated stratum-level realization rates, then applied the realization rates to the population total *ex ante* savings within each stratum to estimate the stratum total *ex post* savings. Next, Cadmus summed the stratum total *ex post* savings to derive the program total *ex post* savings and calculated the program realization rate by dividing the program total *ex post* savings by the program total *ex ante* savings.

Cadmus calculated realization rates, standard errors, and precision for the total *ex post* savings estimates using formulas provided in the Uniform Methods Project's sampling chapter and the Phase III Evaluation Framework using sampling weights (w_i) proportional to the sampling probability of each unit.[164] In stratified sampling, the weights are equal to the stratum population size (N_h) divided by the stratum sample size (n_h), that is, $w_{hi} = N_h/n_h$, for stratum h and unit i. [165]

Cadmus calculated the relative precision of the program's total *ex post* savings and realization rate estimates at a minimum of 85% confidence. It designed the sample with a 15% precision target for the program's total energy savings to achieve PPL Electric Utilities' 85/15 program target for confidence and precision, as stipulated in the Phase III Evaluation Framework. The following sections discuss detailed methodology for each component of the Energy Efficient Home Program.

New Homes

Cadmus calculated the *ex post* evaluated gross savings by summing the *ex post* weather-sensitive and non-weather-sensitive savings. First, Cadmus calculated *ex post* energy savings and demand reductions for the non-weather-sensitive equipment (heat pump water heaters, refrigerators, dishwashers, and lighting) according to the individual appliance and lighting algorithms in the PA TRM. For these equipment types, Cadmus used data collected during site visits in PY8 and by the ICSP's subcontractor in PY9.

For weather-sensitive products, Cadmus examined the REM/Rate files and *ex ante* savings provided by the ICSP's subcontractor to determine if inputs to the simulations and savings were reasonable.

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[164] National Renewable Energy Laboratory. "Chapter 11: Sample Design Cross-Cutting Protocols." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Prepared by Cadmus. April 2013. http://energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf

[165] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Final version August 25, 2016.

Cadmus took a simple random sample from the 837 unique projects in the new homes component to evaluate 40 REM/Rate energy models. Of these 40 sites, 10 were units in a multifamily building; the ICSP's subcontractor modeled them as single-family homes and each unit met the same efficiency requirements. Cadmus also modeled these units as single-family homes (with adiabatic walls and other inputs as needed). Cadmus then determined *ex post* energy savings and demand reductions for envelope and HVAC equipment using output from the REM/Rate simulations that calculated heating and cooling energy savings.

Cadmus used REM/Rate version 15.4.1 and incorporated the built-in baseline reference home that RESNET specifically designed for PPL Electric Utilities' new home component. Cadmus also compared the input data (pertaining to mechanical equipment, lighting, and building envelope) for the ICSP's subcontractor's REM/Rate files against data collected during Cadmus' site visits for 20 homes in PY8.

Seven multifamily buildings with units in the evaluation sample also installed photovoltaic (PV) panels on the roofs. Because the ICSP's software calculated PV system savings, the ICSP reported these energy savings to PPL Electric Utilities. Although the PA TRM does not address PV systems installed on new homes, Cadmus describes its methodology below.

The next sections discuss Cadmus' approach to verifying energy savings and demand reduction.

Method to Verify Heating and Cooling Energy and Demand Savings

Cadmus launched each model in REM/Rate and used an Access database to export annual energy savings and demand reduction totals for heating and cooling for the built-in baseline reference home and the PPL Electric Utilities design (participant) home. By taking the difference between savings from each home, Cadmus calculated annual heating and cooling savings.

Method to Verify PV Energy and Demand Savings

In Pennsylvania, PV systems are not required to meet the IECC 2009 residential energy code or a national standard.[166] Cadmus proposed that the baseline for a PV system installed on a new home should be the same as for a new home with no PV system. The ICSP used the REM/Rate software to determine energy and demand savings. Cadmus used the PVWatts tool to verify the energy savings and found that verified savings from the PV system equaled the program's reported energy savings.[167]

$$\Delta kWh_{PV} = annual\ energy\ production\ from\ PV\ system$$

Demand reduction for PV systems is equal to the power production of the PV system's output, similar to the avoided demand of a typical energy-efficient product. PV system power production is not constant and the timing of the system output is dependent on the orientation and size of the PV system;

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[166] PA TRM Section 1.7 Baseline Estimates states that the typical baseline for new construction should be code or national standard.

[167] PVWatts, developed by the National Renewable Energy Laboratory (NREL), uses hourly solar data from the TMY3 dataset to determine energy production and normal time of day output.

therefore, a custom analysis approach was needed to determine demand savings. Cadmus calculated demand savings for verified PV systems using hourly estimated energy production from PVWatts and the PA TRM definition of peak period for coincident peak demand savings, as shown in Table J-1.

Table J-1. Period for Energy Savings and Coincident Peak Demand Savings

Period	Energy Savings	Coincident Peak Demand Savings
Summer	May through September	June through August (excluding weekends and holidays)
Winter	October through April	N/A
Peak	8:00 a.m. to 8:00 p.m. Mon.-Fri.	2:00 p.m. to 6:00 p.m.
Off-Peak	8:00 p.m. to 8:00 a.m. Mon.-Fri., 12 a.m. to 12 a.m. Sat/Sun & holidays	N/A

Source: PA TRM Section 1.10 Electric Resource Savings

Cadmus estimated hourly energy production of the PV system using PVWatts and the typical meteorological year 3 (TMY3) weather dataset, using the coincident peak demand savings period of hours ending 15:00 through hours ending 18:00, from June 1 through August 31 (inclusive). The PA TRM specifies that peak days are weekday/non-holidays. However, Cadmus included all days in peak demand calculations because power production of PV systems depends on weather, not user behavior. Demand savings for PV systems therefore equal the average power production of the PV system across the coincident peak period.

Cadmus developed the following equation for coincident peak demand savings for PV systems:

$$\Delta kW_{PV} = \frac{1}{n}\sum_{i=peak\ hour}^{n} kW\ production_{peak\ hour}$$

Where:

n	=	number of peak period hours in TMY3 dataset
$kW\ production_{peak\ hour}$	=	kW production at each peak hour

Method to Verify Lighting Energy and Demand Savings

To calculate lighting energy and demand savings, Cadmus used data from PY8 site visits during which lighting inventories were collected and the sample from PY9 participant REM/Rate files. Cadmus did not conduct site visits in PY9. In the PY8 lighting inventory data, Cadmus observed that verified energy savings correlated closely to the documented percentage of high-efficiency lamps in REM/Rate files, so Cadmus developed a regression of PY8 data to estimate energy and demand savings. This method corrects for the known variables in REM/Rate: home size and percentage of high-efficacy lamps. This calculation is described by the following energy and demand savings equation used by Cadmus:

$$Verified\ Lighting\ Savings\ kWh\ = \frac{kWh}{sq-ft} X(\ \%\ High\ Efficinecy\ Reported\ -\ \%\ High\ Efficient\ Baseline) * home\ square\ footage\ *\ ISR$$

$$Verified\ Lighting\ Savings\ kW\ = \frac{\frac{W}{sq-ft} X(\ \%\ High\ Efficinecy\ Reported\ -\ \%\ High\ Efficient\ Baseline) * home\ square\ footage\ *\ ISR}{1000}$$

Where:

kWh/sq-ft	=	0.445 (Regression coefficient for energy)
W/sq-ft	=	0.051 (Regression coefficient for demand)
% High Efficiency Reported	=	REM/Rate documented % of lamps that are high efficiency
% High Efficiency Baseline	=	50% (Pennsylvania Energy Code)
Home Square Footage	=	Home square footage
ISR	=	0.869 In-Service Rate from PY8 site verifications

Method to Verify Appliance Energy and Demand Savings

To determine energy and demand savings for clothes washers, Cadmus used the PA TRM: Measure 2.4.4 ENERGY STAR Clothes Washers protocol, which specifies savings algorithms for ENERGY STAR and non-ENERGY STAR models. The integrated modified energy factor (IMEF) performance metric determined the quantity of energy and demand savings. The baseline minimum IMEF depended on whether the clothes washer was top-loading or front-loading.

For dishwashers, Cadmus used the average verified energy and demand savings determined in PY8 and applied those per-unit savings to each record in PY9. In PY8, Cadmus calculated energy and demand savings using the PA TRM: Measure 2.4.7 ENERGY STAR Dishwashers protocol, which specified savings algorithms for ENERGY STAR models, and findings from site visits. Savings varied depending on the annual energy consumption of the ENERGY STAR-qualified unit and whether the unit's water heating fuel was electricity or natural gas.

For refrigerators, Cadmus used the average verified energy and demand savings determined in PY8 and applied those per-unit savings to each sampled record in PY9. In PY8, Cadmus used the PA TRM: Measure 2.4.1 ENERGY STAR Refrigerators protocol, which specified savings algorithms for ENERGY STAR and non-ENERGY STAR models. Cadmus also calculated energy savings and demand reduction by refrigerator and freezer size, which determined baseline energy consumption. Cadmus determined the energy use for the ENERGY STAR model by looking up the model number in the ENERGY STAR-qualified products list.

J.1.2 New Construction REM/Rate Modeling Findings

The ICSP reports energy savings and demand reduction for the new homes component directly from the REM/Rate software output that HERS raters use to verify that the home meets program requirements. The module calculates energy and demand savings for all components of the homes; however, the methods and equations used by REM/Rate differ from the PA TRM for most components.

Cadmus found that *ex post* and *ex ante* heating and cooling savings agreed exactly.

For lighting and appliances, Cadmus found that *ex post* savings were significantly below *ex ante* estimates. This was primarily because the built-in assumptions REM/Rate uses to estimate energy savings are different than the assumptions the PA TRM uses. REM/Rate uses an outdated methodology to calculate energy and demand savings for high-efficiency lighting, which overestimates energy savings by approximately 100%. REM/Rate also calculates savings for appliances even if the appliances were not installed when the home was rated by HERS raters. Additionally, REM/Rate does not contain all necessary data to accurately define the baseline appliances and verify appliance ENERGY STAR criteria. This is especially true for refrigerators where the size and configuration of the installed refrigerator are not included in the REM/Rate inputs, but the data are needed to verify energy savings.

For clothes washers, Cadmus found that there are additional savings REM/Rate is capturing based on the labeled energy rating (LER). For nine homes, the default LER for the design home was less than for the reference home, resulting in additional savings. However, it was impossible to verify whether a clothes washer was actually installed because the REM/Rate model includes a clothes washer and the HERS raters who generate the model do not document clothes washer LERs.

Additionally, for clothes dryers, Cadmus also found an error in the savings calculations due to an error from either the reference home or REM/Rate's MEF/IMEF (Modified Energy Factor/Integrated Modified Energy Factor). This impacted the savings calculations for 16 homes. Cadmus verified that this calculation creates artificially high savings for clothes dryers.

J.1.3 Audit and Kit and Efficient Equipment Database Review Findings

Cadmus conducted a database review of each program component to perform a high-level overview of data in the PPL Electric Utilities tracking database and savings algorithms to ensure that appropriate data were collected and to confirm that *ex ante* savings were properly calculated using the appropriate PA TRM algorithms. Cadmus discovered some discrepancies across components, including incorrect entry of inputs and erroneous application of factors that affected savings. No issues were found for pool pumps, air source heat pumps, and central air conditioners.

Findings are summarized in Table J-2.

Table J-2. PY9 Energy Efficient Home Database Review Findings Summary for Equipment and Kits

Product	Number of Instances	Type of *Ex Ante* Reporting Difference
In-Home Audit and Kit	All records	Evaluated ISRs for kit products lower than ISRs used by the ICSP in reported savings calculations
Online Assessment	All records	Evaluated ISRs for kit products lower than ISRs used by the ICSP in reported savings calculations
Insulation	66	Incorrect existing R-value, regardless of the previous recorded inches of insulation; missing existing cooling system installation date
Air Sealing	1	Incorrect deemed savings in PPL Electric Utilities' tracking database (entered as negative instead of positive)
Heat Pump Water Heater	48	Incorrect de-rate factor; interactive effects not calculated for some electric space heat homes
Dehumidifier	871	Incorrect efficiency of ENERGY STAR qualified unit (L/kWhee) entered into PPL Electric Utilities' tracking database (2016 ENERGY STAR standard instead of the 2016 TRM, which references the 2012 ENERGY STAR standards); incorrect product capacity entered into PPL Electric Utilities' tracking database
Ductless Heat Pump	0	None
Air Source Heat Pump	0	None
Central Air Conditioning	0	None
Fuel Switching	8	Fuel furnace equivalent full load hours (EFLH) applied in PPL Electric Utilities' tracking database instead of corresponding fuel boiler EFLH[1]; deemed savings in PPL Electric Utilities' tracking database did not match CLEAResult tracking data
Pool Pump	0	None
Refrigerator	1	Error recording reported kWh/yr savings in PPL Electric Utilities' tracking database
Smart Thermostat	5	Incorrect deemed savings in PPL Electric Utilities' tracking database
[1] PPL Electric Utilities informed Cadmus that a separate boiler EFLH is not built into the algorithm, because of the negligible impact on savings.		

J.1.4 Audit and Kit and Efficient Equipment Records Review Findings

The records review and the database review are separate activities and mutually exclusive. Of 33,334 total participants in the Energy Efficient Home program in PY9, Cadmus reviewed a sample of 120 records to evaluate the savings impacts of these program components—audit and kits, weatherization, and efficient equipment. The records reviews examined program documentation (rebate applications, invoices, and AHRI certificates) in detail. The records review accomplished the following:

- Verified that product types were correctly categorized based on the verified installed products
- Verified reported equipment data used for PA TRM energy savings calculations through supporting documentation
- Calculated *ex post* savings using the PA TRM algorithms and verified equipment data

A summary of the records review findings is in Table J-3.

Table J-3. PY9 Energy Efficient Home Program Records Review Findings Summary

Program Component	Realization Rate (kWh)	Number of Projects	Records Reviewed	Discrepancies	Type of Error or Discrepancy
In-Home Audit and Kit	74%	98	40	60	Water heater setback not performed, wrong kit for fuel type, evaluated ISRs for kit products lower than ISRs used by the ICSP in reported savings calculations
Insulation	85%	522	20	6	Incorrect existing R-value, regardless of the previous recorded inches of insulation; missing existing cooling system installation date; incorrect previous inches of insulation; incorrect added R-value
Air Sealing	101%	79	20	1	One record's deemed energy savings and demand reduction entered as negative instead of positive
Dehumidifier	79%	1,283	40	20	Incorrect efficiency of ENERGY STAR qualified unit (L/kWhee) entered into PPL Electric Utilities' tracking database (2016 ENERGY STAR standard values instead of values listed in 2016 TRM, 2012 ENERGY STAR standard values)
Ductless Heat Pump	100%	1,406	40	35	Incorrect entries for existing heating and cooling capacity, installation date, model number, SEER, and HSPF; missing entries on the rebate form for existing heating, existing cooling
Heat Pump Water Heater	103%	511	40	44	Incorrect de-rate factor; interactive effects not calculated for some electric space heat homes

J.1.5 Installation Verification Methodology

Efficient Equipment

In PY9 Cadmus conducted participant surveys to calculate ISRs for dehumidifiers in the equipment stratum because it was a new eligible equipment type. For dehumidifier participants, Cadmus confirmed that rebated products were installed by asking "Is the dehumidifier currently installed?" during the phone and online surveys. Of 72 respondents to the question, all but one said "Yes," the dehumidifier was installed.

Cadmus used ISRs calculated in PY8 for the remaining products in the efficient equipment strata because no program changes were made that affected these products.

Weatherization, Audit and Kits

In PY9, Cadmus used ISRs calculated in PY8 for the audit and kit and weatherization strata because no program changes were made that affected these products. In PY8, Cadmus calculated ISRs for the audit and kits stratum's energy-savings kit products from a participant survey fielded with 121 online assessment recipients (89% for LED light bulbs, 61% for kitchen faucet aerators, 53% for bathroom faucet aerators, 42% for low flow showerheads, 76% for nightlights, and 56% for pipe insulation).

J.2 Net Impact Evaluation

J.2.1 Net-to-Gross Ratio Methodology

New Homes

In PY9, Cadmus used the results of PY8 interviews with participant home builders to assess free ridership. A detailed explanation of the methodology for and results of these interviews can be found in the PY8 Annual Report, section J.2.2.[168]

Audit and Kits, Weatherization and Efficient Equipment

In PY9, Cadmus carried forward NTG ratios from PY8 for the audit and kits and weatherization components, and most products in the efficient equipment component.[169] Cadmus only calculated free ridership and spillover in PY9 for refrigerators and dehumidifiers.

Refrigerators and Dehumidifiers

In PY9, Cadmus conducted telephone surveys with participants purchasing a dehumidifier or refrigerator only to assess net savings for this equipment stratum because dehumidifiers were a new measure in PY9 and the incentive for refrigerators was changed in PY9. The SWE team reviewed and approved the surveys prior to fielding.

Self-Report Surveys

Cadmus calculated the free ridership scores using participant survey responses and the common methods for downstream rebate programs, including influence and intention questions.[170]

To estimate spillover, surveys included questions to determine whether participants installed specific additional high-efficiency products and, if so, whether participation in the Energy Efficient Home Program was important to their decision. Additional high-efficiency product purchases counted toward spillover only if the customer did not receive a rebate and the program had been important to the decision to purchase and install the products.

The assessment includes two components of free ridership—the intention to implement an energy-efficient project without a rebate and the 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 free ridership score ranging from zero to 100.

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[168] PPL Electric Utilities. *Annual Report Program Year 8: June 1, 2016–May 31, 2017.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2017. Available online: http://www.puc.pa.gov/pcdocs/1544671.pdf

[169] Ibid.

[170] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., EcoMetric Consulting, LLC, and Demand Side Analytics, LLC October 21, 2016.

Intention Score

Under the intention/influence method, Cadmus used the following key question to determine how participants' purchasing decisions would have differed in the absence of the program:

> "Which of the following would have happened if you had not received the $(REBATE) (MEASURE) rebate from PPL Electric Utilities?"

Cadmus used the responses to determine each participant's final intention score, then weighted these individual scores by their respective total survey sample *ex post* gross kWh/yr savings to arrive at savings-weighted average intention scores.

Influence Score

Influence is assessed by asking about how much influence—from 1 (no influence) to 5 (extremely influential)— various program elements had on the purchase decision making.

The survey asked the following influence question:

> **"**Please rate the following items on how much influence each item had on your decision to purchase the (MEASURE). Please use a scale from 1 to 5, 1 meaning no influence, and 5 meaning the item was extremely influential in your decision."

From responses to this question, Cadmus obtained data about the influence of PPL Electric Utilities rebates and information about energy efficiency from PPL Electric Utilities as well as the influence of any information about the type of equipment to install from the participant's installer or contractor. Cadmus assessed influence from participants' ratings about how important various program elements were in their decision to purchase energy-efficient products. Cadmus used the responses to determine each participant's final influence score, then weighted these individual influence scores by their respective total survey sample *ex post* gross kWh/yr savings to arrive at savings-weighted average influence scores.

Cadmus then summed the intention and influence components to estimate the total intention and influence method's free ridership average by stratum, weighted by *ex post* gross kWh/yr savings.

J.2.2 Net-to-Gross Ratio Findings

Free Ridership

Table J-4 summarizes the intention, influence, and free ridership scores for the refrigerator and dehumidifier measure categories of the efficient equipment stratum.

Table J-4. Energy Efficient Home Program Intention, Influence, and Free Ridership Score for Refrigerator and Dehumidifier Product Categories

Product Category	Number of Respondents	Intention Score	Influence Score	Free Ridership Score
Refrigerator	105	41%	22%	63%
Dehumidifier	72	36%	12%	48%

Spillover

Table J-5 lists the quantity of energy-efficient spillover equipment types that PY9 refrigerator and dehumidifier measure category respondents attributed to PPL Electric Utilities along with the per-unit energy savings and source of the estimated energy savings used in the spillover analyses.

Table J-5. Energy Efficient Home Program Spillover Products and Savings for Refrigerator and Dehumidifier Measure Categories

Spillover Product	Refrigerator Respondent Quantity	Dehumidifier Respondent Quantity	Per-Unit Savings kWh/yr	Savings Source
Air Conditioning Equipment	1(1)	3	247.7	PY9 PPL Gross Verified Savings
Air Source Heat Pump	0	1	729.4	PY9 PPL Gross Verified Savings
Clothes Washer	3(2)	3	48.7	PPL TRM Feb 2017
Dishwasher	3(3)	3	40.8	PPL TRM Feb 2017
Freezer	1(1)	1	22.0	PPL TRM Feb 2017
Insulation - Ceiling	400 square feet	0	0.61	PY9 PPL Gross Verified Savings
Refrigerator	0	2	59.3	PY9 PPL Gross Verified Savings
Windows	0	20	13.0	PPL TRM Feb 2017

(1) 50% of per-unit savings kWh/yr applied due to a maximum PPL influence rating of three, on a 1 to 5 scale, with 1 meaning "not at all influential" and 5 meaning "extremely influential".
(2) 50% of per-unit savings kWh/yr applied to one unit due to a maximum PPL influence rating of three.
(3) 50% of per-unit savings kWh/yr applied to two units due to a maximum PPL influence rating of three.

Table J-6 shows the spillover results for the PY9 refrigerator and dehumidifier measure categories of the efficient equipment stratum of the Energy Efficient Home Program.

Table J-6. Energy Efficient Home Program Spillover Calculations by Refrigerator and Dehumidifier Measure Categories

Variable	Variable Description	Refrigerators	Dehumidifiers	Source
A	Survey Sample Size (n)	105	72	Survey Data
B	Total Survey Sample Spillover kWh/yr Savings	703	2,142	Survey Data/Engineering Estimates
C	Average SO kWh/yr Savings Per Survey Respondent	6.7	29.7	Variable B ÷ Variable A
D	Program Participant Population	2,012 [1]	1,283 [2]	Program Tracking Data
E	SO kWh/yr Savings Extrapolated to the Participant Population	13,473	38,163	Variable C × Variable D
F	Evaluated Program Population kWh/yr Savings	122,012	235,702	Evaluated Gross Impact Analysis
G	Spillover Percentage Estimate	11%	16%	Variable E ÷ Variable F

[1] 2,012 unique job IDs for a total of 2015 refrigerators.
[2] 1,283 unique job IDs for a total of 1302 dehumidifiers.

J.3 Process Evaluation

J.3.1 Additional Findings

Logic Model Review

A program logic model identifies the relationships between activities and expected results. The Phase III PY9 Energy Efficient Home Program had a similar logic model to the Phase II program. Cadmus reviewed the program's logic model and determined the program operated as expected in PY9. Table J-7 shows the program logic model's expected and actual outcomes.

Table J-7. Energy Efficient Home Program Logic Model Review

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
Develop marketing and educational materials, conduct audits, install low-cost products during audits, mail energy efficiency kits, install major products, provide rebates to customers and builders	**Program Activities**	Delivered program activities as expected
Marketing activities; number of participants and builders; products installed; quality of installations; compensation paid	**Outputs Produced by Program Activities**	Delivered outputs as expected
Residential customers are more aware and knowledgeable of programs and energy efficiency; installation of energy-saving products in homes	**Short-term Outcomes**	Produced short-term outcomes as expected
Residential customers reduce energy use through products and/or behavior change	**Intermediate Outcomes (end of PY10)**	On track to produce intermediate outcomes as expected
Residential customers continue to save energy from upgrades and conservation behavior, as well as through changes in building practices	**Long-term Outcomes (end of phase III)**	To be determined at end of Phase III

Participant Profile

The PY9 customer surveys collected demographic information about Energy Efficient Home Program participants, summarized in Table J-8. Most showed these demographic characteristics:

- Lived in a single-family detached residence (79%; 987 of 1,244)
- Had an average household size of 2.3 people
- Averaged 59 years of age
- Had completed some college education or more (76%; 931 of 1,224)
- Had an annual household income of $50,000 or greater (65%; 627 of 965)

Table J-8. Energy Efficient Home Program Customer Survey Demographics

What type of residence do you live in? Is it…	Survey Participants (n=1,244)
A single-family detached residence	79%
Attached house (townhouse, row house, or twin)	11%
Mobile or manufactured home	4%
Multifamily apartment or condo building with 4 or more units	4%
Something else	1%
What is the highest level of education that you have completed?	**Survey Participants** (n=1,224)
Less than high school diploma or equivalent	1%
High school diploma or equivalent	23%
Technical or business school certificate/two-year college degree/some college	26%
Four-year college degree/bachelor's degree	29%
Graduate or professional degree/masters or PhD	20%
What year were you born?	**Survey Participants** (n=1,168)
Mean birth year (age)	1959 (59 years old)
Standard deviation	13.88
Including yourself, how many people lived in your home full-time during the past 12 months? Full-time is considered more than 9 months in the past year.	**Survey Participants** (n=1,356)
Mean household size	2.3 people
Standard deviation	1.19
In 2017, what was your annual household income before taxes? Please stop me when I read your category. Was it…	**Survey Participants** (n=965)
Under $10,000	2%
$10,000 to under $15,000	2%
$15,000 to under $20,000	4%
$20,000 to under $25,000	5%
$25,000 to under $30,000	4%
$30,000 to under $35,000	5%
$35,000 to under $40,000	4%
$40,000 to under $45,000	5%
$45,000 to under $50,000	4%
$50,000 to under $60,000	10%
$60,000 to under $75,000	12%
$75,000 to under $100,000	17%
$100,000 to under $150,000	18%
$150,000 to under $200,000	4%
$200,000 or more	4%

J.3.2 Survey Approach

Participant Survey Mode Analysis

Social desirability biases are often more present in telephone surveys than in online surveys because of the verbal conversation with an interviewer. For this reason, Cadmus tested the energy-efficient equipment component (all products) for any significant differences between online and phone survey equipment respondents on free ridership scores, overall satisfaction, demographic characteristics, as well as don't know responses and nonresponse. This analysis found no significant differences between survey modes, except for respondent age. Specifically, online respondents (mean age=59.7) were significantly older than phone respondents (mean age=51.4, $p<.10$). Cadmus had no reason to believe respondent age related to savings or satisfaction. Therefore, the results of the surveys contained in this report are unweighted.

The surveys assessed participant satisfaction; the number of completed surveys produced a measurement of program satisfaction with ± 3% precision at 90% confidence.

Contact Instructions

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

Cadmus coordinated with PPL Electric Utilities' contractor to screen the sample and remove the records of any customers called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey), had requested not to be contacted again, or had incomplete information.

Participants who completed the online survey were excluded from the telephone survey. This cleaning and survey sample preparation process reduced the available sample. For surveys using both survey modes, Cadmus sent initial email invitations to the remaining contacts with email addresses and followed up with two reminder email invitations. If the contact did not complete an online survey or was not invited to complete an online survey, Cadmus attempted to reach the contact by telephone up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

Sample Attrition

Table J-9 lists total numbers of records submitted to the survey subcontractor or contacted via online survey and the outcome (final disposition) of each record.

Table J-9. Energy Efficient Home Sample Attrition Table

Description of Call Outcomes	Number of Records			
	In-Home Audit	Online Assessment	Weatherization	Equipment
Population (number of unique jobs) [(1)]	**98**	**19,727**	**601**	**7,263**
Online				
Removed: inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list	1	1,898	158	1,332
Incomplete or invalid email address	9	25	73	1,877
Survey Sample Frame (email invitations sent)	**88**	**5,687**	**370**	**4,054**
Email was returned (bounce back)	3	77	14	191
Did not respond	75	4,580	304	3,422
Opt out	0	15	1	12
PPL Electric Utilities or market research employee	0	64	2	27
Cannot confirm equipment/not aware of participation	3	94	0	10
Did not complete survey	0	168	8	57
Completed Surveys	**7**	**689**	**41**	**335**
Online Response Rate	**8%**	**12%**	**11%**	**8%**
Telephone [(2)]				
Removed: inactive customer, completed survey in past 3 months, on "do not call" list, opted out of survey, selected for a different survey, duplicate contact, recycled A/C only, large C&I sector	N/A	N/A	N/A	584
Incomplete or bad phone number	N/A	N/A	N/A	126
Survey Sample Frame [(3)]	**N/A**	**N/A**	**N/A**	**721**
Final Sample (sent to subcontractor for telephone survey calls)	**N/A**	**N/A**	**N/A**	**721**
Not attempted [(4)]	**N/A**	**N/A**	**N/A**	**0**
Records Attempted	**N/A**	**N/A**	**N/A**	**721**
Non-working number	N/A	N/A	N/A	65
Wrong number, business	N/A	N/A	N/A	12
No answer/answering machine/phone busy	N/A	N/A	N/A	444
Language barrier	N/A	N/A	N/A	2
PPL Electric Utilities or market research employee	N/A	N/A	N/A	10
Cannot confirm equipment/not aware of participation	N/A	N/A	N/A	0
Refusal	N/A	N/A	N/A	12
Terminated survey or partially completed survey	N/A	N/A	N/A	20
Non-specific or specific callback scheduled	N/A	N/A	N/A	31
Completed Surveys	**N/A**	**N/A**	**N/A**	**125 [(5)]**
Telephone Response Rate	**N/A**	**N/A**	**N/A**	**17%**
Total Completed Surveys (total for all modes)	**7**	**689**	**41**	**460**

[(1)] Number of rebates available in PPL Electric Utilities' tracking database at the time of the final survey effort.
[(2)] All equipment products were included in the telephone survey.
[(3)] Not selected for sample because there were more records in PPL Electric Utilities' tracking database than were needed for telephone survey.
[(4)] Selected for sample but target was reached before attempted.
[(5)] 14 responses were from dehumidifier participants and 34 responses were from refrigerator participants.

Appendix K. Evaluation Detail – Winter Relief Assistance Program

K.1 Gross Impact Evaluation

K.1.1 Methodology

Evaluation Sampling Approach

The verification sample for the Winter Relief Assistance Program was designed to meet requirements of 85% confidence and 15% precision. Cadmus organized the population into five strata—one for each job type (baseload, low-cost, and full-cost), one specifically for master-metered multifamily units, and one for targeted manufactured home parks—to allow for a detailed examination of savings in each stratum. Cadmus sampled the population by project number instead of by an account number because master-metered multifamily jobs are tied to a single account number. Table K-1 shows the sampling strategy for all of PY9.

Table K-1. PY9 Winter Relief Assistance Program Sampling Strategy

Stratum	Number of Jobs	Target Levels of Confidence & Precision [1]	Assumed Cv [2]	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Baseload	6,680	85/15	0.8	59	88	Records Review
Low-Cost	4,428		0.6	34	51	
Full-Cost	139		0.5	21	17 [3]	
Manufactured Home Initiative (all job types)	963		0.5	24	36	
Master-Metered Multifamily (all job types)	1,818 [4]		0.5	24	43	
Program Total [5]	**14,028**			**162**	**235**	

[1] By setting the target confidence and precision to 85/15 for records review, sample sizes were sufficient to estimate energy savings for the program with confidence and precision of 85/15.
[2] The assumed Cv is based on the PY8 evaluation, with a minimum Cv of 0.5.
[3] Cadmus selected a random sample of 21 full-cost jobs to achieve assumed Cv of 0.5. Four full-cost jobs were removed from the sample in secondary review as they did not meet the selection criteria. Cadmus removed these jobs from the sample and did not replace them with other jobs since the actual Cv of 0.3 was achieved based on a sample size of 17.
[4] 32 master-metered multifamily buildings that participated in WRAP in PY9 have 1,818 tenant units. Cadmus performed home audit records review and engineering analysis for individual tenant units in master-metered multifamily buildings. Therefore 1,818 jobs were added to the total number of jobs in the sample.
[5] May not match due to rounding.

Most of the full-cost jobs with a single full-cost improvement received attic insulation only instead of insulation at the whole house. Only one full-cost job received wall insulation. In addition, 17 full-cost jobs received HVAC maintenance/repair, seven received smart thermostats and three received programmable thermostats.

Although most of the full-cost jobs had a single full-cost job improvement, as shown in Table K-2, Cadmus divided the full-cost stratum into three substrata—full-cost jobs with zero or one full-cost product,[171] full-cost jobs with two full-cost improvements, and full-cost jobs with three full-cost improvements—to better represent the homes with more full-cost improvements, which result in more interactive effects. Sample sizes were selected to meet requirements of 85% confidence and 15% precision in full-cost stratum level. Cadmus selected a random sample of 21 full-cost jobs to achieve an assumed Cv of 0.5. Four full-cost jobs were removed from the sample in secondary review as they did not meet the selection criteria. Cadmus removed these jobs from the sample and did not replace them with other jobs since the actual Cv of 0.3 was achieved using the sample of 17 full-cost jobs.

Table K-2. PY9 Winter Relief Assistance Program Sampling Strategy for Full-cost Jobs

Stratum	Number of Projects	Target Levels of Confidence & Precision (1)	Actual Cv	Sample Size with 0.3 Cv	Achieved Sample Size	Impact Evaluation Activity
Full-Cost with One Full-Cost Improvement	120	85/15	0.3	9	10	Records Review
Full-Cost with Two Full-Cost Improvements	18		0.3	6	6	
Full-Cost with Three Full-Cost Improvements	1		0.3	1	1	
PY9 Q1-Q2 Total	**139**	**21**		**16**	**17**	
(1) By setting the target confidence and precision to 85/15 for records review, sample sizes were sufficient to estimate energy savings for the stratum with confidence and precision of 85/15.						

The ICSP inspected about 5% of all jobs associated with program participation to ensure project quality and to verify that products were installed as documented. Cadmus did not use the ICSP's verification data to adjust the ISR for *ex post* verified savings because the data uploaded into the PPL Electric Utilities' tracking database contained the final savings after the ICSP took any remedial actions.

Ex Post Verified Savings Methodology

Cadmus calculated *ex post* verified savings through an engineering analysis, a review of audit records, and two participant surveys. For each stratum, 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 its respective stratum population.

Verification Activities

Cadmus conducted independent verification of WRAP energy savings' impact by job type based on the summary of methods described in Table K-3.

171 Some full-cost jobs received baseload and low-cost products. The only full-cost product they received was HVAC maintenance and repair.

Table K-3. Impact Evaluation Methods for WRAP

Job Type	Impact Evaluation Methods Conducted
Baseload Jobs	Conducted a records review for a sample of homes. Conducted engineering analysis by improvements using the PA TRM. Estimated savings for energy education. Estimated ISR for six high impact improvements (LEDs, bathroom aerators, kitchen aerators, showerheads, LED nightlights, and Tier 2 advanced power strips) via survey.
Low-Cost Jobs	
Full-Cost Jobs	
Master-Metered Multifamily (all job types)	
Manufactured Home Park Initiative	Conducted a records review for a sample of homes, collected survey data. Cadmus updated the methodology for limited air sealing and followed the weather stripping IMP, finalized by the SWE on February 28, 2018.

In the following sections, Cadmus gives an overview of the products and services offered in each of WRAP's five strata and the entries in the PA TRM used to determine verified savings.

Baseload Job Type

Baseload jobs require no additional qualifications beyond the general WRAP requirements. However, baseload customers generally have non-electric heating and a non-electric water heater.[172] Table K-4 shows the energy-saving items in the baseload stratum and the PA TRM entries Cadmus used to determine verified energy savings. Customers are eligible for all items offered by the job type, but most customers do not receive all of these items.[173]

Table K-4. PY9 Baseload Items for Winter Relief Assistance Program

Items Offered	PA TRM References
LED Nightlight	LED Nightlight - Section 2.1.4
ENERGY STAR LED Lighting	ENERGY STAR Lighting - Section 2.1.1
Tier 2 Advanced Power Strips	Smart Strip Plug Outlets - Section 2.5.3
Energy Education	Programmable Thermostats – Section 2.2.8 Water Heater Temperature Setback – Section 2.3.6 Low Flow Showerheads – Section 2.3.9 WRAP Participant Survey
Refrigerator Recycle with Replace	Final IMP - EDC Direct Install Refrigerator / Freezer Recycling with Replacement
Refrigerator Recycle without Replace	
Freezer Recycle with Replace	
Freezer Recycle without Replace	
Furnace Whistle (1)	Furnace Whistle – Section 2.2.7
(1) Cooling only; a furnace whistle with electric heating is a full-cost item.	

172 If a customer had an electric water heater but refused water heater measures, the customer was categorized as a baseload customer. This rarely happened.

173 Customers do not receive all items for a variety of reasons. For example, customers refused some items or were not eligible (the customer already had the item in place, their freezer did not need to be recycled, etc.).

Low-Cost Job Type

Homes with electrically heated water qualify for low-cost jobs. Low-cost jobs are eligible for the items in Table K-5 and all items offered to baseload job types.

Table K-5. PY9 Low-Cost Items for Winter Relief Assistance Program

Items Offered	PA TRM References
Low-Flow Faucet Aerator	Low-Flow Faucet Aerators – Section 2.3.8
Low-Flow Showerhead	Low-Flow Showerheads – Section 2.3.9
Water Heater Temperature Setback	Water Heater Temperature Setback – Section 2.3.6
Water Heater Pipe Insulation	Water Heater Pipe Insulation – Section 2.3.7
Water Heater Tank Wrap	Water Heater Tank Wrap – Section 2.3.5
Thermostatic Restriction Valve	Thermostatic Shower Restriction Valve – Section 2.3.10
Heat Pump Water Heater	Heat Pump Water Heater – Section 2.3.1

Full-Cost Job Type

Homes with electric space heat qualify for full-cost jobs, which include all baseload and low-cost items. Table K-6 shows the full-cost eligible jobs.

Table K-6. PY9 Full-Cost Items for Winter Relief Assistance Program

Items Offered	PA TRM References
Air Sealing	Residential Air Sealing – Section 2.6.6
Attic/Wall Insulation	Ceiling / Attic and Wall Insulation – Section 2.6.1
Residential Advanced Smart Thermostat	Residential Thermostat IMP, finalized February 26, 2018
Residential Programmable Thermostat	

Master-Metered Multifamily Buildings

In Phase III, PPL Electric Utilities provided WRAP at no cost in the single-tenant units of master-metered multifamily buildings (in a nonresidential rate class) with income-qualified low-income occupants, subject to landlord approval. These units qualified for baseload, low-cost improvements and, occasionally, full-cost improvements. There were only 64 full-cost jobs out of 1,818 master-metered multifamily jobs, and these received only HVAC maintenance and repair, a service that is not eligible for savings. (See products and services listed in Table K-5 and Table K-6.) Energy efficiency improvements for common areas (e.g., vestibule, basement, hallways, exterior) are not eligible under WRAP.

Manufactured Home Initiative

Manufactured homes with electrically heated water qualified for low-cost jobs. If the home did not have electrically heated water, it qualified for a baseload job. In addition, some manufactured homes were eligible for the minor air sealing improvements—door caddies, door corner pads, closed cell foam weatherstripping, and window kits—based on the auditor's recommendations.[174] The exact combination of products delivered along with minor air sealing depended on the conditions of the individual home. Cadmus evaluated these savings using the weather stripping IMP.[175]

Ex Post Savings Calculation Methodology for Energy Education

Cadmus estimated energy education savings in PY9 similar to PY8; however, in PY9, Cadmus collected more survey data instead of using some of the results from the Energy Efficiency Kits and Education Program as a proxy.

Cadmus selected three behavioral recommendations—adjusting thermostats, washing clothes in cold water, and taking shorter or fewer showers—that reasonably corresponded to energy-saving activities in the PA TRM.[176] Cadmus estimated savings for each half of the year. The next sections discuss the methodology for calculating these behavioral savings and present the results for each half of PY9.

Adjusting Thermostats

Cadmus assumed that participants who adjusted their thermostats saved energy similar to savings from a programmable thermostat and applied the PA TRM's algorithms for programmable thermostat.[177] Table K-7 shows the inputs used to calculate these savings (along with different weightings).

$$\Delta kWh/yr = \left((\Delta kWh_{cool} \times \%CAC \times \%Adjusted\ Cooling) + (\Delta kWh_{heat} \times \%ElectricHeat \times \%Adjusted\ Heating)\right)$$

$$\Delta kWh_{cool} = \frac{CAPY_{cool}}{1000\frac{W}{kW}} \times \frac{1}{SEER \times Eff_{duct}} \times EFLH_{cool} \times ESF_{cool}$$

$$\Delta kWh_{heat} = \frac{CAPY_{heat}}{1000\frac{W}{kW}} \times \frac{1}{HSPF \times Eff_{duct}} \times EFLH_{heat} \times ESF_{heat}$$

$$\Delta kW_{peak} = 0$$

Cadmus calculated energy education savings using the results from two surveys, fielded at the midpoint of the year (Q1-Q2) and at the end of the year (Q3-Q4). The results indicated a greater percentage of respondents who adjusted their thermostats in the second half of the year. This aligns with the ICSP's increased efforts in educating participants.

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174 Usually these homes had electric heat. All homes had either cooling, electric heat, or both.

175 Pennsylvania Public Utility Commission. *Weather Stripping, Caulking and Outlet Gaskets IMP*. June 1, 2017.

176 For washing clothes in cold water, Cadmus used the PA TRM to estimate the energy consumption of a washing machine and used survey data to adjust the usage.

177 Section 2.2.8 in the PA TRM.

Table K-7. PY9 Inputs for Adjusting Thermostats

Variable	Value	Units	Reference/Notes
$CAPY_{cool}$	24,642	Btuh	Weighted average capacities adjusted by home type and square feet; from RECS 2015 microdata (1) and 2012 PA Residential End-Use study; (2) see Table K-8 below
$SEER$	11.9	Btu/(Wh)	PA TRM default
Eff_{duct}	0.8	%	PA TRM default
$EFLH_{cool}$	490	Hours/yr	Weighted based on WRAP PY9 participant data
ESF_{cool}	0.02	%	PA TRM default
$CAPY_{heat}$	24,642	Btuh	Weighted average capacities adjusted by home type and square feet; from RECS 2015 microdata (1) and 2012 PA Residential End-Use study; (2) see Table K-8 below
$HSPF$	3.412	Btu/(Wh)	PA TRM default
$EFLH_{heat}$	1,186	Hours/yr	Weighted based on WRAP PY9 participant data
$\mathrm{ESF_{heat}}$	0.036	%	PA TRM default
$\%\mathrm{CAC}$	22%	%	PY8 site visit data (3)
$\%\mathrm{ElectricHeat}$ – Q1-Q2	17%	%	PY9 survey data
$\%Adjusted\ Heating$ – Q1-Q2	17%	%	
$\%Adjusted\ Cooling$ – Q1-Q2	7%	%	
$\%\mathrm{ElectricHeat}$ – Q3-Q4	44%	%	
$\%Adjusted\ Heating$ – Q3-Q4	40%	%	
$\%Adjusted\ Cooling$ – Q1-Q2	26%	%	

(1) US Energy Information Administration. *2015 RECS Survey Data.* Available online: https://www.eia.gov/consumption/residential/data/2015/index.php?view=microdata.
(2) Dataset from the 2012 Pennsylvania Residential End-Use and Saturation Study submitted to Pennsylvania PUC by GDS Associates, Nexant, and Mondre. Provided to Cadmus by the SWE.
(3) The ICSP does not consistently report cooling saturations so Cadmus used site visit results from PY8.

Cadmus did not use the default cooling and heating capacities, which are noted as 32,000 Btuh in the PA TRM. Cadmus adjusted the defaults based on RECS 2015 microdata and data from the 2012 Pennsylvania Residential End-Use and Saturation Study (both referenced in Table K-7) and used the latter to determine the default.

The reason for this adjustment is that the PA TRM's default capacities most likely overestimate the capacities of income-qualified homes; these homes tend to be smaller and use HVAC equipment that is smaller. Cadmus used the 2012 Residential End-Use study to find the statewide, average Btuh to home square-footage ratio (32,000 Btuh/1,805 sq. ft. = 17.73 Btuh/sq. ft.) then applied that ratio to the average square footage of income-qualified homes from RECS 2015 microdata and weighted it by WRAP home type data to come up with an average capacity for the PY9 WRAP population. Table K-8 shows these sources and this calculation and result.

Table K-8. PY9 Calculation of WRAP Specific Electric HVAC Capacities

Home Type	Square Feet	Average Btuh	Calculated Btuh/Sq. Ft. Ratio	PY9 Weight [1]
Statewide Average [2]	1,805	32,000	17.73 [5]	-
WRAP – Manufactured Home [3]	1,234	21,877		31%
WRAP – Multifamily [4]	1,058	18,763		25%
WRAP – Single-Family [4]	2,004	35,531		44%
WRAP Weighted Average Btuh = 24,642				

[1] The PY9 weight comes from the PPL Electric Utilities' tracking database.
[2] The Btuh comes from the Pennsylvania Public Utility Commission. *Residential Thermostats IMP.* February 26, 2018. This document states that the default capacity is the statewide average. The statewide average square feet comes from GDS Associates, Inc., Nexant, Inc., and Mondre Energy. *Pennsylvania Statewide Residential End-Use and Saturation Study.* 2012. See Figure 4-1: Average Home Square Footage (Conditioned Space) by Statewide Weights. Available online: https://www.puc.pa.gov/electric/pdf/Act129/PA_Residential_Baseline_Report2012.pdf.
[3] The ICSP collected the square footage of the manufactured homes, so Cadmus used the average from PY8 and PY9 for this home type.
[4] US Energy Information Administration. *2015 RECS Survey Data.* Available online: https://www.eia.gov/consumption/residential/data/2015/index.php?view=microdata.
[5] Cadmus is assuming the ratio of 17.73 Btuh/sq. ft. applies to all home types.

Washing Clothes in Cold Water

Cadmus estimated the energy savings from participants washing clothes in cold water in two steps:

- Estimated the energy usage of a clothes washer (using algorithms from the PA TRM)[178]
- Weighted the results based on WRAP PY9 survey results

Cadmus shows the equation used below and the inputs in Table K-9.

$$\Delta kWh/yr = \frac{V_{HW} \times \left(8.3\frac{lb}{gal}\right) \times \left(365\frac{days}{yr}\right) \times \left(1\frac{Btu}{°F \cdot lb}\right) \times (T_{hot} - T_{cold})}{\left(3412\frac{Btu}{kWh}\right) \times EF_{WH}} \times \%ElectricDHW \times \%ColdWashIncrease \times \%HomesWithClothesWasher$$

$$\Delta kW_{peak} = ETDF \times \Delta kWh/yr$$

178 Section 2.3.6 of the PA TRM concerns the water heater temperature setback. One component in the algorithm estimates savings from the clothes washer. Cadmus used these savings to estimate consumption of a clothes washer.

Table K-9. PY9 Inputs for Washing Clothes in Cold Water

Variable	Value	Units	Reference/Notes
V_{HW}	7.32	Gallons/day	PA TRM default
T_{hot}– Q1-Q2	129.33	°F	PA TRM default weighted by the percentage of WRAP participants that received a temperature setback in Q1 and Q2
T_{hot}– Q3-Q4	129.51	°F	PA TRM default weighted by the percentage of WRAP participants that received a temperature setback in Q3 and Q4
T_{cold}	55	°F	PA TRM default for the input temperature of the water (see PA TRM section 2.3.10)
EF_{WH}	0.912	-	Weighted by number of heat pump water heaters installed in WRAP and number of storage water heaters
$ETDF$	0.00008047	-	PA TRM default
$\%ElectricDHW$– Q1-Q2	66%	%	PY9 Survey Data
$\%ColdWashIncrease$– Q1-Q2	3.65%	%	
$\%HomesWithClothesWasher$ – Q1-Q2	90%	%	
$\%ElectricDHW$– Q3-Q4	50%	%	
$\%ColdWashIncrease$– Q3-Q4	0.02%	%	
$\%HomesWithClothesWasher$ – Q3-Q4	75%	%	

Taking Shorter Showers

Cadmus assumed that participants who said they take shorter or fewer showers take a five-minute shower every time. Cadmus estimated shower energy use using section 2.3.9 in the PA TRM, which concerns low-flow showerheads but was a good proxy after adjusting the flow rate to be constant (the weighted flow rate for WRAP participants), then added a term to subtract the energy education recommendation for shower length from the default.[179] Table K-10 shows the inputs used to calculate these savings.

$$\Delta\, kWh/yr = ELEC \times \left[\frac{GPM \times \left(T_{person/day} - T_{person/day,EE}\right) \times N_{persons} \times N_{showers/day} \times 365\frac{days}{yr} \times (T_{out} - T_{in}) \times 8.3\frac{Btu}{gal\cdot°F}}{\#_{showers} \times 3412\frac{Btu}{kWh} \times RE}\right]$$

$$\Delta kW_{peak} = \Delta\, kWh/yr \times ETDF$$

Where:

$$\mathrm{ETDF} = \frac{\mathrm{CF}}{HOU}$$

179 The PA TRM groups like terms and takes the difference of the variables that are changed. In this instance, Cadmus set the flow rate to be constant and changed the time of the showers.

$$CF = \frac{\%_{shower\ use,peak} \times \mathrm{T_{person/day,EE}} \times \mathrm{N_{persons}} \times N_{\frac{\mathrm{showers}}{\mathrm{day}}}}{\#_{\mathrm{showers}} \times 240\frac{minutes}{daily\ peak}}$$

$$HOU = \frac{\mathrm{T_{person/day,EE}} \times \mathrm{N_{persons}} \times N_{\mathrm{showers/day}} \times 365\frac{days}{yr}}{\#_{\mathrm{showers}} \times 60\frac{minutes}{hour}}$$

Table K-10. PY9 Inputs for Taking Shorter Showers

Variable	Value	Reference/Notes
$ELEC$	59%	Actual electric water heater saturation from WRAP data
GPM	2.0	Weighted GPM based on PA TRM defaults and PY9 WRAP tracking data
$T_{person/day}$	7.8	PA TRM default (minutes)
$\mathrm{T_{person/day,EE}}$	5.0	Energy education suggestion (minutes)
$N_{persons}$	2.2	PA TRM defaults weighted by distribution of home types
$N_{showers/day}$	0.6	PA TRM default
T_{hot}	101	PA TRM default (degrees Fahrenheit)
T_{cold}	55	PA TRM default (degrees Fahrenheit)
$\#_{showers}$	1.2	PA TRM default weighted by distribution of home types
RE	0.98	PA TRM default
$\%_{shower\ use,peak}$	11.7%	PA TRM default
CF	0.0026	Calculated based on energy education recommendation
HOU	33	Calculated based on energy education recommendation
$ETDF$	8.0137E-05	Calculated

Ex Post *In-Service Rates Calculation Methodology*

Cadmus fielded two surveys in PY9 to calculate ISRs for six products: LEDs, LED nightlights, kitchen aerators, bathroom aerators, showerheads, and Tier 2 advanced power strips. Cadmus also used the PY8 site visit data along with the PY9 survey data as needed.

Ex Post Demand Reduction

For all projects, Cadmus followed the PA TRM to estimate demand savings. To calculate the kW/yr reduction at the generator, Cadmus applied the residential line loss factor of 0.0833.

K.1.2 Database Review Findings

For both the impact and process evaluations, Cadmus reviewed extracts from the PPL Electric Utilities' tracking database and the ICSP's Energy Reduction Management System (ERMS) database for a census of PY9 project records. The quality control review assessed the completeness of fields necessary to conduct the participant telephone surveys and to verify that items recorded in the PPL Electric Utilities' tracking database for each job sampled matched the items installed from the ICSP's ERMS database. Cadmus found no major issues with either database.

K.1.3 Participant Counts

Cadmus used the unique utility account number as the participant. During the review of extracts from the PPL Electric Utilities' tracking database, Cadmus found cases where the same utility account number was associated with multiple job types. In some cases, this was because a baseload or low-cost job turned into a full cost job when contractors added measures. In other cases, there were multiple delivery channels and job numbers associated with the same utility account number. Therefore, Cadmus developed a system for ranking based on delivery channel and job type in order to avoid double counting. Cadmus then assigned each distinct account number with a job type based on the lowest "rank" associated with it as follows:

```
WHEN [DELIVERYCHANNELJOB] = 'Manufactured Home Initiative' THEN 1
WHEN [DELIVERYCHANNELJOB] = 'Master Metered Multifamily' THEN 2
WHEN [JOBTYPE] = 'FULLCOST' THEN 3
WHEN [JOBTYPE] IN ('LOWCOST', 'LOW COST') THEN 4
ELSE 5.
```

In other words, if an account number had any record associated with it where the delivery channel was "Manufactured Home Initiative," that is how Cadmus assigned the job type, regardless of other jobs associated with the same account, and so on.

Cadmus calculated the WRAP participant counts based on distinct utility account numbers as shown in Table K-11.

Table K-11. PY9 WRAP Participant Counts by Job Type

Job Type	Number of Participants		Difference	Notes
	PPL Electric Utilities' Tracking Database	Cadmus' Count of Distinct Account Numbers		
Baseload	6,692	6,680	12	In PPL Electric Utilities' tracking database extract, 11 account numbers were categorized as both Manufactured Home Initiative and WRAP baseload. Cadmus assigned these to the correct job type category of Manufactured Home Initiative as they all received measures provided only to that job type. 1 account number was categorized as both WRAP baseload and WRAP full-cost. Cadmus assigned this to the full-cost job category as it received measures provided only to WRAP full-cost job type.
Low-cost	4,439	4,428	11	In PPL Electric Utilities' tracking database extract, 11 account numbers were categorized as both Manufactured Home Initiative and WRAP low-cost. Cadmus assigned all to the Manufactured Home Initiative as all received measures provided only to Manufactured Home Initiative job type.
Full-cost	139	139	0	--
Manufactured Home Initiative	963	963	0	--
Master Metered Multifamily	32	32	0	--
Total	**12,265**	**12,242**	**23**	

K.1.4 Records Review Findings

This section presents the key findings from Cadmus' review of records. Taken together, these are the reasons for the differences between reported and verified savings.

PY9 Quarter 1 and Quarter 2

Cadmus sampled Q1 and Q2 together. These are the major findings from the records review in the first half of PY9:

- **LED nightlights continued to be installed in homes and apartments in which there was no baseline nightlight.**
  - Baseload: 39 of 46 jobs in sample had no baseline nightlight.
  - Low-cost: 24 of 26 jobs in sample had no baseline nightlight.
  - Master-metered multifamily: 21 of 21 jobs in sample had no baseline nightlight.
- **Showerheads and aerators were installed where there were efficient showerheads and aerators**. Nevertheless, Cadmus found that this issue was less frequent in PY9 Q1–Q2 than in PY8:
  - Master-metered multifamily: five of the 13 units that had showerheads or aerators had baseline showerheads or aerators with the same GPM.

- **Four and five power strips were distributed to participants; one or two is a more reasonable limit.**
  - 2 homes in the baseload sample received five Tier 2 advanced power strips.
  - 1 home in the low-cost sample received four Tier 2 advanced power strips.
- Large numbers of other products were sometimes distributed.
  - 1 home in the low-cost sample received 13 LED night lights. A somewhat common problem in PY8, this has decreased in PY9 Q1–Q2.
  - 22 homes in the PPL Electric Utilities tracking data received greater than 12 feet of pipe insulation. One reportedly received 144 feet of pipe insulation. In general, pipe insulation should probably be limited to about nine feet.[180]

PY9 Quarter 3 and Quarter 4

Cadmus sampled Q3 and Q4 separately. These are the major findings from the records review in the second half of PY9:

- **Refrigerator replacement/recycling had a product level realization rate of 75%.**
  - In the PPL Electric Utilities tracking database, the new refrigerator unit energy consumption (UEC) is always deemed to be 272 kWh/yr.[181] However, using the actual specifications of the installed ENERGY STAR refrigerator, Cadmus found the new refrigerator UEC was in the range of 309 kWh/yr to 356 kWh/yr (depending on the model).
  - Likewise, the UEC of the existing refrigerator was 1,271 kWh/yr in PPL Electric Utilities' tracking database. Cadmus calculated an average existing UEC using the TRM,[182] along with the input from the tracking database (percentage of replaced refrigerators manufactured before 1990). Cadmus calculated an existing UEC of 1,111 kWh/yr.
- **Other improvements**
  - Like the refrigerator replacement/recycling product, the reported existing UEC for freezer replacement/recycling was too high, causing a measure-level realization rate of 84%.
  - The reported savings of 129 kWh/yr for limited air sealing are based on the average results from a previous PPL Electric Utilities Manufactured Homes pilot. Cadmus used the weather-stripping IMP,[183] which became effective on February 28, 2018, and the number of limited

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180 The PA TRM does not impose a limit on the number of feet of pipe insulation; however, other TRMs, such as the Illinois TRM, do. Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 3: Residential Measures.* Section 5.4.1. February 11, 2016. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final.pdf.

181 Pennsylvania Public Utility Commission. *Refrigerator Replacement IMP Phase III*. September 07, 2016. ENERGY STAR default for refrigerator type 3A in Table 5.

182 Ibid. Table 2.

183 Pennsylvania Public Utility Commission. *Weather Stripping, Caulking and Outlet Gaskets*. February 28, 2018.

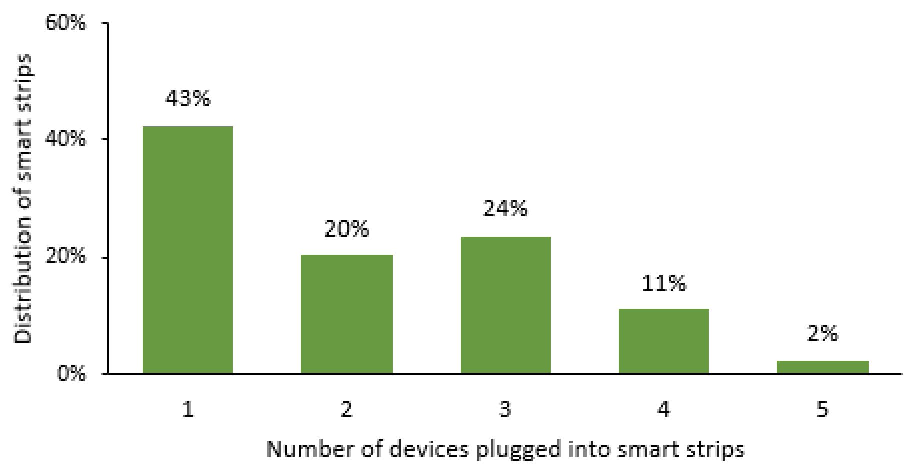
air sealing products delivered in PY9 and calculated the weighted average savings for limited air sealing products as 40.6 kWh/yr.

- Savings for furnace whistles reported in the PPL Electric Utilities tracking database tended to overestimate savings from the actual installed furnace whistles, which depend on the heating type, cooling type, and home location.
- Two showerheads in the sample were installed in a manufactured home with a gas water heater. Therefore, this product's measure-level realization rate was calculated as 85% in PY9 Q4. Cadmus' records reviews in PY8 and PY9 showed that this issue was not common. At the aggregate level, this effect was minimal.

Tier 2 Advanced Power Strips

- In PY9 Q4, Cadmus found that Tier 2 advanced power strips were commonly installed with only one or two devices plugged into them. In PY9 (across all strata), 43% of Tier 2 advanced power strips were installed with only one device plugged in, and 20% were installed with two devices plugged into them. Figure K-1 shows the number of devices installed into Tier 2 advanced power strips from Cadmus' sample in PY9.

Figure K-1. Number of Devices Plugged into Tier 2 Advanced Power Strips in PY9

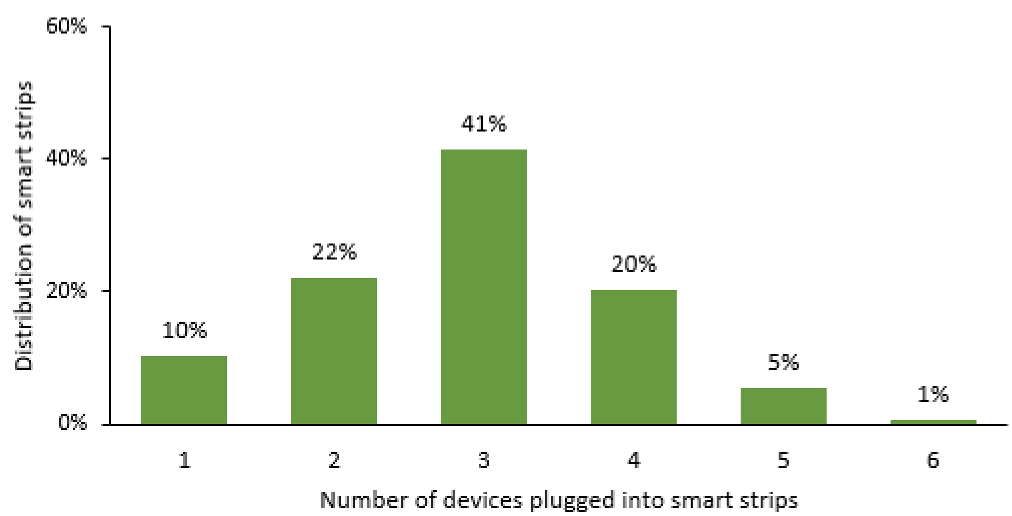


The Phase III 2016 PA TRM assumes five devices are installed in an entertainment center Tier 2 advanced power strip and three devices are installed in an unspecified-use Tier 2 advanced power strip.[184] The current PA TRM language does not limit energy savings for Tier 2 advanced power strips based on the number of devices plugged in.[185] Nevertheless, Cadmus strongly recommends plugging a higher number of devices into Tier 2 advanced power strips to realize their full savings potential. Cadmus applied the following logic to *ex post* savings in PY9:

- Eligible savings are about 200 kWh/yr for a power strip installed in unspecified-use areas regardless of the number of devices plugged into them.
- Eligible savings are about 300 kWh/yr for a power strip is installed in an entertainment center with at least three devices plugged in. If fewer devices are plugged in, eligible savings are about 200 kWh/yr.

Cadmus observed this issue in PY8 as well (Figure K-2) but found that the number of devices plugged into Tier 2 advanced power strips was more evenly distributed in PY8 than in PY9. In PY8, 68% of Tier 2 advanced power strips in Cadmus' sample had three or more devices plugged into them compared to only 37% in PY9.

Figure K-2. Number of Devices Plugged into Tier 2 Advanced Power Strips in PY8



[184] The 2016 PA TRM refers to page 30 in NYSERDA's *Advanced Power Strip Research Report*, August 2011.

[185] Pennsylvania Public Utility Commission. *Technical Reference Manual.* Section 2.5.3. June 2016.

K.1.5 Energy Education Savings Analysis Findings

Table K-12 shows the energy savings recommendations considered in estimating energy education savings, the behavioral element that education could change, the PA TRM reference, the WRAP participant survey results, and the per-unit energy and demand savings in each half of the year. In PY9 Q1-Q2, the verified energy education savings estimate is 27.31 kWh/yr per household; in PY9 Q3-Q4, the verified energy education savings estimate is 81.23 kWh/yr.

The *ex ante* assumption was 160 kWh/yr; verified savings estimates in both halves of the year were much lower than the *ex ante* savings.

Table K-12. Verified Energy Education Savings and Assumptions Summary Table

Energy Savings Recommendation	Behavioral Assumption	PA TRM Reference	*Ex Post* Verified Savings			
			PY9 Q1-Q2		PY9 Q3-Q4	
			kWh/yr	kW	kWh/yr	kW
Adjust Thermostats – Summer	Participants lower their thermostat in the winter and raise it in the summer	Programmable Thermostats – Section 2.2.8	0.40	-	1.56	-
Adjust Thermostats – Winter			11.39	-	75.62	-
Wash Clothes in Cold Water	Participants increase the number of loads of laundry they wash in cold water	Water Heater Temperature Setback – Section 2.3.6	11.20	0.0009	0.04	0.0000
Take Shorter Showers	Participants decrease the duration of each shower	Low Flow Showerheads – Section 2.3.9	4.31	0.0003	4.00	0.0003
Total (1)			**27.31**	**0.0012**	**81.23**	**0.0003**
(1) Each component is summed to get the total.						

Table K-12 shows that the main driver in higher energy education savings in the second half of the year was because more participants said they adjusted their thermostat in the winter (17% in PY9 Q1-Q2 compared to 40% in PY9 Q3-Q4 based on participant phone survey findings).

Cadmus found that the main driver of lower savings was that many participants said they were already taking shorter showers and washing their clothes in cold water. Of survey participants who said they took action after receiving the education, Table K-13 shows the percentage of showers five minutes or less before and after education and percentage of loads of laundry washed in colder water before and after receiving the education.

Table K-13 shows that, for these two components, the survey results in each half of the year were similar. Moreover, there appears to be less opportunity for savings with these components than initially estimated in PY8, because many people are already taking some of these actions and many people are taking no action, both of which combine to have a marginal effect on overall savings.

Table K-13. Calculation and Results of Energy Education Percent Change Components

<table>
<tr><th rowspan="2">Energy Savings Recommendation</th><th colspan="3">Q1-Q2</th><th colspan="3">Q3-Q4</th></tr>
<tr><th>Percent Before</th><th>Percent After</th><th>Percent Change</th><th>Percent Before</th><th>Percent After</th><th>Percent Change</th></tr>
<tr><td colspan="7">Of those who took action</td></tr>
<tr><td>Taking Shorter Showers</td><td>37%</td><td>45%</td><td>8%</td><td>48%</td><td>54%</td><td>6%</td></tr>
<tr><td>Wash Clothes in Cold Water</td><td>59%</td><td>69%</td><td>10%</td><td>61%</td><td>61%</td><td>0.04%</td></tr>
<tr><td colspan="7">Overall Percentage Change</td></tr>
<tr><th rowspan="2">Energy Savings Recommendation and Action</th><th colspan="3">Q1-Q2</th><th colspan="3">Q3-Q4</th></tr>
<tr><th>Percent Change</th><th>Percent of Population</th><th>Overall Percent Change</th><th>Percent Change</th><th>Percent of Population</th><th>Overall Percent Change</th></tr>
<tr><td>Taking Shorter Showers - Action</td><td>8%</td><td>35%</td><td rowspan="2">2.74% (1)</td><td>6%</td><td>54%</td><td rowspan="2">3.48% (1)</td></tr>
<tr><td>Taking Shorter Showers - No Action</td><td>0%</td><td>65%</td><td>0%</td><td>46%</td></tr>
<tr><td>Wash Clothes in Cold Water - Action</td><td>10%</td><td>36%</td><td rowspan="2">3.65%</td><td>0.04%</td><td>55%</td><td rowspan="2">0.02% (1)</td></tr>
<tr><td>Wash Clothes in Cold Water - No Action</td><td>0%</td><td>64%</td><td>0%</td><td>45%</td></tr>
<tr><td colspan="7">(1) Cadmus calculated this by taking the weighted average of the percent change and the proportion of the population that either took action or did not. By definition, those who took no action had a percent change of zero.</td></tr>
</table>

K.1.6 In-Service Rates

Cadmus conducted participant telephone surveys at the end of PY9 to determine the ISRs of six key products—LEDs, LED nightlights, kitchen aerators, bathroom aerators, showerheads, and Tier 2 advanced power strips. For PY9 Q1-Q2, Cadmus averaged the results from PY8 and PY9 Q3-Q4. Table K-14 compares the ISRs from PY8, PY9 Q1-Q2, and PY9 Q3-Q4.

Table K-14. Comparison of ISRs in PY8, PY9 Q1-Q2, and PY9 Q3-Q4

Product	PY8	PY9 Q1-Q2	PY9 Q3-Q4
LEDs	94%	97%	99%
LED Nightlights	69%	83%	96%
Kitchen Aerators	78%	86%	95%
Bathroom Aerators	61%	76%	90%
Showerheads	88%	91%	93%
Tier 2 Advanced Power Strips	44%	66%	88%

K.2 Process Evaluation

K.2.1 Additional Findings

This section includes additional process evaluation findings.

Process Map Review

Cadmus reviewed the process flow maps developed by the ICSP to determine whether the program was implemented as designed or evolved from the original plan. Cadmus concluded that the process flow remained as intended.

Logic Model Review

Cadmus reviewed the logic model and determined that the Winter Relief Assistance Program is operating as expected. Table K-15 lists the outcome of the logic model review.

Table K-15. Winter Relief Assistance Program Logic Model Review

Expected PY9 Outcome	Topics	Actual PY9 Outcome
Marketing and referrals from other low-income programs (Act 129 and Universal Services) identify participants, establish participants' eligibility and conduct energy audits and improvement-eligibility assessments, and include the installation of energy-efficient equipment, provide energy education, and generate referrals to other organizations for participant households.	**Program Activities**	Delivered program activities as expected.
ICSP enrolls income-qualified participants, completes audits, installs energy-saving products, and serves clients.	**Outputs Produced by Program Activities**	Delivered outputs as expected.
Increase program awareness, install energy-efficient equipment in participant homes, increase participant knowledge of energy efficiency and conservation, and provide access to other needed services.	**Short-Term Outcomes**	Produced short-term outcomes as expected.
Energy savings accrue from participant households through installation of efficient equipment.	**Intermediate Outcomes**	Program on track to meet intermediate outcomes.
Energy savings continue to result from energy-efficient equipment upgrades and conservation behaviors in the participating low-income population.	**Long-Term Outcomes**	Program on track to meet long-term outcomes; to be assessed at the end of Phase III.

Participant Profile

From the participant phone surveys, Cadmus collected participant profile data that included details about participant demographics and home characteristics. The participants' homes had the following characteristics:[186]

- Single-family detached residence (19%)
- Attached house (townhouse, rowhouse, or twin) (13%)

[186] 3% of the participants preferred not to answer this question.

- Mobile or manufactured home (41%)
- Multifamily apartment or condo building with 4 or more units (23%)
- Other (3%)

WRAP participants have the following level of education:[187]

- Less than high school diploma or equivalent (15%)
- High school diploma or equivalent (42%)
- Technical or business school certificate/2-year college degree/some college (33%)
- 4-year college degree/bachelor's degree (8%)
- Graduate or professional degree/masters or PhD (2%)

K.2.2 Survey Approach

Contact Instructions

PPL Electric Utilities provided survey contact instructions for conducting surveys. Customers could not be contacted for a survey if they had completed a PPL Electric Utilities or Cadmus survey in the past three months, had opted out of a survey, or had asked not to be contacted again. Telephone survey calls could not take place on Sundays or national holidays. Cadmus prepared a contact list according to instructions and survey subcontractor attempted to contact the remaining records by telephone up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

Sample Attrition

Table K-16 lists the total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

[187] 6% of the participants preferred not to answer this question.

Table K-16. PY9 WRAP Sample Attrition Table for Participant Telephone Surveys

Description of Call Outcomes	Number of Records
Population (number of unique jobs) [1]	**12,232**
Removed: inactive customer, completed survey in past 3 months, on "do not contact" list, opted out of survey, selected for a different survey, duplicate contact, recycled A/C only, large C&I sector	**3,809**
Incomplete or bad phone number	**2,655**
Survey sample frame (sent to subcontractor for telephone survey calls)	**5,768**
Not attempted [2]	**2,338**
Records attempted (telephone)	**3,430**
Non-working number	359
Wrong number, business	130
No answer/answering machine/phone busy	2,173
Language barrier	41
PPL Electric Utilities or market research employee	7
Cannot confirm equipment/not aware of participation	13
Refusal	109
Terminated survey	20
Non-specific or specific callback scheduled	350
Partially completed surveys	0
Completed surveys	**228**
Telephone response rate	**6.6%**

(1) Number of rebates available in PPL Electric Utilities' tracking database at the time of the final survey effort. Total records do not include master-metered multifamily building tenants as there is no contact data available for tenants. Therefore, no surveys were conducted with participating tenants in master-metered multifamily buildings. Cadmus evaluated satisfaction through interviews with master-metered multifamily building property managers.
(2) Selected for sample but target was reached before attempted.

Appendix L. Evaluation Detail – Energy Efficiency Kits and Education Program

L.1 Gross Impact Evaluation

L.1.1 Methodology

Survey Methodology

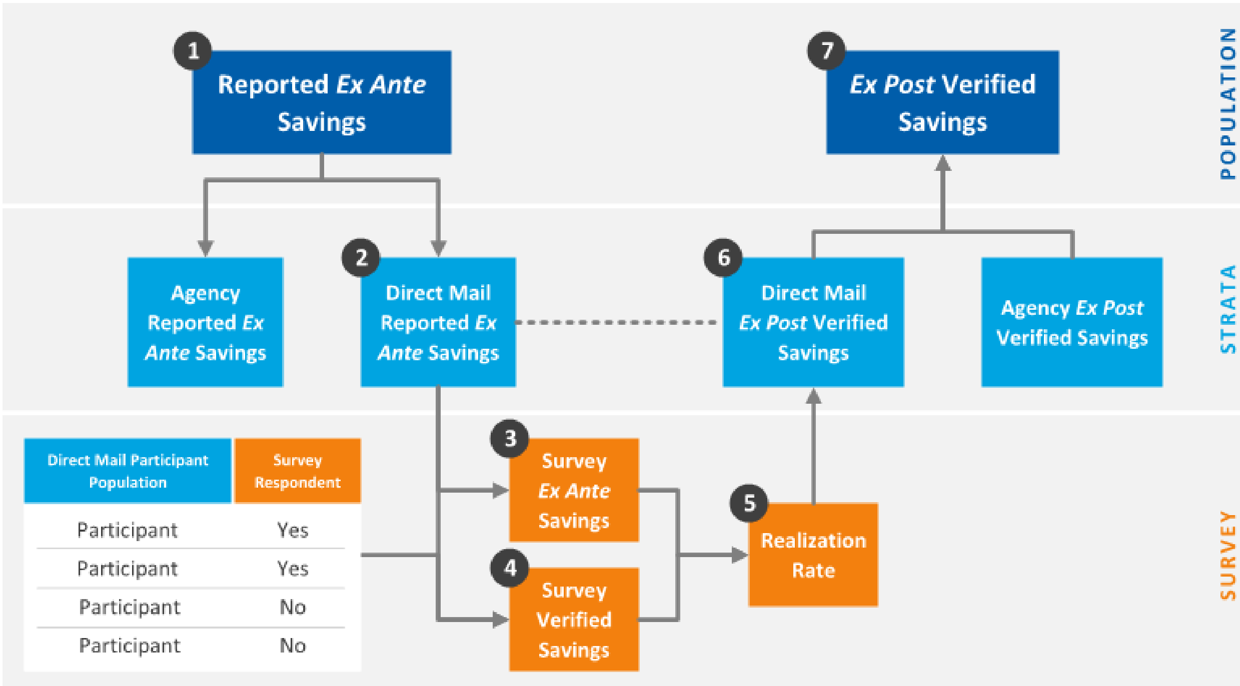
Each kit distributed through the Energy Efficiency Kits and Education Program included a paper survey for the participant to complete and mail back to the ICSP. These surveys collected the necessary data for Cadmus to calculate ISRs and determine the participant actions taken because of the program. Survey data were also used to calculate *ex post* per-unit savings for each item in the energy-savings kit. Cadmus also conducted telephone surveys with a sample of participants who received a kit but did not return a paper survey.

Potential sources of bias in the surveys include nonresponse, recall, and social desirability. Cadmus addressed these by applying best practices in survey design and survey data collection. Surveys did not include leading or ambiguous questions nor double-barreled questions. Cadmus provided clear interviewing and programming instructions so that they were implemented consistently. The SWE team and PPL Electric Utilities reviewed and approved surveys before fielding.

Ex Post *Verified Savings Methodology*

Cadmus estimated *ex post* verified savings for the Energy Efficiency Kits and Education Program for each stratum—agency or direct mail delivery channels—and for the program overall using the ICSP-reported savings, paper and telephone survey responses, and data from enrollment cards collected by the ICSP. Figure L-1 presents a flow diagram of the methodology. The rest of this section describes these items in the methodology in greater detail.

Figure L-1. Ex Post Verified Savings Methodology Flow Diagram



Reported *Ex Ante* Savings (Figure L-1., Items 1 & 2)

Cadmus collected reported savings recorded in PPL Electric Utilities' tracking database for each product and kit distributed to the population of program participants. Part of Cadmus' quality control process for evaluating this program involved understanding how the ICSP calculated reported savings, so Cadmus verified that the ICSP had calculated per-unit savings according to the ISRs and the PA TRM inputs specified in PY9 plans and had made similar assumptions to Cadmus' in assigning savings to program participants.

Survey *Ex Ante* and Survey Verified Savings (Figure L-1., Items 3, 4 & 5)

Cadmus estimated stratum-level (agency or direct mail) realization rates using individual survey responses from the sample of program participants who returned a survey or responded to the telephone survey. Cadmus assigned per-unit survey *ex ante* and survey-verified savings to every participant, kit, and product in the survey data. Survey *ex ante* and survey-verified savings are defined as follows:

- **Survey *ex ante* savings** are the reported *ex ante* savings assigned to the subset of program participants who returned a survey and provided enough information to verify their savings for a particular product. Survey *ex ante* savings incorporate participants' information, such as water heater configuration and type of home, from the enrollment cards.
- **Survey verified *ex post* savings** are Cadmus' verification of savings assigned to the subset of program participants who returned a survey and provided enough information to verify their savings for a particular product. Survey-verified savings incorporate data from the enrollment cards and the participants' responses to survey questions about product installations.

Assigning Survey Ex Ante *and Survey Verified Savings*

Cadmus assigned survey *ex ante* and survey verified savings to program participants based on the criteria listed in Table L-1.

Table L-1. Criteria for Assigning Survey *Ex Ante* and Survey Verified Savings

Criteria	Survey *Ex Ante* Savings [(1)]	Survey Verified Savings
Whether the respondent answered the product-specific question(s)	✓	✓
How the participant answered questions on the enrollment card about home characteristics	✓	✓
How the respondent answered the questions asking if products were installed		✓
How the respondent answered questions about actions taken that could result in behaviorally based energy savings		✓
[(1)] Cadmus used the ICSP-reported *ex ante* savings for survey-*ex ante* savings based on the listed criteria. The ICSP incorporated information from the enrollment cards when calculating reported *ex ante* savings.		

Table L-2 shows how Cadmus assigned survey *ex ante* and survey verified savings to each program participant and product, a showerhead in this example. Cadmus included participants in the realization rate analysis if it could definitively verify whether the participant achieved savings for a particular product. In cases where it could not verify savings, because the participant either did not return a survey or did not respond to the necessary installation question, Cadmus did not include savings in the realization rate analysis for that particular product.

Table L-2. Example of Assigning Survey *Ex ante* and Survey Verified Savings

Program Participant (PPL Tracking Database)	Electric Water Heater (Enrollment Card)	Population Total *Ex Ante* kWh/yr (ICSP)	Survey Respondent (Survey Data)	Installed Product (Survey Data)	Survey *Ex ante* kWh/yr	Survey Verified kWh/yr	Savings Included in Realization Rate
Participant A	Yes	230.46	Yes	Yes	230.46	360.09	Yes
Participant B	Yes	230.46	Yes	No	230.46	0	Yes
Participant C	Yes	230.46	Yes	Yes	230.46	360.09	Yes
Participant D	No	0	Yes	Yes	0	0	Yes
Participant E	Yes	230.46	Yes	No Response	N/A	N/A	No
Participant F	No Response	230.46	Yes	No	230.46	0	Yes
Participant X	Yes	230.46	No	N/A	N/A	N/A	No
Participant Y	Yes	230.46	No	N/A	N/A	N/A	No
Participant Z	No	0	No	N/A	N/A	N/A	No

The example provides four distinct scenarios:

- **Participants A, B, C, & D.** Cadmus had enough information to verify showerhead savings for these participants. Their showerhead survey *ex ante* and survey verified savings were included in the realization rate.

- **Participant E.** Although Participant E returned a survey, Cadmus could not confirm if the showerhead from the kit had been installed because the participant did not answer that question. Therefore, Cadmus did not include this participant's showerhead survey *ex ante* and survey verified savings in the realization rate. However, Participant E's responses about other products could still be included in the realization rate analysis.
- **Participant F.** This participant responded to all the necessary survey questions for Cadmus to verify showerhead savings. Although this participant did not answer the question about the type of water heater in the home, Cadmus could verify showerhead savings because the participant did not install the showerhead. Therefore, Cadmus assigned 0 kWh/yr survey verified savings and included the showerhead savings in the realization rate analysis.
- **Participants X, Y, & Z.** These participants did not return a survey, so Cadmus could not verify savings for any of their products.

Cadmus assigned survey verified savings using information from the enrollment card, specifically water heater configuration, clothes washing location, type of space heating, type of space cooling, and type of home. The ICSP assigned reported savings based on the data uploaded to PPL Electric Utilities' tracking database. Although there should be no discrepancies between data in PPL Electric Utilities' tracking database and in the enrollment cards, Cadmus investigated both sources and confirmed the correct information with the ICSP when the two sources did not match. Cadmus found several differences between the database and the enrollment cards and verified with the ICSP that the enrollment cards reflected the most accurate information. Cadmus therefore used information from the enrollment card and not the database to assign survey verified savings.

Cadmus calculated realization rates for each stratum as the ratio of survey verified savings to survey *ex ante* savings. Because the kit contains one survey that asks questions about each item, survey responses for products may be correlated within customers. Cadmus accounted for these correlations by rolling savings up to the kit level prior to calculating realization rates and precision.

Calculating Survey Verified Savings

Cadmus independently calculated survey verified savings per the PA TRM and the associated algorithms.[188] These algorithms involve open variables for which the ICSP or Cadmus can use either the default or the option of "EDC data gathering." Table L-3 lists the algorithm inputs and sources of the data collected.

[188] Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2016.

Table L-3. 2016 PA TRM Open Variables

Product	Survey Data	Enrollment Card	Kit Specification Sheet
LED	ISR		Bulb wattage
LED Nightlight	ISR		Bulb wattage
Low Flow Showerhead	ISR	Water heater fuel type, type of home	Low flow GPM
Kitchen Faucet Aerator	ISR	Water heater fuel type, type of home	Low flow GPM
Tier 2 Advanced Power Strip	ISR, Equipment plugged into power strip		
Furnace Whistle	ISR	Home heating fuel type, home cooling configuration	
Adjusting Thermostat for Cooling in the Summer	ISR	Home cooling configuration	
Adjusting Thermostat for Heating in the Winter	ISR	Home heating fuel type	
Water Heater Temperature Setback	ISR	Water heater fuel type, laundry location	

Ex Post Verified Savings (Figure L-1., Items 6 & 7)

To calculate stratum-level *ex post* savings, Cadmus applied the stratum-level realization rates to stratum *ex ante* savings and took the sum of stratum-level *ex post* savings to estimate the program-level *ex post* savings. Cadmus calculated confidence and precision for the *ex post* savings and realization rate estimates in each stratum and for the program as a whole.

L.1.2 Database Review Findings

Cadmus reviewed PPL Electric Utilities' program tracking database for all PY9 records for Energy Efficiency Kits and Education Program participants. It reviewed the PPL Electric Utilities account numbers, kit numbers, and home characteristics and compared these to information from the enrollment cards recorded in the ICSP's electronic database to ensure that records were traceable between both databases.

Prior to Cadmus' review of the database, PPL Electric Utilities' tracking database listed a total of 13,406 kits. Cadmus discovered several discrepancies and accounted for them as follows:

- Thirty-seven kits were present in PPL Electric Utilities' tracking database but not in the enrollment data. Cadmus confirmed with the ICSP that these kits were delivered to the participant and applied *ex post* savings.
- Twenty-eight non-water-product kits were present in the PPL Electric Utilities' tracking database that included rows for showerheads and kitchen aerators. Cadmus confirmed with the ICSP that these kits did not include showerheads or kitchen aerators and estimated the realization rate assigning zero savings for these products.

- Twenty-eight water-product kits were present in the PPL Electric Utilities' tracking database missing rows for showerheads and kitchen aerators. Cadmus confirmed with the ICSP that these kits included showerheads and kitchen aerators and estimated the realization rate assigning appropriate savings for these products.

Based on data from the ICSP, Cadmus increased the number of returned kits from 109 kits to 114 kits.

As a result of the review, Cadmus decreased the total unique distributed (and not returned) kits to 13,203 program kits, representing 99% database accuracy for the program, as shown in Table L-4.

Table L-4. Accuracy of PY9 Data for Energy Efficiency Kits and Education Program

Sector	Product	PY9 Kits in PPL Electric Utilities' Tracking Database [1]	Database Accuracy	PY9 Verified Kits
Low-Income	Energy-savings kit	13,208	99%	13,203
[1] The number of unique kits in PPL Electric Utilities' tracking database that were not indicated as returned.				

As mentioned, the number of unique CSP job numbers in PPL Electric Utilities' tracking database does not necessarily reflect the unique number of distributed kits, nor does it identify all kits that have been returned in PY9. Cadmus verified 13,203 kits as distributed and not returned from the 13,406 unique CSP job numbers provided in PPL Electric Utilities' tracking database using these steps:

- **109 unique kits** were returned to the ICSP according to PPL Electric Utilities' tracking database. However, these kits were associated with **198 unique CSP job numbers**:
    - **20 of these unique CSP job numbers** were distributed in PY8 but returned in PY9, and therefore are only associated with one unique CSP job number per kit.
    - **89 of these unique CSP job numbers** were associated with another CSP job number, i.e., one unique CSP job number indicated the originally distributed kit, and one unique CSP job number was associated with the returned kit.
    - **(20)(1) + (89)(2) = 198 unique CSP job numbers** in PPL Electric Utilities' tracking database.
- **5 unique kits** were indicated as returned in the ICSP tracking data but not in PPL Electric Utilities' tracking database. Cadmus verified with the ICSP that these kits were returned. Each of these kits was only associated with one unique CSP job number.
- **198 + 5 = 203 unique CSP job numbers** associated with returned kits.
- **13,406 – 203 = 13,203 kits distributed and not returned**.

L.1.3 Survey Findings

Cadmus estimated ISRs for all products in the energy-savings kits. Table L-5 provides these ISRs and the ISRs the ICSP used for planning. As in PY8, the difference in ISRs for LED bulbs is primarily driven by the delivery channel of the reported ISR; the data were gathered through surveys that were included in the kit in Phase II when the kits only included two bulbs. Cadmus observed that ISRs remain relatively high until after the fourth bulb, when installations drop off dramatically, ranging from 72% to 66% for the fifth and sixth bulbs. Results are similar across strata.

Also similar to PY8, Cadmus observed lower advanced power strip ISRs and higher furnace whistle ISRs than used for planning by the ICSP. Note that the evaluated furnace whistle ISR provided in the table does not include a fuel saturation rate, consistent with the value provided as the ICSP planning ISR. Finally, Cadmus provided an ISR for energy education calculated as the number of energy education activities participants received savings for out of the number of activities for which they were eligible to achieve savings. Agency participants engaged in just under half of the activities, and direct mail participants engaged in just over half of the activities.

Table L-5. PY9 Energy Efficiency Kits and Education Program Product-Level ISRs

Product	Agency		Direct Mail	
	Survey-Gathered ISR	ICSP Planning ISR	Survey-Gathered ISR	ICSP Planning ISR
LED Bulbs	84%	96%	84%	98%
First Bulb	97%	96%	97%	98%
Second Bulb	95%	96%	96%	98%
Third Bulb	91%	96%	91%	98%
Fourth Bulb	84%	96%	83%	98%
Fifth Bulb	72%	96%	71%	98%
Sixth Bulb	67%	96%	66%	98%
LED Nightlight	92%	87%	91%	92%
Low-Flow Showerhead	64%	64%	60%	72%
Kitchen Faucet Aerator	65%	63%	59%	75%
Tier 2 Advanced Power Strip	69%	77%	62%	83%
Furnace Whistle	35%	17%	31%	20%
Energy Education	45%	100%	55%	100%

As described in *Section 13.3.4 Gross Impact Evaluation Results*, the increase in realization rate between PY8 and PY9 was driven by the saturation of kit types distributed to customers because the ICSP's planned per-unit energy education savings aligned closer to kits with water products than to kits without water products. Table L-6 provides the evaluated per-unit energy education savings participants achieved by delivery channel and kit type based on participant survey responses to key questions. The ICSP reported per-unit energy education savings of 253 kWh/yr for all participants, regardless of delivery channel or kit type.

Table L-6. Energy Education Savings by Delivery Method and Kit Type

Delivery Method	Kit Type	Average Evaluated kWh/yr	Average Evaluated kW/yr	Sample Size
Agency	Electric	252.63	0.0153	143
	Non-Electric	20.96	0.0123	93
Direct Mail	Electric	355.15	0.0217	935
	Non-Electric	86.19	0.0115	316

L.1.4 Behavior Savings Methodology

Cadmus estimated the impacts of electric consumption associated with behavior changes by participants in the Energy Efficiency Kits and Education Program using calculations derived from a combination of engineering estimates, secondary research, and survey data. These savings estimates were associated with the following behavior changes:

- Lowering the water heater temperature
- Washing more loads of laundry in cold water
- Adjusting the home thermostat per the heating or cooling season

The next sections provide details about the algorithms Cadmus used to estimate savings for these three behavior changes. Cadmus used the same energy education savings algorithms for participants of the Low-Income Winter Relief Assistance Program (WRAP) in PY9. See *Chapter 12 Winter Relief Assistance Program* for details.

Water Heater Temperature Reduction

The Energy Efficiency Kits and Education program encourages participants to reduce the temperature setting of their electric water heater to save energy. Cadmus estimated savings for this action by following the PA TRM engineering calculation provided in Equation L-1.[189] 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 L-2 is the algorithm Cadmus used to determine demand savings for reducing the water heater temperature.

Equation L-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 L-2

$$\Delta \mathrm{kWpeak} = ETDF \times \Delta\, kWh/yr$$

Table L-7 provides a description of the variables in Equation L-1 and Equation L-2.

[189] Pennsylvania Public Utility Commission. *Pennsylvania Technical Reference Manual.* June 2016.

Table L-7. Protocol Inputs for Electric Water Heater Temperature Reduction Algorithm

Product	Input	*Ex Post* Savings Input		
		Source	Value	Notes
Electric Water Heater Temperature Reduction	Water heater fuel type [1]	Enrollment Card	Data gathering	Provided by the ICSP
	Washing machine located in home [1]	Enrollment Card	Data gathering	Provided by the ICSP
	Energy factor of water heater (EF_{WH})	TRM Default	0.904	Section 2.3.6; Table 2-64
	R value of electric water heater tank (R_{tank})	TRM Default	8.3	Section 2.3.6; Table 2-64
	Surface area of water heater tank (A_{tank})	TRM Default	24.99 sq. ft.	Section 2.3.6; Table 2-64
	Thermal efficiency of electric heater element (η_{elec})	TRM Default	0.98	Section 2.3.6; Table 2-64
	Volume of hot water used per day by clothes washer (V_{HW})	TRM Default	7.32 gallons/day	Section 2.3.6; Table 2-64
	Temperature setpoint of electric water heater initially (T_{hot_i})	TRM Default	130°F	Section 2.3.6; Table 2-64
	Temperature setpoint of electric water heater after setback (T_{hot_f})	TRM Default	119°F	Section 2.3.6; Table 2-64
	Energy to demand factor *(ETDF)*	TRM Default	0.00008047	Section 2.3.6; Table 2-64
[1] Required to assign savings; not considered an open variable but ICSP is required to collect.				

Cadmus applied Equation L-1 and Equation L-2 to survey respondents who indicated on the enrollment card that the home had an electric water heater. Respondents who indicated the home did not have an electric water heater received zero electric savings for water heater temperature setback.

Furthermore, Cadmus applied the clothes washer portion of savings (corresponding to the second term in the equation) only to participants who indicated on the enrollment card that they had a washing machine in their home or apartment. Respondents who wash their laundry at an on- or off-site public laundry facility were not eligible to receive the clothes washer portion of water heater temperature reduction savings.

Table L-8 provides the per-respondent savings applied to eligible participants.

Table L-8. Electric Water Heater Temperature Reduction Savings

Unit	Tank Loss	Clothes Washer	Total
kWh/yr	86.77	79.09	165.86
kW/yr	0.0070	0.0064	0.0134

Washing More Loads of Laundry in Cold Water

Cadmus estimated the savings associated with washing more loads of laundry in cold water, a behavior encouraged by the Energy Efficiency Kits and Education Program. Cadmus estimated these savings by following Equation L-3, in which the change in percentage of loads washed in cold water before and after the program is applied to the energy savings achieved when lowering the temperature of the water used by the clothes washer. Table L-9 provides a description of the variables in Equation L-3.

Equation L-3

$$\Delta\, kWh/yr = \frac{V_{HW} \times \left(8.3\frac{lb}{gal}\right) \times \left(365\frac{days}{yr}\right) \times \left(1\frac{Btu}{°F \cdot lb}\right) \times \left(T_{hot\ i} - T_{hot\ f}\right)}{\left(3412\frac{Btu}{kWh}\right) \times EF_{WH}} * (\Delta Loads\ Washed\%)$$

In PY9, the paper survey did not include a question appropriate for determining any behavior change related to program participation. To determine the change in the percentage of loads washed in cold water, Cadmus applied the average change estimated in the PY7 evaluation of the Energy Efficiency Kits and Education Program (formerly the E-Power Wise Program).[190] Because these respondents could indicate no change (by responding with the same pre- and post-percentage of loads washed in cold water), Cadmus applied clothes washer savings to all survey respondents with an electric water heater and in-home laundry and could adjust the starting temperature of water ($T_{hot\ i}$) depending on whether the respondent had lowered the water heater setting and thereby not double-count savings from water heater temperature setback.

Table L-9. Protocol Inputs for Washing Clothes in Cold Water Algorithm

Product	Input	*Ex Post* Savings Input		
		Source	Value	Notes
Washing More Loads of Laundry in Cold Water	Water heater fuel type [1]	Enrollment Card	Data gathering	Provided by the ICSP
	Washing machine located in home [1]	Enrollment Card	Data gathering	Provided by the ICSP
	Energy factor of water heater (EF_{WH})	TRM Default	0.904	Section 2.3.6; Table 2-64
	Volume of hot water used per day by clothes washer (V_{HW})	TRM Default	7.32 gallons/day	Section 2.3.6; Table 2-64
	Temperature setpoint of electric water heater (T_{hot_i})	TRM Default	130°F (did not change water heater setpoint);	
	Temperature setpoint of water supply (T_{hot_f})	119°F (did change water heater setpoint)	Section 2.3.6; Table 2-64	
	Change in percentage of loads washed in cold water ($\Delta Loads\ Washed\%$)	TRM Default	55°F	Section 2.3.1; Table 2-45
	Energy to demand factor *(ETDF)*	PY7 E-Power Wise Survey Data	17.81%	Cadmus verified in PY7
[1] Required to assign savings; not considered an open variable but ICSP is required to collect.				

Table L-10 provides the per-respondent savings applied to eligible participants.

190 PPL Electric Utilities. *Annual Report Program Year 7: June 1, 2015–May 31, 2016*. Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 15, 2016.

Table L-10. Washing More Loads of Laundry in Cold Water Savings

Unit	Lowered Water Heater Setpoint	Did Not Lower Water Heater Setpoint
kWh/yr	81.95	96.04
kW/yr	0.0066	0.0077

Adjusting Thermostat for Heating and Cooling Season

The Energy Efficiency Kits and Education Program recommends to participants that they save energy by raising their thermostat setpoint for cooling in the summer and lowering their thermostat setpoint for heating in the winter. Cadmus applied Equation L-4, Equation L-5, and Equation L-6 to calculate the cooling and heating savings.

Equation L-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 L-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 L-6

$$\Delta \text{kWpeak} = ETDF \times \Delta kWh_{cool}$$

Equation L-4 and Equation L-5 first determine the average annual energy use of a residential electric HVAC system then apply a savings factor for the thermostat adjustment. The savings factors ($ESF_{tstat-cool}$ and $ESF_{tstat-heat}$) are based on the evaluation results of the Iowa 2011 through 2017 Energy Wise Program, which provided recent savings data.[191]

Table L-11 presents the results of the Iowa Energy Wise evaluations for reducing heating temperature, and Table L-12 presents the results for increasing cooling temperature. The changes in thermostat setpoint temperatures came from the survey responses of participants who either reduced their heating

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191 Cadmus. *Iowa 2011 Energy Wise Program.* May 1, 2012. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2012 Energy Wise Program.* May 2013. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2013 Energy Wise Program.* June 24, 2014. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2014 Energy Wise Program.* January 31, 2015. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2015 Energy Wise Program.* January 30, 2016. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2016 Energy Wise Program.* February 22, 2017. Prepared for Iowa Utility Association.
Cadmus. *Iowa 2017 Energy Wise Program.* March, 2018. Prepared for Iowa Utility Association.

temperature or increased their cooling temperature. The percentage of savings per change in degrees comes from the U.S. Department of Energy.[192]

Table L-11. Iowa Energy Wise Program Evaluations: Reducing Heating Temperature

Year	Change in Temp °F	% Savings/°F	Energy Savings Factor (1)
2011	-3.2	1%	3.2%
2012	-4.2	1%	4.2%
2013	-5.1	1%	5.1%
2014	-5.3	1%	5.3%
2015	-5.1	1%	5.1%
2016	-3.7	1%	3.7%
2017	-4.0	1%	4.0%
Average	**-4.4**	**1%**	**4.4%**

(1) The energy savings factor is the absolute value of the change in temperature multiplied by the percent savings per degree; therefore, the energy savings factors are positive even though the temperature changes are negative.

Table L-12. Iowa Energy Wise Program Evaluations: Increasing Cooling Temperature

Year	Change in Temp °F	Percentage Savings/°F	Energy Savings Factor
2011	3.1	1%	3.1%
2012	4.2	1%	4.2%
2013	5.0	1%	5.0%
2014	5.9	1%	5.9%
2015	4.8	1%	4.8%
2016	3.8	1%	3.8%
2017	3.8	1%	3.8%
Average	**4.4**	**1%**	**4.4%**

Table L-13 provides a description of the variables in Equation L-4, Equation L-5, and Equation L-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).

192 This is 1% of the baseline savings per every one degree, per the U.S. Department of Energy's *Energy Saver* article "How Much Can You REALLY Save with Energy Efficiency Improvements?" Last updated October 7, 2016. Available online: https://energy.gov/energysaver/articles/how-much-can-you-really-save-energy-efficient-improvements

Table L-13. Thermostat Setting Behavior Change Algorithm Inputs

Product	Input	*Ex Post* Savings Inputs		
		Source	**Value**	**Notes**
Adjusting Thermostat for Heating and Cooling	Presence of electric heating system (yes/no) [(1)]	Enrollment Card	Data Gathering	Provided by the ICSP
	Presence of electric cooling system (yes/no) [(1)]	Enrollment Card	Data Gathering	Provided by the ICSP
	Type of electric heating system	Enrollment Card	Data Gathering	Provided by the ICSP
	Type of electric cooling system	Enrollment Card	Data Gathering	Provided by the ICSP
	Capacity of cooling system ($CAPY_{cool}$)	TRM Default	32,000 Btu/hour	Section 2.2.8; Table 2-41
	Capacity of heating system ($CAPY_{heat}$)	TRM Default	32,000 Btu/hour	Section 2.2.8; Table 2-41
	Seasonal energy efficiency ratio ($SEER$)	TRM Default	11.9 Btu/Wh	Section 2.2.8; Table 2-41
	Heating seasonal performance factor ($HSPF$)	TRM Default	3.412 Btu/Wh	Section 2.2.8; Table 2-41
	Duct system efficiency (Eff_{duct})	TRM Default	0.8	Section 2.2.8; Table 2-41
	Equivalent full load hours for cooling ($EFLH_{cool}$)	TRM Default	Allentown = 487	Section 2.2.8; Table 2-41
			Erie= 389	
			Harrisburg= 551	
			Philadelphia= 591	
			Pittsburgh = 432	
			Scranton = 417	
			Williamsport = 422	
	Equivalent full load hours for heating ($EFLH_{heat}$)	TRM Default	Allentown = 1,193	Section 2.2.8; Table 2-41
			Erie = 1,349	
			Harrisburg = 1,103	
			Philadelphia = 1,060	
			Pittsburgh = 1,209	
			Scranton= 1,296	
			Williamsport = 1,251	
	Energy to Demand Factor ($ETDF$): demand coincidence factor/$EFLH_{cool}$	TRM Default	0.647	Section 2.2.1; Table 2-12.
	Energy savings factor for the thermostat adjustment during the cooling season ($ESF_{tstat-cool}$)	Iowa 2011-2017 Energy Wise Program Evaluations; DOE Energy Saver article	4.4%	Average across all years
	Energy savings factor for the thermostat adjustment during the heating season ($ESF_{tstat-heat}$)	Iowa 2011-2017 Energy Wise Program Evaluations; DOE Energy Saver article	4.4%	Average across all years

(1) Required to assign savings; not considered an open variable but ICSP will be required to collect.

L.2 Process Evaluation

L.2.1 Additional Findings

This section includes additional process evaluation findings.

Logic Model Review

Cadmus reviewed the logic model and determined that the Energy Efficiency Kits and Education Program is operating as expected. Table L-14 lists the outcome of the logic model review.

Table L-14. Logic Model Review

Expected PY9 Outcome	Topics	Actual PY9 Outcome
Identify potential income-qualifying participants, conduct education and outreach, provide training to trainers, provide workshops for low-income customers, and provide free energy-savings kits with energy efficiency products.	**Program Activities**	Delivered program activities as expected.
Free energy-savings kits distributed to customers, workshops and one-on-one sessions conducted, trainers trained, and low-income consumers educated.	**Outputs Produced by Program Activities**	Delivered outputs as expected.
Training and energy-savings workshops educate low-income customers about energy efficiency to help them reduce their energy consumption and energy costs. Items installed from the kit and behavior changes result in energy savings.	**Short-Term Outcomes**	Produced short-term outcomes as expected.
Low-income customer base becomes more knowledgeable and continues to make informed and effective decisions about their energy use. This will result in additional energy savings, customer satisfaction, and environmental benefits.	**Intermediate Outcomes**	Program on track to meet intermediate outcomes.
Items installed from the kit and behavioral changes learned from the program continue to produce energy savings.	**Long-Term Outcomes**	Program on track to meet long-term outcomes; to be assessed at the end of Phase III.

Participant Profile

From the ICSP, Cadmus collected enrollment card data that included details about participant demographics and home characteristics for all customers who received an energy efficient kit. As shown in Table L-15, the majority of participants' homes had the following characteristics:

- Were single family homes or apartments with two or fewer units (62%) or row or town homes (16%)
- Had two or fewer occupants in home (51%)
- Had just one shower in the home (69%)

- Had laundry facilities inside the home (82%)Had one to three bulbs on for two or more hours a day (51%) and four to six bulbs on for two or more hours a day (35%)

Cadmus found some statistically significant differences in home characteristics between participants who were served through the agency channel and participants who were served through direct mail. Of the agency-served participants, a smaller percentage had two or more showers (12%) and laundry facilities inside their homes (67%). Of the direct mail-served participants, 35% had two or more showers in their homes and 86% had laundry facilities inside their homes.[193] Differences are likely driven by delivery channel – customers who enroll in the program via a direct mailer have been specifically identified by PPL Electric Utilities, as opposed to customers who walk into the agencies of their own accord.

Table L-15. Energy Efficiency Kits and Education Program Customer Survey Demographics by Delivery Channel

Home Type (1)			
Participant Answers	**Direct Mail (n=10,201)**	**Agency (n=2,172)**	**Total (n=12,373)**
Single/Twin/Apartment (2 units)	64%	50%	62%
Apartment Building (3 or more units)	12%	25%	14%
Row House/Townhouse	16%	19%	16%
Mobile Home/Trailer	8%	6%	8%
Number of Occupants in Home (1)			
Participant Answers	**Direct Mail (n=10,498)**	**Agency (n=2,177)**	**Total (n=12,675)**
1	20%	29%	22%
2	30%	25%	29%
3	20%	18%	20%
4	16%	14%	16%
5+	14%	14%	14%
Annual Household Income (1)			
Participant Answers	**Direct Mail (not asked)**	**Agency (n=2,077)**	**Total (n=2,077)**
$0 - $17,820	N/A	60%	60%
$17,821 - $24,030	N/A	27%	27%
$24,031 - $30,240	N/A	8%	8%
$30,241 - $36,450	N/A	3%	3%
$36,451 or greater	N/A	2%	2%

[193] Cadmus used a two-tailed t-test to test for significance at the 95% confidence interval. The p-values for each of the demographic factors are as follows: two or more showers – p-value of < 0.0001; in-home laundry facilities – p-value of < 0.0001; in-home dishwasher – p-value of < 0.0001.

Number of Showers [1]			
Participant Answers	**Direct Mail (n=10,574)**	**Agency (n=2,152)**	**Total (n=12,726)**
1	66%	88%	69%
2	30%	11%	26%
3 or More	5%	1%	4%
Laundry Facility Location [1]			
Participant Answers	**Direct Mail (n=10,594)**	**Agency (n=2,164)**	**Total (n=12,758)**
Inside Home	86%	67%	82%
Off-Site Laundry Facility	8%	26%	11%
On-Site Common Laundry	6%	7%	6%
Number of Bulbs on for Two or More Hours [1]			
Participant Answers	**Direct Mail (n=10,605)**	**Agency (n=1,426)**	**Total (n=12,793)**
1-3	48%	65%	51%
4-6	36%	28%	35%
7-9	11%	5%	10%
10 or more	6%	2%	5%
[1] Percentages may not total 100% due to rounding.			

L.2.2 Survey Approach

Contact Instructions

Before selecting a sample of participants for telephone surveys, Cadmus coordinated with PPL Electric Utilities' contractor to screen the sample. Cadmus removed records of customers who had been called in the past three months (for a PPL Electric Utilities survey or a Cadmus survey) or had requested not to be contacted again. Cadmus removed any records with incomplete information and, when sampling participants for the non-responder survey, excluded customers who had returned a paper survey to the ICSP. Cadmus used all remaining records in the telephone survey sample frame.

Cadmus contacted participants in the sample frame by telephone, making up to five attempts over several days, at different times of the day, and scheduling callbacks whenever possible. It was not necessary to contact all records selected in the survey sample frame to reach the targeted number of completed surveys in all but one quota group; the survey firm attempted to contact all agency responders to reach this quota, but only completed 20 of the targeted 70 surveys.

Survey Attrition

Table L-16 lists the total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

Table L-16. Energy Efficiency Kits and Education Sample Attrition Table for Telephone Survey

Description of Outcomes	Number of Records
Telephone	
Population (number of participants) [(1)]	**7,693**
Removed: inactive customer, completed survey in past 3 months, on "do not contact" list, opted out of survey, selected for a different survey, duplicate contact	227
Removed: incomplete or bad telephone number	476
Survey sample frame (sent to subcontractor for telephone survey calls)	**6,990**
Not attempted [(2)]	3,020
Records attempted	**3,970**
Non-working number	489
Wrong number, business	68
No answer/answering machine/phone busy	2,502
Language barrier	36
PPL Electric Utilities or market research employee	83
Refusal	177
Terminated survey	49
Non-specific or specific callback scheduled	336
Completed surveys	**230**
Response rate	**6%**
[(1)] Number of participants in PPL Electric Utilities tracking database at the time of the final survey effort.	
[(2)] Selected for sample but target was reached before attempted.	

Appendix M. Evaluation Detail – Appliance Recycling Program

This appendix documents details of the impact and process evaluation methodologies and results for the Appliance Recycling Program.

M.1 Gross Impact Evaluation

M.1.1 Part-Use Factor Findings

Part-use is an adjustment factor specific to appliance recycling that is used to convert the unit energy consumption (UEC) into an average per-unit gross savings. The UEC itself is not equal to the gross savings for the following reasons:

- The UEC model yields an estimate of annual consumption.
- Not all recycled refrigerators would have operated year-round had they not been decommissioned through the program.

As instructed in the Phase III TRM, to calculate EDC-specific part-use factors, Cadmus followed the methodology for recycled appliances described in the Uniform Methods Project.[194] Cadmus calculated part-use factors using PY8 participant survey data because the PY9 participant survey did not collect data to determine part-use factors.

The part-use methodology relies on information from surveyed customers regarding pre-program usage patterns, that is, how many months of the year prior to recycling was the appliance plugged in and running.

The final estimate of part-use reflects how appliances were likely to operate had they not been recycled (rather than how they previously operated). For example, it is possible that a primary refrigerator operated year-round would have become a secondary appliance and operated part of the time.

The methodology accounts for these potential shifts in usage types. Specifically, part-use is calculated using a weighted average of the following prospective part-use categories and factors:

- Appliances that would have run full-time (part-use = 1.0)
- Appliances that would not have run at all (part-use = 0.0)
- Appliances that would have operated a portion of the year (part-use is between 0.0 and 1.0)

Cadmus calculated a weighted average part-use factor, representing the three participant usage categories as defined by the appliance's operational status during the year before recycling. For example, Cadmus gave participants who did not use their appliance at all during the prior year a part-use factor of zero, as no immediate savings were generated by the appliance's retirement.

194 National Renewable Energy Laboratory. "Chapter 7: Refrigerator Recycling Evaluation Protocol." *Uniform Methods Project.* Available online: http://energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf

Using primary data gathered through the PY8 participant surveys, Cadmus took the following steps to determine part-use:

1. Determined whether recycled refrigerators were primary or secondary units (treating all stand-alone freezers as secondary units).
2. Asked participants who indicated they had recycled a secondary refrigerator or freezer if the appliance had operated year-round, operated for a portion of the preceding year, or was unplugged and not operated. Cadmus assumed all primary units operated year-round.
3. Asked participants who indicated they operated their secondary refrigerator or freezer for only a portion of the preceding year to estimate the total number of months that the appliance remained plugged in. This allowed the calculation of the portion of the year in which the appliance remained in use. Cadmus determined that the average refrigerator, operating part-time, had a part-use factor of 0.35, or four months. Freezers operating part of the time had a part-use factor of 0.25, or three months.

These three steps resulted in information about how refrigerators and freezers operated prior to recycling, as shown in Table M-1.

Table M-1. Historical Part-Use by Appliance Type [1]

Usage Type and Part-Use Category	Percent of Recycled Units	Part-Use Factor
Secondary Refrigerators Only	**n = 163**	
Not in Use	11%	0
Used Part Time	24%	0.35
Used Full Time	64%	1
Weighted Average		**0.73**
All Refrigerators (Primary and Secondary)	**n = 375**	
Not in Use	5%	0
Used Part Time	10%	0.35
Used Full Time	85%	1
Weighted Average		**0.88**
All Freezers	**n = 135**	
Not in Use	16%	0
Used Part Time	16%	0.25
Used Full Time	69%	1
Weighted Average		**0.73**
[1] Calculated using primary customer survey data from PY8 (2016-2017)		

In many cases, the way an appliance was used historically (prior to being recycled) is not indicative of how the appliance would have been used had it not been recycled. To account for this, Cadmus next asked surveyed participants how they would have (likely) operated their appliances had they not recycled them through the program. For example, if surveyed participants said they would have kept a primary refrigerator in the program's absence, Cadmus asked if they would have continued to use the appliance as their primary refrigerator or would have relocated it, using it as a secondary refrigerator.

Participants who said they would have discarded their appliance independent of the program were not asked about the future usage of that appliance, because that would be determined by another customer. Since the future use type of discarded refrigerators is unknown, Cadmus applied the weighted part-use average of all units (0.90) for all refrigerators that would have been discarded independent of the program. By using this approach, the team acknowledges that the discarded appliances might be used as either primary or secondary units in the would-be recipient's home.

Cadmus then combined the part-use factors shown in Table M-1 with participants' self-reported actions had the program *not* been available. This resulted in the distribution of likely future usage scenarios and corresponding part-use estimates.

The weighted average of these future scenarios, shown in Table M-2, produced the part-use factor for refrigerators and freezers.

Table M-2. Prospective Part-Use by Appliance Type [1]

Use Prior to Recycling	Likely Use Independent of Recycling	Part-Use Factor	Percentage of Participants
Primary Refrigerators	Kept (as primary unit)	1	8%
	Kept (as secondary unit)	0.73	8%
	Discarded	0.88	37%
Secondary Refrigerators	Kept	0.73	16%
	Discarded	0.88	30%
Overall		**0.84**	**100%**
Freezers	Kept	0.73	38%
	Discarded	0.73	62%
Overall		**0.73**	**100%**
[1] Calculated using primary customer survey data from PY8 (2016-2017)			

Applying the part-use factors from Table M-2 to the modeled annual consumption from Table M-3 yields the average gross per-unit energy savings. Table M-3 shows that the average gross savings for refrigerators is 974 kWh/yr and savings for freezers is 688 kWh/yr.

Table M-3. Part-Use Adjusted Gross per-unit Savings

Appliance	Average Per-Unit Annual Energy Consumption (kWh/Year)	Part-Use Factor [1]	Adjusted Per-Unit Gross Energy Savings (kWh/Yr)	Precision at 90% Confidence
Refrigerators	1,159	0.84	979	10%
Freezers	942	0.73	686	21%
[1] Calculated using primary customer survey data from PY8 (2016-2017)				

M.1.2 Regression Variable Findings

Table M-4 summarizes program averages or proportions determined through primary data gathering for each open variable in the TRM regression equation and compares these to the TRM default values. The TRM default values were used to calculate the reported savings for appliances recycled in PY9.

Table M-4. UEC Input Comparison for Refrigerator and Freezer Savings Algorithms

Equipment	Independent Variable	TRM Default	PY9 EDC Data Gathering Value
Refrigerator Recycling	Appliance Age (years)	29.41	24.3
	Dummy: Manufactured Pre-1990	35%	36%
	Appliance Size (cubic feet)	18.34	18.95
	Dummy: Single-Door Configuration	5%	4.6%
	Dummy: Side-by-Side Configuration	19%	22%
	Dummy: Percent of Primary Usage (in absence of program)	65%	54%
	Interaction: Located in Unconditioned space x CDDs	0.36	0.63
	Interaction: Located in Unconditioned space x HDDs	2.08	4.39
Freezer Recycling	Appliance Age (years)	37.49	30.2
	Dummy: Manufactured Pre-1990	60%	59%
	Appliance Size (cubic feet)	15.74	15.74
	% of appliances that are chest freezers	28%	32%
	Interaction: Located in Unconditioned space x HDDs	4.93	6.87
	Interaction: Located in Unconditioned space x CDDs	0.843	0.999

M.2 Process Evaluation

M.2.1 Additional Findings

This section includes additional process evaluation findings.

Participant Profile

The customer surveys conducted in PY9 (2017-2018) collected demographic information about Appliance Recycling Program participants, as summarized in Table M-5. The majority of survey respondents showed the following demographic characteristics.

- Lived in a single-family detached residence (87%; 521 of 598)
- Had an average household size of 2.5 people
- Averaged 61 years of age
- Had completed some college education or more (75%; 448 of 595)
- Had an annual household income of $50,000 or greater (63%; 281 of 446)

Table M-5. Appliance Recycling Program Customer Survey Demographics

What type of residence do you live in? Is it…	Survey Participants (n=598) *
A single-family detached residence	87%
Attached house (townhouse, row house, or twin)	7%
Mobile or manufactured home	4%
Multifamily apartment or condo building with 4 or more units	2%
Something else	1%
What is the highest level of education that you have completed?	**Survey Participants** (n=595) *
Less than high school diploma or equivalent	1%
High school diploma or equivalent	24%
Technical or business school certificate/two-year college degree/some college	32%
Four-year college degree/bachelor's degree	25%
Graduate or professional degree/masters or PhD	18%
What year were you born?	**Survey Participants** (n=565)
Mean birth year (age)	1957 (61 years old)
Standard deviation	12.88
Including yourself, how many people lived in your home full-time during the past 12 months? Full-time is considered more than 9 months in the past year.	**Survey Participants** (n=576)
Mean household size	2.5 people
Standard deviation	1.21
In 2017, what was your annual household income before taxes? Please stop me when I read your category. Was it…	**Survey Participants** (n=446) *
Under $10,000	2%
$10,000 to under $15,000	2%
$15,000 to under $20,000	3%
$20,000 to under $25,000	4%
$25,000 to under $30,000	7%
$30,000 to under $35,000	5%
$35,000 to under $40,000	5%
$40,000 to under $45,000	3%
$45,000 to under $50,000	5%
$50,000 to under $60,000	11%
$60,000 to under $75,000	14%
$75,000 to under $100,000	14%
$100,000 to under $150,000	19%
$150,000 to under $200,000	3%
$200,000 or more	3%
*Percentages may not total 100% due to rounding.	

M.2.2 Survey Approach

Contact Instructions

Cadmus conducted online quarterly surveys with a census of all participants in the first quarter (Q1) through Q3. Cadmus did not include participation from Q4 because the program did not change, and enough participants had completed surveys in Q1 through Q3.

PPL Electric Utilities provided survey contact instructions for conducting surveys. Customers could not be contacted for a survey if they completed a PPL Electric Utilities or Cadmus survey in the past three months, had opted out of a survey, or had asked not to be contacted again.

Cadmus coordinated with PPL Electric Utilities' contractor to screen the sample and remove the records of any customers called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey), had requested not to be contacted again, or had incomplete information. Cadmus also excluded inactive customers, customers who had recycled only an air conditioner or who were in the large commercial and industrial (C&I) sector, or customers who were selected for another survey. This cleaning and survey sample preparation process reduced the available sample. Cadmus sent email invitations to the remaining contacts with email addresses and followed up with one reminder email invitation.

Sample Attrition

Table M-6 lists total numbers of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

Table M-6. Appliance Recycling Program Online Survey Attrition

Description of Outcomes	Number of Records
Online Survey	
Population (number of unique jobs) [1]	**9,071**
Removed: incomplete, inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list	1,121
Email was incomplete or invalid	3,595
Survey Sample Frame (email invitations sent to all eligible)	**4,355**
Email was returned (bounce back)	283
Did not respond	3,375
Opt-out of surveys	11
PPL Electric Utilities or market research employee	36
Did not complete survey	38
Completed Surveys	**612**
Online Response rate	**14%**

[1] Number of rebates for refrigerators and freezers available in PPL Electric Utilities' tracking database through the third quarter of the year, at the time of the final survey effort.

Appendix N. Evaluation Detail – Student Energy Efficient Education Program

N.1 Gross Impact Evaluation

N.1.1 Methodology

Evaluation Sampling Approach

Table N-1 lists the program sampling strategy for the impact evaluation. The impact evaluation activities produced results with ± 85% precision at 1.03% confidence.

Table N-1. Student Energy Efficient Education Program Impact Evaluation Sampling Strategy

Stratum	Population Size	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
Bright Kids, Take Action, Take Action Pilot, Innovation, Innovation Pilot	24,214(1)	N/A (2)	All available	24,214(1)	Records review
Bright Kids	5,003	N/A	All available	3,796	Online and paper HEWs
Take Action	12,422	N/A	All available	8,663	Online and paper HEWs
Take Action Pilot	1,658	N/A	All available	1,353	Online and paper HEWs
Innovation	4,109	N/A	All available	2,646	Online and paper HEWs
Innovation Pilot	1,022	N/A	All available	765	Online and paper HEWs
Program Total	**24,214**			**17,223**	

(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.

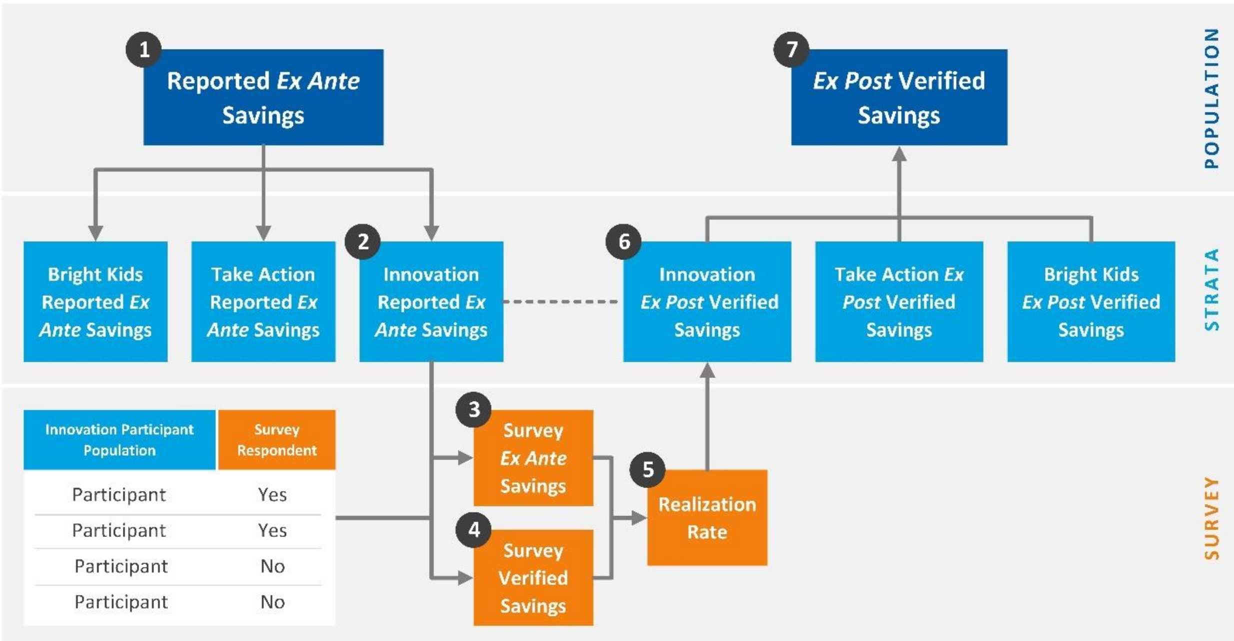
Ex Post *Verified Savings Methodology*

Cadmus estimated *ex post* verified savings for the Student Energy Efficient Education Program for each student cohort and for the program overall using the ICSP's reported savings and the paper and online Home Energy Worksheets (HEWs). Figure N-1 presents a flow diagram of the methodology. The rest of this section describes the methodology in greater detail.

Reported *Ex Ante* Savings (Flow Diagram Items 1 & 2)

Cadmus collected reported savings for each product and kit distributed to the population of program participants through PPL Electric Utilities' tracking database. Part of Cadmus' quality control process for evaluating the Student Energy Efficient Education Program involved understanding how the ICSP calculated reported savings. To do this, Cadmus verified that the ICSP calculated per-unit savings according to the planning ISRs and PA TRM inputs specified in the planning documentation Cadmus received during PY8. This process ensured that Cadmus and the ICSP were not making drastically different assumptions in assigning savings to program participants.

Figure N-1. *Ex Post* Verified Savings Methodology Flow Diagram



Survey *Ex Ante* and Survey-Verified Savings (Flow Diagram Items 3, 4, & 5)

Cadmus estimated stratum-level realization rates using individual survey responses for the sample of program participants who returned a HEW. Cadmus assigned per-unit survey *ex ante* and survey-verified savings to every participant, kit, and product in the survey data. Survey *ex ante* and survey-verified savings are defined as follows:

- ***Survey* ex ante *savings*** are reported *ex ante* savings assigned to the subset of program participants who returned a HEW and provided enough information on the HEW to verify their savings for a particular product.
- ***Survey-verified savings*** are savings verified by Cadmus and assigned to the subset of program participants who returned a survey. Survey-verified savings incorporate data from responses to HEW questions about product installations, home characteristics, and heating and water heating fuel saturations.

Cadmus assigned survey *ex ante* and survey-verified savings to program participants based on the criteria listed in Table N-2. A discussion on the PA TRM inputs that Cadmus collected through survey data are provided in the *Survey-Verified Savings Inputs* section in this appendix.

Table N-2. Criteria for Assigning Survey *Ex Ante* and Survey Verified Savings

Criteria	Survey *Ex Ante* Savings [1]	Survey-Verified Savings
Whether the respondent answered the product-specific question(s)	✓	✓
How the respondent answered questions about home characteristics		✓
How the respondent answered the questions asking if products were installed		✓

[1] Cadmus used the ICSP-reported *ex ante* savings for survey *ex ante* savings based on the listed criteria.

Table N-3 provides an example of how Cadmus assigned survey *ex ante* and survey-verified savings to each program participant and kit product, which, in this example, is a showerhead from the Take Action cohort. Cadmus included participants in the realization rate analysis if it could definitively verify whether the participant achieved savings for a particular product. In cases where it could not verify savings, because either the participant did not return a HEW or did not respond to the necessary installation question, it did not include them in the realization rate analysis.

In the example, Cadmus had enough information from program participants A through E to verify their showerhead savings:

- Although Participant D did not respond to the installation question, they indicated they did not have electric heat so they are ineligible to receive savings regardless of whether they installed the product. Therefore, Cadmus assigned this participant 0 kWh/yr savings.
- Similarly, although Participant E did not indicate water heat fuel type, they indicated they did not install the product, so Cadmus assigned this participant 0 kWh/yr savings.
- Participant F's showerhead savings were not included in the realization rate because Cadmus could not confirm whether the participant installed the showerhead from the kit, based on the participant's response to the installation question in the survey.
- Participant G's showerhead savings were not included in the realization rate because Cadmus could not confirm whether the participant had electric water heat based on the participant's response to the water heating fuel type question in the survey.
- Participants X, Y, and Z did not return a survey, so Cadmus could not verify savings for any of their products.

Table N-3. Example of Assigning Survey *Ex Ante* and Survey Verified Savings

Program Participant (PPL EU)	Reported *Ex Ante* kWh/yr (ICSP)	Survey Respondent (Survey Data)	Installed Product (Survey Data)	Electric Water Heat (Survey Data)	Survey *Ex Ante* kWh/yr	Survey Verified kWh/yr	Savings Included in Realization Rate
Participant A	121.42	Yes	Yes	Yes	121.42	390.09(1)	Yes
Participant B	121.42	Yes	No	Yes	121.42	0	Yes
Participant C	121.42	Yes	Yes	No	121.42	0	Yes
Participant D	121.42	Yes	No Response	No	121.42	0	Yes
Participant E	121.42	Yes	No	No Response	121.42	0	Yes
Participant F	121.42	Yes	No Response	Yes	N/A	N/A	No
Participant G	121.42	Yes	Yes	No Response	N/A	N/A	No
Participant X	121.42	No	N/A	Yes	N/A	N/A	No
Participant Y	121.42	No	N/A	Yes	N/A	N/A	No
Participant Z	121.42	No	N/A	No	N/A	N/A	No

(1) Survey-verified savings calculated for this example assuming respondent indicated four people in the home and two showers.

Ex Post Verified Savings (Flow Diagram Items 6 & 7)

To calculate cohort-level *ex post* savings, Cadmus applied the cohort-level realization rates to cohort-reported *ex ante* savings. Taking the sum of cohort-level *ex post* savings estimated the program-level *ex post* savings.

Cadmus calculated confidence and precision for the *ex post* savings and realization rate estimates in each cohort and for the program as a whole.

Survey-Verified Savings Inputs

Cadmus independently calculated verified savings according to the PA TRM and the associated algorithms.[195] These algorithms include open variables for which the ICSP or Cadmus can use either the default or the option of "EDC data gathering." Table N-4 lists the algorithm inputs, method of data collection, and source of the data collected.

Table N-4. PA TRM Algorithm Open Variables

Product	Open Variable	Data Collection Method	Data Collector
LED	In-service rate (ISR)	HEW ISR	ICSP's Subcontractor
	Wattage of installed bulb	Spec sheet	ICSP
Showerhead	ISR	HEW ISR	ICSP's Subcontractor
	GPM of installed	Spec sheet	ICSP
	Number of persons in household	HEW	ICSP's Subcontractor
	Number of showers in household	HEW	ICSP's Subcontractor
	Water heater fuel	HEW	ICSP's Subcontractor
Kitchen Faucet Aerator	ISR	HEW ISR	ICSP's Subcontractor
	Water heater fuel	HEW	ICSP's Subcontractor
	Housing type	HEW	ICSP's Subcontractor
	Number of persons in household	HEW	ICSP's Subcontractor
Smart Power Strip	ISR	HEW ISR	ICSP's Subcontractor
	Use (entertainment, computer, unspecified)	HEW ISR	ICSP's Subcontractor
Water Heater Setback	Number of degrees water heater turned down (calculated using the midpoint of the ranges provided in HEW response options)	HEW	ICSP's Subcontractor
	Washing machine located in home	HEW	ICSP's Subcontractor
	Water heater fuel	HEW	ICSP's Subcontractor

[195] Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2016, errata update February 2017. Available online: http://www.puc.state.pa.us/Electric/docs/Act129/TRM-2016_Errata_Feb2017.docx

N.1.2 Database Review Findings

Cadmus reviewed both PPL Electric Utilities' and the ICSP's databases as well as the sources for inputs used in *ex ante* savings calculations. Cadmus compared the number of HEWs the ICSP collected and the number of HEWs reported in PPL Electric Utilities' tracking database.

The database the ICSP provided to Cadmus contained 17,223HEWs (which Cadmus used for its savings analysis), while PPL Electric Utilities' tracking database suggested that 17,317 HEWs were returned, a discrepancy of 94 HEWs missing from the ICSP's database (resulting in database accuracy of 99.5%). In addition, one respondent returned the HEW survey with invalid survey responses (i.e., response options not available on the HEW). Cadmus removed this respondent from the survey analysis (but retained this participant in the population).

Within the PPL Electric Utilities' tracking database, Cadmus found a few discrepancies for Innovation Pilot power strips:

- For the Innovation Pilot, Tier 2 advanced power strips savings were not claimed for the entire population of distributed kits. Instead, the ICSP claimed savings only for the quantity of power strips confirmed as installed from the returned surveys.
- As a result of the ICSP's approach to claim savings for Innovation Pilot power strips, teacher records in PPL Electric Utilities' tracking database were missing data entirely for power strips when teachers did not return any HEWs. This happened for five teacher records, representing 82 students. A further 177 students who did not return a survey were also not represented.
- When the ICSP claimed power strip savings for Innovation Pilot records, it included an ISR (72%). However, since it claimed savings only for power strips confirmed as installed from the surveys, the ICSP essentially applied the ISR twice.

Altogether, these discrepancies understated the savings for Tier 2 advanced power strips. Cadmus calculated *ex post* savings based on the quantity of power strips distributed and not the quantity used by the ICSP to claim *ex ante* savings. This led to substantially higher verified savings than reported savings for the Innovation Pilot.

N.1.3 Equipment Level Realization Rates

Table N-5 presents the realization rates for each equipment type or improvement by stratum. Realization rates at the equipment type or improvement level use the total *ex ante* reported savings (Sample Reported kWh) and total verified savings (Sample Evaluated kWh) for the sample of students who returned surveys. Evaluated savings use data gathered from the HEWs to calculate verified savings. Reported savings are calculated by the ICSP and may use different inputs. The Primary Driver column identifies which differences in the data gathered from the HEW (for verified savings) and planning inputs (for reported savings) primarily led to realization rates higher or lower than 100%.

Table N-5. Energy Realization Rates by Stratum and Measure

Stratum	Equipment Type or Improvement	Sample Reported kWh[1]	Sample Evaluated kWh	Realization Rate	Primary Driver
Bright Kids	LED	436,084	398,124	91%	Lower HEW ISR than used to calculate reported savings, likely due to addition of fourth bulb.
Innovation	LED	296,564	285,821	96%	Lower survey-gathered ISR than planned, likely due to addition of fourth bulb.
	Water Heater Setback	44,936	42,531	95%	The survey found an average change in water heater setting of 5.4 degrees (calculated using the midpoint of the ranges provided in HEW response options), compared to the planned value of 11 degrees from the TRM.
	Showerhead	262,888	307,042	117%	ISR and electric water heater saturation from survey were higher than planned.
	Tier 1 Smart Strip	111,778	132,901	119%	ISR from survey was higher than planned, and entertainment center savings were applied to 33% of smart strips rather than 0% planned.
Innovation Pilot	LED	85,741	87,049	102%	Higher ISR than planned.
	Water Heater Setback	12,938	10,331	80%	The survey found an average change in water heater setting of 5.1 degrees (calculated using the midpoint of the ranges provided in HEW response options), compared to the planned value of 11 degrees from the TRM.
	Showerhead	76,094	108,992	143%	ISR and electric water heater saturation from survey were higher than planned.
	Tier 2 Advanced Power Strip	73,204	136,187	186%	Cadmus evaluated savings for all kits rather than just those confirmed as installed. The claimed savings for those installed also included an ISR, although one was being implicitly applied.
Take Action	Faucet Aerator	226,451	482,779	213%	Number of people per home from the survey data was more than double the planning value derived from the TRM.
	LED	958,821	908,056	95%	Lower survey-gathered ISR than planned, likely due to addition of fourth bulb.
	Water Heater Setback	144,917	86,662	60%	Survey found an average change in water heater setting of 5.1 degrees (calculated using the midpoint of the ranges provided in HEW response options), compared to the planned value of 11 degrees from the TRM.
	Showerhead	842,735	882,895	105%	The survey-gathered ISR was higher than planned.
Take Action Pilot	Faucet Aerator	35,390	65,668	186%	Number of people per home from the survey data was more than double the planning value derived from the TRM.
	LED	149,639	139,986	94%	The survey-gathered ISR was lower than planned, likely due to addition of fourth bulb.
	Water Heater Setback	22,080	17,155	78%	The survey found an average change in water heater setting of 5.4 degrees (calculated using the midpoint of the ranges provided in HEW response options), compared to the planned value of 11 degrees from the TRM.
	Showerhead	132,760	118,155	89%	The survey-gathered showers-per-home estimate was substantially higher than planned value derived from the TRM.

(1) Because N/A and zero should be distinguished when calculating the sample evaluated savings, corresponding savings are also removed from the sample reported savings. Therefore, sample reported savings will be lower than reported savings in PPL Electric Utilities' tracking database.

Appendix O. Evaluation Detail – Demand Response Program

O.1 Gross Impact Evaluation

The principal objective of the Demand Response Program impact evaluation was to estimate participant load impacts from Act 129 events and to determine whether PPL Electric Utilities complied with the demand response load reduction targets of Act 129. During PY9, Pennsylvania initiated three Act 129 demand response events on June 13, 2017, July 20, 2017, and July 21, 2017.

This appendix describes the methodology, including sampling and savings estimation, for estimating the program load impacts.

O.1.1 Methodology

Evaluation Sampling Approach

In PY9, 93 facilities participated in one or more Act 129 demand response events. Table O-1 shows the number of participant facilities by customer type stratum. About two-thirds of participants were small commercial facilities. Cadmus estimated load impacts for all participant facilities except one. As discussed further below, it was not possible to estimate savings for one small C&I facility because this facility's readings were estimates, not actuals, during event hours.

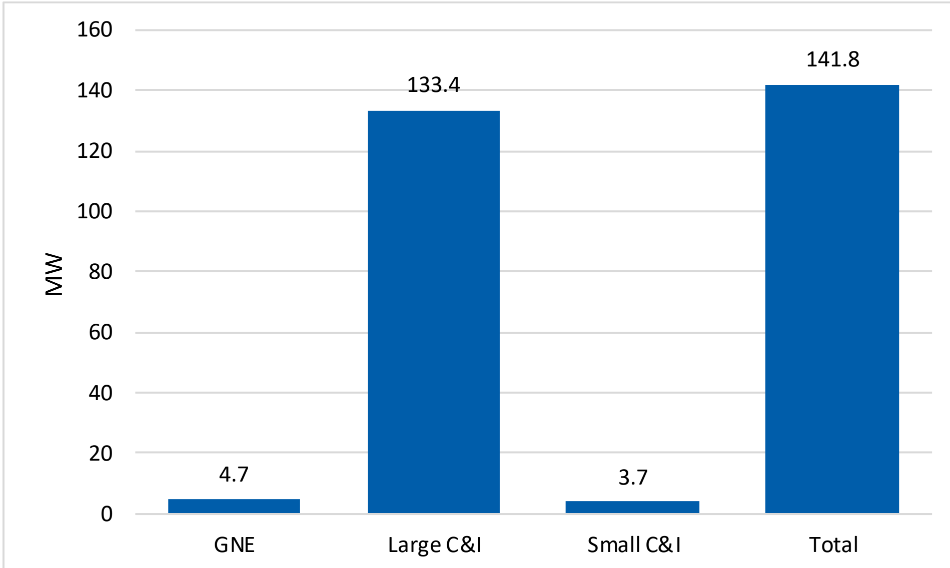
Table O-1. PY9 Program Sampling Strategy

Stratum	Population Size	Target Levels of Confidence & Precision	Target Sample Size	Achieved Sample Size	Evaluation Activity
GNE	10	N/A	10	10	Analysis of load impact data
Large Commercial and Industrial	23	N/A	23	23	Analysis of load impact data
Small Commercial	60	N/A	60	59	Analysis of load impact data
Program Total	**93**	**N/A**	**93**	**92**	**Analysis of load impact data**

As Figure O-1 shows, although they represented 65% of participant facilities, small commercial facilities contracted for only 3.7 MW or 2.6% of the program's enrolled capacity.[196] Large C&I customers contracted for 133.4 MW or 94% of the program's enrolled capacity. GNE customers contracted for the remaining capacity of 4.7 MW.

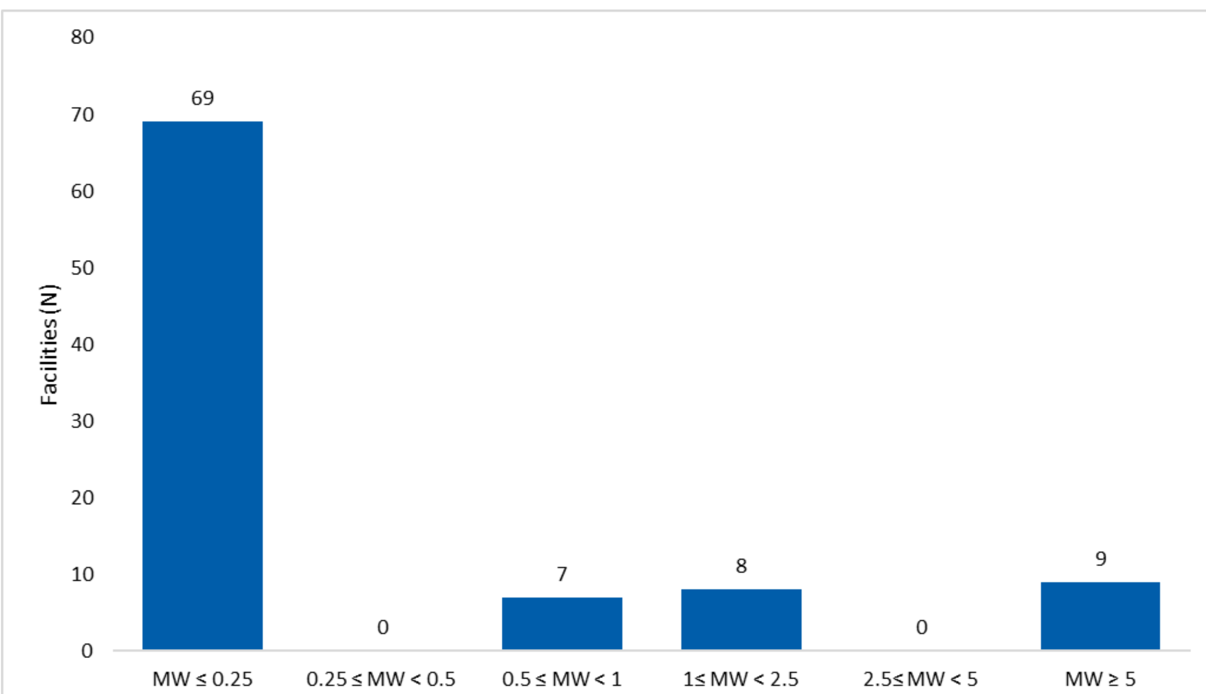
[196] Contracted capacity refers to the capacity committed by the facility to CPower and enrolled in the program. The capacity provided by the facility during Act 129 events may have differed from the contracted amount.

Figure O-1. Enrolled Demand Response Capacity by Customer Segment



As Figure O-2 shows, most enrolled demand response capacity was provided by a small number of facilities. Of 93 participants, 69, or 74%, each contracted for less than 250 kW. Only 17 facilities contracted to supply one or more megawatts. Collectively, these facilities contracted for 94% of the program's enrolled capacity.

Figure O-2. Distribution of Demand Response Program Enrolled Capacity



Note: To protect the identity of participants, this figure does not display bins above 5 MW.

Ex Post Verified Savings Methodology

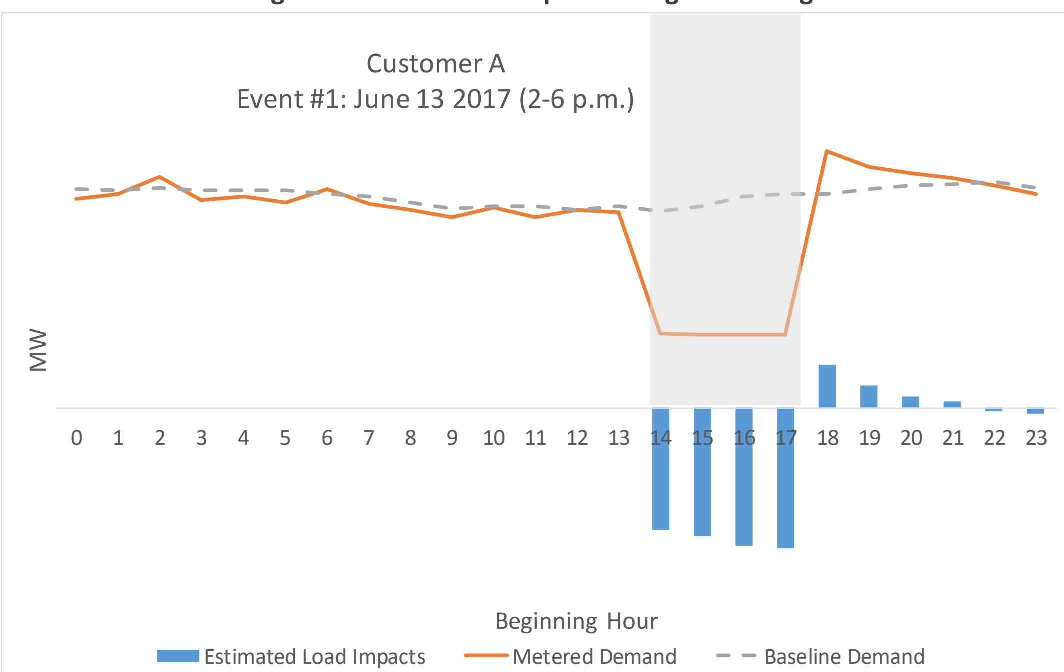
Cadmus analyzed AMI interval consumption data for individual participant facilities. A facility was defined as the area over which the participant's electricity consumption was metered and the load reductions measured during PY9 Demand Response Program period (June 1, 2017, to September 30, 2017). Cadmus estimated the facility load impacts as the difference between baseline electricity demand and metered demand, as shown in this equation:

kW impact = Baseline kW - Metered kW

Baseline demand is a counterfactual and represents what the facility's load would have been if the load curtailment event had not been called. The baseline is unobservable and must be estimated. Accurate estimation of load impacts requires establishing a valid baseline.

Figure O-3 illustrates the demand response event savings estimation for a hypothetical participant facility (Customer A). The shaded area shows the event window between 2:00 p.m. and 6:00 p.m. The solid line shows the metered consumption, and the dashed gray line shows the estimated baseline. The demand savings shown as blue bars represent the reduction in demand relative to the baseline caused by the event. Figure O-3 also depicts an increase in load, or snapback, after the event, shown as metered load lying above the baseline during hours 18 through 20. The average demand savings per event hour are calculated as the average of the estimated hourly load reductions between 2:00 p.m. and 6:00 p.m.

Figure O-3. Demand Response Program Savings



Data Collection

Cadmus collected data from several sources to evaluate the PY9 Demand Response Program impacts. Table O-2 lists the data and sources.

Table O-2. Data Sources

Data	Population	Period	Variables	Source
Customer information system data	Demand Response Program participant facilities	From beginning of enrollment to end of summer 2017	Customer name, account number, business segment, ICSP baseline calculation method, enrolled MW, event hour participation indicators and reported load reductions, advance notification times, PJM economic market participation dates	CPower (ICSP)
PJM day-ahead forecasts and Act 129 event dates and hours	PPL Electric Utilities Demand Response Program participants	Summer 2017	Event dates and hours	PPL Electric Utilities, CPower (ICSP), PJM Interconnection LLC website
Facility interval consumption data	PPL Electric Utilities Demand Response Program participants	April 1, 2017–September 30, 2017	15 minute or hour interval kWh, estimated read indicator	PPL Electric Utilities
Weather	11 weather stations in PPL Electric Utilities service area	June 2017–August 2017	Dry-bulb temperature	NOAA
Line losses	Commercial and industrial electric utility customers	Phase III Act 129	Line loss factor	PA Technical Resource Manual (2016), Table 1-4

PPL Electric Utilities provided 15-minute or one-hour interval consumption data between April 1, 2017, and September 30, 2017, for 93 participant facilities. Cadmus aggregated all facility 15-minute interval data to the hour level. The energy consumption data included a very small percentage (0.1%) of missing readings. Also, a small percentage of intervals was estimated or included one or more estimated or missing 15-minute intervals. Cadmus flagged these observations and set them to missing for the analysis. Estimated readings were not used in the calculation of facility baselines or in estimating savings. In fact, it was not possible to estimate demand savings for one small commercial facility because its consumption was estimated during each event hour in PY9.

Cadmus also screened the data for outliers but did not remove any observations. Before June 1, 2017, a small number of big box stores had negative readings during a small number of morning hours, but Cadmus inferred from the time of day and outside temperature as well as corroborating articles in the press about solar panel installations by participating big box store chains that these probably represented negative net demand for utility-supplied electricity because of on-site solar generation of electricity.

Table O-3 summarizes the outcome of the kWh data cleaning process.

Table O-3. Energy Data Summary

Observations	Number	Percentage
Participant facilities	93	100%
Total observations	408,456	100%
Obs. with missing kWh readings	261	0.1%
Obs. with estimated kWh readings	7,407	1.8%
Obs. in final analysis sample	400,788	98.1%

The ICSP provided Cadmus information about each participant facility's business segment, customer baseline calculation method, enrolled MW, participation in each event hour, and event advance notification times. The ICSP also provided information about facilities that had participated in the PJM economic market. During PY9, three Act 129 participant facilities participated in the PJM market.

Cadmus located the closest National Oceanic and Atmospheric Administration (NOAA) weather station and mapped hourly temperature data to the kWh data. Cadmus mapped weather data to participant facilities from 11 stations across the PPL Electric Utilities service area. The average temperature during event hours was 90.2°F.

Table O-4 shows summary statistics for the analysis sample, including weekday event and non-event hours between 2:00 p.m. and 6:00 p.m. for all facilities and by customer segment. Participants consumed an average of 0.93 MWh per event hour per facility, although there was significant variation in consumption between customer segments. Large C&I facilities consumed about 2.4 MWh per hour per facility, while small C&I participants consumed about one-tenth of this amount.

The ICSP estimated average savings per participant facility per event hour of 2.4 MW, but on average, only 52% of facilities participated in each event hour. Small C&I facilities participated in only 33% of event hours because only one of 60 facilities participated in the July 20 event and none participated in the July 21 event.

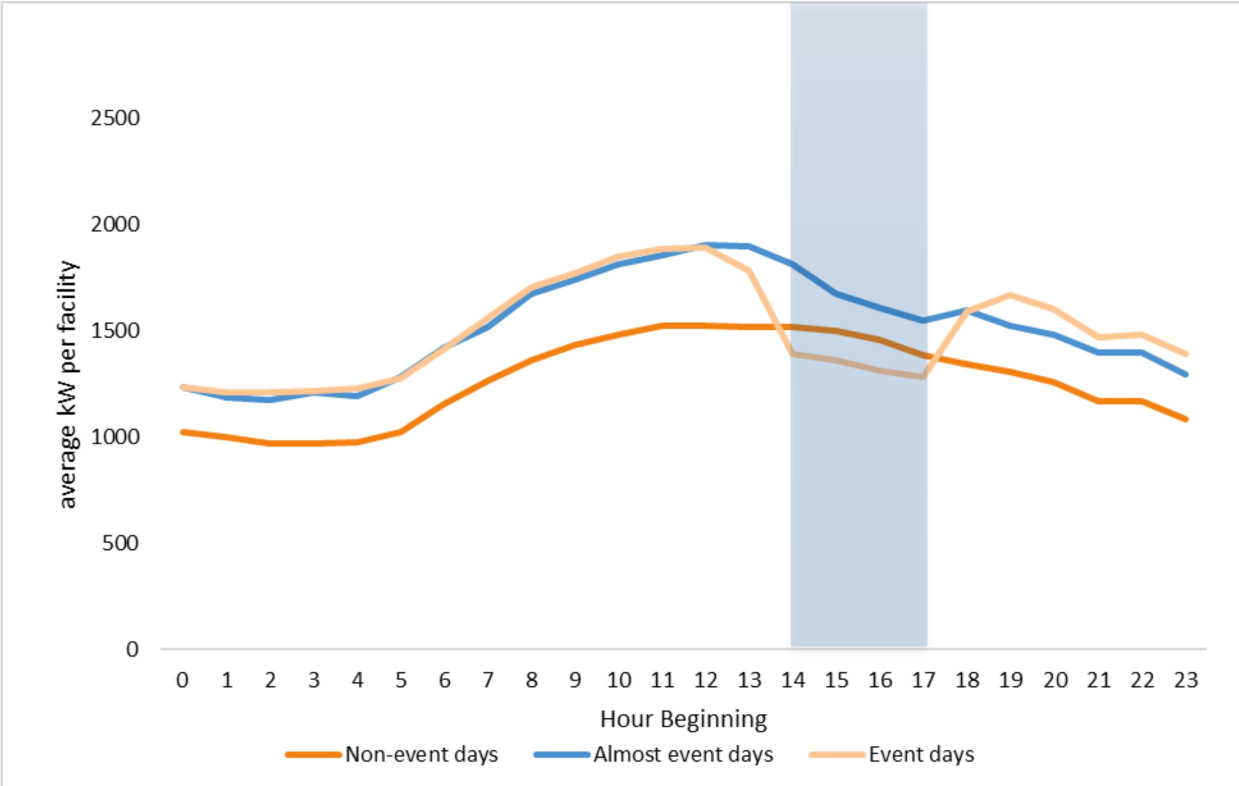
Table O-4. Sample Summary Statistics

		All Facilities	GNE	Large C&I	Small C&I
Panel A: Event Hours					
kWh/hour		936.4	1339.3	2408.7	281.2
		(2294.3)	(2080.4)	(3950.0)	(125.5)
Outside Temperature (°F)		90.2	91.1	91.3	89.6
		(4.2)	(3.4)	(2.8)	(4.6)
Event Participation (=1 if Yes, =0 if No)		0.52	0.93	0.83	0.33
		(0.50)	(0.25)	(0.37)	(0.47)
CPower Savings Estimate		2384.4	283.0	5896.8	-11.0
		(5813.4)	(543.7)	(8056.6)	(64.8)
PJM Economic Participation		0	0	0	0
		0.0	0.0	0.0	0.0
N		1,116	120	276	720
Panel B: Non-event Hours					
kWh/hour		2041.4	1467.7	6802.1	262.3
		(5058.5)	(1787.9)	(8324.8)	(122.4)
Outside Temperature (°F)		74.3	75.1	74.5	74.1
		(9.8)	(9.8)	(9.8)	(9.8)
Event Participation (=1 if Yes, =0 if No)		0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0
CPower Savings Estimate		0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0
PJM Economic Participation		0.003	0.000	0.011	0.000
		(0.05)	0.00	(0.10)	0.00
N		46,132	4,960	11,408	29,764
Note: All summary statistics are sample hourly averages for hours between 2:00 p.m. and 6:00 p.m. on event and non-event days between April 1, 2017 and September 30, 2017. Sample standard deviations in parentheses.					

For GNE, large C&I, and small C&I facilities, Figure O-4, Figure O-5, and Figure O-6 show the average kWh per hour per facility on event days, “almost Act 129 event days,” and all other non-holiday weekdays between June 1, 2017, and September 30, 2017, that were not notification days. Almost-event days were July 12, 2017, and July 13, 2017. In PY9, these days had the highest day-ahead PJM forecasts that did not qualify them as Act 129 days nor provide a natural baseline for assessing the impact of Act 129 events. These figures show demand at the meter and do not account for line losses.

For GNE facilities, the Act 129 event impacts between 2:00 p.m. and 6:00 p.m. are clearly evident as a reduction in load relative to demand on almost-event days. On average, demand on non-event days was significantly less than was demand on event or almost-event days, and the difference was greatest during the late morning and early afternoon. Event days tended to be warmer, and space conditioning was a major electricity end use in GNE facilities. The difference between event and non-event days suggests that many of the non-event days may not provide an accurate baseline for event days.

Figure O-4. Average kW per GNE Participant Facility in PY9



The impacts of Act 129 events between 2:00 and 6:00 p.m. on loads of large C&I facilities are also evident in Figure O-5. Average demand per facility during non-event hours (outside the 2:00 p.m. to 6:00 p.m. window) was significantly less on event days than on non-event or almost-event days. This suggests that at least some participants may have reduced their loads in preparation for the events on the days before events or the event days in response to receiving event notifications. On non-event days, average demand per facility was constant and suggests demand was not sensitive to weather. On almost-event days, there was a reduction in load relative to non-event days between 2:00 p.m. and 6:00 p.m. This may have been the result of PJM market economic program participation by several Act 129 participants. Four large C&I participants with significantly more than 20 MW of combined enrolled demand response capacity participated in the PJM market on July 12 or July 13.

Figure O-5. Average kW per Large C&I Participant Facility in PY9

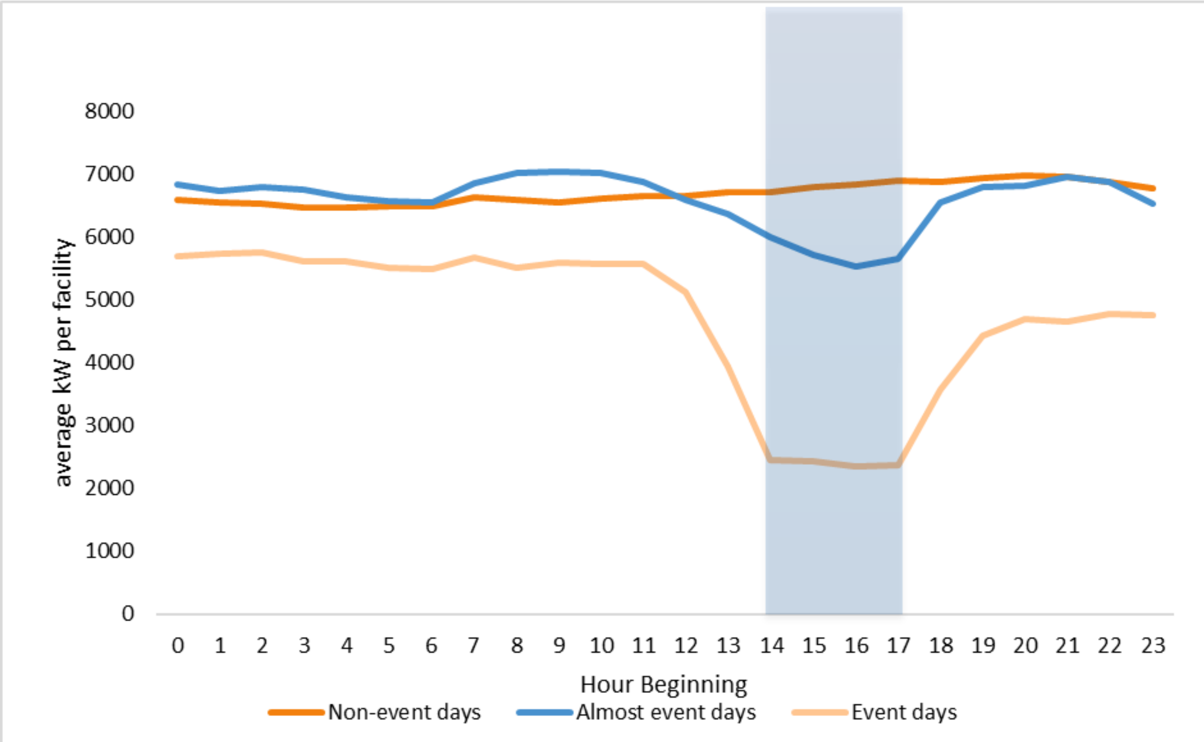


Figure O-6 shows loads for small C&I facilities on the June 13 event, non-event days, and almost-event days. Fifty-nine small C&I facilities participated in the June 13 event. Loads on non-event days were lower than on event and almost-event days and do not exhibit a shape suggestive of significant energy consumption for air conditioning, again suggesting that some non-event days may not provide a valid baseline.

Baseline Calculation Approach

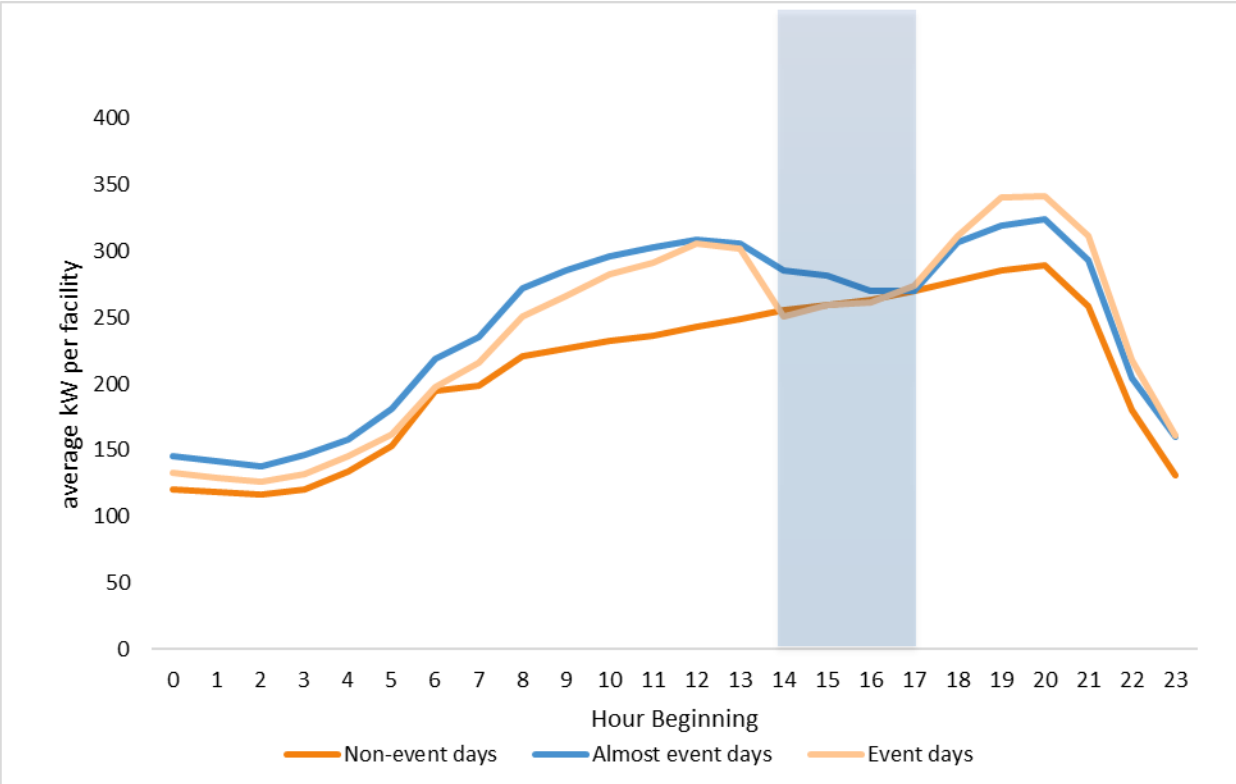
Day-Matching Customer Baselines and Regression Baselines

Cadmus estimated individual consumption baseline for each participant facility and event using either a day-matching approach or regression. Day-matching identifies a set of nearby, non-event, non-holiday weekdays for each event day, referred to as the *basis window*. For each event hour, the baseline is the average consumption during the same hour of the days or subset of days in the basis window. Cadmus considered a variety of general day-matching methods for estimating the baselines of participating facilities:

- *Y Previous Days*: This is the average load of Y days in the CBL basis window.
- *X Highest of Y Previous Days*: This is the average load of the X days with highest loads of Y days in the basis window.

Y Previous Days of Same Day Type: This is the average load of Y days of the same day type (e.g., Wednesday) in the basis window. For example, if Y=3 and the event occurs on a Wednesday, the CBL basis window would only include three previous Wednesdays.

Figure O-6. Average kW per Small C&I Participant Facility in PY9



When applying a day-matching method, Cadmus excluded the following types of days from the basis window:

- Weekend days
- Days with average load between 2 p.m. and 6 p.m. less than 25% of the average load of all days in the baseline window. This exclusion follows PJM protocol and should result in the exclusion of most days when a facility had abnormally low consumption. Cadmus replaced excluded days with the next permissible day.
- Holidays
- Facility closures
- Previous event days
- Weekdays more than 45 days before the event day
- PJM economic participation days
- Act 129 notification days

Cadmus did not make any adjustments to the estimated baseline based on the difference between the baseline and the metered load during hours preceding the event. Adjustments of this kind were not permitted because PPL Electric Utilities' Demand Response Program involved day-ahead notification of

Act 129 events.[197] Below, Cadmus provides evidence that some participant facilities adjusted their loads in response to the advance notifications.

Day-matching was the method employed by the ICSP to estimate impacts and make settlement calculations. By aligning, to the extent possible, its day-matching baseline calculation methods with Cadmus, the ICSP eliminated a possible source of difference between the reported and evaluation impact estimates.

Cadmus employed regression analysis as the second baseline calculation approach. Regression involves estimating an equation to predict hourly consumption as a function of multiple independent variables such as day of the week, hour of the day, and weather. Regression controls for the impacts of weather on energy consumption better than day-matching and is expected to be superior to day-matching especially for facilities with weather-sensitive loads.

Standard Errors of Demand Savings Estimates

Cadmus calculated 90% confidence intervals for the gross verified demand savings from the standard errors for the savings estimates of individual facilities. For facilities with regression baselines, Cadmus estimated the standard errors for the estimates of average demand savings per event hour using the estimated variances and co-variances of the hourly demand savings estimates. For facilities with day-matching baselines, Cadmus followed SWE's and PJM's guidance to predict loads on non-event days in 2017 and to estimate the margin of error at the 90% confidence level as the root mean square error (RMSE). Cadmus calculated the RMSE for the day-matching baseline using baseline predictions for hours between 2:00 p.m. and 6:00 p.m. on non-holiday, non-event and non-notification days between June 1, 2017, and September 30, 2017.

Act 129 Events in Program Year 9

Table O-5 presents the Act 129 event dates, hours, advance notification date and times, and the average outside temperature during events in PY9.

Table O-5. PY9 Act 129 Events Dates and Times

Event Date	Event Hours	Advance Notification Date and Time	Average Outside Temperature (°F) During Event
Tuesday, June 13, 2017	2:00 p.m. - 6:00 p.m.	June 12, 2017, 10:33 a.m.	92.4
Thursday, July 20, 2017	2:00 p.m. - 6:00 p.m.	July 19, 2017, 10:02 a.m.	90.8
Friday, July 21, 2017	2:00 p.m. - 6:00 p.m.	July 20, 2017, 11:02 a.m.	89.5
Note: Advance notification times were obtained from CPower through Cadmus data request.			

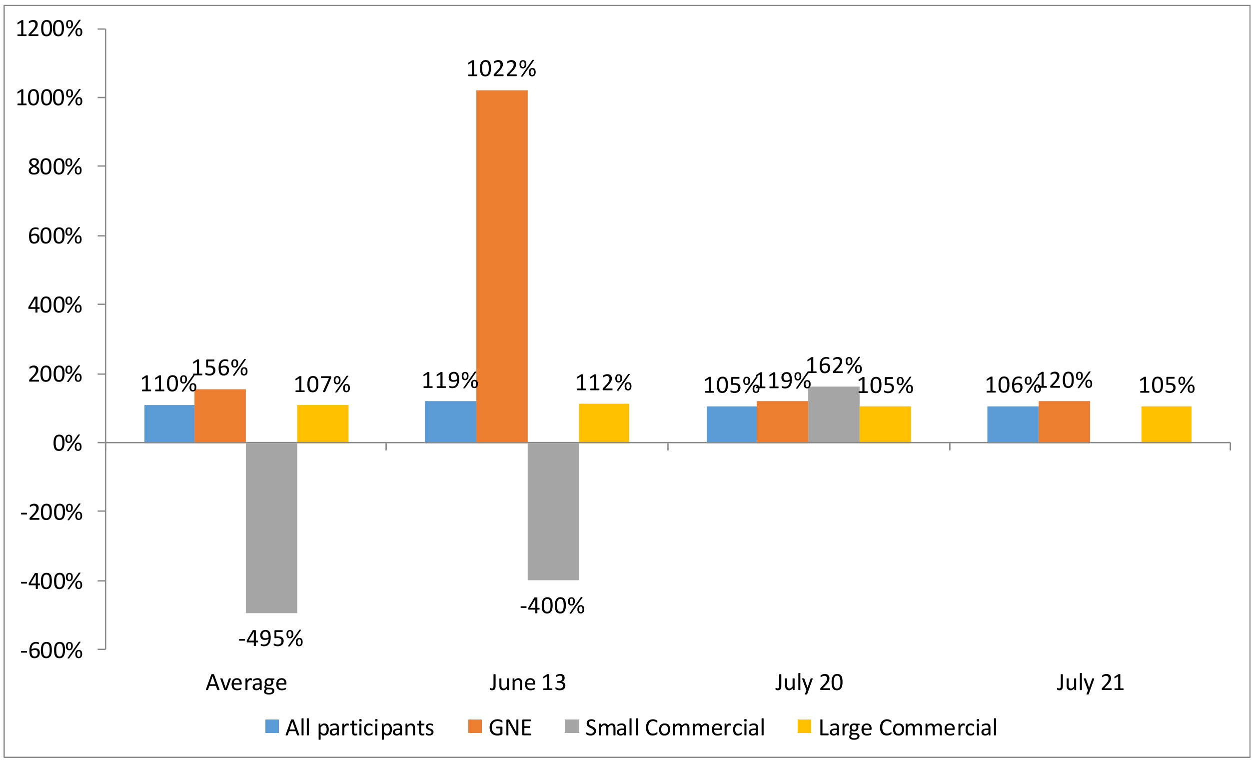
197 See Goldberg, Miriam, and G. Kennedy Agnew. *Measurement and Verification for Demand Response.* Prepared for the National Forum on the National Action Plan on Demand Response: Measurement and Verification Working Group. 2013. The exception to this rule would be an adjustment based on an exogenous variable such as weather or the PJM day-ahead forecast of load or actual load.

Note that the second and third events were on consecutive days. Participants received notification of the July 21, 2017 event before the start of the July 20 event. This may have caused some large C&I customers not to resume normal business operations after the July 20 event ended because another event would occur during the next day.

O.1.2 Realization Rate Findings

Figure O-7 shows the savings realization rate—the ratio of gross verified to gross reported savings—for each Act 129 event and the average across events. The realization rates ranged from 105% for the July 20 event to 119% for the June 13 event. Across all events, the savings realization rate was 110%. The biggest discrepancies between gross reported and verified savings occurred for GNE and small commercial participants. For the June 13 event, Cadmus estimated savings of 3.1 MW for small C&I participants while the ICSP estimated savings of -0.7 MW. Similarly, for the same event, Cadmus estimated savings of 3.5 MW for GNE participants while the ICSP estimated savings of 0.3 MW.

Figure O-7. Event Savings Realization Rates



Note: Realization rates estimated based on Cadmus analysis of AMI interval consumption data for participant facilities and ICSP reported demand savings.

For the June 13 event, Cadmus estimated savings approximately 20% higher than the ICSP (CPower) for two reasons. First, as noted above, the day-matching estimator that the ICSP used for the GNE and small C&I facilities substantially underpredicted baseline demand and therefore demand savings during events. Second, Cadmus excluded event notification days from the basis window while the ICSP did not. As shown above, several large C&I facilities with large enrolled capacity may have reduced their consumption in response to the June 12 event notification. Including notification days has the effect of reducing the estimated baseline and savings.

O.2 Process Evaluation

O.2.1 Additional Findings

This section includes additional process evaluation findings.

Logic Model Review

Cadmus reviewed the Demand Response Program's logic model and determined this program is operating as expected. Table O-6 summarizes the outcome of the logic model review.

Table O-6. Demand Response Program Logic Model Review

Expected PY9 Outcome	Logic Model Element	Actual PY9 Outcome
ICSP recruits eligible C&I customers, identifies event days and sends notifications, estimates peak reductions for each participant, prepares to process incentives	**Program Activities**	Program activities conducted as planned
ICSP successfully recruits customers, customers enroll in events, and incentives paid	**Outputs Produced by Program Activities**	Delivered most outputs as expected in PY9; incentive payments delayed
Act 129 demand reduction requirements met	**Short-term Outcomes**	Produced short-term outcomes (PY9)
Proven reliability of the Demand Response Program to deliver demand reductions, compliance with the PaPUC's Act 129 demand response rules	**Intermediate Outcomes (second and third program year)**	On track to produce intermediate outcomes
PPL Electric Utilities meets the PaPUC's Act 129 DR requirements, customers are satisfied with the program and with PPL Electric Utilities	**Long-Term Outcomes (end of Phase III)**	On track to produce long-term outcomes

Participant Profile

Most participating companies (16 of 26) in PPL Electric Utilities' Demand Response Program are large C&I customers with the remaining participation equally divided between small C&I and GNE customers (Table O-7). Manufacturing, the predominant participant industry, contributes roughly 94% of the total load reduction, followed by the retail industry. Event load reduction is largely driven by a select few participants—the top five participants, ranked by enrolled MW load reduction, represent 74% of the total enrolled MW, and the top 10 participants represent 92%.

Table O-7. Participant and Respondent Profile

Sector	Unique Participating Companies	Interview Respondents
Large C&I	16	6
Small C&I	5	3
GNE	5	1
Total	**26**	**10**

O.2.2 Survey Approach

Contact Instructions

Cadmus contacted all 26 unique participating companies in the PY9 Demand Response Program. First each respondent received in introductory email from the ICSP and then Cadmus followed this up with telephone calls and emails.

Sample Attrition

Table O-8 lists total numbers of records contacted and the outcome (final disposition) of each record.

Table O-8. Demand Response Participant Interview Sample Attrition Table

Description of Telephone Call Outcomes	Count
Population (number of unique companies)	**26**
Removed: incomplete or bad phone number, inactive customer, completed survey in past 3 months, on "do not contact" list, opted out of survey, selected for a different survey, duplicate contact	**0**
Survey Sample Frame (used for telephone interview calls)	**26**
Not attempted	**0**
Records Attempted	**26**
Refusal	1
No answer/answering machine/phone busy/no response	15
Non-specific or specific callback scheduled	0
Partial complete (not included in survey findings analysis)	0
Completed Surveys	**10**
Response Rate (completed surveys divided by number of records attempted)	**38%**

Appendix P. Non-Energy Benefits

P.1 Non-Energy Benefits of Water-Saving Products

Cadmus quantified non-energy benefits in accordance with the SWE's Guidance Memo.[198] Non-energy benefits associated with water-saving measures include the gallons of water saved. According to the recommendation in the Guidance Memo, Cadmus assumed $0.01 in avoided cost, per-gallon saved, in TRC testing (after gross-up for distribution losses). Cadmus assumed 20% losses on water distribution, which is the low end of the range provided in the guidance memo (20% to 25%). The avoided cost of water is escalated over the TRC test horizon using the same inflation/escalation assumption embedded elsewhere in the TRC model.

P.2 Non-Energy Benefits of Natural Gas Savings

Per the Guidance Memo, Cadmus assumed that there is a natural gas therms penalty (negative benefit). Cadmus applied the therms penalty to the *ex post* kWh/yr savings, which incorporates the electric energy heating penalty in accordance with the TRM.

Therm benefits are calculated using the average annual avoided gas costs submitted with PPL Electric Utilities' Phase III EE&C plan.[199] The gas rate is an assumed marginal cost, so a distribution loss factor is applied to gross up impacts in the home to the water heating system.

P.3 Lighting Interactive Effects

The Guidance Memo states that "Installation of LED lighting equipment in homes and businesses with natural gas heating systems leads to an increase in gas usage because LEDs generate less waste heat than inefficient technologies. The reduced heat in the space must be compensated for by the heating system. The PA TRM provides interactive effect assumptions for electric heating and cooling systems, but not fossil fuel… The gas heating fuel share and percentage of lamps installed in interior sockets are taken from the 2014 Residential Baseline Study (Tables 5-29 and 5-50 and Figure 5-12)."[200]

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198 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

199 PPL Electric Utilities' revised EE&C plan (Docket No. 2015-2515642) filed with the Pennsylvania PUC December, 2017.

200 Guidance on the Inclusion of fossil fuel and H_2O benefits in the TRC Test, Statewide Evaluation Team, March 25, 2018.

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