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PPL Electric Utilities Annual Report to the Pennsylvania Public Utility Commission

Phase IV of Act 129 PY16 Annual Report (June 1, 2024 – May 31, 2025) for Pennsylvania Act 129 of 2008 Energy Efficiency and Conservation Plan

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Acronyms

AHRI	Air Conditioning, Heating, and Refrigeration Institute
AMI	Advanced metering infrastructure
ASHP	Air-source heat pump
C&I	Commercial and industrial
CADR	Clean air delivery rate
CDD	Cooling degree day
CEI	Continuous energy improvement
CF	Coincidence factor
CHP	Combined heat and power
C.L.	Confidence limit
CSP	Conservation service provider or curtailment service provider
CSS	Cross-sector sales
Cv	Coefficient of variation
DLC	DesignLights Consortium
DR	Demand response
DHW	Domestic hot water
DY	Delivery Year
EDC	Electric distribution company
EDT	Eastern Daylight Time
EER	Energy efficiency ratio
EE&C	Energy efficiency and conservation
EFLH	Equivalent fuel load hours
EM&V	Evaluation, measurement, and verification
EISA	Energy Independence and Security Act
EUL	Effective useful life
FCM	Forward Capacity Market
GNE	Government, nonprofit, educational
GPM	Gallons per minute
HDD	Heating degree day
HER	Home energy report
HEW	Home energy worksheet
HIM	High-impact measure
HOU	Hours of use
HP	Horsepower
HPWH	Heat pump water heater
HSPF	Heating seasonal performance factor
HVAC	Heating, ventilating, and air conditioning
ICSP	Implementation conservation service provider
IECC	International Energy Conservation Code
IMC	Incremental measure cost
IMP	Interim measure protocol
IPMVP	International Performance Measurement and Verification Protocol
ISR	In-service rate
kW	Kilowatt
kWh	Kilowatt-hour
KPI	Key performance indicator
LED	Light-emitting diode
LIURP	Low-Income Usage Reduction Program
M&V	Measurement and verification
MMMF	Master-metered multifamily
MW	Megawatt
MWh	Megawatt-hour
NPV	Net present value
NTG	Net-to-Gross
N/A	Not Applicable
O&M	Operations and maintenance
P3TD	Phase III to date
P4TD	Phase IV to date
PA PUC	Pennsylvania Public Utility Commission
PAC	Program administrator cost
PIV TD	Phase IV to date
PSA	Phase IV to date preliminary savings achieved; equal to VTD + PYRTD
PSA+CO	PSA savings plus carryover from Phase III
PY	Program Year: for example, PY16, from June 1, 2024, to May 31, 2025
PYRTD	Program year reported to date
PYVTD	Program year verified to date
PYTD	Program year to date
QA/QC	Quality assurance/quality control
REA	Remote energy assessment
RTD	Phase IV to date reported gross savings
SEEE	Student Energy Efficient Education
SEER	Seasonal energy efficiency ratio
SKU	Stock keeping unit

SMI	Secondary market impacts
SWE	Statewide evaluator
T&D	Transmission and distribution
tLED	Tubular LED
TRC	Total resource cost
TRM	Technical reference manual
UEC	Unit energy consumption
VTD	Phase IV to date verified gross savings
VTD+CO	Phase IV to Date Preliminary Savings Achieved + Carryover
WACC	Weighted average cost of capital
ZERH	Zero energy ready homes

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 energy efficiency and conservation (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 electric distribution company (EDC) or its program Implementation Conservation Service Providers (ICSP) and stored in the program tracking system.

Unverified Reported Gross: The Phase IV 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 measurement and verification (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 Technical Reference Manual (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 Total Resource Cost (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. Program Year to Date (PYTD) values for energy efficiency will always be reported gross savings in a semi-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 IV to Date (P4TD): The energy and peak demand savings achieved by an EE&C program or portfolio within Phase IV of Act 129. Reported in several permutations described below.

Phase IV to Date Reported (RTD): The sum of the reported gross savings recorded to date in Phase IV of Act 129 for an EE&C program or portfolio.

Phase IV to Date Verified (VTD): The sum of the verified gross savings recorded to date in Phase IV of Act 129 for an EE&C program or portfolio, as determined by the impact evaluation finding of the independent evaluation contractor.

Phase IV to Date Preliminary Savings Achieved (PSA): The sum of the verified gross savings (VTD) from previous program years in Phase IV where the impact evaluation is complete plus the reported gross savings from the current program year.

Phase IV to Date Preliminary Savings Achieved + Carryover (PSA+CO): The sum of the verified gross savings from previous program years in Phase IV plus the reported gross savings from the current program year plus any verified gross carryover savings from Phase III of Act 129. This is the best estimate of an EDC's progress toward the Phase IV compliance targets.

Phase IV to Date Verified + Carryover (VTD + CO): The sum of the verified gross savings recorded to date in Phase IV plus any verified gross carryover savings from Phase III of Act 129.

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PORTFOLIO COMPLIANCE TARGETS

PPL Electric Utilities offers energy efficiency programs to large and small commercial and industrial, residential, and income-eligible customers.

VERIFIED ENERGY SAVINGS

Phase IV has saved **1,281,627 MWh/yr***

103% of the compliance target

116% of planned

PY16 saved **299,591 MWh/yr**

*Includes Phase III carryover savings

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **176.16 MW/yr**

122% of planned

PY16 has reductions of **62.83 MW/yr**

LOW-INCOME PROGRAM

Phase IV has saved **82,703 MWh/yr***

114% of the compliance target

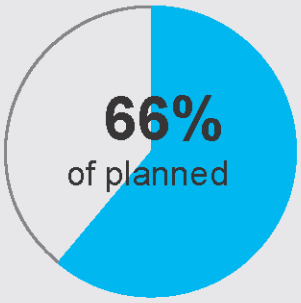
107% of planned

PY16 saved **15,530 MWh/yr**

*Includes Phase III carryover energy savings

EXPENDITURES ($1,000)

Phase IV expenditures **$205,178**



100% of planned

PY16 expenditures **$65,225**

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PORTFOLIO PARTICIPATION AND SATISFACTION

PY16 PARTICIPATION

A total of **594,812** participants

553,878 Residential

35,575 Low-Income

5,359 Non-Residential

PROGRAM SATISFACTION

84% Overall Portfolio Satisfaction

91% satisfied with Non-Residential Program

84% satisfied with Residential Program

78% satisfied with Low-Income Program

PARTICIPANT COMMENTS

"Great customer service and it was easy to apply for the rebates."

"The rebate program related to lighting upgrades at our facility, met our objective, and PPL Electric Utilities greatly assisted with completing all documents needed in the process and support effort."

"This is such a great experience for my students. The presenters did an amazing job. All my students were engaged and couldn't wait to come back to the classroom to play the Kahoot on what they learned. I think this is great for my students' families as well because I teach in a low-income school. A lot of students were provided items that could help lower their energy bills, that they may not have been able to get on their own. Such a great program!"

"I had an excellent experience with the person I dealt with and products provided to me."

"I was happy to hear about and receive the rebate."

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 Phases I (2008 through 2013), II (2013 through 2016), and III (2016 through 2021). In late 2020, 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 IV. These plans were updated based on stakeholder input and subsequently approved by the PUC in 2021.

Implementation of Phase IV of the Act 129 programs began on June 1, 2021. This report documents the progress and effectiveness of the Phase IV EE&C accomplishments for PPL Electric Utilities in program year 16 (PY16), as well as the cumulative accomplishments of the Phase IV programs since inception. This report also documents the energy savings carried over from Phase III. The Phase III carryover savings count toward EDC savings compliance targets for Phase IV.

This report details the participation, spending, reported gross, verified gross energy (MWh), and peak demand (MW), and verified net impacts of the energy efficiency programs in PY16. Compliance with Act 129 savings goals is ultimately based on verified gross savings. This report also includes estimates of cost-effectiveness according to the Total Resource Cost (TRC) test.[1]

PPL Electric Utilities has retained Cadmus as an independent evaluation contractor for Phase IV 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 performed a process evaluation to examine the design, administration, implementation, and market response to the EE&C plan. This report presents the key findings and recommendations identified by the process evaluation and documents any changes to the EE&C plan delivery that were considered based on the recommendations.

1.1. Executive Summary

PPL Electric Utilities continued to successfully implement all energy efficiency programs for Phase IV Act 129 in PY16. In PY16, programs operated effectively, met their program objectives, and exceeded planned energy savings and demand reduction goals (116% and 122%, respectively). Each program chapter presents recommendations focused on ways to fine-tune program implementation.

PPL Electric Utilities has met the portfolio energy savings compliance target, including Phase III carryover savings (306,275 MWh/yr) through PY16, and has achieved gross verified energy savings of 1,281,627

[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. The 2021 TRC Test Order for Phase IV of Act 129 was adopted by PUC Order at Docket No. M-2019-3006868 on December 19, 2019.

MWh/yr, accounting for 103% of the Phase IV overall five-year compliance target of 1,250,157 MWh/yr. In PY16, PPL Electric Utilities achieved 299,591 MWh/yr in verified savings.

Through PY16, PPL Electric Utilities achieved system-level demand reductions of 176.16 MW/yr, which represents 77% of the Phase IV overall five-year compliance target of 229 MW/yr. In PY16, PPL Electric Utilities exceeded the PY16 projected estimate of 51.44 MW/yr and achieved 62.83 MW/yr in system-level verified demand reductions, or 122% of demand projections.

PPL Electric Utilities has met the compliance target of 72,509 MWh/yr of verified gross energy savings for the low-income sector for Phase IV. PPL Electric Utilities has achieved 114% of the Phase IV low-income energy-savings compliance target through PY16 (82,703 MWh/yr), including carryover savings from Phase III (31,089 MWh/yr).

PPL Electric Utilities delivered programs for 83% of the Phase IV cumulative projected budget through PY16, estimated in the EE&C plan, expending $205,177,665.[2] The acquisition cost in PY16 is $0.22 per annual kWh and is $0.21 per annual kWh for Phase IV (EDC expenditures/first-year savings). The portfolio-level PY16 total cost of conserved energy (TRC costs/net present value [NPV] lifetime kWh, at generation) is $0.058/kWh. In PY16, the portfolio-level utility cost of conserved energy (program administrator cost [PAC]/NPV lifetime kWh, at generation) is $0.020/kWh. The TRC includes PPL Electric Utilities' and the customers' costs, while the PAC only includes PPL Electric Utilities' costs.

A portfolio is cost-effective when the TRC benefit-cost ratio exceeds 1.0. The PY16 and phase-to-date portfolio is cost-effective with a portfolio-level TRC of 1.31 (PY16) and 1.42 (phase-to-date).

In PY16, the evaluated net-to-gross (NTG) ratio is 0.71, which includes spillover attributable to the Energy Efficient Homes components of the Residential Program.

In Phase IV, PPL Electric Utilities established a goal to achieve 85% or greater of *very satisfied* and *somewhat satisfied* customers in each program, as shown in Figure 1-1.[3] Respondents to participant satisfaction surveys across the programs reported satisfaction levels between 78% to 91%. In PY16, satisfaction ratings for all three programs and the portfolio overall decreased over PY15. Portfolio satisfaction and satisfaction with the Residential and Low-Income Programs significantly decreased in PY16 compared to PY15.[4] Satisfaction with the Non-Residential program decreased in PY16 but not significantly.

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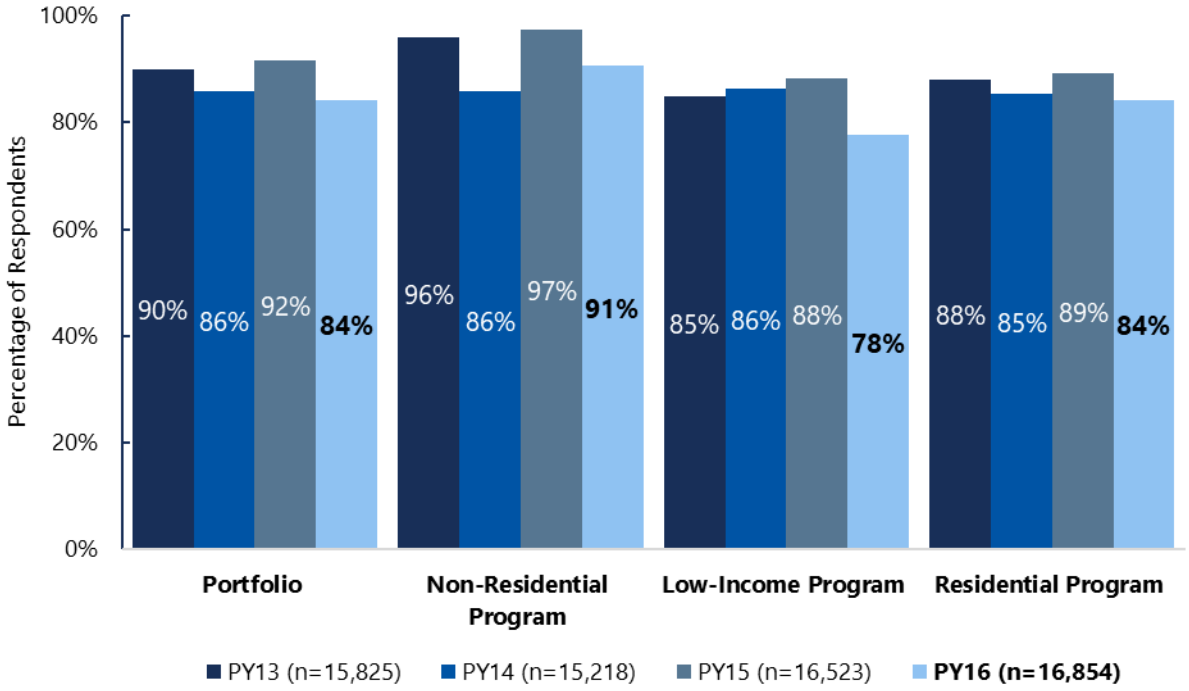
[2] Through PY16, PPL Electric Utilities estimated a budget of $248,426,000.

[3] The customer satisfaction goal is listed in PPL Electric Utilities' EE&C Plan (Docket No. M-2020-3020824) revised March 27, 2025.

[4] Differences between PY16 and PY15 results are statistically different at the 90% confidence level, p-value < 0.10.

Figure 1-1.Portfolio-Level Program Satisfaction
***Very* and *Somewhat Satisfied* Combined**



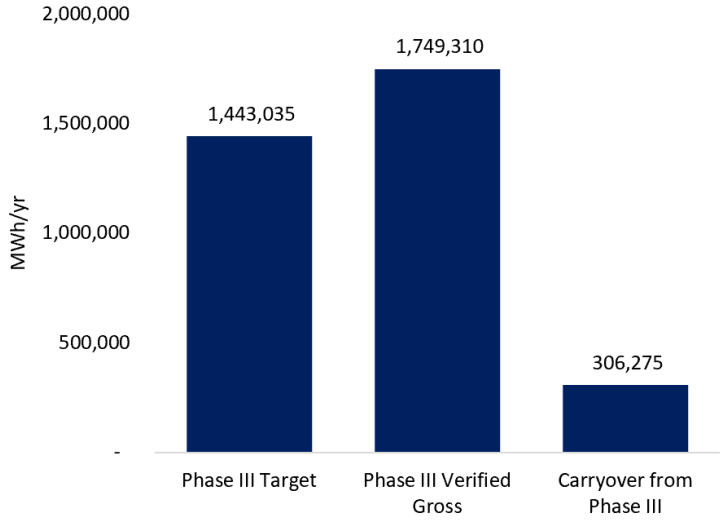
Source: Participant survey question, "Thinking about your overall experience with the PPL Electric Utilities program/component, how would you rate your overall satisfaction?" Program satisfaction results include all responses to the satisfaction question, averaged to compute the portfolio-level satisfaction. These totals may not reflect the number of "completed" surveys as reflected in Table 4-4. Non-Residential includes Custom and Efficient Equipment downstream survey respondents, Low-Income includes remote energy assessment and direct install survey respondents, and Residential includes Appliance Recycling, Energy Efficient Homes Equipment and Audit and Weatherization, Home Energy Reports and students and teacher survey respondents. Cadmus did not complete new customer satisfaction research for the Appliance Recycling component so the satisfaction rating is averaged across PY13 to PY15.

2. Summary of Achievements

2.1. Carryover Savings from Phase III of Act 129

PPL Electric Utilities has a total of 306,275 MWh/year of portfolio-level carryover savings from Phase III. Figure 2-1 compares PPL Electric Utilities' Phase III verified gross savings total to the Phase III compliance target to illustrate the carryover calculation.

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

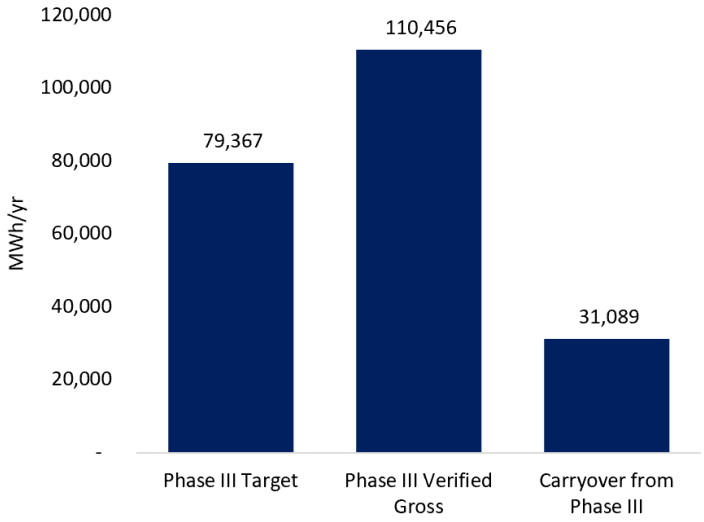


The PA PUC's Phase IV Implementation Order also allows EDCs to carry over savings in excess of the Phase III low-income savings goal.[5,6] Figure 2-2 shows the calculation of carryover savings for the low-income customer segment.

[5] Pennsylvania Public Utility Commission. *Energy Efficiency and Conservation Program Implementation Order*, at Docket No. M-2020-3015228, (*Phase IV Implementation Order*), entered June 18, 2020.

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

Figure 2-2. Low-Income Carryover from Phase III



2.2. Phase IV Energy Efficiency Achievements to Date

The Phase IV energy savings targets (MWh) were established at the meter level, and peak demand reduction targets (MW) were set at the system level. Accordingly, this report presents MWh totals at the meter level and peak demand savings adjusted for transmission and distribution losses to reflect system-level savings.

Table 2-1 shows the achievements since the beginning of PY16 on June 1, 2024, through the end of May 31, 2025.

Table 2-1. PY16 Energy and Demand Achievements to Date[1]

PYTD	Reported Gross Savings (PYRTD)	Verified Savings (PYVTD)	System-Level Verified Savings (PYVTD)	Unverified (PYRTD)	Realization Rate[2]
Energy Savings (MWh/yr)[3]	321,395	299,591	N/A	7,462	93%
Peak Demand Reductions (MW/yr)[3]	64.63[4]	58.87	62.83	1.73	97% [5]

[1]Savings do not include unverified PY15 savings verified in PY16.
[2]Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Realization rates include unverified savings. Realization rates in different chapters were calculated by removing unverified reported savings from the denominator.
[3]Savings may not match other tables or figures due to rounding.
[4]Reported savings do not include the application of distribution losses.
[5]Realization rates in this table were applied to verified demand reductions with application of distribution losses.

Table 2-2 shows the Phase IV achievements through the end of PY16, including carryover savings. Including carryover savings from Phase III, PPL Electric Utilities has achieved 1,281,627 MWh/yr of verified savings through the end of PY16. This represents 103% of the Phase IV energy savings

compliance target of 1,250,157 MWh/yr. PPL Electric Utilities has achieved 176.16 system-level demand reductions or 77% of the Phase IV demand reduction savings compliance target of 229 MW/yr.

Table 2-2. Phase IV Energy and Demand Achievements to Date

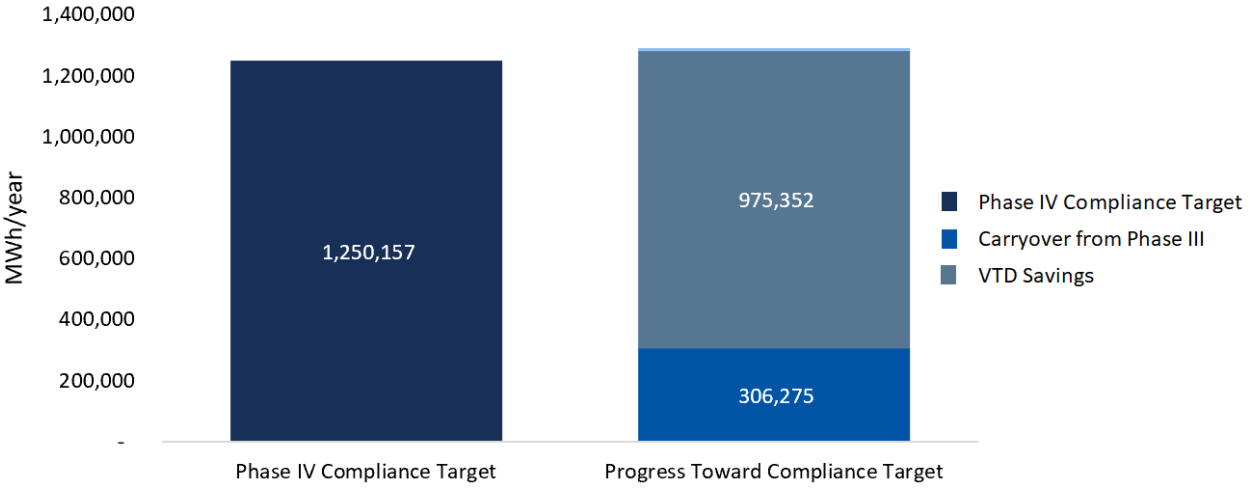
P4TD	Reported Gross Savings (P4RTD)	Verified Savings (P4VTD)	System-Level Verified Savings (P4VTD)	Unverified (P4RTD)[1]	Realization Rate[2]
Energy Savings (MWh/yr)[3]	1,003,870	1,281,627 [4]	N/A	7,479	97% [5]
Peak Demand Reductions (MW/yr)[3]	175.06[6]	164.43	176.16	1.73	101% [7]

[1]Unverified savings do not include the application of distribution losses.
[2]Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Realization rates include unverified savings. Realization rates in different chapters were calculated by removing unverified reported savings from the denominator.
[3]Savings may not match other tables or figures due to rounding.
[4]Verified energy savings include Phase III carryover of 306,275 MWh/yr.
[5]Realization rate excludes Phase III carryover of 306,275 MWh/yr.
[6]Reported savings do not include the application of distribution losses.
[7]Realization rates were applied to verified demand reductions with application of distribution losses.

Figure 2-3 summarizes PPL Electric Utilities' progress toward the Phase IV MWh portfolio compliance target, and Figure 2-4 summarizes progress toward the Phase IV MW portfolio compliance target. Unverified energy savings total is 7,479 MWh/yr (1,317 MWh/yr for the Non-Residential Program and 6,162 MWh/yr for the Residential Program). The total unverified demand reduction is 1.73 MW/yr (0.39 MW/yr for the Non-Residential Program and 1.34 MW/yr for the Residential Program).[7] Cadmus will verify these savings in PY17.

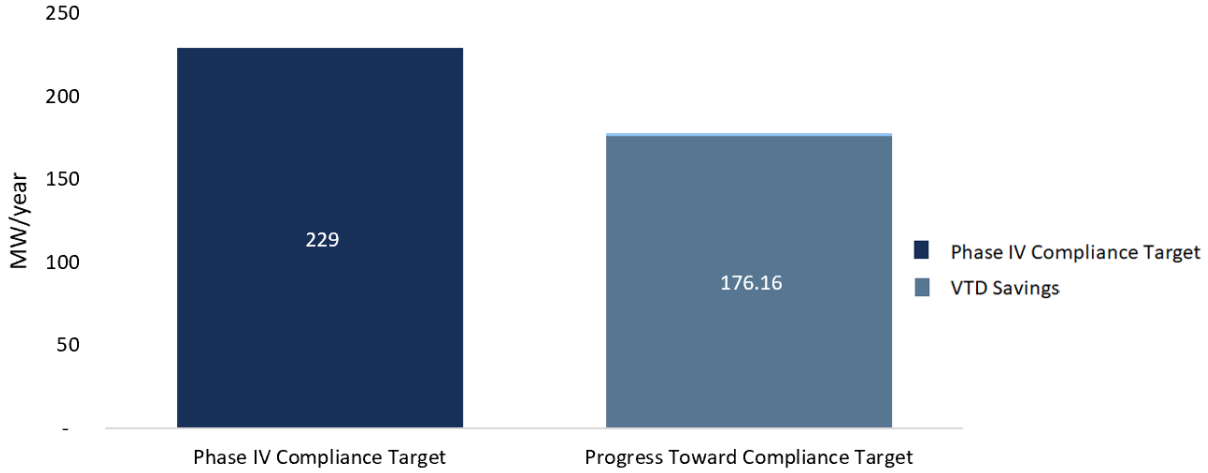
[7] The sum of individual program-level demand reductions does not match total due to rounding.

Figure 2-3. EE&C Plan Performance Toward Phase IV Portfolio Compliance Target (MWh/yr)



Note: Unverified savings represent a small proportion of total so do not appear in chart (17 PY15 and 7,462 PY16 MWh/yr).

Figure 2-4. EE&C Plan Performance Toward Phase IV Portfolio Compliance Target (MW/yr)

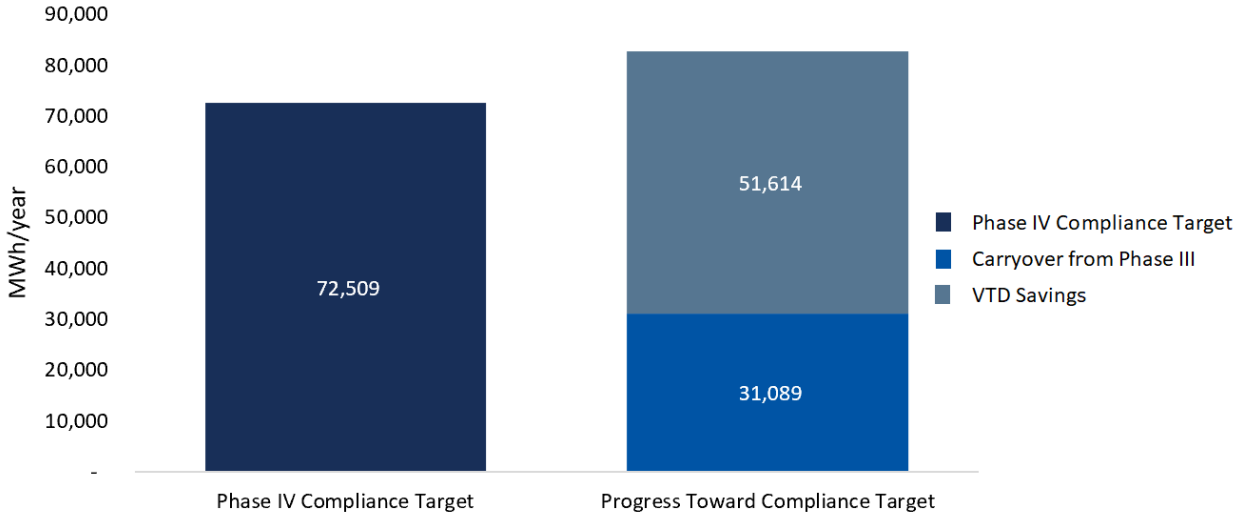


Note: Unverified savings represent a small proportion of total so do not appear in chart (0.0004 PY15 and 1.73 PY16 MW/yr).

The Phase IV Implementation Order directed EDCs to offer conservation measures to the low-income customer segment based on the proportion of electric sales attributable to low-income households. PPL Electric Utilities' target proportion is 9.95%. PPL Electric Utilities offers a total of 77 EE&C measures to its residential and non-residential customer classes. There are 18 distinct measures available to the low-income segment at no cost to the customer. This represents 23.4% of the total measures offered in the EE&C plan and exceeds the proportionate number of measures targeted.

The PA PUC also established a low-income energy savings target of 5.8% of the portfolio savings goal. The low-income savings target for PPL Electric Utilities is 72,509 MWh/yr verified gross savings. Figure 2-5 compares the VTD performance for the low-income customer segment to the Phase IV savings target. Including Phase III Low-Income carryover savings, PPL Electric Utilities has surpassed the Phase IV low-income energy-savings compliance target by 14% or approximately 10,000 MWh in PY16.

Figure 2-5. EE&C Plan Performance Toward Phase IV Low-Income Compliance Target (MWh/yr)



2.2.1. Phase IV Performance, Multifamily Housing

Table 2-3 lists verified gross electric energy savings (PYVTD) from multifamily housing across all programs, including energy savings from low-income households.

Table 2-3. Multifamily Housing

Program	PYVTD (MWh/yr)	Phase IV VTD (MWh/yr)
Low-Income	3,867	14,183
Portfolio Total	7,378	21,132

Master-Metered Multifamily Housing Summary

In compliance with the June 2023 settlement agreement, PPL Electric Utilities agreed to several reporting requirements on its expanded efforts with master-metered multifamily (MMMF) customers. PPL Electric Utilities worked with 12 property managers at 12 MMMF locations throughout its service territory. The Low-Income Program treated 1,441 units at 22 buildings (accounts) in PY16. The units (and tenants) received LED lighting, water-saving measures, smart strips, and energy education. One hundred and five customers received comprehensive measures during their appointments. The cost of the direct installation, comprehensive measures, and labor was $466,310.

The Low-Income Program achieved 567 MWh/yr of energy savings and 0.43 MW/yr of system-level demand reductions in PY16 in MMMF housing. PPL Electric Utilities updated marketing collateral, completed outreach to customers in prior phases, and nonprofit housing authorities to develop additional MMMF opportunities. Additionally, PPL Electric Utilities' Low-Income ICSP used multiple proprietary software and database resources to locate additional opportunities. These efforts will continue in PY17.

Additionally, the Non-Residential Program treated the common areas of 23 affordable MMMF buildings in PY16. The common areas in these buildings received lighting improvements and HVAC upgrades. These buildings achieved 441 MWh/yr of verified gross electric energy savings, 0.08 MW/yr of verified demand reductions, and $27,653 in incentives for these projects.

2.3. Phase IV Performance by Customer Segment

Table 2-4 presents participation, savings, and spending by customer sector for PY16. The EDC tariff defines residential, small commercial and industrial (C&I), and large C&I sectors, and statute (66 Pa. C.S. § 2806.1) defines the residential low-income sector and government, nonprofit, educational (GNE) sector. The residential low-income segment is a subset of the residential customer class, and the GNE segment includes customers who are part of the residential, small C&I, or large C&I rate classes. Cadmus removed the savings, spending, and participation values for the low-income and GNE segments from the parent sectors.

Table 2-4. PY16 Summary Statistics by Customer Segment[1]

Parameter	Residential (Non-LI)	Low-Income	Small C&I (Non-GNE)	Large C&I (Non-GNE)	GNE	Total[2]
Reported Number of Participants[3]	552,977	35,560	3,983	809	1,484	594,813
PYRTD MWh/yr[4]	54,518	17,690	89,410	119,791	39,986	321,395
PYRTD MW/yr[4]	7.11	1.80	23.24	24.14	8.33	64.63
PYVTD MWh/yr[4]	48,878	14,964	83,820	113,456	38,474	299,591
System-Level PYVTD MW/yr[4]	5.92	1.66	23.03	23.85	8.37	62.83
PY16 Incentives ($1000)[4],[5]	$7,358	$6,094	$12,263	$6,682	$3,596	$35,993

[1] This table does not include PY15 unverified savings verified in PY16.
[2] Columns may not sum to totals due to rounding.
[3] Verified participation totals discussed in each chapter and appendix and shown in the infographics may differ from the reported participation in this table.
[4] Savings may not match other tables or figures due to rounding.
[5] PPL Electric Utilities reports the number of participants and PYRTD using their participant tracking database; however, they use the incentive amounts from a separate accounting system since they are reported along with the other expenditures.

Table 2-5 shows savings for the GNE sector as defined by statute (66 Pa. C.S. § 2806.1) for residential, small, and large C&I customer sectors defined by the EDC tariff.

Table 2-5. PY16 Energy and Demand Summary of Government, Nonprofit, and Education Sector Customers

Parameter	GNE Customers with Residential Rate Codes	GNE Customers with Small C&I Rate Codes	GNE Customers with Large C&I Rate Codes	GNE Total[1]
PYRTD MWh/yr[2]	16	16,011	23,959	39,986
PYRTD MW/yr[2]	-	3.56	4.77	8.33
PYVTD MWh/yr	17	15,392	23,064	38,474
System-Level PYVTD MW/yr	-	3.53	4.84	8.37

[1] Columns may not sum to totals due to rounding. These totals will not match the values in other tables showing totals by customer sector.
[2] Does not include PY15 unverified savings verified in PY16.

Table 2-6 summarizes plan performance by sector since the beginning of Phase IV.

Table 2-6. Phase IV Summary Statistics by Customer Segment

Parameter	Residential (Non-LI)	Low-Income	Small C&I (Non-GNE)	Large C&I (Non-GNE)	GNE	Total[1]
Reported Number of Participants[2]	2,254,730	102,098	131,973	3,321	6,357	2,498,480
RTD MWh/yr[3]	196,085	52,425	354,209	296,369	104,783	1,003,870
RTD MW/yr[3]	25.57	5.60	70.02	53.67	20.22	175.06
VTD MWh/yr[3],[4]	177,720	81,621 [4]	352,214	290,389	104,496	1,281,627 [4],[5]
System-Level VTD MW/yr[3]	24.12	5.69	72.12	53.65	20.57	176.16 [5]
Phase IV Incentives ($1000)[6]	$26,717	$15,622	$41,238	$17,984	$11,540	$113,102

[1] Columns may not sum to totals due to rounding.
[2] Verified participation totals discussed in each chapter and appendix and shown in the infographics may differ from the reported participation in this table.
[3] Savings may not match other tables or figures due to rounding.
[4] Verified energy savings include Phase III carryover for the low-income sector of 31,089 MWh/yr. The total includes Phase III carryover savings of 306,275 MWh/yr not attributed to individual sectors; therefore, the sum of savings by sector will not match the total.
[5] Includes adjustments to savings made by the SWE. Includes PY15 unverified savings that were verified in PY16.
[6] PPL Electric Utilities reports the number of participants and PYRTD using their participant tracking database; however, they use the incentive amounts from a separate accounting system since they are reported along with the other expenditures.

2.4. Summary of Participation by Program

Participation is defined differently for some programs and program components, depending on the program delivery channel and data tracking practices. Table 2-7 shows the participant definition by program and component, along with the current participation totals for PY16 and Phase IV.

Table 2-7. EE&C Plan Participation by Program

Program/Component	Participant Definition	PYTD Participation[1]	P4TD Participation[1]
Non-Residential Program			
Custom	Unique job number; commercially operable job that received an incentive payment during the reporting period.	283	676
Efficient Equipment (downstream)	Unique job number; corresponds to each unique job that received a rebate.	668	2,645
Efficient Equipment (midstream)	Unique job number; corresponds to each purchase of discounted products.	4,409	19,006
Low-Income Program			
Low-Income Assessment	Unique bill account number; corresponds to an income-eligible household that receives an audit and program services or receives a welcome kit.	35,575	102,156
Residential Program			
Appliance Recycling	Unique job number; corresponds with each unique appliance decommissioned through the program component during the program year.	18,204[1]	55,309
Efficient Lighting	Number of discounted bulbs sold.	0	1,588,224
Energy Efficient Homes New Homes	Unique job number; corresponds to a rebated project.	1,920	6,291 [2]
Energy Efficient Homes Audit and Weatherization	Unique job number; corresponds to a rebated project. Households could have more than one rebated project.	1,868 [3]	5,740 [3]
Energy Efficient Homes Online Marketplace	Unique job number; corresponds to a rebated project.	3,723	19,143
Energy Efficient Homes Equipment (downstream)	Unique job number; corresponds to a rebated project. Households could have more than one rebated project.	10,600 [3]	38,312 [3]
Energy Efficient Homes Equipment (midstream)	Unique job number; corresponds to each purchase of discounted products.	31	42
Energy Efficient Homes Instant Discount	Unique job number; corresponds to each discounted item purchased.	69,736	152,762
Home Energy Report (HER) [4]	Unique household that received at least one report	427,592	427,592
Student Energy Efficient Education	The number of participants is counted as the number of energy conservation kits delivered.	20,204	80,582
Portfolio Total		**594,813**	**2,498,480**

[1] Includes incentive adjustments and may differ from total participants shown in infographics.
[2] Includes High-Performance Homes pilot participants.
[3] Includes Deep Energy Retrofits pilot participants.
[4] Differs from total participants reported in the impact analysis.

2.5. Summary of Impact Evaluation Results

During PY16, Cadmus completed impact evaluations for most program components in the portfolio. Table 2-8 summarizes the realization rates and NTG ratios by program component.

Table 2-8. PY16 Impact Evaluation Results Summary

Program	Component	Energy Realization Rate[1]	Demand Realization Rate[1]	Net-to-Gross Ratio
Non-Residential	Custom	93%	95%	0.74 [2]
	Efficient Equipment	100%	90%	0.64 [3]
Low-Income	Low-Income	84%	85%	1.0 [4]
Residential	Appliance Recycling	93%	96%	0.50 [5]
	Energy Efficient Homes	100%	89%	0.57 [6]
	Home Energy Reports	122%	-	1.0 [4]
	Student Energy Efficient Education	100%	100%	1.0 [4]
Portfolio Total		**95%**	**94%**	**0.71 [7]**

[1]Does not include unverified savings in the denominator. Realization rates were applied to verified demand reductions before application of distribution losses.
[2] PY14 evaluated NTG ratio.
[3] PY15 evaluated NTG ratios used for midstream lighting stratum. PY14 NTG ratios used for downstream, direct discount, direct install lighting stratum and downstream, direct discount, direct install non-lighting stratum. PY15 benchmarking NTG ratios used for midstream non-lighting stratum. The NTG ratio for the overall component is the verified gross population energy savings weighted average of the NTG ratios applied to stratum.
[4] No free ridership is expected or measured per the evaluation plan. Therefore, the NTG ratio is 1.00.
[5] PY15 evaluated NTG ratio.
[6] PY16 evaluated NTG ratios used for Downstream Equipment. Cadmus applied measure-level NTG ratios from the PY16 Downstream Equipment NTG research for measures similar to Midstream Equipment stratum measures. PY16 Downstream Equipment evaluated NTG ratios used for Midstream Equipment stratum. PY15 evaluated NTG ratios used for Online Marketplace stratum. PY14 evaluated NTG ratios used for the Audit and Weatherization stratum. PY13 evaluated NTG ratio used for the New Homes stratum. PY15 evaluated measure-level NTG ratios from Downstream Equipment and Online Marketplace stratums used for PY15 Instant Discount stratum measures that were like PPL program measures, and PY15 benchmarking NTG ratios used where there was not a similar PPL NTG researched value to leverage. For the PY16 high-performance homes strata, a deemed NTG ratio of 1.00 was applied, per the evaluation plan. The NTG ratio for the overall component is the verified gross population energy savings weighted average of the NTG ratios applied to each stratum.
[7] Weighted by PY15 program-verified gross energy savings.

2.6. Summary of Energy Impacts by Program

Act 129 compliance targets are based on annualized savings estimates (MWh/year). Each program year, the annual savings achieved by program activity are recorded as incremental annual, or first-year, savings and added to an EDC's progress toward compliance (section *2.6.1 Incremental Annual Energy Savings by Program* presents incremental annual savings estimates). Lifetime energy savings incorporate the effective useful life (EUL) of installed measures and estimate the total energy savings associated with program activity. Cadmus used participant lifetime savings in the TRC test to assess the economics of upgrades by the SWE and calculate the emissions benefits of Act 129 programs. Section *2.6.2 Lifetime Energy Savings by Program* presents the lifetime energy savings by program.

2.6.1. Incremental Annual Energy Savings by Program

Table 2-9 summarizes PY16 PYTD energy savings by program and for Phase IV to date. This report presents energy impacts at the meter level, which do not reflect adjustments for transmission and distribution losses. Cadmus adjusted verified gross savings by the energy realization rate and verified net savings by the realization rate and the NTG ratio.

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

Program	PYRTD (MWh/yr)	PYVTD Gross (MWh/yr)	PYVTD Net (MWh/yr)	RTD (MWh/yr)	VTD Gross (MWh/yr)	VTD Net (MWh/yr)
Non-Residential	248,286[1]	234,987	165,410	755,673 [1]	747,612	502,830
Low-Income	18,402	15,530	15,530	53,840	82,703 [2]	51,614 [3]
Residential	54,708 [1]	49,074	32,611	194,357 [1]	176,126	116,357
Portfolio Total[4]	**321,395** [1]	**299,591**	**213,552**	**1,003,870** [1]	**1,281,627** [2]	**670,801** [3]

[1] Includes unverified savings.
[2] Includes 31,089 MWh/yr of carryover savings for the Low-Income Program and a total of 306,275 MWh/yr carryover savings for the Portfolio. The sum of the VTD Gross column will not match the Portfolio total row because carryover savings are not attributed to either the Non-Residential Program or the Residential Program.
[3] VTD Net does not include carryover savings from Phase III of 31,089 MWh/yr for the Low-Income Program or 306,275 MWh/yr for the portfolio.
[4] Total may not match the sum of rows due to rounding.

The previously reported VTD savings from prior years, for the following programs, have changed since the PY15 final annual report was submitted:

- **Non-Residential**
  - Custom Component: 41,612 MWh/yr savings were reported, but not verified in PY15 final annual report. Those savings have since been verified with an energy realization rate of 87% and an NTGR of 0.74, which yields an additional 36,146 MWh/yr of gross verified energy savings and an additional 26,748 MWh/yr of net verified energy savings. These verified gross savings are attributed to the residential (2,154 MWh/yr), small C&I (21,355 MWh/yr), large C&I (7,372 MWh/yr), and GNE (5,265 MWh/yr) sectors' VTD savings in PY15.
- **Residential**
  - Energy Efficient Homes Instant Discount: 11,206 MWh/yr savings were reported, but not verified in PY15 final annual report. Those savings have since been verified with an energy realization rate of 10% and an NTGR of 0.73, which yields an additional 1,115 MWh/yr of gross verified energy savings and an additional 814 MWh/yr of net verified energy savings. These savings are attributed to the Residential customer sector.
  - Energy Efficient Homes Midstream: 6 MWh/yr savings were reported, but not verified in PY15 final annual report. Those savings have since been verified with an energy realization rate of 101% and an NTGR of 0.52, which yields an additional 6 MWh/yr of gross verified energy savings and an additional 3 MWh/yr of net verified energy savings. These savings were attributed to the Residential customer sector.

- Energy Efficient Homes Downstream Equipment: SWE audit activities recommended an increase of PY15 gross verified energy savings of 3,481 MWh/yr to 18,558 MWh/yr.
- Student Energy Efficient Education: SWE audit activities recommended a decrease of PY14 gross verified energy savings of 115 MWh/yr to 5,037 MWh/yr and a decrease of PY15 gross verified savings of 116 MWh/yr to 5,221 MWh/yr.

2.6.2. Lifetime Energy Savings by Program

Table 2-10 summarizes the PYTD and P4TD lifetime energy savings by program. Cadmus adjusted the lifetime savings to account for reduced lighting savings following the 2020 Energy Independence and Security Act (EISA) backstop. Specifically, after the 2020 EISA implementation, Cadmus reduced screw-based LED savings to the difference in energy usage between the efficient bulb and the new baseline. Savings do not include those beyond 15 years for any rebated item, per the Pennsylvania TRC Order.[8]

Table 2-10. Lifetime Energy Savings by Program (MWh)

Program Name	PYVTD Gross Lifetime (MWh)	PYVTD Net Lifetime (MWh)	VTD Gross Lifetime (MWh)	VTD Net Lifetime (MWh)
Non-Residential	3,492,989	2,474,243	10,573,982	7,109,672
Low-Income	111,296	111,296	403,957	403,956
Residential	445,577	266,620	1,716,548	1,054,256
Portfolio Total(1)	**4,049,862**	**2,852,159**	**12,694,487**	**8,567,885**

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

2.7. Summary of Peak Demand Reduction Impacts by Program

Act 129 defines peak demand savings 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. Unless indicated otherwise, verified peak demand impacts from energy efficiency in this report are presented at the system level, meaning they have been adjusted to account for transmission and distribution losses.

PPL Electric Utilities uses the following line loss percentages/multipliers by sector:[9, 10]

- Residential: 1.0875
- Small C&I: 1.0875

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8 The 2019 TRC Test Order for Phase IV of Act 129 was adopted by PA PUC order at Docket No. M-2019-3006868 on December 19, 2019.

9 Pennsylvania Public Utility Commission. February 2021. *Technical Reference Manual.* Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards.

10 For GNE records, the line loss multiplier was calculated as a blended rate of 1.068 using the proportion of reported demand reductions of the residential and small C&I sectors compared to the large C&I sector (57% and 43%, respectively).

- Large C&I: 1.042
- GNE: 1.068

Table 2-11 summarizes the peak demand impacts by energy efficiency program through the current reporting period.

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

Program Name	PYRTD (MW/yr)	System-Level PYVTD Gross (MW/yr)	System-Level PYVTD Net (MW/yr)	RTD (MW/yr)	System-Level VTD Gross (MW/yr)	System-Level VTD Net (MW/yr)
Non-Residential	55.65	55.19	39.38	144.53	147.07	100.34
Low-Income	1.87	1.73	1.73	5.75	5.82	5.82
Residential	7.10 [1]	5.91	3.45	24.79	23.27	14.87
Portfolio Total[2]	**64.63**	**62.83**	**44.56**	**175.06**	**176.16**	**121.03**

[1] Includes unverified savings.
[2] Total of individual program demand reductions may not sum to total due to rounding.

The previously reported VTD savings from prior years, for the following programs, have changed since the PY15 final annual report was submitted:

- **Non-Residential**
  - Custom Component: 10.08 MW/yr demand reductions were reported, but not verified in PY15 final annual report. Those demand reductions have since been verified with a realization rate of 93% and an NTGR of 0.74, which yields an additional 10.15 MW/yr of gross verified demand reductions and an additional 7.51 MW/yr of net verified demand reductions. These verified gross demand reductions were attributed to the residential (0.79 MW/yr), small C&I (6.56 MW/yr), large C&I (1.24 MW/yr), and GNE (1.57 MW/yr) sectors' VTD demand reductions in PY15.
- **Residential**
  - Energy Efficient Homes Instant Discount: 0.08 MW/yr demand reductions were reported, but not verified in PY15 final annual report. Those demand reductions have since been verified with a realization rate of 12% and an NTGR of 0.73, which yields an additional 0.01 MW/yr of gross verified demand reductions and an additional 0.01 MW/yr of net verified demand reductions. These demand reductions were attributed to the Residential customer sector.
  - Energy Efficient Homes Midstream: 0.001 MW/yr demand reductions were reported, but not verified in PY15 final annual report. Those demand reductions have since been verified with a demand reduction realization rate of 93% and an NTGR of 0.52, which yields an additional 0.001 MW/yr of gross verified demand reductions and an additional 0.001 MW/yr of net verified demand reductions. These demand reductions were attributed to the Residential customer sector.

- Energy Efficient Homes Downstream Equipment: SWE audit activities recommended a decrease of PY15 gross verified demand reduction of 0.14 MW/yr to 1.24 MW/yr (system-level).
- Student Energy Efficient Education: SWE audit activities recommended a decrease of PY14 gross verified demand reduction of 0.01 MW/yr to 0.48 MW/yr (system-level) and a decrease of PY15 gross verified demand reduction of 0.02 MW/yr to 0.56 MW/yr (system-level).

2.7.1. Peak Demand Savings Nominated to PJM Forward Capacity Market (FCM)

For Phase IV of Act 129, EDCs are expected to retain the capacity rights to Act 129 projects and nominate a portion of the resources acquired to PJM Forward Capacity Market. If the resources clear, proceeds flow back to the rate class that generated the Act 129 savings to offset cost recovery via riders.

Table 2-12 summarizes PPL Electric Utilities' plans for wholesale recognition of Phase IV peak demand savings by Act 129 program year and PJM delivery year (DY), including nominated MW savings from PY16.

Table 2-12. Planned FCM Nominations by Act 129 Program Year and PJM DY

Act 129 Program Year	Estimated MW Acquisition for FCM	DY 22/23 MW Range	DY 23/24 MW Range	DY 24/25 MW Range	DY 25/26 MW Range	DY 26/27 MW Range	DY 27/28 MW Range	DY 28/29 MW Range	DY 29/30 MW Range
PY13	1.4	1.4	1.4	1.4	0				
PY14	[1 to 10]		1.5	1.5	0	N/A			
PY15	[1 to 10]			1.9	1.9	N/A	N/A		
PY16	[1 to 10]				5.9	N/A	N/A	N/A	
PY17	[1 to 10]					N/A	N/A	N/A	N/A
Phase IV Total[(1)]	**[5.4 to 41.4]**	**1.4**	**2.8**	**4.8**	**7.8**	**N/A**	**N/A**	**N/A**	**N/A**

[(1)] Sum of rows may not match total due to rounding.

Table 2-13 lists the measures selected by PPL Electric Utilities to be offered into PJM.

Table 2-13. PY16 Measures Selected for PJM

Measure Category	Measure	PY13	PY14	PY15	PY16
Large C&I Commercial Lighting	LED fixtures	✓	✓	✓	✓
	LED linear replacements	✓	✓	✓	✓
	LED screw-ins	✓	✓		✓
	Custom			✓	✓
Large C&I Commercial Lighting - Midstream	LED linear fixture				✓
	LED linear lamp				✓
	Exterior LED fixture				✓
	LED downlight/trim kit				✓
	LED fluorescent replacement				✓
	LED high bay/low bay				✓
	Pin-based LED bulb				✓
Small C&I Commercial Lighting	LED fixtures	✓	✓	✓	
	LED linear replacements	✓	✓	✓	
Small C&I and Residential Efficient Lighting	LED bulged reflector	✓			
	LED candelabra base	✓	✓	✓	
	LED globe	✓	✓	✓	
	LED multifaceted reflector	✓		✓	
	LED parabolic aluminized reflector	✓		✓	
	LED reflector	✓	✓	✓	
	LED retrofit kit	✓	✓	✓	
	LED specialty	✓		✓	
Low-Income	LED bulbs		✓	✓	✓

PPL Electric Utilities nominated lighting measures to qualify into PJM based on the ease of project measurement and verification and the availability of PJM-required information.

The qualified MW volumes by rate class for PY16, with anticipated monetization in PJM 2025-2026 DY[11], include the following:

- Large C&I: 6.212 MW
- Small C&I: 0.677 MW
- Residential: 0.115 MW
- Low-Income: 0.833 MW

These resources are anticipated to result in PJM revenues from 2025-2026 DY that will be paid in full (in addition to 2025-2026 DY) to PPL Electric Utilities through the PJM-member curtailment service provider (CSP) and distributed proportionally to the associated rate classes.

[11] Due to FERC review of complaints seeking to disqualify some energy efficiency capacity earlier than the end of the current year and/or invalidate prior year participation, the values shown are subject to change.

2.8. Summary of Fuel-Switching Impacts

Act 129 allows EDCs to achieve electric savings by converting electric equipment to non-electric equipment. Table 2-14 summarizes key fuel-switching metrics in PY16 and to date in Phase IV.

Table 2-14. Fuel Switching Summary

Metric	PY16	P4TD
Number of Products Offered and Implemented		
Air-Source Heat Pump (ASHP)	3	20
Electric Baseboards	4	34
Electric Furnaces	2	13
Water Heaters Gas - Electric Resistance	0	43
Water Heaters Propane - Electric Resistance	0	36
Combined heat and power (CHP)	2	4
Verified Savings		
VTD Energy Savings Achieved via Fuel Switching (MWh/yr)	16,656	32,081
Phase IV Verified To-Date Increased Fossil Fuel Consumption Due to Fuel Switching Measures (MMBTU/yr)	56.83	109
Incentives		
Phase IV Verified To-Date Incentive Payments for Fuel Switching Measures ($1,000)	$505	$1,533

2.9. Summary of Renewable Energy Impacts

Act 129 allows EDCs to incentivize behind-the-meter solar photovoltaics and other renewable energy generation measures that offset the need for electricity from the grid. Table 2-15 summarizes the energy savings, peak demand reduction, and incentive totals for renewable energy measures in PY16 and Phase IV to date by customer sector.

Table 2-15. Renewables Summary

Metric	PY16		P4TD	
	Residential	Non-Residential	Residential	Non-Residential
Renewable Energy Measures Implemented	**Solar PV**	**Solar PV**	**Solar PV**	**Solar PV**
VTD Energy Savings Achieved via Renewables (MWh/yr)	332	68,904	3,748	105,983
VTD System-Level Peak Demand Savings Achieved via Renewables (MW/yr)	0.14	24.92	1.39	38.11
Incentive Payments for Renewable Energy Measures ($1,000)	$133	$11,624	$1,270	$22,855

2.10. Summary of Cost-Effectiveness Results

Table 2-16 presents a detailed breakdown of portfolio finances and cost-effectiveness. Cadmus calculated TRC benefits using gross verified impacts. PY16 NPV costs and benefits are expressed in 2024 dollars. NPV costs and benefits for P4TD financials are expressed in 2021 dollars.

Cadmus calculated TRC benefit-cost ratios 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. *Appendix C* shows the TRC ratios by program and for the portfolio.

Table 2-16. Summary of Portfolio Finances – Gross Verified

Row	Cost Category	PYTD ($1,000)		P4TD[2] ($1,000)	
1	**Incremental Measure Costs (IMCs)**	**$155,231**		**$394,615**	
2	Rebates to Participants and Trade Allies	$26,127		$75,834	
3	Upstream/Midstream Incentives	$3,206		$11,216	
4	Material Cost for Self-Install Programs (EE&C Kits)	$1,185		$6,161	
5	Direct Installation Program Materials and Labor	$5,475		$10,392	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)[6]	$119,238		$291,012	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$697	$462
8	Administration and Management[3]	$1,748	$4,004	$5,766	$14,478
9	Marketing	($892)	$6,257	$4,461	$10,505
10	Program Delivery[4]	$0	$14,981	$0	$39,978
11	EDC Evaluation Costs	$2,738		$6,948	
12	SWE Audit Costs	$396		$1,594	
13	**Program Overhead Costs (Sum of rows 7 through 12)**[6]	**$29,232**		**$84,890**	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)**[5],[6]	**$184,463**		**$481,022**	
15	Total NPV Lifetime Electric Energy Benefits	$127,613		$370,320	
16	Total NPV Lifetime Electric Capacity Benefits	$86,343		$235,261	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$7,429		$22,342	
18	Total NPV Lifetime Fossil Fuel Impacts	$6,471		$16,735	
19	Total NPV Lifetime Water Impacts	$13,068		$36,139	
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)**[6]	**$240,924**		**$680,797**	
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.31**		**1.42**	

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = $2021

[2] P4TD benefits do not include carry-over energy savings from Phase III

[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.

[4] Includes CSP 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.

[5] Row 14 (portfolio-level TRC costs) includes excess incentives from the Residential Efficient Lighting program component; $1,516,214 in P4TD. Per Phase IV TRC Order, excess incentives are to be treated as a TRC cost, so the sum of row 1 and 13 do not add up to row 14.

[6] Sum of rows may not add up to total due to rounding.

2.11. Comparison of Performance to Approved EE&C Plan

Table 2-17 presents PY16 expenditures compared to the budget estimates set forth in the EE&C plan for PY16 and P4TD. PY16 values are expressed in 2024 dollars, and P4TD values are expressed in 2021 dollars. *Appendix C* presents program-level comparisons of expenditures to plans.

Table 2-17. Comparison of Expenditures to Phase IV EE&C Plan ($1,000)

Expenditures	Budget from EE&C Plan	Actual Expenditures[1]	Ratio (Actual/Plan)
PY16 Portfolio	$64,938	$65,225	100%
PIV TD	$248,426	$205,178	83%

Source: PPL Electric Utilities Phase IV EE&C plan, Table 6.
[1] Includes SWE audit costs.

Table 2-18 compares PY16 and P4TD verified gross program savings to the energy savings projections set forth in the EE&C plan. PPL Electric Utilities exceeded PY16 planned energy savings and demand reductions and is on track to meet the Phase IV compliance targets. *Appendix C* presents program-level comparisons of actual savings to plans.

Table 2-18. Comparison of Actual Program Savings to EE&C Plan Projections

Savings	EE&C Plan Projections Through PY16	VTD Gross Savings	Ratio (Actual/Plan)
PY16 Portfolio MWh/yr	258,286	299,591	116%
PIV TD MWh/yr	1,123,857 [1]	975,352[1]	87%
PY16 Portfolio MW/yr (System-Level)	51.44	62.83	122%
PIV TD MW/yr (System-Level)	200.25	176.16	88%

Source: PPL Electric Utilities Phase IV EE&C plan, Table 4 and Table 5.
[1] Excludes Phase III carryover.

2.11.1. Program Summary

This section provides a summary of why program savings in PY16 varied from projections estimated in the EE&C plan. The individual program chapters and appendices include more detail.

Non-Residential Program Components

The Non-Residential Program exceeded PY16 planned energy savings as estimated in the EE&C Plan by 12% and demand savings by 26%. The energy realization rate was 95% and the demand reduction realization rate was 94%. The realization rates were influenced by differences in building types and fixture wattage assumptions within the Efficient Equipment Lighting subcomponents, differences in installed equipment quantities and capacities for Efficient Equipment non-lighting subcomponents, and additional data needs and applied waste heat factors within the Custom subcomponent. These differences resulted in a reduction in energy and demand realization rates for PY16. Additional details about the factors that led to differences between reported and verified savings and the overall realization rate for the Non-Residential Program in PY16 are included in *Section 5. Non-Residential Program*, *Appendix D*, and *Appendix E*.

Residential Program Components

The Residential Program exceeded projected PY16 energy savings as estimated in the EE&C Plan by approximately 49% primarily due to the addition of the Home Energy Report component. The Program also slightly exceeded the PY16 projected demand reductions by 4%..

The energy realization rate was 101% and the demand realization rate was 94% for the program overall. The Energy Efficient Homes and Appliance Recycling components had demand reduction realization rates lower than 100% due to a variety of reasons, including corrected baseline conditions, updated installation rates, and updated per-unit savings for appliance recycling. Additional details are in *Section 7. Residential Program*, *Appendix G, Appendix I, Appendix J*, and *Appendix N*.

Low-Income Program

Including carryover from Phase III, the Low-Income Program has exceeded the Phase IV compliance target by 14%. The Low-Income energy realization rate was 84% and the demand realization rate was 85%. The factors that led to differences between reported and verified savings and the overall realization rate for the Low-Income Program in PY16 are included in *Section 6. Low-Income Program*.

2.11.2. PY17 Program Changes

PPL Electric Utilities has made the following program changes for PY17.

Non-Residential Program Components

- **Custom.** The Custom component allows customers to receive incentives for the completion of complex and comprehensive projects that involve measures not covered by the Efficient Equipment component. Retro-commissioning (RCx) lite was introduced in PY17. After two successful Building Operator Certification level 1 courses in partnership with Pennsylvania College of Technology, PPL Electric Utilities expanded this offering and is launching a level 2 course for past participants in PY17. Incentives for SCI customers' custom projects increased to match the LCI incentive level for the remainder of the phase.
- **Efficient Equipment.** The Efficient Equipment component continues to offer incentives through downstream and midstream delivery channels. Midstream lighting incentives increased at the start of PY17, along with the addition of occupancy sensors. The midstream offering is expanding to include HVAC, VFDs, and Refrigeration measures. Efficient Equipment incentives for SCI customers also increased to match the LCI incentive level for the remainder of the phase, along with Direct Discount incentives.

Residential Program Components

- **Appliance Recycling.** The Appliance Recycling component continues to offer both contactless and in-home pickups, with approximately 60% of the participants still preferring the contactless option. A limited time offer for small appliances was introduced in PY16 that increased the rebate from $10 to $25. This offer will continue into PY17. In PY16, PPL Electric Utilities held six small appliance pick-up events and will continue offering these events throughout the PPL Electric Utilities territory for the remainder of the phase. These are geographically focused

events that encourage customers to sign up and drop off room air conditioners and dehumidifiers at a central location. In PY16, PPL Electric Utilities also added a school fundraiser option where schools host small appliance recycling drives. The rebates support student clubs, organizations, and teams. These fundraising events will continue through the end of the phase. In addition, retailer partnerships continue to expand and remove secondhand appliances that would otherwise be sold and remain on the grid instead of being responsibly recycled.

- **Efficient Lighting.** This component has sunset and is no longer offered.
- **Energy Efficient Homes.** A number of this component's initiatives will continue, change, or expand into PY17:
  - In PY16, PPL Electric Utilities removed spray foam and advanced power strips from the Instant Discount channel to pivot the portfolio toward more cost-effective measures, including a newly added air purifier rebate. In PY17, room ACs, smart thermostats, and water measures will also be added to this channel.
  - PPL Electric Utilities will continue to offer virtual assessments and in-home audits in PY17. In addition, the PY16 comprehensive retrofit and deep energy retrofit bonuses, which provide additional incentives when customers complete upgrades, such as air sealing, insulation, and HVAC equipment, will continue in PY17.
  - PPL Electric Utilities will continue to recruit distributors to offer discounts at point-of-purchase through the midstream delivery channel in PY17.
  - The New Homes subcomponent had strong performance in efficient new home construction in PY16, and PPL Electric Utilities expects to see that continue in PY17, with updates that reflect changes in funding availability. This strategic adjustment will allow PPL Electric Utilities to fulfill rebates through the remainder of PY17.
  - In PY16, PPL Electric Utilities offered a limited-time heat pump and water heater incentive to encourage the installation of advanced heating/cooling and hot water systems in new residential construction. These limited-time offer incentives will continue in PY17.
  - The central heat fuel switch rebate continued in PY16 and will reach its cap and end in early PY17.
- **Home Energy Report (HER).** PPL Electric Utilities launched a behavioral program component in PY16. This component encompassed both paper and digital reports for treatment participants and promoted behavioral energy efficiency by motivating customers to become more efficient through similar home comparisons. PPL Electric Utilities also offered a new energy analyzer to educate all residential customers, as well as small and medium business customers, and both will continue for the remainder of the phase.
- **Student Energy Efficient Education.** In PY16, this component continued to actively engage students and teachers through interactive presentations. All three student cohorts, Bright Kids, Take Action, and Innovation, were fully subscribed for PY16 and are already fully subscribed for PY17.

- **EV Charging Pilot.** PPL Electric Utilities initiated an EV Charging Equipment Pilot in PY16 to realize energy savings and gain insight into customer purchasing and charging preferences of EV chargers in its territory. For a limited time in PY17, PPL Electric Utilities will offer up to 1,000 customers the option to purchase Level 2 EV chargers through an online marketplace or submit a rebate for past charging equipment or certain model EV purchases. This pilot requires charging data sharing.

Low-Income Program

- **Low-Income.** The Low-Income Program continues to offer a broad selection of no-cost energy-saving measures, services, and education to qualifying low-income customers residing in single-family homes, individually and MMMF units, and manufactured homes. Trends indicate a higher customer preference for in-home assessments versus virtual appointments in PY16. PPL Electric Utilities expects this trend to continue in PY17, though it will continue to offer both appointment types. The program will continue to expand multifamily unit assessments for the remainder of Phase IV. In PY16, the program began offering shower aerators to assessment-eligible customers who do not want to replace their existing showerheads to increase the number of water-saving measures installed. The program closely coordinates with other assistance programs, including the Low-Income Usage Reduction Program and OnTrack, and with natural gas utilities when feasible. PPL Electric Utilities worked to coordinate services with local community-based assistance organizations like food banks in PY16 and is continuing in PY17. In PY17, the program will continue offering appointments during evening and weekend hours to allow for more flexible scheduling for low-income customers. The program is also evaluating expanded call center hours that include Saturdays in PY17. PPL Electric Utilities expects there will be a continued need for both comprehensive and health and safety measures in PY17.

2.12. Findings and Recommendations

Cadmus does not have any overarching recommendations that affect more than one program. Specific recommendations for each program are in their respective sections.

3. Portfolio Finances and Cost Recovery

This section provides an overview of the expenditures associated with PPL Electric Utilities' portfolio and the recovery of those costs from ratepayers.

3.1. Program Finances

Table 3-1 shows program-specific and portfolio total finances for PY16. The columns in this table are adapted from the Direct Program Cost categories in the PA PUC's EE&C plan template for Phase IV.[12] Non-incentives include EDC materials, labor, and administration costs (including costs associated with an EDC's own employees) as well as ICSP materials, labor, and administration costs (including the program implementation contractor and the costs of any other outside vendors EDCs employ to support program delivery). The dollar figures shown in Table 3-1 are based on EDC tracking of expenditures with no adjustments to account for inflation.[13]

Table 3-1. PY16 Program and Portfolio Total Finances ($1,000)

Program	Incentives	Non-Incentives	Total Cost[(2)]
Non-Residential	$22,293	$10,624	$32,917
Low-Income	$6,440	$3,785	$10,225
Residential	$7,259	$6,671	$13,931
Common Portfolio Costs[(1)]	-	$7,756	$7,756
Portfolio Total[(2)]	**$35,993**	**$28,836**	**$64,829**
SWE Costs[(3)]	-	-	$396
Total[(2)]	**$35,993**	**$28,836**	**$65,225**

[(1)] Common portfolio costs are costs applicable to more than one customer class or more than one program or that provide portfolio-wide benefits. These costs include PPL Electric Utilities' labor and materials, legal review, PPL Electric Utilities' tracking system, EE&C plan development, etc.
[(2)] Totals may not sum due to rounding.
[(3)] SWE costs are outside of the 2% spending cap.

[12] Pennsylvania Public Utility Commission. September 9, 2020. "Implementation of Act 129 of 2008—Phase IV. Energy Efficiency and Conservation Plan Template. Docket No. M-2020-3015228." https://www.puc.pa.gov/pcdocs/1676672.docx

[13] The cost-recovery of program expenses through riders generally happens promptly so that costs are being recovered from ratepayers in the same dollars that they are incurred.

Table 3-2 shows program-specific and portfolio total finances since the inception of Phase IV.

Table 3-2. Phase IV Program and Portfolio Total Finances ($1,000)

Program	Incentives	Non-Incentives	Total Cost[2]
Non-Residential	$71,100	$31,603	$102,703
Low-Income	$16,295	$13,430	$29,724
Residential	$25,707	$20,740	$46,448
Common Portfolio Costs[1]	-	$24,586	$24,586
Portfolio Total[2]	**$113,102**	**$90,359**	**$203,462**
SWE Costs[3]	-	-	$1,716
Total [2]	**$113,102**	**$90,359**	**$205,178**

[1] Common portfolio costs are costs applicable to more than one customer class or more than one program or that provide portfolio-wide benefits. These costs include PPL Electric Utilities' labor and materials, legal review, PPL Electric Utilities' tracking system, EE&C plan development, etc.
[2] Totals may not sum due to rounding.
[3] SWE costs are outside of the 2% spending cap.

3.2. 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 four customer sectors to ensure that the electric rate classes that finance the programs are the rate classes that receive the direct energy 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. Readers should be mindful of the differences between Table 3-3 and the information presented in *2.3. Phase IV Performance by Customer Segment*. For example, since the low-income customer segment is a subset of PPL Electric Utilities' residential tariff(s), it is not listed in Table 3-3.

Table 3-3. EE&C Plan Expenditures by Cost-Recovery Category ($1,000)

Cost Recovery Sector	Rate Classes Included	PY16 Spending	P4TD Spending
Residential & Low-Income (100/200)	Residential (primarily RS)	$27,061	$87,568
Small C&I (300)	Small C&I (primarily GS1 & GS3)	$19,865	$64,470
Large C&I (400)	Large C&I (primarily LP4 & LP5)	$11,264	$31,353
GNE	Residential, Small C&I, and Large C&I	$7,034	$21,785
Portfolio Total[1][2]	**-**	**$65,225**	**$205,178**

[1] Includes costs for SWE audit.
[2] Totals may not sum due to rounding.

For Phase IV of Act 129, PPL Electric Utilities nominated a portion of peak demand reduction acquired via EE&C programs into the PJM Forward Capacity Market. Proceeds from resources that clear in the

FCM flow back to the rate class that generated the savings to offset cost recovery. Table 3-4 shows the proceeds received in PY16 and P4TD net of CSP fees and other administrative costs.[14]

Table 3-4. FCM Proceeds from Recognized Peak Demand Reductions ($1,000)

Cost Recovery Sector	Rate Classes Included	PY16 Proceeds	P4TD PJM Proceeds
Residential and Low-Income (100/200)	Residential (primarily RS)	$16.77	$24.96
Small C&I (300)	Small C&I (primarily GS1 and GS3)	$25.77	$40.72
Large C&I (400)	Large C&I (primarily LP4 and LP5)	$22.46	$33.68
GNE	Residential, Small C&I, and Large C&I	N/A	N/A
Portfolio Total(1)	-	$65.00	$99.36
(1) Includes costs for SWE audit.			

At the portfolio level, PY16 cost recovery requirements were lowered by 0.1% due to the FCM proceeds received from recognition of 4.8 MW for the 2024-2025 DY. P4TD cost recovery requirements have been lowered by 0.05% due to the FCM proceeds received from recognition of 1.4 MW for the 2022-2023 DY, 2.8 MW for the 2023-2024 DY, and 4.8 MW for the 2024-2025 DY. PPL Electric Utilities expects to receive an additional $772,152 of proceeds for the 2025/2026 DY. Beginning in the 2026/2027 DY, peak demand reduction from energy efficiency is no longer an eligible resource, so Phase V cost recovery will be unaffected by proceeds from Phase IV peak demand reductions.

[14] Due to FERC review of complaints seeking to disqualify some energy efficiency capacity earlier than the end of the current year and/or invalidate prior year participation, the values shown are subject to change.

4. Evaluation Activities

This section documents the gross impact and process evaluation activities conducted in PY16. This report documents and discusses the outcomes of these activities in subsequent sections. Not every program or program component receives an evaluation every year. Table 4-1 lists the activities for each program and component in PPL Electric Utilities' portfolio.

Table 4-1. PY16 Evaluation Activity Matrix

Program/Component	Gross Impact	Net Impact	Process
Non-Residential Program			
Custom	✓(3)	✓(1)	✓
Efficient Equipment Non-Lighting Downstream	✓	✓(1)	✓
Efficient Equipment Lighting Downstream	✓	✓(1)	✓
Efficient Equipment Non-Lighting (Midstream)	✓	✓(1)	✓
Efficient Equipment Lighting (Midstream)	✓	✓(1)	✓
Low-Income Program			
Low-Income Assessment	✓	-	✓
Residential Program			
Appliance Recycling	✓(2)	✓(1)	✓
Efficient Lighting	-	-	-
Energy Efficient Homes New Homes	-	-	✓
Energy Efficient Homes Audit and Weatherization	✓	✓(1)	✓
Energy Efficient Homes Equipment (downstream)	✓(3)	✓	✓
Energy Efficient Homes Equipment (midstream)	✓	✓(4)	✓
Energy Efficient Homes Online Marketplace	✓(2)	✓(1)	✓
Energy Efficient Homes Instant Discount	✓(2)	✓(1)	✓
Home Energy Reports	✓	-	✓
Student Energy Efficient Education	✓(2)	-	✓

(1) Applying a historical NTG ratio to verified savings.
(2) Applying a historical realization rate to verify a portion or all of PY16.
(3) A portion of savings were unverified in PY16 and will be verified in PY17.
(4) Applying historical NTG ratio to some subcomponents and a downstream NTGR to others.

4.1. Impact Evaluation

Table 4-2 provides an impact evaluation overview for Phase IV with two rows for each initiative. Plans for upcoming years, including PY17, are tentative. The first row indicates the sampling and data collection frequency or the years the impact evaluation will be conducted. The second row shows how savings from the initiative will be presented in that year's final annual report, where:

- V = verified using the results of the impact evaluation completed that year.
- H = verified using the results of a historic impact evaluation.
- U = unverified until the results of the impact evaluation are available.

Table 4-2. Gross Impact Overview

Initiative	Plan	PY13	PY14	PY15	PY16	PY17
Non-Residential						
Custom Large	Sampling	Impact	Impact	Impact	Impact	Impact
	Reporting	V	V	V	V [2]	V
Custom Small	Sampling	Two-year sample[1]		Two-year sample [1]		Impact
	Reporting	U	V	U	V	H
Custom CHP	Sampling	Impact	Impact	Impact	Impact	Impact
	Reporting	V	V	V	V	V
Efficient Equipment Non-Lighting (Downstream)	Sampling	Impact	Impact	Impact	Impact	None
	Reporting	V	V	V	V	H
Efficient Equipment Non-Lighting (Midstream)	Sampling	None	Two-year sample[1]		Impact	Impact
	Reporting		U	V	V	V
Efficient Equipment Lighting (Downstream)	Sampling	Impact	Impact	Impact	Impact	None
	Reporting	V	V	V	V	H
Efficient Equipment Lighting (Midstream)	Sampling	Impact	Impact	Impact	Impact	Impact
	Reporting	V	V	V	V	V
Low-Income						
Low-Income (Remote Energy Assessments)	Sampling	Impact	Impact	None	Impact	Impact
	Reporting	V	V	H	V	V
Low-Income (In-home Assessments)	Sampling	Two-year sample[1]		None	Impact	Impact
	Reporting	U	V	H	V	V
Low-Income (Welcome Kits)	Sampling	Impact	Impact	Impact	Impact	Impact
	Reporting	V	V	V	V	V
Residential						
Appliance Recycling (Refrigerators and Freezers)	Sampling	Impact	Impact	Impact	None	None
	Reporting	V	V	V	H	H
Appliance Recycling (Room Air Conditioners and Dehumidifiers)	Sampling	Impact	Impact	Impact	Impact	Impact
	Reporting	V	V	V	V	V
Energy Efficient Home (Audit and Weatherization)	Sampling	None	Impact	None	Impact	None
	Reporting		V	H	V	H
Energy Efficient Home (Midstream Equipment)	Sampling	None	None	Two-year sample[1]		None
	Reporting			U	V	H
Energy Efficient Home (Downstream Equipment)	Sampling	Impact	None	Impact	Impact	None
	Reporting	V	H	V	V	H
	Sampling	Impact	Two-year sample[1]		Impact	Impact

Initiative	Plan	PY13	PY14	PY15	PY16	PY17
Energy Efficient Home (Online Marketplace)	Reporting	V	U	V	H	V
Energy Efficient Home (New Homes)	Sampling	Two-year sample [1]		Impact	None	Impact
	Reporting	U	V	V	U	V
Energy Efficient Home (Instant Discount)	Sampling	None	Two-year sample[1]		None	Impact
	Reporting		U	V	H[3]	V
Efficient Lighting (Lighting)	Sampling	Impact	None	None	None	None
	Reporting	V	H	H		
Home Energy Report (HER)	Sampling	None	None	None	Impact	Impact
	Reporting				V	V
Student Energy Efficient Education (All Strata)	Sampling	Impact	Two-year sample[1]		None	Impact
	Reporting	V	U	V	H	V

[1] In general, the two-year sample will include the first through fourth quarters (Q1-Q4) of the first year in the sample and Q1 and Q2 of the second year in the sample.
[2] One large project was left unverified and will be verified in PY17.
[3] Savings for spray foam were verified in PY16 and a historical realization rate was applied to verified savings for other measures.

Impact evaluation activities varied by program in PY16. Table 4-3 lists the impact evaluation activities conducted for each program component in PY16. The individual program chapters and corresponding appendices discuss the impact evaluation activities, methodology, analysis, and findings.

Table 4-3. PY16 Impact Evaluation Activities by Program Component

Program and Component	Database Review	Desk Reviews	Site Visits	Metering	Engineering Analysis	Billing Analysis
Non-Residential Program						
Custom	✓	✓	✓	✓	✓	
Efficient Equipment Non-Lighting (downstream)	✓	✓	✓		✓	
Efficient Equipment Lighting (downstream)	✓	✓			✓	
Efficient Equipment Non-Lighting (midstream)	✓	✓			✓	
Efficient Equipment Lighting (midstream)	✓	✓			✓	
Low-Income Program						
Low-Income Assessment	✓	✓			✓	
Residential Program						
Appliance Recycling	✓					
Efficient Lighting						
Energy Efficient Homes New Homes	✓					
Energy Efficient Homes Audit and Weatherization	✓	✓			✓	
Energy Efficient Homes Equipment (downstream)	✓	✓			✓	
Energy Efficient Homes Equipment (midstream)	✓	✓			✓	
Energy Efficient Homes Online Marketplace	✓					
Energy Efficient Homes Instant Discount	✓				✓	
Energy Efficient Homes Deep Energy Retrofits Pilot	✓					
Energy Efficient Homes High Performance Home Pilot	✓					
Home Energy Reports	✓					✓
Student Energy Efficient Education	✓					

4.2. Process Evaluation

This section summarizes the process evaluation activities of PPL Electric Utilities' PY16 portfolio.

Table 4-4 lists the process evaluation activities conducted for each program in PY16, along with the total number of survey and interview respondents reached for each component and delivery channel. A more detailed explanation of the program components' survey methodology is in their respective appendices.

Table 4-4. PY16 Portfolio Process Evaluation Activities by Component

Program and Component	Completed Participant Survey or Interview [1]	Stakeholder Interviews/ Feedback	Trade Ally Interviews	Market Actor Interviews	Logic Model Review
Non-Residential Program					
Custom	✓ (n=7)	-	-	-	-
Efficient Equipment	✓ (n=27)	✓ (n=2)	-	-	-
Low-Income Program					
Low-Income Assessment	✓ (n=256)	-	-	✓ (n=1)	-
Residential Program					
Appliance Recycling	- [2]	✓ (n=2)	-	-	-
Energy Efficient Homes Audit and Weatherization	✓ (n=44)	✓ (n=3)	-	-	-
Energy Efficient Homes Equipment (downstream)	✓ (n=260)		-	-	-
Energy Efficient Homes Equipment (midstream)	-		✓ (n=2)	-	-
Home Energy Reports (HER)	✓ (n=997)	✓ (n=3)	-	-	✓
Student Energy Efficient Education	✓ (n=15,249)	✓(n=2)			
Total	**n=16,840**	**12**	**2**	**1**	**-**

[1] Includes all survey modes: online, telephone, and paper. For additional details, see the program chapter and appendix. This may not match the totals used for program satisfaction, net-to-gross, or impact inputs.
[2] Cadmus did not conduct new customer satisfaction research for Appliance Recycling and used results from PY13-PY15 to calculate program and portfolio-level satisfaction.

PPL Electric Utilities

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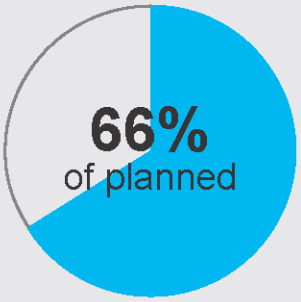
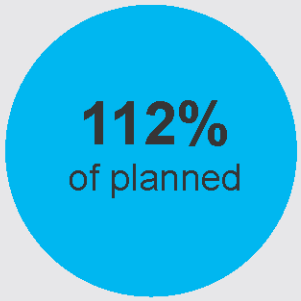
NON-RESIDENTIAL PROGRAM

The Non-Residential Program offers financial incentives to all large and small commercial and industrial customers, including government and education institutions and master metered low-income multifamily buildings.

VERIFIED ENERGY SAVINGS

Phase IV has saved **747,612 MWh/yr**

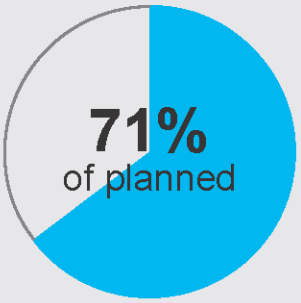


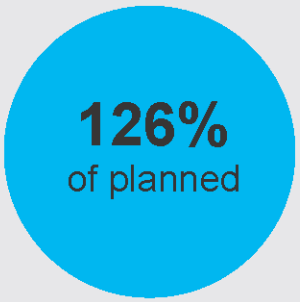


PY16 saved **234,987 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **147.07 MW/yr**





PY16 has reductions of **55.19 MW/yr**

PY16 PARTICIPATION

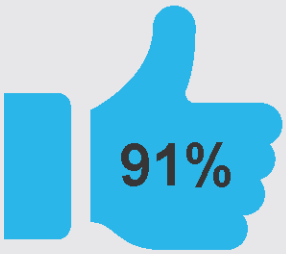
A total of **5,359** participants

282 Custom

324 Efficient Equipment Non-Lighting

4,753 Efficient Equipment Lighting

PARTICIPANT SATISFACTION



Satisfied with overall program

96% satisfied with Efficient Equipment

86% satisfied with Custom

5. Non-Residential Program

PPL Electric Utilities' Non-Residential Energy Efficiency Program offers financial incentives to customers in a non-residential rate class and for any building or business type. The program ICSP, CLEAResult, manages program operations and oversees rebate and incentive delivery.

The program comprises these two distinct components:

- **Efficient Equipment** offers lighting and equipment (non-lighting) through four delivery channels: downstream rebates, direct discount, direct install, and midstream.
- **Custom** provides financial incentives to customers who install products or offer services through a downstream delivery channel that are not offered in PPL Electric Utilities' other programs.

The evaluation methodology and findings for the two Non-Residential Program components are described in *Appendix D. Evaluation Detail – Efficient Equipment Component* and *Appendix E. Evaluation Detail – Custom Component*.

5.1. Participation and Reported Savings by Customer Segment

Table 5-1 presents the participation counts, reported energy and demand savings, and incentive payments for the Non-Residential Program in PY16 by customer segment.

Table 5-1. PY16 Non-Residential Participation and Reported Impacts

Parameter	Residential (Non-LI)	Small C&I (Non-GNE)	Large C&I (Non-GNE)	GNE	Total[1],[2]
PYTD # Participants	3	3,220	809	1,328	5,360
PYRTD MWh/yr	382	88,197	119,791	39,917	248,286
PYRTD MW/yr	0.13	23.07	24.14	8.31	55.65
PYVTD MWh/yr[3]	332	82,793	113,456	38,407	234,987
System-Level PYVTD MW/yr[3]	0.14	22.85	23.85	8.35	55.19
PY16 Incentives ($1000)	$133	$11,885	$6,682	$3,593	$22,293

[1] The totals in this table do not include PY15 unverified savings verified in PY16.
[2] Total may not sum due to rounding.
[3] Savings for one custom job were left unverified in PY16 and will be verified in PY17.

Table 5-2 shows the Non-Residential Program's verified gross energy savings and demand reductions.

Table 5-2. Non-Residential Program Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified [1]	PY16 Verified	PY16 Unverified	Phase IV Verified [2]
MWh/yr	129,833	210,406	172,385	234,987	1,317	747,612
System-Level MW/yr	21.26	36.65	33.96	55.19	0.39[3]	147.07

[1] Includes PY15 savings verified in PY16.
[2] Phase IV verified savings may not match sum of program years due to rounding and does not include unverified savings.
[3] This does not include the application of line losses.

5.2. Gross Impact Evaluation

Cadmus calculated gross verified savings using data from the PPL Electric Utilities' tracking database and a combination of evaluation activities, including records review, desk review, engineering analyses, site visits, and billing analysis. Table 5-3 and Table 5-4 show the gross energy savings and demand reduction realization rates for components of the Non-Residential Program in PY16. Additional details about the evaluation approach and findings are presented in *Appendix D. Evaluation Detail – Efficient Equipment Component* and *Appendix E. Evaluation Detail – Custom Component*.

Table 5-3. PY16 Non-Residential Gross Impact Results for Energy

Need Component	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 90% C.L.[2]	PYVTD (MWh/yr)
Custom	162,264	93%	0.17	4.6%	150,260
Efficient Equipment Non-Lighting	6,616	96%	0.16	4.6%	6,377
Efficient Equipment Lighting	78,090	100%	0.12	2.6%	78,350
Program Total[3][4]	**246,969**	**95%**	**0.21**	**3.2%**	**234,987**
Custom Large Unverified	1,317	-	-	-	-
Verified + Unverified Total[3][4]	**248,286**	**95%**	**0.21**	**3.2%**	**234,987**
PY15 Custom (PY15 verified in PY16)	41,612	87%	0.17	11.3%	36,146

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Realization rates in this table do not include unverified savings in the denominator. The Custom component realization rate with PY16 unverified savings is 91%.
[2] Relative precision in this table is reported at the 90% confidence level and will not match tables in the appendices, where relative precision is reported at the 85% confidence level.
[3] Savings may not match other tables or figures due to rounding.
[4] Totals may not sum due to rounding.

Table 5-4. PY16 Non-Residential Gross Impact Results for Demand

Component	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 90% C.L.[2]	PYVTD (MW/yr)	System-Level PYVTD (MW/yr)
Custom	38.44	95%	0.36	9.6%	36.70	38.96
Efficient Equipment Non-Lighting	1.25	89%	0.38	11.4%	1.12	1.21
Efficient Equipment Lighting	15.57	90%	0.28	6.6%	14.03	15.02
Program Total[3],[4]	**55.26**	**94%**	**0.48**	**7.3%**	**51.85**	**55.19**
Custom Large Unverified	**0.39**	-	-	-	-	-
Verified + Unverified Total[3], [4]	**55.65**	**93%**	**0.48**	**7.3%**	**51.85**	**55.19**
PY15 Custom (PY15 verified in PY16)	10.08	93%	0.34	22.5%	9.41	10.15

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified demand reductions. Realization rates were applied to verified demand reductions before application of distribution losses. The custom component realization rate is 95% with PY16 unverified demand reductions.
[2] Relative precision in this table is reported at the 90% confidence level and will not match tables in the appendices, where relative precision is reported at the 85% confidence level.
[3] Savings may not match other tables or figures due to rounding.
[4] Totals may not sum due to rounding.

The following factors affected the reported and verified savings and led to the observed realization rates:

- For non-lighting projects, the most significant adjustments affecting the overall realization rate occurred in the HVAC stratum projects. These adjustments involved corrections to installed equipment model parameters, application of IMP methodology and SWE guidance in the calculation process, and removal of sub-measures not implemented. Additional adjustments in other end uses addressed facility type, equipment size, and quantities installed. While these changes had inconsistent impacts on individual project realization rates, they collectively lowered the overall realization rate. See *Section D.1.2. Gross Impact Results* for more information on factors that affected observed realization rates for the Efficient Equipment component.
- For lighting projects, adjustments were primarily driven by inconsistencies between the reported and verified hours of use, coincidence factors, fixture wattages, and fixture control strategies. Many fixture wattage updates involved minor changes due to rounding and alignment with DLC listings. See *Section D.1.2. Gross Impact Results* for more information on factors that affected observed realization rates for the Efficient Equipment component.
- For custom projects, a significant impact on the realization rates was attributed to solar projects, which required one month of summer data to align with the Solar IMP. For a large horticultural lighting project that accounted for 20% of the program year's verified savings, adjustments made based on additional operating data impacted the demand reductions and a change to the waste heat factor contributed to a reduction in energy savings. See *Section E.1.2 Gross Impact Results* for more information on factors that affected observed realization rates for the Efficient Equipment component.

5.3. Net Impact Evaluation

The methods used to determine net savings for downstream, upstream, and midstream delivery channels are provided in the Phase IV Evaluation Framework,[15] which discusses the common methods used to determine free ridership and spillover.

Because Cadmus did not conduct new primary research to assess net savings for the Non-Residential Program in PY16, the evaluation used the historic NTG ratios listed in Table 5-5.[16] Findings from net savings research are not used to adjust compliance savings in Pennsylvania. Instead, this research provides directional information for program planning purposes.

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[15] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

[16] PPL Electric Utilities. September 30, 2023. *Phase IV of Act 129 Program Year 14 Annual Report (June 1, 2022–May 31, 2023).* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus.

Table 5-5 presents NTG ratios for the components of the Non-Residential Program in PY16.

Table 5-5. PY16 Non-Residential Net Impact Evaluation Results

Component	Program Year	PYVTD (kWh/yr)	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision (at 85% CL)
Custom	PY14	150,259,848	26%	0%	0.74	3%
Efficient Equipment Non-Lighting	PY14	5,807,642	84%	0%	0.16	84%
Efficient Equipment Lighting	PY14	41,823,690	35%	0%	0.65	10%
Midstream Lighting	PY15	36,526,360	30%	0%	0.70	10%
Midstream Equipment Non-Lighting	PY15 Benchmarking	569,791	6%	0%	0.94[1]	-
Program Total	**-**	**234,987,331 [2]**	**30%[3]**	**0%[3]**	**0.70[3]**	**5%**

[1] Midstream agriculture NTGR is 0.95, and midstream food service is 0.81.
[2] May not sum due to rounding.
[3] Weighted by PY16 component verified gross energy savings.

5.4. Verified Savings Estimates

In Table 5-6, Cadmus determined and applied realization rates and NTG ratios to the reported energy and demand savings estimates to calculate the verified savings estimates for the Non-Residential Program in PY16. Cadmus added these totals to the verified savings achieved in previous program years to calculate the P4TD program impacts.

Table 5-6. PY16 and P4TD Savings Summary for the Non-Residential Program

Savings Type	Energy (MWh/yr)	Demand (MW/yr)
PYRTD	248,286	55.65
PYVTD Gross	234,987[1]	55.19[1][2]
PYVTD Net	165,410[1]	39.38[1][2]
RTD	755,673	144.53
VTD Gross	747,612[3]	147.07[2][3]
VTD Net	502,830[3]	100.34[2][3]

[1] Does not include PY15 unverified savings verified in PY16.
[2] Verified peak demand reductions include application of distribution losses.
[3] Includes PY15 unverified savings verified in PY16.

The VTD savings contribution from PY15 has changed since the final PY15 annual report. Cadmus verified savings for PY15 small stratum Custom jobs in PY16 and included these savings in the VTD gross totals (36,146 MWh/yr and 10.15 system-level MW/yr).

5.5. Forecasted Savings and Expenditures

Table 5-7 and Table 5-8 show Phase IV Non-Residential Program performance by sector compared to the original and revised EE&C Plan projections and Phase III performance, as per the June 2023 settlement agreement.

Table 5-7. Phase IV Anticipated Total Large and Small C&I Savings (MWh/yr)

Sector	Program Component	Current Actuals + Pipeline (MWh)[1]	Original Plan (MWh)	Revised Plan (MWh)	Phase III Totals (MWh)[2]
Small C&I	Efficient Equipment	301,383	409,239	387,268	350,079
	Custom	171,827	161,077	257,545	42,276
Large C&I	Efficient Equipment	155,525	256,122	247,810	162,130
	Custom	290,293	544,117	233,298	133,388

[1] Includes PY13 VTD, PY14 VTD, PY15 VTD, PY16 VTD, PY16 unverified, and PY17 pipeline. Does not include verified or unverified Residential customer sector savings.
[2] GNE accounted for an additional 89,000 MWh/yr for Efficient Equipment and 134,000 MWh/yr for Custom in Phase III.

Table 5-8. Phase IV Anticipated Large and Small C&I Savings (MW/yr)

Sector	Program Component	Current Actuals + Pipeline (MW)[1]	Original Plan (MW)	Revised Plan (MW)	Phase III Totals (MW)[2]
Small C&I	Efficient Equipment	66.15	62.51	60.30	48.33
	Custom	47.03	22.90	63.57	5.00
Large C&I	Efficient Equipment	25.98	38.32	37.40	22.06
	Custom	55.04	68.30	30.64	15.41

[1] Includes PY13 VTD, PY14 VTD, PY15 VTD, PY16 VTD, PY16 unverified, and PY17 pipeline. Actuals include line losses, while pipeline and PY16 unverified values do not. Does not include verified or unverified Residential customer sector savings.
[2] GNE accounted for an additional 13.85 MW/yr for Efficient Equipment and 19.73 MW/yr for Custom in Phase III.

Table 5-9 shows the projected expenditures for the Small and Large C&I sectors for Phase IV, along with the planned expenditures.

Table 5-9. Phase IV Large and Small C&I Planned Expenditures (per $1,000)

Sector	Spend Type	Current Actuals + Pipeline ($)[1]	Original Plan ($)	Actual/Pipeline vs. Original Plan	Revised Plan ($)	Actual/Pipeline vs. Revised Plan
Small C&I[2]	Incentives	$57,830	$52,422	110%	$69,501	83%
	Non-Incentives	$26,233	$24,416	107%	$31,337	84%
Large C&I	Incentives	$33,375	$57,690	58%	$40,611	82%
	Non-Incentives	$17,571	$28,216	62%	$21,295	83%

[1] Includes PY13 VTD, PY14 VTD, PY15 VTD, PY16 VTD and PY17 pipeline. GNE costs used a ratio of 67% applied to Small C&I and 33% applied to Large C&I. Does not include costs associated with verified or unverified Residential customer sector savings.
[2] Plans include $2,000,000 allocated to the Low-Income Program for Master-Metered Multifamily

5.6. Process Evaluation

This section provides high-level results and findings from the process evaluation of the Non-Residential Program. Methodology and additional details for the Efficient Equipment and Custom components are discussed in the Efficient Equipment component *Appendix D.3. Process Evaluation* and the Custom component *Appendix E.3. Process Evaluation*, respectively. Cadmus conducted a process evaluation in PY16 to assess participant satisfaction, evaluate what is working well and what could be improved,

determine the influence of the component on decision-making, and make recommendations for program modification and improvement.

The evaluation activities are summarized in Table 5-10.

Table 5-10. Non-Residential Process Evaluation Activities

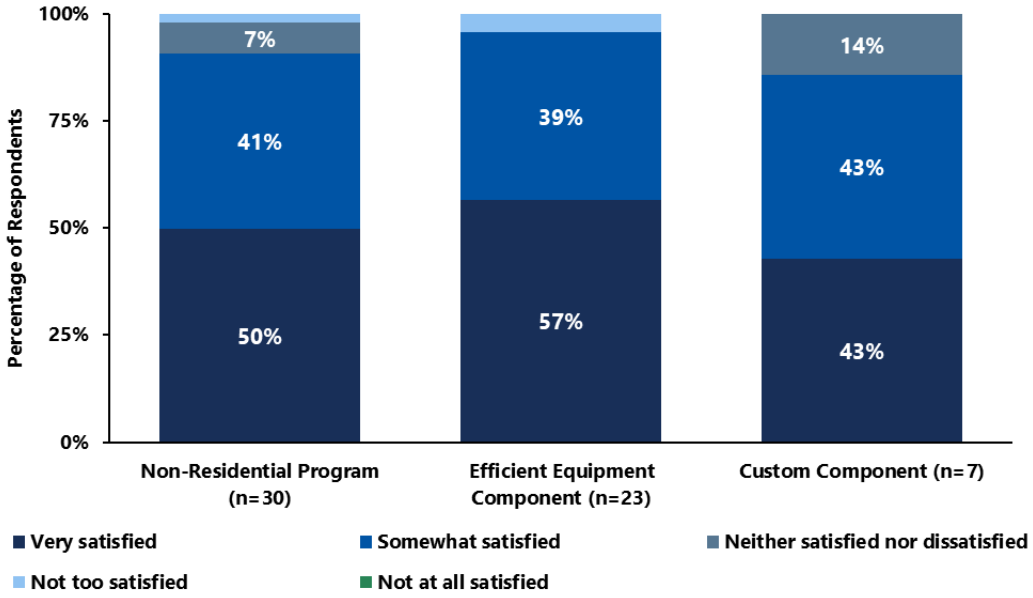
Activity	Audience [1]	Methodology
Efficient Equipment Downstream, Direct Install, and Direct Discount Delivery Channels		
In-depth Interviews	Administration staff (n=2)	Telephone
Surveys	Participants (n=27)	Telephone and online
Custom		
Surveys	Participants (n=7)	Telephone and online
[1] Survey and interview respondents could skip questions, and not all answered each question, so the number of responses may differ from what is reported here.		

Cadmus conducted staff interviews in February 2025 via phone. The team completed surveys with Custom and downstream Efficient Equipment participants between November 2024 and January 2025.

5.6.1. Process Evaluation Key Findings

For Phase IV, PPL Electric Utilities established a goal to achieve 85% or more satisfied participants within the Non-Residential Program. As shown in Figure 5-1, the program exceeded this goal, with 91% of Non-Residential Program survey respondents reporting they were satisfied with their program experience in PY16.

Figure 5-1. PY16 Non-Residential Program Overall Satisfaction



Source: Distributor, contractor, and end-user midstream Efficient Equipment survey question: "Thinking about your overall experience with PPL Electric Utilities' Midstream Distributor Instant Discount Program, how would you rate your satisfaction? Would you say you are…?" Custom and downstream Efficient Equipment survey question: "Thinking about your overall experience with the PPL Electric Utilities Business Energy Efficiency Rebate Program, how would you rate your satisfaction?" Values less than 5% are not labeled in the chart. Not all respondents answered this question.

Table 5-11 shows key findings from individual process evaluations for components in the Non-Residential Program.

Table 5-11. Non-Residential Program Key Process Evaluation Findings

Program Component	Finding
Efficient Equipment – Downstream and Direct Install	• Participants were satisfied with the component overall (96% satisfied), with PPL Electric Utilities as an energy provider (96%), and the outcome of their most recent energy efficiency initiative (88%). The most common drivers of satisfaction with the component were energy savings (mentioned by 50%) and the rebate amount (45%). Additionally, 44% reported that the program exceeded their expectations, 52% said it met their expectations, and only 4% said it fell short of their expectations. *(Section D.3.1)*
Efficient Equipment – Midstream	• Midstream lighting participation has increased due to greater uptake from lower-performing distributors, though participation in food service and agriculture has been limited, and no incentive applications have been received for HVAC projects.
Efficient Equipment – Custom	• Six of seven survey respondents were satisfied with the component overall (86%), and the same number were satisfied with PPL Electric Utilities as an energy provider (86%), and with the outcome of their most recent energy efficiency initiative (86%). The most common drivers of satisfaction were the rebate amount and the ease of the application process (both mentioned by 4 of 6 satisfied respondents). Three respondents reported their experience with the program exceeded their expectations (43%), three said it met their expectations (43%), and one said it fell short of their expectations (14%). *(Section E.3.1)*

5.7. Program Finances and Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 5-12. The TRC benefits were calculated using gross verified impacts. PY16 NPV costs and benefits are expressed in 2024 dollars. NPV costs and benefits for P4TD financials are expressed in 2021 dollars.

Table 5-12. Summary of Non-Residential Program Finances – Gross Verified

Row	Cost Category	PYTD ($1,000)		P4TD[2] ($1,000)	
1	**IMCs**	**$132,714**		**$314,443**	
2	Rebates to Participants and Trade Allies	$19,951		$59,317	
3	Upstream/Midstream Incentives	$2,342		$5,717	
4	Material Cost for Self-Install Programs (EE&C Kits)	$0		$0	
5	Direct Installation Program Materials and Labor	$0		$11	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)[6]	$110,421		$249,398	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$0	$0
8	Administration and Management[3]	$145	$1,906	$615	$6,996
9	Marketing	$0	$652	$0	$2,009
10	Program Delivery[4]	$0	$7,921	$0	$19,394
11	EDC Evaluation Costs	$0		$0	
12	SWE Audit Costs	$0		$0	
13	**Program Overhead Costs [5] (Sum of rows 7 through 12)**[6]	$10,624		$29,014	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)[5], [6]**	**$143,338**		**$343,458**	
15	Total NPV Lifetime Electric Energy Benefits	$111,029		$313,932	
16	Total NPV Lifetime Electric Capacity Benefits	$78,506		$202,779	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$7,429		$22,278	
18	Total NPV Lifetime Fossil Fuel Impacts	($4,965)		($23,021)	
19	Total NPV Lifetime Water Impacts	$9		$26	
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)**[6]	**$192,008**		**$515,994**	
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.34**		**1.50**	

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = $2021.
[2] P4TD benefits do not include carry-over energy savings from Phase III.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.
[4] Includes CSP 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.
[5] Portfolio-level costs are not assigned to specific programs.
[6] Sum of rows may not add up to total due to rounding.

Table 5-13 presents program financials and cost-effectiveness on a net savings basis. A detailed description of net savings research is provided in *Appendix D.2 Net Impact Evaluation, Appendix E.2 Net Impact Evaluation,* and *Appendix K Net Savings Impact Evaluation.* As stated in the 2021 TRC Order, free rider incentives are not included as an additional program cost, as these would have occurred even in the absence of a program.

Table 5-13. Summary of Non-Residential Program Finances – Net Verified

Row	Cost Category	PYTD ($1,000)		P4TD ($1,000)	
1	**IMCs**	**$94,550**		**$272,628**	
2	Rebates to Participants and Trade Allies	$19,951		$59,317	
3	Upstream/Midstream Incentives	$2,342		$5,717	
4	Material Cost for Self-Install Programs (EE&C Kits)	$0		$0	
5	Direct Installation Program Materials and Labor	$0		$11	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)	$72,257		$207,582	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$0	$0
8	Administration and Management [3]	$145	$1,906	$615	$6,996
9	Marketing	$0	$652	$0	$2,009
10	Program Delivery [4]	$0	$7,921	$0	$19,394
11	EDC Evaluation Costs	$0		$0	
12	SWE Audit Costs	$0		$0	
13	**Program Overhead Costs [5] (Sum of rows 7 through 12)**	**$10,624**		**$29,014**	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)[5] [6]**	**$105,174**		**$301,642**	
15	Total NPV Lifetime Electric Energy Benefits	$78,623		$280,249	
16	Total NPV Lifetime Electric Capacity Benefits	$56,047		$178,860	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$4,949		$20,135	
18	Total NPV Lifetime Fossil Fuel Impacts	($3,401)		($21,669)	
19	Total NPV Lifetime Water Impacts	$1		$20	
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)**	**$136,220**		**$457,594**	
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.30**		**1.52**	

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = $2021

[2] P4TD benefits do not include carry-over energy savings from Phase III

[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.

[4] Includes CSP 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.

[5] Portfolio-level costs are not assigned to specific programs.

[6] Sum of rows may not add up to total due to rounding.

5.8. Status of Recommendations

In PY16, the Non-Residential Program exceeded the PY16 plans, achieving 55.19 MW/yr in system-level demand reductions (126% of goal) and 234,987 MWh/yr in verified energy savings (112% of goal). Overall, the Non-Residential Program exceeded its customer satisfaction target with 91% of survey respondents reporting they were satisfied with their program experience. Table 5-14 below provides recommendations, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Conclusion 1: For **downstream non-lighting** projects, discrepancies were identified in some sampled HVAC projects, leading to lower realization rates.	• Each of the three sampled HVAC tune-up projects included the refrigerant charge correction sub-measure in reported savings calculations; however, this was not implemented for PTAC and PTHP tune-up measures. *(See Section D.1.2)* • Reported savings calculations used the new generation efficiency metrics and converted them to legacy metrics; however, the specification sheets provided already listed legacy metrics. These conversions should only be applied when the desired efficiency metric is unavailable. *(See Section D.1.2)*
Conclusion 2: For **downstream lighting**, some reported fixture wattages differed from the listed wattages in the DLC's ENERGY STAR QPL.	• For the Downstream Lighting subcomponent, 25 projects in the sample were adjusted for wattages. *(See Section D.1.2)*
Conclusion 3: For **midstream lighting**, one sampled job was found to have an ineligible fixture.	• One fixture in the sample was ineligible and resulted in zero savings. *(See Section D.1.2)*

The impact evaluation activities in PY16 led to the following findings and recommendations from Cadmus to PPL Electric Utilities, along with a summary of how PPL Electric Utilities plans to address the recommendations in program delivery (Table 5-14).

Table 5-14. Status of Recommendations for the Non-Residential Program

Program Component	Conclusion	Recommendation	EDC Status of Recommendation
Efficient Equipment Non-Lighting	**Conclusion 1:** For **downstream non-lighting** projects, discrepancies were identified in some sampled HVAC projects, leading to lower realization rates.	Ensure inputs to savings calculations match the work performed, project documentation, and technology specifications.	Implemented
Efficient Equipment Lighting	**Conclusion 2:** For **downstream lighting**, some reported fixture wattages differed from the listed wattages in the DLC's ENERGY STAR QPL.	Apply DLC's ENERGY START QPL listed wattages for all fixtures in the submitted Appendix C workbook.	Being considered
	Conclusion 3: For **midstream lighting**, one sampled job was found to have an ineligible fixture.	Remove ineligible fixtures from the program channel.	Implemented

PPL Electric Utilities

CADMUS

LOW-INCOME PROGRAM

The Low-Income Program offers a broad selection of no-cost energy-saving improvements and education to income-eligible customers to help reduce their electric consumption.

VERIFIED ENERGY SAVINGS

Phase IV has saved **82,703 MWh/yr***

114% of the compliance target

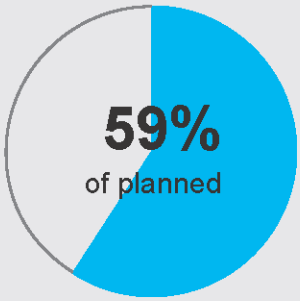
107% of planned

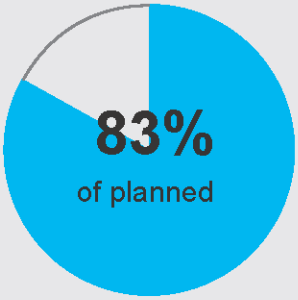
PY16 saved **15,530 MWh/yr**

*Includes Phase III carryover energy savings

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **5.82 MW/yr**





PY16 has reductions of **1.73 MW/yr**

PY16 PARTICIPATION

A total of **35,575** unique households participated

25,118 households received welcome kits

4,620 households received full-cost jobs

3,832 households received baseload jobs

3,498 households received low-cost jobs

1,731 master metered multifamily building jobs

Sum of participation in each job type exceeds number of households because some households received more than one treatment type.

PARTICIPANT SATISFACTION

78% Satisfied with overall program

84% satisfied with welcome kits

78% satisfied with on-site assessments

78% satisfied with remote energy assessments

6. Low-Income Program

The Act 129 Low-Income Program is designed to reduce electric consumption for income-eligible 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.[17, 18]

The Low-Income Program is administered by the ICSP, CMC Energy, which is responsible for a comprehensive range of services, including outreach, customer recruitment, home energy assessments, education, and the distribution of customized kits containing energy-saving items. In addition, the ICSP operates a customer call center and supports marketing and tracking efforts for both Act 129 and the Low-Income Usage Reduction Program. The ICSP also oversees the direct installation of energy-efficient equipment in customers' homes. Qualified contractors are engaged to perform installations, provide related services, and replace outdated or inefficient equipment with program-approved, energy-efficient alternatives. PPL Electric Utilities administers the Low-Income Program and oversees ICSP activities, as summarized in Table 6-1.

Table 6-1. Low-Income Program Summary

Program Channel	Target Market	Eligibility Requirements	Delivery Channels	Participant Definition
Remote Energy Assessment (REA)	Income-eligible customers; household income must be at or below 150% of the Federal Poverty Guidelines	Customers in PPL Electric Utilities' territory; single-family homes, individually metered multifamily buildings, and manufactured homes; customers may choose which delivery method they prefer	Remote assessment via telephone and a customized kit of items mailed to customer	Customers who receive a remote home energy assessment
In-Home (Direct Install)			On-site energy assessment and direct installation of technology	Customers who receive an on-site energy assessment
Master-Metered Multifamily (MMMF)		Customers in PPL Electric Utilities' territory; master-metered multifamily buildings (tenant units); receive landlord's approval		
Welcome Kits		Customers in PPL Electric Utilities' territory	Kit mailed to customer	Customers who receive a welcome kit

PPL Electric Utilities offers qualifying customers a range of energy-saving products and services, including HVAC, lighting, weatherization, water-saving, heating, appliances, and home health and safety.

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17 Household income must be at or below 150% of the Federal Poverty Guidelines.

18 Individually metered income-eligible multifamily residences are eligible for the same improvements as individually metered single-family income-eligible residences under the Low-Income Program. Individually metered manufactured homes are eligible for the same improvements as any other type of individually metered home receiving services from the Low-Income Program.

Consistent with PY15, in PY16, the ICSP provided eligible electric water heating customers with welcome kits containing three domestic hot water (DHW) saving products: one bathroom faucet aerator rated at 0.5 GPM, one kitchen faucet aerator rated at 1.25 GPM, and one energy-efficient showerhead rated at 1.5 GPM. Welcome kits contained instructions for product installation, including where to install each faucet aerator and a postcard. The postcard encouraged participation in an energy assessment through the Low-Income Program and provided participants with the ICSP contact phone number and program website.

In PY16, the ICSP continued to offer on-site assessments and remote assessments via telephone. All on-site and remote assessments involved an auditor visiting (in person or on the phone with the customer) each room in the home and asking the resident questions about the home's energy-consuming equipment, ultimately gathering information about the home's water heater and heating fuel type, the number and wattage of light bulbs in each room, and the number of showers and sinks. The home energy auditor refers to a pre-approved list of products and services, as well as criteria to determine if appliances and other large equipment can be replaced based on customer need and according to program guidelines. Auditors also provided tips and education on how participants could save energy based on their energy needs, home, and the condition of the energy equipment. For remote assessments, the ICSP mailed a comprehensive kit of energy-saving items customized to each participant's responses. If the remote energy assessment customer needed assistance, the ICSP arranged for an on-site visit. For on-site assessments, technicians directly installed equipment.

In PY16, PPL Electric Utilities provided four types of service (also known as job types) at no cost to income-qualified customers. The program offered baseload services to customers without electric heat and without an electric water heater, low-cost services to customers without electric heat but with electrically heated water, full-cost services to customers with both electric heat and electrically heated water, and a welcome kit to any eligible customer.

6.1. Participation and Reported Savings by Customer Segment

Table 6-2 shows the participation counts, reported and verified energy and demand savings, and incentives (i.e., value of improvements provided) for the Low-Income Program. Participants are defined as unique households (billing account number) who receive a welcome kit or a home assessment and program services.

Table 6-2. PY16 Low-Income Program Participation and Reported Impacts

Parameter	Residential Low-Income	Small C&I Low-Income	GNE Low-Income	Total[1]
PY16 # Participants[2]	35,560	15	0	**35,575**
PYRTD MWh/yr	17,690	712	0	**18,402**
PYRTD MW/yr	1.80	0.08	0	**1.87**
PYVTD MWh/yr	14,964	567	0	**15,530**
System-Level PYVTD MW/yr	1.66	.07	0	**1.73**
PY16 Incentives ($1,000)	$6,094	$346	0	**$6,440**

[1] Total may not match the sum of columns due to rounding.
[2] This count is based on PY16 unique household participants. Note that this count of participants excludes repeat customers between strata.

Table 6-3 shows the Low-Income Program's verified gross energy savings and demand reductions.

Table 6-3. Low-Income Program Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified	PY16 Verified	Phase IV Verified[1]
MWh/yr	9,151[2]	12,872	14,062	15,530	82,703 [3]
System Level MW/yr	1.02[4]	1.53	1.53	1.73	5.82

[1] Phase IV verified savings may not match the sum of program years due to rounding.
[2] PY13 verified savings for the Low-Income Program were reduced by 1,422 MWh/yr to a total of 9,027 MWh/yr in accordance with the SWE's PY13 Annual Report findings.
[3] Phase IV Verified Savings include 31,089 MWh/yr carryover savings from Phase III.
[4] PY13 verified system-level demand reductions for the Low-Income Program were reduced by 0.21 MW/yr to a total of 1.02 system-level MW/yr in accordance with the SWE's PY13 Annual Report findings.

6.2. Gross Impact Evaluation

In PY16, the Low-Income Program reported energy savings of 18,402 MWh/yr and achieved a program energy realization rate of 84%, weighted by stratum, as shown in Table 6-4. The program reported demand reductions of 1.87 MW/yr and achieved a program demand realization rate of 85%, as shown in Table 6-5. Both tables are shown by stratum (job type).

Table 6-4. PY16 Low-Income Program Gross Impact Results for Energy

Stratum[1]	PYRTD MWh/yr	Energy Realization Rate[2]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)[3]
Remote Energy Assessment					
REA Baseload	537	88%	0.15	6.8%	472
REA Low-Cost	1,372	102%	0.30	13.3%	1,395
REA Full-Cost	28	82%	0.47	24.9%	23
REA Subtotal[4]	**1,937**	**98%**	**0.40**	**9.5%**	**1,889**
On-Site Assessment					
On-Site Assessment Baseload	2,113	86%	0.14	7.7%	1,822
On-Site Assessment Low-Cost	2,931	104%	0.23	12.1%	3,040
On-Site Assessment Full-Cost	5,384	82%	0.47	24.9%	4,424
On-Site Assessment Master-Metered Multifamily	712	80%	0.13	6.8%	567
On-Site Assessment Subtotal[4]	**11,139**	**88%**	**0.43**	**11.0%**	**9,853**
Welcome Kits					
Welcome Kit	5,326	71%	-	-	3,788
Welcome Kits Subtotal[4]	**5,326**	**71%**	**-**	**-**	**3,788**
Program Total[4]	**18,402**	**84%**	**0.37**	**6.9%**	**15,530**

[1] In PY16, Cadmus aggregated jobs by job type and delivery type.

[2] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.

[3] Savings may not match other tables or figures due to rounding.

[4] Total may not match the sum of rows due to rounding.

Table 6-5. PY16 Low-Income Program Gross Impact Results for Demand

Stratum[1]	PYRTD MW/yr	Demand Realization Rate[2]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)[3]	System-Level PYVTD (MW/yr)[3]
Remote Energy Assessment						
REA Baseload	0.06	76%	0.43	18.9%	0.05	0.05
REA Low-Cost	0.14	106%	0.27	12.2%	0.15	0.17
REA Full-Cost	0.003	82%	0.52	27.6%	0.002	0.002
REA Subtotal[4]	**0.21**	**96%**	**0.41**	**9.7%**	**0.20**	**0.22**
On-Site Assessment						
On-Site Assessment Baseload	0.25	84%	0.14	7.6%	0.210	0.23
On-Site Assessment Low-Cost	0.30	107%	0.29	15.3%	0.33	0.35
On-Site Assessment Full-Cost	0.48	82%	0.52	27.6%	0.39	0.42
On-Site Assessment Master-Metered Multifamily	0.08	86%	0.19	10.1%	0.06	0.07
On-Site Assessment Subtotal[4]	**1.11**	**90%**	**0.43**	**11.3%**	**0.99**	**1.08**
Welcome Kits						
Welcome Kit	0.56	71%	-	-	0.40	0.43
Welcome Kits Subtotal[4]	**0.56**	**71%**	**-**	**-**	**0.40**	**0.43**
Program Total[4]	**1.87**	**85%**	**0.37**	**6.9%**	**1.59**	**1.73**

[1] In PY16, Cadmus aggregated jobs by job type and delivery type.
[2] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Realization rates are applied to verified demand reductions before the application of distribution losses.
[3] Savings may not match other tables or figures due to rounding.
[4] Total may not match the sum of rows due to rounding.

The following factors contributed to discrepancies between reported and verified savings, as well as to the realization rates observed across the baseload, low-cost, full-cost, and MMMF REA and on-site strata:

- **Home Occupancy Assumptions for Water Equipment.** The ICSP assumes the quantity of home occupants based on home type per the PA TRM. As in previous analyses, Cadmus used the number of occupants verified by the ICSP during the home assessment for water-saving equipment, while the ICSP assumed the quantity of home occupants based on home type per the PA TRM. This adjustment includes bathroom and kitchen low-flow aerators, low-flow showerheads, and thermostatic shower restriction valves (TSRV). In most cases within the on-site and REA low-cost strata, the number of occupants observed in the home assessment was greater than the TRM assumption, leading to higher *ex post* savings and increased energy and demand realization rates.
- **Baseline RAC Assumptions.** Cadmus applied PA TRM default baseline EER values for room air conditioning (RAC) replacement and recycling measures where project documentation was unavailable, while the ICSP used a lower baseline EER value than the value in the PA TRM. The ICSP's tracking database included an EER value of 8.0 for 75% of RAC measures within the sample. Audit information to verify baseline RAC efficiencies was not available, and Cadmus

used the TRM default value of 9.8. This resulted in a lower measure-specific realization rate. While there were only eight RAC measures within the sample, these measures accounted for 11% of the total reported sample demand savings.

- **ISR and Baseline Bulb Assumptions.** Realization rate discrepancies for LED lighting were largely driven by the differences between Cadmus and the auditor's use of ISRs and baseline bulb assumptions. For remote energy assessments, the ICSP assumed the baseline bulb to be incandescent when the customer described the bulb as “glass” and “hot” to the touch. When a participant described the bulb with these characteristics, Cadmus adjusted the baseline bulb assumption to halogen. The difference in the baseline wattage between halogen and incandescent bulbs resulted in evaluated savings being lower than reported on REA projects. For LED lighting evaluated savings, Cadmus calculated and applied an ISR value based on PY16 participant survey findings, which was the primary reason for discrepancies between reported and verified savings for the on-site strata.
- **Baseline R-Value Assumptions.** The ceiling insulation measure accounts for approximately 12% of all reported energy savings within the sample. It appears that the ICSP used a baseline R-value of 3 in place of the TRM default R-5. While EDC data gathering is permitted for this measure’s input per the TRM, the ICSP’s development package indicates that a minimum value of R-5 should be utilized. The difference in assumptions for the baseline R-value resulted in an evaluated realization rate of 54% and impacted the full-cost stratum realization rate which affected overall realization rate for PY16.
- **Dehumidifier Deemed Value Adjustments.** Cadmus made adjustments to reflect the deemed value for dehumidifier savings per the latest IMP. The ICSP used deemed savings associated with the ENERGY STAR Most Efficient dehumidifiers; however, observed units were not the Most Efficient models per ENERGY STAR datasheets.

The following factors led to variation between reported and verified savings and to the observed realization rates for the welcome kit stratum. Welcome kits account for about 30% of total reported savings in PY16 and have a large impact on the program’s overall performance.

- **Electric Water Heat Assumption**.
  - The PY16 participant survey results showed that 76% of homes that received a welcome kit had electric water heat; therefore, Cadmus applied this value in its analysis in place of the 100% assumption applied by the ICSP.
  - Cadmus used a weighted average to calculate the recovery efficiency of the water heater based on data from the 2023 SWE baseline study, whereas the ICSP used the standard electric water heater default TRM value of 0.98 for all equipment.
- **Multiple Welcome Kit Delivery.** The ICSP provided welcome kits to 207 duplicate customers, with each customer receiving two kits. The ICSP indicated that this was an error. As such, Cadmus did not include savings for the duplicate kits in the verified savings.
- **Housing Type Assumption.** While not resulting in differences in realization rates, the ICSP separated welcome kit savings from single-family and multifamily households in PY16, which

resulted in different savings for either household type. Cadmus compared a sample of these deliveries to PY16 participant survey data and confirmed that the ICSP's household classification (i.e., where the kit was delivered) was accurate. Cadmus used single-family and multifamily inputs where relevant.

6.3. Net Impact Evaluation

The Low-Income Program is offered to income-eligible customers at no cost. No free riders are anticipated because income-constrained customers are not likely to purchase energy-efficient products on their own. An NTG ratio of 1.0 is appropriate for this program. Therefore, Cadmus did not estimate net savings.

6.4. Verified Savings Estimates

As shown in Table 6-6, Cadmus determined the realization rates and NTG ratios and applied these values to the reported energy savings and demand reduction estimates to calculate the verified savings estimates for the PY16 Low-Income Program. Cadmus added these totals to the verified savings achieved in previous program years to calculate the P4TD program impacts.

Table 6-6. PY16 and P4TD Savings Summary for the Low-Income Program

Savings Type	Energy (MWh/yr)	Demand (MW/yr)
PYRTD	18,402	1.87
PYVTD Gross	15,530	1.73 [(1)]
PYVTD Net	15,530	1.73 [(1)]
RTD	53,840	5.75
VTD Gross	82,703[(2)]	5.82[(1),(3)]
VTD Net	51,614	5.82[(1),(3)]

[(1)] Verified demand reductions include line-loss adjustments.
[(2)] Includes Phase III carryover of 31,089 MWh/yr. PY13 verified savings for the Low-Income Program were reduced by 1,422 MWh/yr to a total of 9,027 MWh/yr in accordance with the SWE's PY13 Annual Report findings.
[(3)] PY13 verified system-level demand reductions for the Low-Income Program were reduced by 0.21 MW/yr to a total of 1.02 system-level MW/yr in accordance with the SWE's PY13 Annual Report findings.

No changes were made to reported VTD savings since the PY15 report was submitted.

6.5. Process Evaluation

The process evaluation activities were consistent with the evaluation plan and included bi-monthly check-ins with PPL Electric Utilities and the ICSP staff to enable program delivery status updates, a participant customer satisfaction survey, and interviews with MMMF building owners.

Methodology

Table 6-7 lists the process evaluation sampling strategy. For the survey sample frame, Cadmus removed duplicate records and customers who had requested no contact in a previous survey. See *Appendix L Survey Bias* for details about Cadmus' approach to reducing survey bias and contact instructions.

Cadmus attempted to reach a census from the 10 unique MMMF building owner records and completed one interview. Both Cadmus and the ICSP made multiple attempts via email and telephone to reach all participants; however, despite these attempts, the target was not met due to low response.

Sample sizes noted in this report may vary by survey or interview question because respondents could skip questions they chose not to answer; therefore, not all respondents provided answers to every question. Cadmus included all survey and interview respondents who answered at least one question, even if they did not complete the survey or interview.

Table 6-7. Low-Income Program Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size[1]	Sample Frame[2]	Assumed Cv in Sample Design	Target Sample Size	Achieved Sample Size[3]	Percent Contacted [4]
On-Site Participants	Participants who had in-home assessments completed	Online survey	7,280	5,903	0.50	Minimum of 36	154	51%
Remote Energy Assessment (REA)	Participants who completed REAs	Online survey	1,481	1,251	0.50	Minimum of 30	64	100%
Welcome Kits	Participants who received a welcome kit	Online survey	18,582	12,319	0.50	Minimum of 30	38	33%
MMMF Building managers	MMMF building owner/operator participants	Interviews	11	10	N/A	~ 5	1	100%
Program Total			**27,354**	**19,483**	**-**	**> 101**	**257**	**-**

[1] This represents the number of participants at the time of the evaluation survey. Process population size may differ from impact numbers, which include the final count of participants for the program year.
[2] The sample frame is a list of participants with contact information who have an opportunity to complete the survey and who were sent an email to complete the survey. The final sample frame includes unique records in the PPL Electric Utilities database at the time of the surveys. 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, had been selected for another program survey, did not have valid contact information (email), or had previously opted out of the online survey.
[3] This represents the number of respondents who completed the survey. The analysis used all responses to the survey, regardless of whether every question was answered.
[4] Percent contacted means the percentage of the sample frame contacted to complete surveys or interviews, even if the record was invalid.

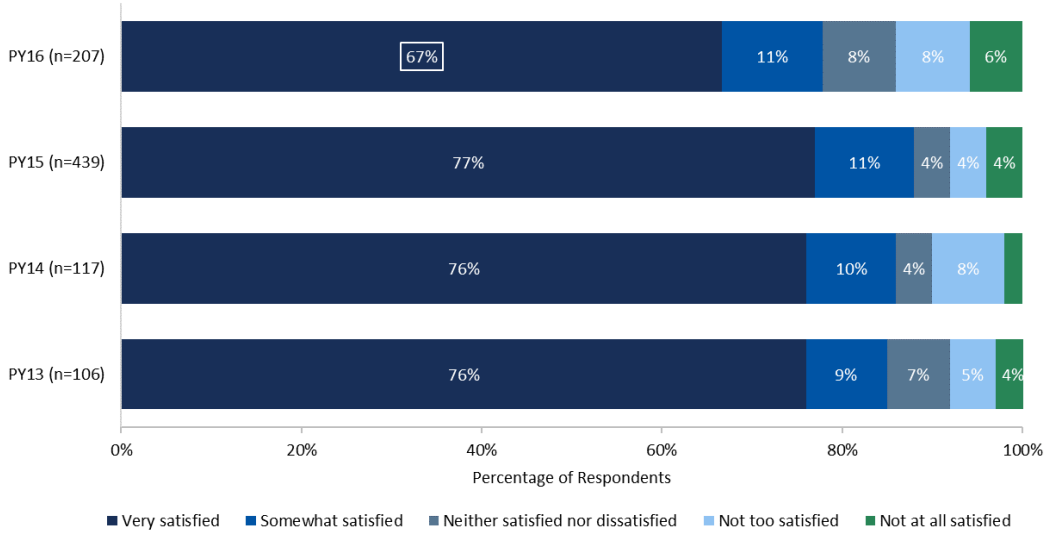
6.5.1. Program Experience

This section presents evaluated findings on program satisfaction, energy-saving behaviors, and program experience.

Overall Program Satisfaction

Overall, 78% of remote and on-site assessment survey respondents (n=207) were *very* or *somewhat satisfied* with the program. Figure 6-1 shows that program satisfaction in PY16 was significantly different from PY15 (78% and 88%, respectively).

Figure 6-1. PY16 Overall Satisfaction with Low-Income Program by Year



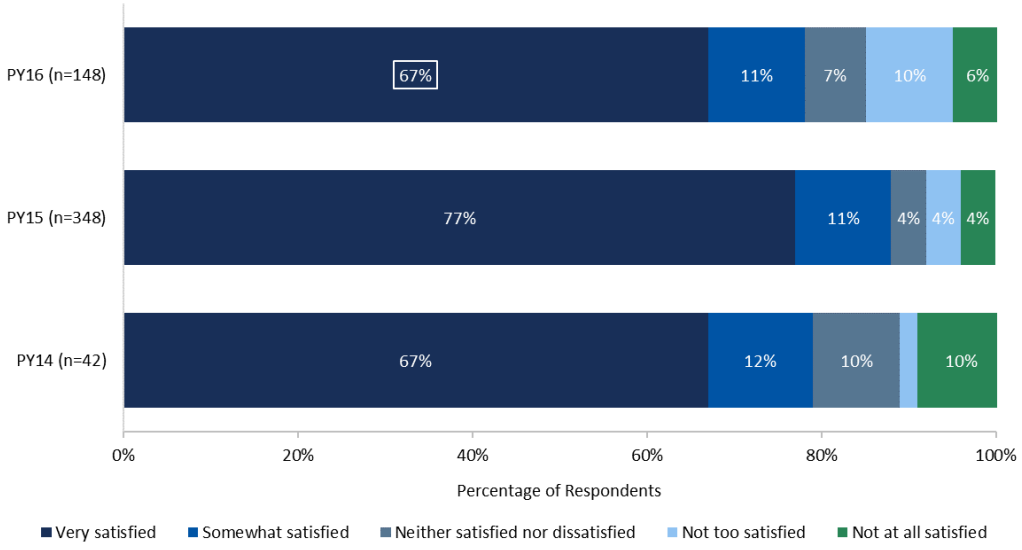
Source: Participant survey, "Now, thinking about your overall experience with the WRAP program, how would you rate your satisfaction?" Totals may not sum due to rounding. Sample sizes reflect partially completed surveys. The percentage in the box indicates that the difference between PY15 and PY16 is statistically significant at the 90% confidence level.

Cadmus completed one interview with a MMMF property owner. This interview respondent said they were *very satisfied* with the program due to its simplicity, trade ally professionalism, financial savings, and visual improvement to the property. The respondent said they were motivated to participate in the program because of energy savings, bill reductions, and property improvements resulting in better lighting.

Satisfaction by Strata

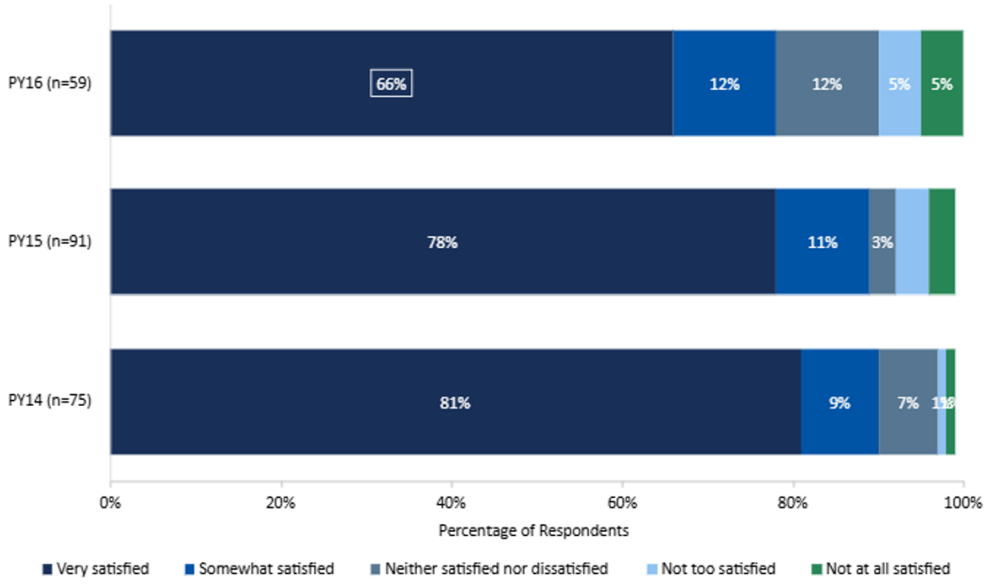
Both REA and on-site respondent satisfaction declined significantly in PY16 compared to PY15 (Figure 6-2 and Figure 6-3). While differences are significant between PY15 and PY16 in both channels, Cadmus did not find any significant differences in satisfaction by program delivery channel (REA and on-site).

Figure 6-2. PY16 On-Site Satisfaction with Low-Income Program by Year



Source: Participant survey, "Now, thinking about your overall experience with the WRAP program, how would you rate your satisfaction?" Totals may not sum due to rounding. Sample sizes reflect partially completed surveys.

Figure 6-3. PY16 REA Satisfaction with Low-Income Program by Year



Source: Participant survey, "Now, thinking about your overall experience with the WRAP program, how would you rate your satisfaction?" Totals may not sum due to rounding. Sample sizes reflect partially completed surveys.

Likelihood to Recommend

The PY16 participant survey included a question to measure a net promoter score (NPS). NPS is a metric of brand loyalty that measures how likely customers are to recommend a product or service to others. In the PY16 survey, respondents rated their likelihood to recommend the program on a 10-point scale,

where 1 meant not at all likely and 10 meant extremely likely. Respondents giving a rating of 9 or 10 are known as "promoters," those who give a rating of 7 or 8 are known as "passives," and those who give a rating of 1 to 6 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 the percentage of detractors (passives are excluded from the calculation). An NPS of +50 or above is generally considered excellent.

As shown in Table 6-8, the Low-Income Program achieved a positive NPS above +50, indicating that there are more promoters than detractors among the respondents.

Table 6-8. Net Promoter Score: Likelihood to Recommend the Low-Income Program

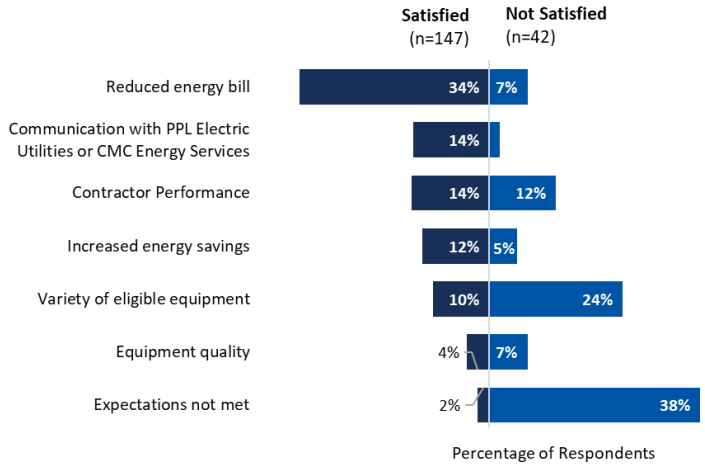
Rating Classification	Overall Low-Income Assessment (n=203)	REA (n=58)	On-Site (n=145)
Promoters (9 or 10)	72%	74%	71%
Passives (7 or 8)	8%	5%	9%
Detractors (1 through 6)	20%	21%	20%
NPS	**+52**	**+53**	**+51**
Source: Participant survey, "How likely is it that you would recommend this program to a friend, family member, or colleague?" (n=203)			

Drivers of Program Satisfaction

To better understand what drives program satisfaction, the survey asked participants what factor most affected their program satisfaction rating. Figure 6-4 shows the most common reasons REA and on-site respondents were satisfied or dissatisfied with the program. Similar to PY14 and PY15, the most common driver for respondents reporting they were *very* or *somewhat satisfied* (n=147) was the reduced energy bill (34%).

Among respondents who were *neither satisfied nor dissatisfied*, *not too satisfied*, or *not at all satisfied*, the variety of eligible equipment was a main factor (24%; n=42). Respondents who gave low satisfaction scores most frequently cited "other" as the reason they gave the rating. Cadmus reviewed open-ended responses and classified these responses as "expectations not met." For example, two respondents were expecting refrigerators, three expected air conditioner units, and one expected a smart strip and did not receive the equipment. Additionally, five respondents said they did not receive any equipment they were expecting from the program.

Figure 6-4. PY16 REA and On-Site Drivers of Program Satisfaction



Source: Participant survey, "What factor(s) most affected the overall experience rating you gave?" Multiple responses allowed. (n=189)

Opinion of PPL Electric Utilities

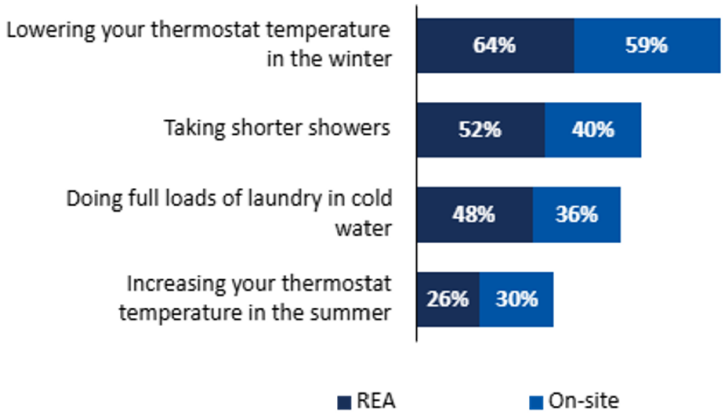
Of 186 REA and on-site survey respondents who answered a question about how program participation impacted their opinion of PPL Electric Utilities, over half (52%) said their opinion of PPL Electric Utilities had improved after participating in the Low-Income Program, 37% said their opinion had not changed, and 11% said their opinion decreased.

Of all REA and on-site participants who reported that their opinion of PPL Electric Utilities decreased following program participation, 12 provided a reason. Two non-electric heat respondents reported they were not happy with the increased monthly energy costs or the lack of a decrease in their monthly energy costs, despite installing energy-saving equipment. Seven respondents reported they had not yet received the equipment or services they were promised, and three electric heat customers said their issues were not addressed through participating in the program, such as mobile home upgrade options or additional insulation and blower door tests not conducted.

6.5.2. Energy-Saving Behaviors

The PY16 survey included a set of questions to better understand the types of energy-saving behavior in which participants engaged. Of 196 respondents answering, 84% said their energy advisor provided recommendations about how to save electricity and reduce energy costs (91% REA, n=54; 81% on-site, n=142). Of respondents who answered about which recommendations were provided, most received the recommendation to lower thermostats in the winter (64% REA, 59% on-site), and respondents least frequently reported that the advisor provided the recommendation to increase the thermostat in the summer (26% REA, 30% on-site). The auditor may not have made recommendations for seasonal thermostat settings because of the time of the visit. Figure 6-5 breaks down the responses by REA and on-site participants.

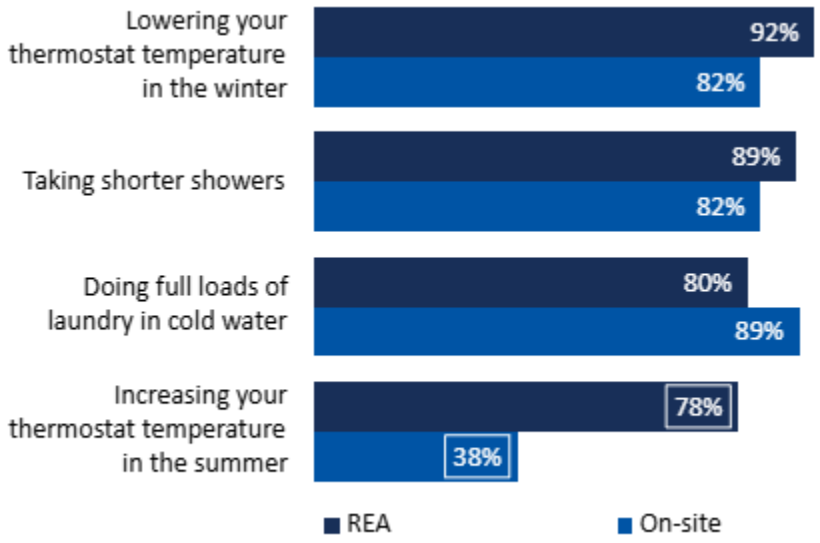
Figure 6-5. PY16 Participant Recall of Receiving Energy Advisor Recommendations



Source: Participant survey, "Which of the following recommendations did the energy advisor provide you during the home energy assessment? Select all that apply." Sample sizes reflect partially completed surveys. (n=148)

Similarly, of the recommendations, participants most frequently followed the suggestion to lower the thermostat temperature in the winter (Figure 6-6). Participants least frequently followed the recommendation to increase their thermostat temperature in the summer, with a significant difference between REA and on-site participants following this recommendation. Cadmus conducted the survey in spring 2025, which may have impacted these results either from a lack of participant recall over a longer period or the recommendation may not have been given if the visit occurred in winter or spring.

Figure 6-6. PY16 Adoption of Energy Advisor Recommendations

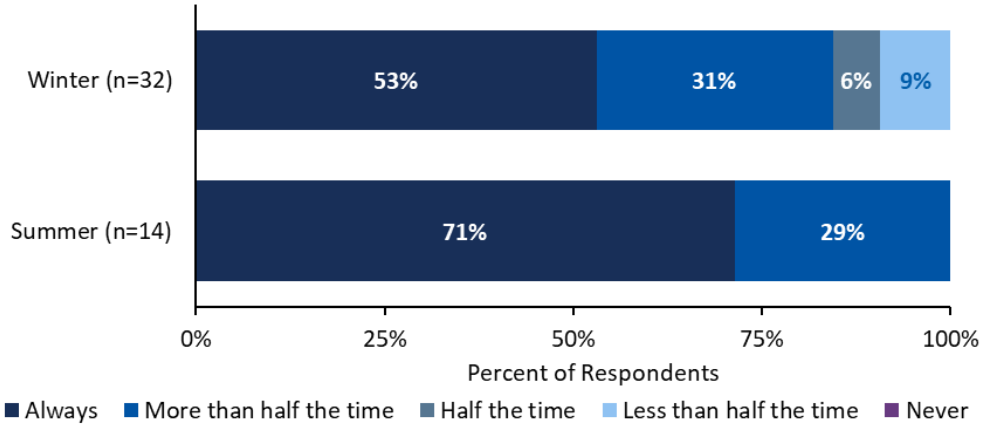


Source: Participant survey, "Which of the following recommendations did you follow? (Select all that apply)" Sample sizes reflect partially completed surveys. REA and On-site difference was found significant at the 90% CL in a z test, p=0.00

Thermostat Settings

Among those who reported following thermostat setback advice (n=139), 60% indicated they had a manual thermostat. Of respondents with manual thermostats who answered the question about winter settings (n=32), over three-quarters (84%, 27 respondents) reported following the recommendation more than half the time in the winter, with over half (53%, 17 respondents) following the recommendation all the time. For the summer, all respondents (100%, 14 respondents) reported following the recommendations more than half the time, with nearly three quarters (71%, 10 respondents) following the recommendation all the time (Figure 6-7).

Figure 6-7. PY16 How Often Respondents Followed Recommended Manual Thermostat Settings



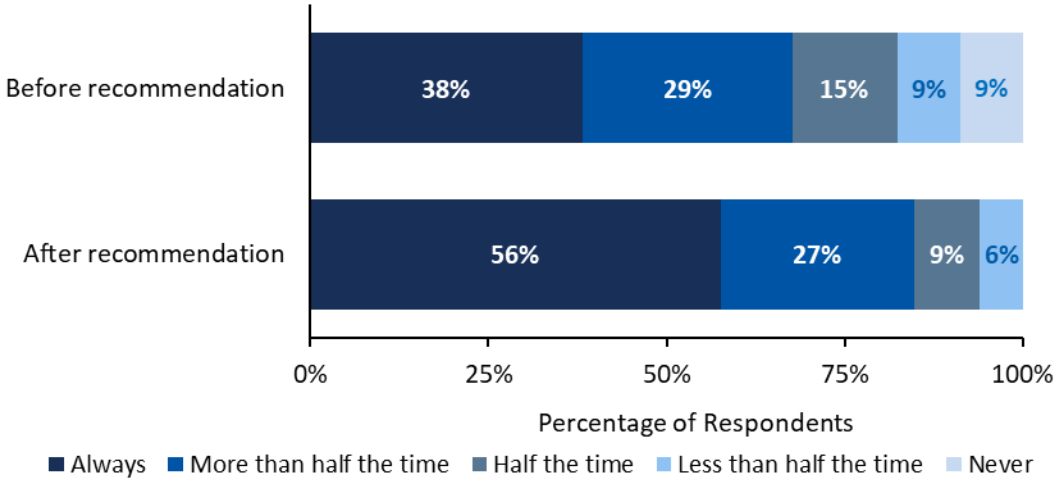
Source: Participant survey, "About how often throughout the winter have you set your thermostat to the decreased temperature recommendation after the energy advisor provided energy-saving recommendations?"; "About how often throughout the summer have you set your thermostat to the increased temperature recommendation after the energy advisor provided energy-saving recommendations?" Sample sizes reflect partially completed surveys.

One-quarter of respondents (25%; n=34) who reported following energy advisor recommendations to make thermostat adjustments in the summer or winter had a programmable or basic Wi-Fi thermostat. Among those who reported following thermostat setback advice, only one respondent set their thermostat for the summer, and nine set their thermostats for winter. The one respondent with summer settings said they kept temperatures the same. Of the nine with winter settings, six reported it was set lower this past winter, one kept it the same, and two plan to set it lower next winter.

Laundry Practices

Of those who followed recommendations to do full loads of laundry in cold water (n=37), all respondents reported washing laundry at home (84%) or in an on-site common laundry area (11%). Before the recommendation, 67% (n=34) washed laundry in cold water more than half the time (Figure 6-8). After the recommendation, 83% washed laundry in cold water more than half the time. Before receiving the recommendation, three respondents reported they never washed clothing in cold water, but after the recommendation, they now wash their clothing in cold water.

Figure 6-8. PY16 Energy-Saving Laundry Practices Before and After Receiving Recommendations

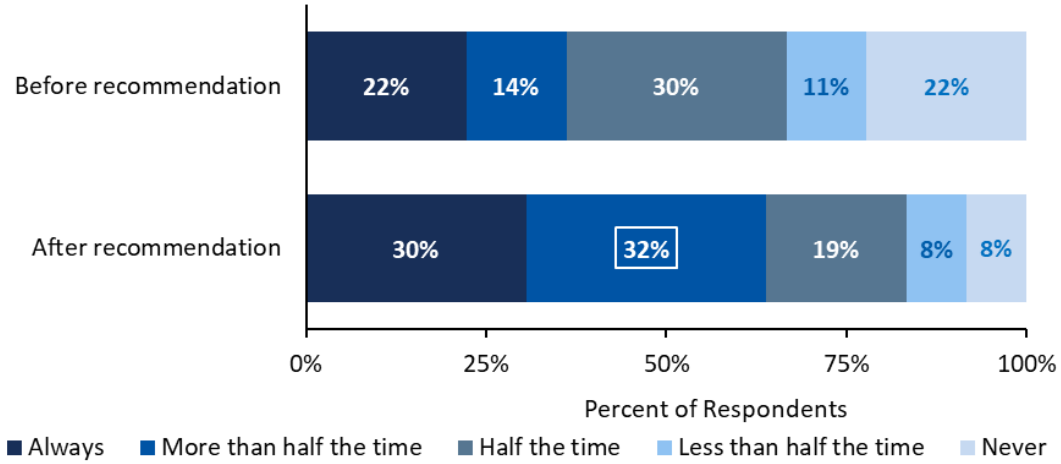


Source: Participant survey, "Please indicate about how often you washed your clothes in cold water before and after the energy advisor provided energy-saving recommendations." Totals may not sum due to rounding. Sample sizes reflect partially completed surveys. (n=34)

Showering Practices

Of those who reported following advice to take shorter showers (n=38), 36% said they took shorter showers more than half the time before the recommendation (Figure 6-9). After receiving the recommendation, 62% said they take shorter showers more than half the time, nearly doubling the number who said they took short showers before the recommendation. The difference between participants who took shorter showers more than half the time after the recommendation is statistically significant.

Figure 6-9. PY16 Energy-Saving Showering Practices Before and After Receiving Recommendations

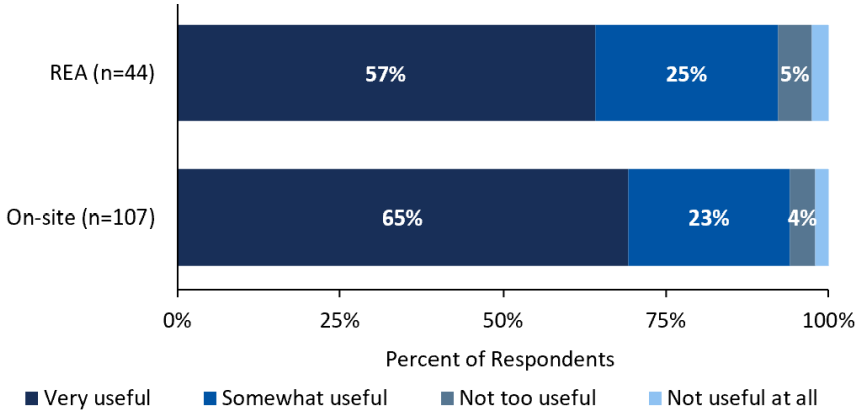


Source: Participant survey, "Please indicate about how often you took showers that were five minutes or less before and after the energy advisor provided energy-saving recommendations." Totals may not sum due to rounding. Sample sizes reflect partially completed surveys (n=37). The difference in respondents taking shorter showers more than half the time after the recommendation was statistically significant at the 90% confidence level in a z test, p=0.06

6.5.3. Information from the Energy Advisor

Both REA and on-site respondents said that the information provided by the energy advisor was useful (n=151), with 88% of on-site respondents and 82% of REA respondents reporting that the recommendations were *very* or *somewhat useful* (Figure 6-10).

Figure 6-10. PY16 Usefulness of Information from Energy Advisor



Source: Participant survey, "Thinking about the information you received from the WRAP energy advisor, how useful was this information in helping you understand ways to save energy in your home?" Totals may not sum due to rounding. Sample sizes reflect partially completed surveys. (n=151)

When asked, one-third (33%) of REA and on-site respondents said they wanted additional information from the energy advisor. Forty-three of these respondents provided feedback on information they wish they had received.[19]

Most commonly, respondents said they wanted more information about the usefulness of the equipment and more information about options for replacing outdated appliances (47%; 20 respondents and 29 responses). Six respondents wanted more energy efficiency education, such as why the equipment was helpful, or more information on rebates, and options to replace outdated appliances. Six respondents also said they wanted refrigerator replacements, four said AC replacements, three said additional insulation, and two said a furnace check. Respondents further identified various weatherization improvements they did not receive, such as windows (two respondents), doors (two respondents), air sealing (one respondent), and baseboards (one respondent). Two respondents did not identify specific products, but said they expected more than outlet covers and showerheads.

Nineteen percent (nine respondents) reported a lack of follow-up from the program on promised equipment. Specifically, four respondents said fridge and freezer replacements, two said AC units, and one said insulation. Respondents reported that all of these were offered in visits, but never followed up on. Two respondents did not identify the equipment they expected. Three respondents reported inquiring about equipment they were promised, but never received a response. Additionally, two respondents reported negative contractor experiences, and one reported general negative feedback;

[19] The survey allowed multiple responses so the total number of responses in this section exceeds the number of respondents who provided responses.

one respondent also reported wanting more bill support, and one wanted more accessible services for disabled folks.

On the other hand, 19% (nine) of respondents provided compliments about their program experience, including the knowledge, professionalism, and friendliness of their contractor. Three respondents were also grateful for the program's support of low-income families, with one stating it was "very helpful."

Reasons for Not Installing Measures

Table 6-9 shows the reasons respondents did not install equipment, with the most common response being that they did not receive it. Responses for showerheads varied widely, indicating a range of concerns with the equipment.

Table 6-9. Reasons for Not Installing Measures

Measure	Did not receive	Did not fit	Did not like design	Water pressure too weak	Water pressure too strong	Did not like how it worked	Too hard to install
Air purifier (n=9)	9						
Dehumidifier (n=8)	8						
Thermostatic valves (n=8)	8						
Bathroom aerators (n=7)		2	2	3			
Kitchen aerators (n=7)		2	2	3			
Showerhead (n=20)	5	4		4	2	3	2
Power strips (n=10)	6					4	
LED night lights (n=10)	10						
LED bulbs (n=8)	6						2

Source: Participant survey, "Why did you not install all the [measures] or remove the [measures] that were installed?"

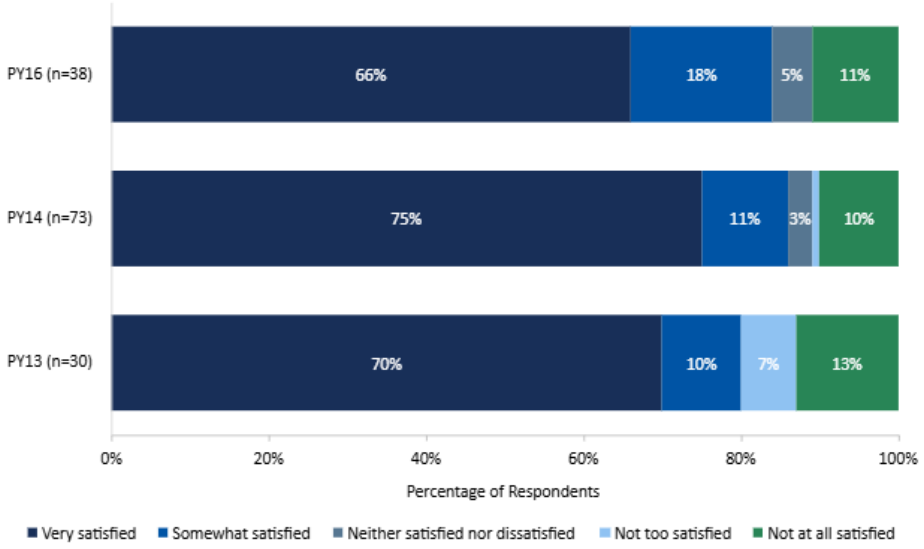
6.5.4. Welcome Kits

Survey respondents who received welcome kits rated satisfaction with their experience with the kits, provided insights about their satisfaction ratings, and rated the influence of the kits on their opinion of PPL Electric Utilities.

Satisfaction with Welcome Kits

Most respondents were satisfied with the kit (n=38), (Figure 6-11) with 84% overall satisfaction (as measured by responses of *very* or *somewhat satisfied*). These results are similar to PY13 and PY14. Cadmus did not survey welcome kit respondents in PY15.

Figure 6-11. PY16 Overall Satisfaction with Welcome Kits

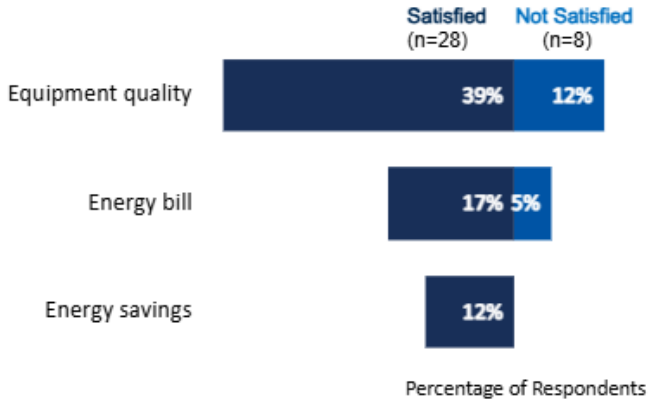


Source: Participant survey, "Now, thinking about your overall experience with the welcome kit, how would you rate your satisfaction?" (PY16 n=38)

Drivers of Satisfaction with Welcome Kits

To better understand what drives program satisfaction, the survey asked participants what factor most affected their program satisfaction rating. Figure 6-12 shows the most common reasons welcome kit respondents were satisfied or dissatisfied with the welcome kit. The most common driver for both satisfied and dissatisfied respondents was the quality of equipment.

Figure 6-12. PY16 Welcome Kit Drivers of Program Satisfaction



Source: Participant survey, "What factor(s) most affected the overall experience rating you gave?" Multiple responses allowed. (n=41)

Opinion of PPL Electric Utilities

Of the 37 welcome kit respondents who answered this question, over half (62%) said their opinion of PPL Electric Utilities had improved after participating in the Low-Income Program, 30% said their opinion had not changed, and 7% said their opinion had decreased.[20]

Of all welcome kit participants who reported that their opinion of PPL Electric Utilities decreased following the program, only one provided an explanation. They said it was because of the lack of quality equipment and the high cost of electricity.

6.6. Program Finances and Cost-Effectiveness Reporting

Table 6-10 provides a detailed breakdown of program finances and cost-effectiveness. Cadmus calculated TRC benefits using gross verified impacts.

Table 6-10 provides a detailed breakdown of program finances and cost-effectiveness. Cadmus calculated TRC benefits using gross verified impacts. PY16 NPV costs and benefits are expressed in 2024 dollars. NPV costs and benefits for P4TD financials are expressed in 2021 dollars. Net verified savings are equal to gross verified savings because the program is assumed to have an NTG ratio of 1.0.

Table 6-10. Summary of Low-Income Program Finances – Gross and Net Verified

Row	Cost Category	PYTD ($1,000)		P4TD ($1,000)(2)	
1	**IMCs**	**$6,440**		**$14,844**	
2	Rebates to Participants and Trade Allies	$435		$632	
3	Upstream/Midstream Incentives	$0		$0	
4	Material Cost for Self-Install Programs (EE&C Kits)	$530		$3,832	
5	Direct Installation Program Materials and Labor	$5,475		$10,380	
6	**Participant Costs (Row 1 minus the sum of Rows 2 through 5)(6)**	**$0**		**$0**	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$0	$0
8	Administration and Management(3)	$164	$639	$698	$2,558
9	Marketing	$0	$270	$0	$810
10	Program Delivery(4)	$0	$2,713	$0	$8,381
11	EDC Evaluation Costs	$0		$0	
12	SWE Audit Costs	$0		$0	
13	**Program Overhead Costs (5) (Sum of rows 7 through 12)(6)**	**$3,785**		**$12,446**	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)(5), (6)**	**$10,225**		**$27,290**	
15	Total NPV Lifetime Electric Energy Benefits	$3,560		$9,972	
16	Total NPV Lifetime Electric Capacity Benefits	$1,821		$5,351	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$0		$64	
18	Total NPV Lifetime Fossil Fuel Impacts	($118)		($161)	
19	Total NPV Lifetime Water Impacts	$8,937		$24,218	

[20] Total does not sum to 100% due to rounding.

Row	Cost Category	PYTD ($1,000)	P4TD ($1,000)[2]
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)[6]**	**$14,200**	**$39,443**
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.39**	**1.45**

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = 2021.
[2] P4TD benefits do not include carryover energy savings from Phase III.
[3] Includes rebate processing, tracking system, general administration, program management, general management, legal, and technical assistance.
[4] Includes CSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, and QA/QC documentation. These costs cannot be quantified separately and are included as program delivery costs.
[5] Portfolio-level costs are not assigned to specific programs.
[6] The sum of rows may not add up to the total due to rounding.

6.7. Recommendations

Overall, the Low-Income Program continues to deliver reliable savings and receives positive ratings from participants. The Low-Income Program achieved 9,853 MWh/yr in verified savings from on-site assessments, 1,889 MWh/yr in verified savings from REAs, and 3,788 MWh/yr in verified savings from the welcome kits. The program achieved an overall customer satisfaction rating of 78% (n=207). Increased satisfaction was driven by energy bill savings while lower satisfaction was driven by unmet program expectations.

Conclusion 1: A Better understanding of program benefits, including bill savings and equipment available through the program, could increase satisfaction.	• Several dissatisfied participants who expected to receive refrigerator replacements and AC units did not receive the equipment or any further communication or follow-up from the program (See section *6.5.1 Program Experience*). • When asked what additional information they would like from the contractor, customers noted wanting more information on the usefulness of the program and available equipment replacement. (See section *6.5.3 Information from the Energy Advisor*). • The largest driver of satisfaction for REA and on-site participants was energy bill savings (See section *6.5.1 Program Experience*).
Conclusion 2: Verified savings calculations across multiple measures used assumptions that differed from *ex ante* assumptions.	• *Ex post* DHW savings differ from *ex ante* savings due to home occupant assumptions. In PY16, 117% and 123% realization rates were observed for energy and demand, respectively, for DHW equipment within the sample (kitchen and bathroom aerators, showerheads, and TSRVs) (See section *6.2 Gross Impact Evaluation*). • For ceiling insulation installation, a baseline R-value of 3 was assumed in place of the development package minimum and TRM default of R-5. (See section *6.2 Gross Impact Evaluation*). • Sampled room air conditioning recycling and replacement equipment reported a baseline EER value less than the TRM default without supporting documentation. (See section *6.2 Gross Impact Evaluation*). • Savings for welcome kits are based on the assumption that participant homes have electric water heat. Per PY16 survey results, 76% of welcome kit recipients reported having electric water heat (n=37). (See section *6.2 Gross Impact Evaluation*).

Cadmus' impact and process evaluation activities in PY16 led to the conclusion and recommendation shown in Table 6-11. The table also includes a summary of how PPL Electric Utilities plans to address the recommendation in program delivery.

Table 6-11. Status of Recommendations for the Low-Income Program

Conclusion	Recommendation	EDC Status of Recommendation
Conclusion 1: A Better understanding of program benefits, including bill savings and equipment available through the program, could increase satisfaction.	• Remind auditors in trainings and other communications to provide customers with accurate information about equipment they may be eligible for through the program. Additionally, remind contractors to focus on the usefulness of program participation and customer benefits such as energy bill savings. • Develop a checklist on the audit form listing which products were recommended so that follow-up can be done to ensure delivery matches recommendations and note when it does not to determine if adjustments should be made to the number and type of recommendations.	Implemented
Conclusion 2: Verified savings calculations across multiple measures used assumptions that differed from *ex ante* assumptions.	• Include photo documentation of baseline equipment (i.e., nameplates or equipment vintage) with audit documentation. • Apply the most recent evaluation survey results, indicating the percentage of electric water heat customers. • If possible, incorporate actual occupant data into DHW calculations to better estimate *ex ante* savings.	Photo documentation implemented; others under consideration

PPL Electric Utilities

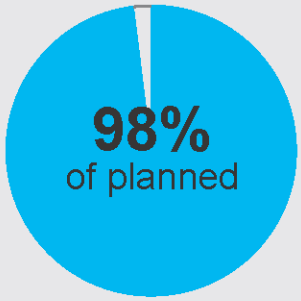
CADMUS

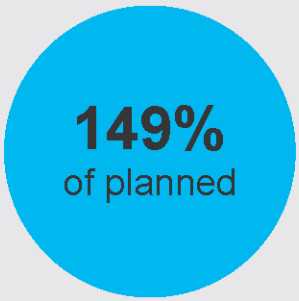
RESIDENTIAL PROGRAM

The Residential Program offers financial incentives to recycle inefficient appliances, purchase rebated and discounted equipment, build energy-efficient new homes, educate students about energy efficiency, and encourages customers to save energy by sending home energy reports.

VERIFIED ENERGY SAVINGS

Phase IV has saved **176,126 MWh/yr**

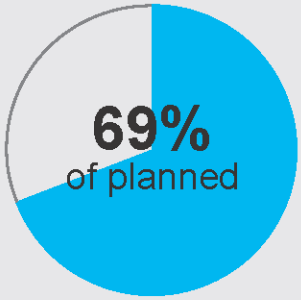


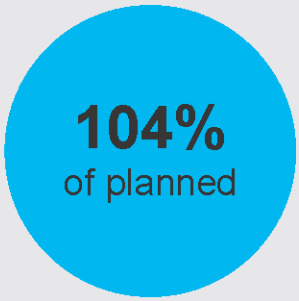


PY16 saved **49,074 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **23.27 MW/yr**





PY16 has reductions of **5.91 MW/yr**

PY16 PARTICIPATION

A total of **553,878** rebates or discounts

427,592 Home Energy Reports

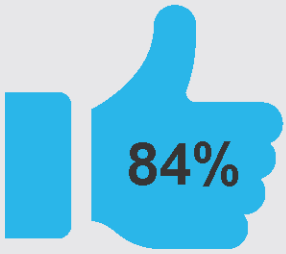
87,878 Energy Efficient Homes*

20,204 Student Energy Efficient Education

18,204 Appliance Recycling

*Includes number of instant discount purchases

PARTICIPANT SATISFACTION



Satisfied with overall program

96% satisfied with Appliance Recycling

90% satisfied with Energy Efficient Homes

85% satisfied with Student Energy Efficient Education

65% satisfied with Home Energy Reports

7. Residential Program

The Residential Program is a comprehensive offering comprising new construction, retrofit, appliance recycling, home energy reports, and kit delivery streams for PPL Electric Utilities' residential customers. The program ICSP, CLEAResult, manages program operations and oversees rebate and incentive delivery, with assistance from several subcontractors for specific markets and delivery mechanisms. The evaluation methodology and findings for each Residential Program component are described in separate appendices.

In PY16, the program has four major components:

- **Appliance Recycling** offers an incentive to customers who turn in eligible, working appliances and provides free pick-up and environmentally responsible recycling services. Eligible products include freezers, refrigerators, room air conditioners, and dehumidifiers. Participation is counted as the number of appliances recycled.
- **Energy Efficient Homes** offers incentives to home builders to construct program-qualifying homes more efficient than code, downstream incentives for high-efficiency products and equipment, instant discounts for qualifying energy-efficient products at retailers, discounted products via an Online Marketplace, and home energy audits, energy kits, and downstream rebates for weatherization solutions. Additionally, this component began offering midstream incentives through HVAC and refrigeration distributors in PY15 and introduced two pilot programs, the Deep Energy Retrofits pilot and the High-Performance Homes pilot. Participation is counted as the number of rebated projects or homes.
- **Home Energy Report (HER)** delivers both paper and digital reports to residential single-family homes and promotes behavioral energy efficiency by motivating customers to become more efficient through similar home comparisons. Participation is counted as the number of homes randomly assigned to the treatment group that receive reports.
- **Student Energy Efficient Education (SEEE)** offers free kits with energy-saving products and energy education for students and teachers in grade schools and high schools in PPL Electric Utilities' territory. Participation is counted by the number of kits delivered.

7.1. Participation and Reported Savings by Customer Segment

Table 7-1 presents the participation counts, reported energy and demand savings, and incentive payments for the Residential Program in PY16 by customer segment.

Table 7-1. PY16 Residential Participation and Reported Impacts[1]

Parameter	Residential (Non-LI)	Small C&I (Non-GNE)	GNE	Total[2]
PY16 # Participants	552,974	748	156	553,878
PYRTD MWh/yr	54,136	501	70	54,708
PYRTD MW/yr	6.98	0.10	0.02	7.10
PYVTD MWh/yr[3]	48,546	461	67	49,074
System-Level PYVTD MW/yr[3]	5.79	0.10	0.02	5.91
PY16 Incentives ($1,000)	$7,225	$32	$3	$7,259

Note: This table does not include results from the Low-Income Program.
[1] The totals in this table do not include PY15 unverified savings verified in PY16.
[2] Total may not sum due to rounding.
[3] Savings for the Deep Energy Retrofits Pilot and the New Homes subcomponent were left unverified in PY16 and will be verified in PY17.

Table 7-2 shows the Residential Program's verified gross energy savings and demand reductions.

Table 7-2. Residential Program Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified[1]	PY15 Unverified[2]	PY16 Verified	PY16 Unverified[2]	Phase IV Verified [3], [4]
MWh/yr	34,603	43,595	48,854	17	49,074	6,145	176,126
System-Level MW/yr	4.92	6.07	6.37	0.0004[5]	5.91	1.34 [5]	23.27

[1] Includes savings for all program components left unverified in PY15 and verified in PY16 except for those associated with the Deep Energy Retrofits pilot. These will be verified in PY17.
[2] Includes unverified savings for the Deep Energy Retrofits pilot and the New Homes subcomponent.
[3] Phase IV verified savings may not match sum of program years due to rounding.
[4] Does not include PY15 and PY16 unverified savings.
[5] This does not include the application of line losses.

7.2. Gross Impact Evaluation

Cadmus conducted a gross impact evaluation for all Residential Program components in PY16 using a basic level of rigor except for the HER component, which was evaluated with an enhanced level of rigor. Evaluation methods and sampling approaches differed by component to reflect the unique design, delivery, and historical performance. For Student Energy Efficient Education, Cadmus applied historical realization rates, combined PY14 and PY15, presented in the PY15 annual report. For Energy Efficient Homes, Cadmus applied historical realization rates to some subcomponents and completed desk reviews of project documentation and contractor invoices and conducted a participant survey to gather

some evaluation inputs. For the Appliance Recycling component, Cadmus surveyed a sample of participants to inform the part-use factor. For the HER component, Cadmus conducted a billing analysis.

Cadmus left savings for the Deep Energy Retrofits pilot unverified in PY15 and PY16 and will verify these savings in PY17. Cadmus also left savings for the New Homes subcomponent unverified to review demand savings discrepancies; these saving will be verified in PY17.

Gross savings verification methodology details, sampling approach, and detailed findings are discussed in the individual appendices of this report (*Appendix G, Appendix I, Appendix J* and *Appendix N)*.

The Residential Program overall achieved a 101% realization rate for energy (Table 7-3) and a 94% realization rate for demand (Table 7-4).

Table 7-3. PY16 Residential Program Gross Impact Results for Energy

Component	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 90% C.L.[2]	PYVTD (MWh/yr)
Appliance Recycling	11,737	93%	6.89	11.3%	10,963
Energy Efficient Homes	25,451[3]	100%	5.44	9.0%	25,389
Home Energy Reports	6,215	122%	-	-	7,562
Student Energy Efficient Education	5,160	100%	0.97	1.6%	5,160
Residential Subtotal [4]	**48,563 [3]**	**101%**	**3.21**	**5.3%**	**49,074**
Low-Income (Residential)[5]	18,402	84%	4.80	7.9%	15,530
Program Total[4]	**66,965**	**96%**	**2.70**	**4.0%**	**64,604**
Energy Efficient Homes Unverified	6,145	-	-	-	-
Total (Verified + Unverified)[4]	**73,109**	**88%**	**2.70**	**4.0%**	**64,604**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Relative precision in this table is reported at the 90% confidence level and will not match tables in the appendices, where relative precision is reported at the 85% confidence level.
[3] Reported totals do not include records left unverified. If including unverified savings, the realization rate for Energy Efficient Homes and the Residential Program is 80% and 90%, respectively.
[4]Totals may not sum due to rounding and may not match other tables or figures due to rounding.
[5] Low-Income is shown as a subsector of residential in this table per sampling requirements in the Evaluation Framework.

Table 7-4. PY16 Residential Program Gross Impact Results for Demand

Component	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 90% C.L.[2]	PYVTD (MW/yr)	System-Level PYVTD (MW/yr)
Appliance Recycling	3.37	96%	3.76	6.2%	3.25	3.53
Energy Efficient Homes	1.88[3]	89%	7.69	12.6%	1.67	1.82
Home Energy Reports	-	-	-	-	-	-
Student Energy Efficient Education	0.52	100%	1.07	1.8%	0.52	0.56
Residential Subtotal[4]	**5.76[3]**	**94%**	**3.26**	**5.4%**	**5.44**	**5.91**
Low-Income (Residential)[5]	1.87	85%	4.82	7.9%	1.59	1.73
Program Total[4]	**7.64**	**92%**	**2.75**	**4.5%**	**7.03**	**7.64**
Energy Efficient Homes Unverified	1.34	-	-	-	-	-
Total (Verified + Unverified)[4]	**8.98**	**78%**	**2.75**	**4.5%**	**7.03**	**7.64**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Relative precision in this table is reported at the 90% confidence level and will not match tables in the appendices, where relative precision is reported at the 85% confidence level.
[3] Reported totals do not include records left unverified. If including unverified savings, the realization rate for Energy Efficient Homes and the Residential Program is 52% and 77%, respectively.
[4] Totals may not sum due to rounding and may not match other tables or figures due to rounding.
[5] Low-Income is shown as a subsector of residential in this table per sampling requirements in the Evaluation Framework.

The following factors led to variation between the reported and verified savings and to the observed realization rates for the subcomponents or components verified in PY16. Additional details can be found in *Appendix I. Evaluation Detail – Energy Efficient Homes.*

- The Downstream Equipment subcomponent of Energy Efficient Homes had energy realization rates of 107% for HVAC equipment and 103% for all other equipment and demand realization rates of 89% for HVAC equipment and 99% for other equipment. The variations were due to discrepancies between the efficiency ratings recorded in the tracking database and those in the AHRI database and differences in reported and survey-verified baseline equipment types.
- The midstream equipment subcomponent had an energy realization rate of 101% and a demand reduction realization rate of 93% because of differences in inputs between *ex ante* and *ex post* calculations. Cadmus sourced all impact inputs from AHRI certificates and project invoices for each model number in the tracking database.
- The instant discount subcomponent had an energy realization rate of 76% and a demand reduction realization rate of 84% because of low realization rates for spray foam. Spray foam had an energy realization rate of 10% and a demand reduction realization rate of 12%. These realization rates were largely driven by a low ISR (5%) which Cadmus determined through a series of participant and general population surveys.
- The Audit and Weatherization subcomponent had an energy realization rate of 73% and a demand reduction realization rate 107% of because of low realization rates for weatherization measures and high realization rates for audit measures. Weatherization measures had an energy

realization rate of 64% and a demand realization rate of 101%, whereas audit measures had energy realization rate of 141% and demand reduction realization rate of 143%. These realization rates were largely driven by differences in installed heating equipment type or differences in ISR values which Cadmus determined through participant surveys.

7.3. Net Impact Evaluation

The methods used to determine net savings for the downstream, upstream, and midstream channels are provided in the Evaluation Framework,[21] which discusses the common methods used to determine free ridership and spillover. The methods for each component and subcomponent are in Table 7-5.

Table 7-5. PY16 Net Impact Evaluation Methodology

Component/ Subcomponent	NTG Notes
Appliance Recycling	Applied historical NTG ratio from PY15 to PY16 verified savings
Energy Efficient Homes Downstream Equipment	Administered online self-report surveys to assess free ridership and spillover
Energy Efficient Homes Midstream Equipment	Applied PY16 downstream equipment NTG ratios for similar measures
Energy Efficient Homes Online Marketplace	Applied historical NTG ratios from PY15 to PY16 verified savings
Energy Efficient Homes Instant Discount	Applied historical NTG ratios from PY15 to PY16 verified savings
Energy Efficient Homes Audit and Weatherization	Applied historical NTG ratio from PY14 to PY16 verified savings
Energy Efficient Homes High-Performance Homes	Used a deemed NTG ratio of 1.00 to calculate net savings, per the evaluation plan
Home Energy Report	
Student Energy Efficient Education	

Additional information about the NTG methodology used for the Downstream Equipment stratum in the Energy Efficient Homes component is provided in *Appendix I. Evaluation Detail – Energy Efficient Homes* and *Appendix K. Net Savings Impact Evaluation.*

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 7-6 presents NTG ratios for the components of the Residential Program in PY16.

[21] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

Table 7-6. PY16 Residential Program Net Impact Evaluation Results

Component	PYVTD (kWh/yr)	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision (at 85% CL)
Appliance Recycling	10,962,834	50%	0%	0.50	5%
Energy Efficient Homes	25,388,820	43.74%	0.49%	0.57	10%
Home Energy Reports	7,562,194	N/A	N/A	1.00	N/A
Student Energy Efficient Education	5,159,916	N/A	N/A	1.00	N/A
Program Total	**49,073,764**[1]	**N/A**	**N/A**	**0.66**[2]	**5%**

[1] May not sum due to rounding.
[2] Weighted by PY16 verified gross energy savings.

The PY16 Residential Program total NTG ratio of 0.66 is heavily weighted toward the Appliance Recycling and Energy Efficient Homes component NTG ratios, as these components represented 74% of the Residential Program verified gross population energy savings.

7.3.1. High-Impact Measure Research

The Phase IV Evaluation Framework requires the identification and oversampling of high-impact equipment and services to assess free ridership with greater certainty. The PY16 evaluation plan stated that up to three Energy Efficient Homes downstream equipment stratum measure categories would be selected as high-impact measures based on contribution to component savings and other characteristics. Cadmus selected downstream equipment HVAC measures, including air source heat pumps, central air conditioners, and ductless heat pumps, as high-impact measures for the PY16 evaluation. The PY16 evaluation plan specified to treat Energy Efficient Homes midstream HVAC channel as a high-impact measure in PY16, but Cadmus determined that, due to participation challenges, there would not be enough information to conduct a robust midstream HVAC channel NTG analysis and did not report an NTG ratio from PY16 primary research. Cadmus applied measure-level NTG ratios from the PY16 Downstream Equipment HVAC NTG research (shown in Table 7-7) to Midstream Equipment stratum measures of the same measure categories. The NTG research for downstream equipment HVAC measure represents 37% of the total Residential Program verified gross energy savings in PY16.

Table 7-7 presents findings for PY16 high-impact measures.

Table 7-7. PY16 Residential High-Impact Measure Net-to-Gross

High-Impact Measure	PYVTD kWh/yr	Free Ridership	Spillover	Net-to-Gross Ratio
Energy Efficient Homes - Downstream Equipment Air-Source Heat Pump [1]	2,566,035	58%[2]	0%	0.42
Energy Efficient Homes - Downstream Equipment Central Air Conditioner [1]	349,272	47%[2]	0%	0.53
Energy Efficient Homes - Downstream Equipment Ductless Heat Pump [1]	15,196,154	47%[2]	0%	0.53
Total	**18,111,461**	**49%**[3]	**0%**	**0.51**

[1] Estimated from PY16 survey data.
[2] Weighted by the survey sample-verified program kWh/yr savings.

High-Impact Measure	PYVTD kWh/yr	Free Ridership	Spillover	Net-to-Gross Ratio
[3] The overall high-impact measure research free ridership estimate of 49% was weighted by each measure's verified kWh/yr population savings.				

7.4. Verified Savings Estimates

As shown in Table 7-8, Cadmus applied the realization rates and NTG ratios to the reported energy and demand savings estimates to calculate the verified savings estimates for the Residential Program in PY16. These totals are added to the verified savings achieved in previous program years to calculate the P4TD program impacts.

Table 7-8. PY16 and P4TD Savings Summary for the Residential Program

Savings Type	Energy (MWh/yr)[1]	Demand (MW/yr)[1]
PYRTD	54,708 [2]	7.10 [2]
PYVTD Gross	49,074 [3]	5.91 [3],[4]
PYVTD Net	32,611 [3]	3.45 [3],[4]
RTD	194,357 [5]	24.79 [5]
VTD Gross	176,126	23.27 [4]
VTD Net	116,357	14.87 [4]

[1] Does not include the Low-Income Program.
[2] Includes unverified PY16 savings from Deep Energy Retrofits pilot.
[3] Does not include PY15 unverified savings verified in PY16.
[4] Verified peak demand reductions include application of distribution losses.
[5] Includes unverified PY15 and PY16 savings from Deep Energy Retrofits pilot.

The VTD savings contribution in the final PY15 annual report changed for the following reasons:

- Cadmus verified savings for PY15 Instant Discount spray foam jobs and midstream jobs in the Energy Efficient Homes component, increasing savings by 1,065 MWh/yr and 0.01 MW/yr.
- SWE audit activities resulted in an increase of 3,251 MWh/yr and a decrease of 0.17 MW/yr. These adjustments impacted the Student Energy Efficient Education and Energy Efficient Homes components.

7.5. Process Evaluation

This section provides high-level results and findings from the process evaluation of the Residential Program. Methodology and additional details are discussed in the individual appendices of this report.

Cadmus conducted a process evaluation in PY16 to gather updates from program administration staff and ICSPs, assess participant experience, and make recommendations for program modification and improvement.

The evaluation activities are summarized in Table 7-9. Modifications to Cadmus' evaluation plans are noted in the individual program component appendices of this report.

Table 7-9. PY16 Residential Program Evaluation Activities

Activity	Audience	Methodology
Appliance Recycling[2]		
In-depth Interviews	Administration staff (n=2)	Telephone
Energy Efficient Homes		
In-depth Interviews	Administration staff (n=3)	Telephone
	Distributors (n=1)	Telephone
	Contractors (n=1)	Telephone
Surveys	Participants (n=304) [1]	Online
Home Energy Reports		
In-depth Interviews	Administration staff (n=3)	Telephone
Surveys	Participants/treatment group (n=475) [1]	Online
	Non-participants/control group (n=522) [1]	Online
Student Energy Efficient Education		
In-depth Interviews	Administration staff (n=2)	Telephone
Surveys	Participant students and teachers (n=15,249) [1]	Paper and Online

[1] Represents completed surveys. Survey and interview respondents could skip questions, and not all answered each question, so the number of responses may differ from what is reported here.
[2] The Appliance Recycling component was not conducted in PY16, so the survey sample size represents participants from PY13-PY15.

The Cadmus team conducted staff interviews in February and March 2025 via phone, and the online participant surveys were conducted between April and June 2025. In-depth phone interviews with participating HVAC contractors and distributors were completed in May 2025.

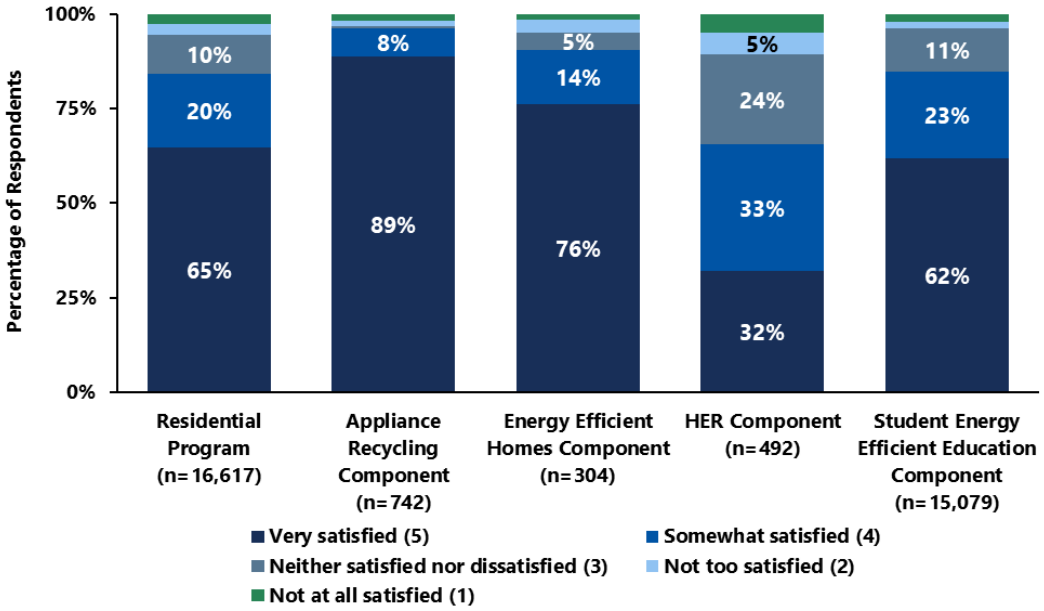
7.5.1. Process Evaluation Key Findings

For Phase IV, PPL Electric Utilities established a Residential Program goal to achieve 85% or greater of *very satisfied* and *somewhat satisfied* customers,[22] which it nearly met with 84% of participants reporting they were satisfied (Figure 7-1). Ninety percent of customers were satisfied with the Energy Efficient Homes component (n=304), 85% of student and teacher respondents (n=15,079) were satisfied with the Student Energy Efficient Education component, and 65% of HER participants were satisfied with the home energy reports they received. The Appliance Recycling component was not conducted in PY16, so the Cadmus team calculated satisfaction by averaging the percentages from PY13 through PY15 (n=742), yielding a satisfaction score of 96%.

Participant satisfaction with Energy Efficient Homes program components increased from 86% to 90% in PY16, and satisfaction with the Student Energy Efficient Education is consistent with the 85% satisfaction reported in PY15.

[22] The customer satisfaction goal is stipulated in PPL Electric Utilities' EE&C Plan (Docket No. M-2020-3020824) filed with the PA PUC, March 27, 2025.

Figure 7-1. PY16 Residential Program Overall Satisfaction



Source: PY16 Participant surveys question, "Thinking about your overall experience with the PPL Electric Utilities [PROGRAM] rebate program, how would you rate your overall satisfaction?" PY16 SEEE Student Home Energy Worksheet question, "Please rate your overall satisfaction with the Think! Energy program." PY16 SEEE Teacher Evaluation Form question, "Please share your impression of Think! Energy – Overall Experience." PY16 HER Participant survey question, "How would you rate your overall satisfaction with the Home Energy Reports?" Percentages may not total 100% or match other sections of the report due to rounding.

Table 7-10 shows key findings from individual process evaluations for components in the Residential Program. Additional details are in the program component appendices.

Table 7-10. Residential Program Key Process Evaluation Findings

Program Component	Finding
Energy Efficient Homes	• Downstream Equipment, Audit, and Weatherization participants were satisfied with their experience; 90% of participants were *very satisfied* or *somewhat satisfied* (n=304). Component level satisfaction was statistically higher in PY16 than PY15. *(Section I.3.1)* • Downstream Equipment respondents' satisfaction was particularly driven by the rebate they received, the amount of time it took to receive the rebate, and increased energy savings 56%, 56%, and 50%, respectively). Audit and Weatherization respondents' satisfaction was particularly driven by the actual rebate they received (38%) and increased energy savings (32%). *(Section I.3.1)* • Both the interviewed distributor and contractor were *somewhat satisfied* with the midstream equipment program and believed that the program helped them with their sales of high-efficiency equipment. *(Section I.3.2)*
SEEE	• Satisfaction with the SEEE program component overall remained high in PY16 across both students and teachers, with a satisfaction level of 85%. *(Section J.3.1)* • A higher proportion of teachers rated themselves as *very satisfied* with the presentations in PY16 compared to PY15 (93% vs. 87%). *(Section J.3.1)* • Compared to PY15, slightly fewer students rated the presentations positively in PY16 (82% vs. 83%). Specifically, fewer students in the Innovation cohort rated themselves as satisfied with the presentation compared to the previous year (76% vs. 80%).*(Section J.3.1)*
Home Energy Reports	• Customers received and read the reports; 89% of treatment respondents said they recalled seeing or receiving a HER, with 57% of those who recalled HERs reporting that someone in their household always reads them, and another 27% said that someone usually reads the reports or at least part of them. *(Section N.4.1)* • Over two-thirds (65%; n=492) of treatment group respondents said they were satisfied with the HERs, with most believing the reports were easy to read (79%) and that the information provided was useful (63%). However, only 37% said the similar home comparisons were accurate. *(Section N.4.1)* • Treatment respondents (72%; n=460) were likelier than control respondents (63%; n=520) to have heard about PPL Electric Programs and rebate offers in the past six months and were more likely to view PPL Electric Utilities as a source for energy efficiency information and rebates (62% vs. 56%; n=471 and 529, respectively). *(Section N.4.1)* • Treatment respondents were significantly more satisfied with PPL Electric Utilities overall compared to control respondents (79% vs. 71%; n=496 and 566, respectively). *(Section N.4.1)*

7.6. Program Finances and Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness is presented in Table 7-11. Cadmus calculated the TRC benefits using gross verified impacts. PY16 NPV costs and benefits are expressed in 2024 dollars. NPV costs and benefits for P4TD financials are expressed in 2021 dollars.

Table 7-11. Summary of Residential Program Finances – Gross Verified

Row	Cost Category [1]	PYTD ($1,000)		P4TD ($1,000)	
1	**IMCs**	**$16,076**		**$65,327**	
2	Rebates to Participants and Trade Allies	$5,741		$15,885	
3	Upstream/Midstream Incentives	$864		$5,499	
4	Material Cost for Self-Install Program Components (EE&C Kits)	$654		$2,329	
5	Direct Installation Materials and Labor	$0		$0	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)[6]	$8,817		$41,615	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$0	$0
8	Administration and Management	$141	$940	$601	$2,395
9	Marketing	$0	$1,243	$0	$3,882
10	Program Delivery	$0	$4,347	$0	$12,204
11	EDC Evaluation Costs	$0		$0	
12	SWE Audit Costs	$0		$0	
13	**Program Overhead Costs (Sum of rows 7 through 12)**[6]	**$6,671**		**$19,083**	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)**[5],[6],[7]	**$22,748**		**$85,927**	
15	Total NPV Lifetime Electric Energy Benefits	$13,023		$46,417	
16	Total NPV Lifetime Electric Capacity Benefits	$6,016		$27,131	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$0		$0	
18	Total NPV Lifetime Fossil Fuel Impacts	$11,554		$39,917	
19	Total NPV Lifetime Water Impacts	$4,122		$11,896	
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)**[6]	**$34,716**		**$125,359**	
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.53**		**1.46**	

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = 2021.

[2] P4TD benefits do not include carry-over energy savings from Phase III.

[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.

[4] Includes CSP rebate processing, direct program management, customer support, technical assistance to customers, site visits, legal, and QA/QC documentation. These costs cannot be quantified separately and are included as "Program Delivery" costs.

[5] Portfolio-level costs are not assigned to specific programs.

[6] Sum of rows may not add up to total due to rounding.

[7] Row 14 (portfolio-level TRC costs) includes excess incentives from the Residential Efficient Lighting program component; $1,516,214 in P4TD. Per Phase IV TRC Order, excess incentives are to be treated as a TRC cost, so the sum of rows 1 and 13 do not add up to row 14.

Table 7-12 presents program financials and cost-effectiveness on a net savings basis. As stated in the 2021 TRC Order, free rider incentives are not included as an additional program cost, as these would have occurred even in the absence of the program.

Table 7-12. Summary of Residential Program Finances – Net Verified

Row	Cost Category[1]	PYTD ($1,000)		P4TD[2] ($1,000)	
1	**IMCs**	**$9,994**		**$59,804**	
2	Rebates to Participants and Trade Allies	$5,741		$15,885	
3	Upstream/Midstream Incentives	$864		$5,499	
4	Material Cost for Self-Install Program Components (EE&C Kits)	$654		$2,329	
5	Direct Installation Materials and Labor	$0		$0	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)[6]	$2,734		$36,092	
		EDC	**CSP**	**EDC**	**CSP**
7	Program Design	$0	$0	$0	$0
8	Administration and Management	$141	$940	$601	$2,395
9	Marketing	$0	$1,243	$0	$3,882
10	Program Delivery	$0	$4,347	$0	$12,204
11	EDC Evaluation Costs	$0		$0	
12	SWE Audit Costs	$0		$0	
13	**Program Overhead Costs (Sum of rows 7 through 12)**[6]	**$6,671**		**$19,083**	
14	**Total NPV TRC Costs (Sum of rows 1 and 13)**[5],[6],[7]	**$16,665**		**$80,452**	
15	Total NPV Lifetime Electric Energy Benefits	$7,886		$41,888	
16	Total NPV Lifetime Electric Capacity Benefits	$3,632		$25,066	
17	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$0		$0	
18	Total NPV Lifetime Fossil Fuel Impacts	$7,811		$36,683	
19	Total NPV Lifetime Water Impacts	$4,089		$11,867	
20	**Total NPV TRC Benefits (Sum of rows 15 through 19)**[6]	**$23,418**		**$115,503**	
21	**TRC Benefit-Cost Ratio (Row 20 divided by Row 14)**	**1.41**		**1.44**	

[1] Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025); P4TD = 2021

[2] P4TD benefits do not include carry-over energy savings from Phase III

[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance.

[4] Includes CSP 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.

[5] Portfolio-level costs are not assigned to specific programs.

[6] Sum of rows may not add up to total due to rounding.

[7] Row 14 (portfolio-level TRC costs) includes excess incentives from the Residential Efficient Lighting program component; $1,564,058 in P4TD. Per Phase IV TRC Order, excess incentives are to be treated as a TRC cost, so the sum of rows 1 and 13 do not add up to row 14.

7.7. Status of Recommendations

Overall, the Residential Program exceeded the PY16 planned energy savings and demand reductions by approximately 67% and 20%, respectively. Additionally, the Residential Program almost met its customer satisfaction target with 84% of participants reporting they were satisfied. Table 7-13 provides recommendations, along with a summary of how PPL Electric Utilities plans to address the recommendations.

Conclusion 1 (Energy Efficient Homes): Mismatched information in the participant database and the documentation led to differences in realization rates for several midstream and downstream equipment measures.	• All of the ductless heat pump, air source heat pump, and central air conditioning projects had discrepancies in SEER or HSPF, or both, even in cases where the project documentation included the AHRI certificate. *(See Section I.1.2)* • For three heat pump water heater projects, the energy factor provided in the tracking database did not match the specifications of the equipment models provided in the project documentation. For one of these projects, the tank size also did not match. *(See Section I.1.2)*
Conclusion 2: (Energy Efficient Homes): Improving the application process could lead to higher customer satisfaction and a more positive perception of PPL Electric Utilities.	• Eight Downstream Equipment respondents provided reasons why their opinion of PPL Electric Utilities decreased after participating in the program. Three ductless heat pump purchasers reported issues with applying for rebates. One smart thermostat purchaser cited an issue with the rebate. Three air source heat pump purchasers cited issues with the application or rebate, and one was confused about equipment qualifications, saying that their "thermostat should be covered" in addition to their heat pump. *(See Section I.3.1)* • Eleven Downstream Equipment respondents said that PPL Electric Utilities could improve the program by refining the application process. One respondent said that PPL Electric Utilities should "clarify what needs to be submitted at the time of submission," so that they are not required to resubmit their application later; a problem echoed by two others. Additionally, two respondents who suggested improved communication said that they needed more guidance from customer service on how to scan and submit paperwork. *(See Section I.3.1)* • One midstream contractor said that they would like there to be fewer questions for homeowners on the application, which is something their customers have complained about. *(See Section I.3.1)*
Conclusion 3: (Energy Efficient Homes): Expanding program-eligible downstream and midstream equipment offerings could increase customer satisfaction and program participation.	• One distributor suggested adding smart thermostats to the midstream delivery channel to entice more contractors to participate, since thermostats are often part of full system replacements, which include equipment that currently qualifies. *(See Section I.3.2)*

- The most common suggestion to improve the program was to broaden the rebate offerings (17 respondents). For example, several respondents suggested that rebates "include more types of equipment," including dishwashers. *(See Section I.3.1)*

Conclusion 4 (HER): Customers generally read and had positive attitudes toward the reports; however, they did not agree that similar home comparisons were accurate, which may have impacted their motivation to follow recommended behavior changes.

- A majority of treatment respondents (89%) recalled receiving home energy reports. Over half of respondents who recalled the home energy reports (57%) reported that someone in their household always reads them, and 27% reported that someone usually reads the reports or parts of the report, indicating that most recipients are engaging with the reports and only a few are disregarding them. *(See Section N.4.1)*
- Most respondents said the reports were easy to read (79%), liked the look of the reports (68%), and believed the information was useful (63%). *(See Section N.4.1)*
- Less than half of respondents (48%) said the reports motivated them to engage in energy-saving behavior, and only 37% reported that the similar home comparisons were accurate. *(See Section N.4.1)*
- A majority of treatment group respondents (65%) said they were satisfied with the reports. Among those who said they were satisfied with the reports, the primary drivers of satisfaction were the tips to optimize energy efficiency (63%), comparisons to similar homes (62%), and the energy-saving tips to consider (59%). *(See Section N.4.1)*
- Conversely, for those who were less than satisfied with the reports, the most frequently cited reasons were that respondents did not believe the comparisons were accurate (33%) and that they did not need reminders or tips about their energy use (24%). *(See Section N.4.1)*

Conclusion 5 (HER): The HER component generated savings throughout the study period, though early impacts may be understated due to staggered report delivery.

- Customers began receiving their first reports on different start dates, starting in December and extending through May. *(See Section N.1.4)*

Conclusion 6 (HER): The HER component did not generate uplift savings through other residential downstream programs, but it increased participation in other programs, showing an engagement benefit even with limited incremental savings.

- The treatment group (recipients of the home energy reports) was statistically significantly more likely than the control group to report having heard about PPL Electric Utilities programs and rebate offers that help save energy and money over the past six months (72% vs. 63%). Overall, report recipients had the highest levels of awareness of appliance recycling and appliance rebates. *(See Section N.4.1)*
- Although uplift savings were negative, participation uplift was positive. This suggests that the Home Energy Report component encouraged customers to participate in other efficiency programs, but those participants did not generate the expected incremental savings. It is likely that treatment customers adopted additional energy efficiency measures through downstream programs; however, the measured savings attributable to these actions were relatively low. *(See Section N.1.5)*

The impact and process evaluation activities in PY16 led to the following findings and recommendations from Cadmus to PPL Electric Utilities, along with a summary of how PPL Electric Utilities plans to address the recommendations in program delivery (Table 7-13).

Table 7-13. Status of Recommendations for the Residential Program

Program Component	Conclusion	Recommendation	EDC Status of Recommendation
Energy Efficient Homes Downstream and Midstream Equipment	**Conclusion 1:** Mismatched information in the participant database and the documentation led to differences in realization rates for several midstream and downstream equipment measures.	Ensure inputs recorded in the tracking data, such as efficiency ratings and energy factors, match project documentation, such as AHRI certificates.	Implemented
	Conclusion 2: Improving the application process could lead to higher customer satisfaction and a more positive perception of PPL Electric Utilities.	Conduct additional research to identify specific application challenges.	Implemented
		Review the midstream homeowner application to see if there are redundancies or other information that could be removed to reduce customer application burden.	Being considered
	Conclusion 3: Expanding program-eligible downstream and midstream equipment offerings could increase customer satisfaction and program participation.	Consider expanding downstream and midstream component offerings to include equipment, such as ENERGY STAR dishwashers in the downstream channel and smart thermostats in the midstream channel.	Being considered
Home Energy Reports	**Conclusion 4:** Customers generally read and had positive attitudes toward the reports; however, they did not agree that similar home comparisons were accurate, which may have impacted their motivation to follow recommended behavior changes.	Conduct further research to find ways to improve the perception of accuracy in similar homes comparisons and to refine current messaging strategies to increase energy savings behaviors and engagement. This could include secondary research or primary research (content analysis, focus groups, A/B testing, etc.)	Being considered
	Conclusion 5: The HER component generated savings across the study period, though early impacts may be understated due to staggered report delivery.	Ensure more consistent and timely delivery of reports in future implementations to maximize program effect and accurately capture early-period savings.	Implemented
	Conclusion 6: The HER component did not generate uplift savings through other residential downstream programs, but it increased participation in other programs, showing an engagement benefit even with limited incremental savings.	Leverage the Home Energy Reports' ability to drive cross-program participation while exploring ways to strengthen incremental savings from residential programs.	Implemented

Appendix A. Site Inspection Summary

Table A-1 summarizes the program components and subcomponents that received verification site visits by Cadmus or the ICSP (listed in the Inspection Firm column), including the number of inspections, discrepancies, and the resolution of the discrepancies.

Table A-1. PY16 Site Visit Summary

Program Component	Inspection Firm	Inspections Conducted		Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
		In-Person	Virtual		
Custom	CLEAResult (the ICSP)	89	89	0	• Submitter's estimate of original savings was not accurate • Actual metered data used in place of estimates • Project was not modeled accurately originally compared to the installed condition • Project scope deviated from the original submission
Custom	Warren Energy Engineering (on behalf of Cadmus)	28	2	13	• Discrepancies were found in six Large stratum solar PV projects and seven of eight small stratum sites based on more recent post data obtained from the site. Equipment quantity discrepancy was noted in one small stratum site.
Efficient Equipment Direct Discount Lighting	CLEAResult (the ICSP)	117	19	0	• Scope of work changes • Incorrect fixture codes used • Wrong number of lights submitted on application • Wrong HOU given on Appendix C form vs. what was found from customer interviews on site • Wrong amount of bulbs in the fixtures submitted • Building type change • Integrated fixtures not used in application • Incorrect wattage selected for baseline fixtures
Efficient Equipment Downstream Lighting	CLEAResult (the ICSP)	48	30		• Scope of work changes • Incorrect fixture codes used • Wrong number of lights submitted on application • Wrong HOU given on Appendix C form vs. what was found from customer interviews on site

Program Component	Inspection Firm	Inspections Conducted		Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
		In-Person	Virtual		
					• Wrong amount of bulbs in the fixtures submitted
					• Building type change
					• Incorrect wattage selected for baseline fixtures
Equipment (non-lighting)	DNV (on behalf of Cadmus)	0	2	2	• Installed Quantity - 3/40 installed at a different facility, 3/40 in storage (other)
					• Savings Methodology - Adherence to IMP efficiency instructions/algorithms (HVAC)
Efficient Equipment (non-lighting)	CLEAResult (the ICSP)	14	2	0	• Project savings may have increased or decreased as a result of site visits, which made the projects switch from prescriptive to customer-submitted HOU (HVAC)
					• Ineligible equipment removed from applications (HVAC)
					• Project scope deviated from the original submission (HVAC)
					• Quantity change (battery charger)
New Homes	PSD (the ICSP's subcontractor)	106	0	98	• Appliances (70) – Appliance discrepancies were most often caused by misreported equipment efficiency ratings or failing to use defaults if not installed
					• Windows (57) – Window discrepancies are most often caused by misreported window area or the orientation of the windows.
					• Cooling Equipment (42) – Cooling Equipment discrepancies were most often caused by misreported efficiency ratings.
					• Orientation (40) – Orientation discrepancies are caused by misreported building orientation.
					• Hatches (27) – Hatch discrepancies were most often caused by misreported R-values or exclusion from model
					• Duct Leakage (22) – Duct Leakage discrepancies were most often caused by misreported CFM at 25 pascals
Energy Efficient Homes Air Sealing	CLEAResult (the ICSP)		7	0	• No discrepancies found
Energy Efficient Homes Air Source Heat Pump	CLEAResult (the ICSP)	8	74	0	• No discrepancies found
Energy Efficient Homes Attic Insulation (R0 to R49)	CLEAResult (the ICSP)	2	50	2	• Discrepancies most often were a result of the projects not meeting program requirements (existing R-value over 30 or new R-value below 49)
Energy Efficient Homes Central AC	CLEAResult (the ICSP)	4	57	1	• Indoor unit different from what was on the invoice, which created an ineligible combination

Program Component	Inspection Firm	Inspections Conducted		Sites with Discrepancies from Reported Values	Summary of Common Discrepancies
		In-Person	Virtual		
Energy Efficient Homes Central Heat Fuel Switch	CLEAResult (the ICSP)		7	1	• Discrepancies were a result of the existing system already being a natural gas system or installation in a newly constructed home
Energy Efficient Homes Ductless Heat Pump	CLEAResult (the ICSP)	18	314		• No discrepancies found
Energy Efficient Homes Smart Thermostat	CLEAResult (the ICSP)		4		• No discrepancies found
Energy Efficient Homes Wall Insulation	CLEAResult (the ICSP)	1	13	3	• Discrepancies were a result of installations not completed in a qualifying basement or crawlspace area of the home
Energy Efficient Homes Water Heater Fuel Switch	CLEAResult (the ICSP)				• Measure not offered in PY16
Low-Income (Baseload)	CMC (the ICSP)	259	92 Remote Inspections and 4,060 quality confirmation surveys sent	120	• Customers had broken items that needed to be replaced (11 times); three of the cases had missed opportunities that were identified and installed. Tech coaching was provided. • In one case, an item was shipped but never arrived. An inspection confirmed this, and the missing items were installed.
Low Income (Low-Cost)	CMC (the ICSP)	675	206 Remote Inspections and 8,415 quality confirmation surveys sent.	245	• Six cases involved defective items that needed to be replaced • Five of the cases had missed opportunities that were identified and installed. Tech coaching was provided.

Appendix B. PY16 and P4TD Summary by Customer Segment and Low-Income Carveout

Table B-1 summarizes the Low-Income Program, initiatives, and customer segments that contributed to the low-income carveout in PY16 and P4TD.

Table B-1. Summary of Low-Income Carveout Energy Savings (MWh/Year)

Program	Customer Segment	PYVTD Gross (MWh/yr)	VTD Gross (MWh/yr)
Low-Income	Low-Income	14,964	50,532
	Small C&I	567	1,024
	GNE	-	59
Subtotal		**15,530**	**51,614**
Phase III Carryover		-	31,089
Total		**15,530**	**82,703**

Appendix C. Summary of Program-Level Impacts, Cost Effectiveness, and High-Impact Measure NTG

C.1. Program- and Initiative-Level Impacts Summary

Table C-1 summarizes the energy impacts by program and initiative through PY16.

Table C-1. Incremental Annual Energy Savings by Program and Initiative (MWh/Year)

Program/Initiative	PYRTD (MWh/yr)	PYVTD Gross (MWh/yr)[1]	PYVTD Net (MWh/yr)[1]	RTD (MWh/yr)	VTD Gross (MWh/yr)[2]	VTD Net (MWh/yr)[2], [3]
Non-Residential						
Custom	163,581	150,260	111,192	395,192	377,323	258,158
Efficient Equipment	84,705	84,727	54,218	360,481	370,288	244,672
Subtotal[4]	**248,286**	**234,987**	**165,410**	**755,673**	**747,612**	**502,830**
Low-Income						
Subtotal[4]	**18,402**	**15,530**	**15,530**	**53,840**	**82,703 [5]**	**51,614[6]**
Residential						
Appliance Recycling	11,737	10,963	5,481	37,466	35,998	18,987
Efficient Lighting	-	-	-	8,763	8,969	9,597
Energy Efficient Homes	31,596	25,389	14,408	119,965	103,381	59,996
Home Energy Reports	6,215	7,562	7,562	6,215	7,562	7,562
Student Energy Efficient Education	5,160	5,160	5,160	21,948	20,515	20,515
Subtotal[4]	**54,708**	**49,074**	**32,611**	**194,357**	**176,126**	**116,357**
Portfolio Total[4]	**321,395**	**299,591**	**213,552**	**1,003,870**	**975,352[6]**	**670,801**
Carryover	-	-	-	-	306,275	-
Portfolio Total with Carryover[4]	**321,395**	**299,591**	**213,552**	**1,003,870**	**1,281,627**	**670,801**

[1] Does not include PY15 savings verified in PY16.

[2] Includes PY15 unverified savings, verified in PY16.

[3] VTD Net does not include carryover savings.

[4] Subtotals and totals may not match the sums of rows due to rounding and may not match figures or tables in other sections of the report due to rounding.

[5] Includes 31,089 MWh/yr of carryover attributed to the Low-Income Program.

[6] Excludes carryover attributed to the Low-Income Program.

Table C-2 summarizes peak demand impacts by energy efficiency program and initiative through the current reporting period.

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

Program/Initiative	PYRTD (MW/yr)	System-Level PYVTD Gross (MW/yr)[1]	System-Level PYVTD Net (MW/yr)[1]	RTD (MW/yr)	System-Level VTD Gross (MW/yr)[2]	System-Level VTD Net (MW/yr)[2]
Non-Residential						
Custom	38.83	38.96	28.83	82.31	85.09	59.34
Efficient Equipment	16.82	16.23	10.56	62.22	61.98	41.01
Subtotal[3]	**55.65**	**55.19**	**39.38**	**144.53**	**147.07**	**100.34**
Low-Income						
Subtotal[3]	**1.87**	**1.73**	**1.73**	**5.75**	**5.82**	**5.82**
Residential						
Appliance Recycling	3.37	3.53	1.76	9.25	9.80	5.14
Efficient Lighting	-	-	-	1.27	1.41	1.51
Energy Efficient Homes	3.21	1.82	1.12	12.15	9.99	6.14
Home Energy Reports	-	-	-	-	-	-
Student Energy Efficient Education	0.52	0.56	0.56	2.12	2.07	2.07
Subtotal[3]	**7.10**	**5.91**	**3.45**	**24.79**	**23.27**	**14.87**
Portfolio Total[3]	**64.63**	**62.83**	**44.56**	**175.06**	**176.16**	**121.03**

[1] Does not include PY15 savings verified in PY16.
[2] Includes PY15 unverified savings, verified in PY16, and may not match figures or tables in other sections of the report due to rounding.
[3] Subtotals and totals may not match the sums of rows due to rounding.

C.2. Program-Level Cost-Effectiveness Summary

Table C-3 and Table C-4 show the TRC ratios by program and for the portfolio for PY16. Cadmus calculated the benefits using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table C-3. PY16 Gross TRC Ratios by Program ($1,000)

Program/Initiatives	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Non-Residential				
Custom	$122,050	$108,009	1.13	$14,041
Efficient Equipment	$69,959	$35,329	1.98	$34,629
Non-Residential Subtotal[1]	**$192,008**	**$143,338**	**1.34**	**$48,670**
Residential				
Low-Income	$14,200	$10,225	1.39	$3,975
Appliance Recycling	$3,796	$2,525	1.50	$1,271
Efficient Lighting	$0	$1	n/a	($1)
Energy Efficient Homes	$23,504	$17,861	1.32	$5,643
Home Energy Report	$244	$673	0.36	($429)
Student Energy Efficient Education	$7,171	$1,687	4.25	$5,484
Residential Subtotal[1],[2]	**$48,916**	**$32,973**	**1.48**	**$15,943**
Common Portfolio Costs	**n/a**	**$8,152**	**n/a**	**n/a**
Portfolio Total[1]	**$240,924**	**$184,463**	**1.31**	**$56,462**

Note: Costs and benefits are expressed as follows PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025

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

[2] The Low-Income Program is shown as a subsector of residential in this table.

Table C-4. PY16 Net TRC Ratios by Program ($1,000)

Program/Initiatives	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Non-Residential				
Custom	$90,317	$81,381	1.11	$8,936
Efficient Equipment	$45,903	$23,793	1.93	$22,110
Non-Residential Subtotal[1]	**$136,220**	**$105,174**	**1.30**	**$31,046**
Residential				
Low-Income	$14,200	$10,225	1.39	$3,975
Appliance Recycling	$1,898	$2,525	0.75	($627)
Efficient Lighting	$0	$1	n/a	($1)
Energy Efficient Homes	$14,104	$11,778	1.20	$2,326
Home Energy Report	$244	$673	0.36	($429)
Student Energy Efficient Education	$7,171	$1,687	4.25	$5,484
Residential Subtotal[1],[2]	**$37,618**	**$26,890**	**1.40**	**$10,728**
Common Portfolio Costs	**n/a**	**$8,152**	**n/a**	**n/a**
Portfolio Total[1]	**$173,837**	**$140,216**	**1.24**	**$33,622**

Note: Costs and benefits are expressed as follows PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025

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

[2] The Low-Income Program is shown as a subsector of residential in this table.

Table C-5 and Table C-6 summarize cost-effectiveness by program for Phase IV of Act 129. Cost and benefits are expressed in 2021 dollars.

Table C-5. Phase IV Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Non-Residential				
Custom	$257,505	$180,279	1.43	$77,226
Efficient Equipment	$258,489	$163,179	1.58	$95,310
Non-Residential Subtotal[1]	**$515,994**	**$343,458**	**1.50**	**$172,536**
Low-Income	$39,443	$27,290	1.45	$12,153
Appliance Recycling	$10,516	$7,588	1.39	$2,928
Efficient Lighting	$5,886	$2,594	2.27	$3,292
Energy Efficient Homes	$83,963	$70,681	1.19	$13,282
Home Energy Report	$211	$582	0.36	($371)
Student Energy Efficient Education	$24,783	$4,482	5.53	$20,302
Residential Subtotal[1],[2]	**$164,803**	**$113,217**	**1.46**	**$51,585**
Common Portfolio Costs	**n/a**	**$24,347**	**n/a**	**n/a**
Portfolio Total[1]	**$680,797**	**$481,022**	**1.42**	**$199,775**

Note: Costs and benefits are expressed as follows PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025

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

[2] The Low-Income Program is shown as a subsector of residential in this table.

Table C-6. Phase IV Net TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Non-Residential				
Custom	$219,885	$148,429	1.48	$71,456
Efficient Equipment	$237,709	$153,213	1.55	$84,496
Non-Residential Subtotal[1]	**$457,594**	**$301,642**	**1.52**	**$155,952**
Residential				
Low-Income	$39,443	$27,290	1.45	$12,153
Appliance Recycling	$8,877	$7,588	1.17	$1,288
Efficient Lighting	$5,886	$2,594	2.27	$3,292
Energy Efficient Homes	$75,746	$65,158	1.16	$10,588
Home Energy Report	$211	$582	0.36	($371)
Student Energy Efficient Education	$24,783	$4,482	5.53	$20,302
Residential Subtotal[1],[2]	**$154,946**	**$107,694**	**1.44**	**$47,252**
Common Portfolio Costs	**n/a**	**$24,347**	**n/a**	**n/a**

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Portfolio Total[1]	**$612,540**	**$433,684**	**1.41**	**$178,857**

Note: Costs and benefits are expressed as follows PY13 = 2021, PY14 = 2022, PY15 = 2023, PY16 = 2024, PY17 = 2025
[1] Total may not match sum of rows due to rounding.
[2] The Low-Income Program is shown as a subsector of residential in this table.

C.3. High-Impact Measure Net-to-Gross

Findings from NTG research are not used to adjust compliance savings in Pennsylvania. Instead, NTG research provides directional information for program planning purposes. The PY16 evaluation plan prescribed selecting up to three Energy Efficient Homes downstream equipment stratum measure categories as high-impact measures based on contribution to component savings and other characteristics. Cadmus selected downstream equipment HVAC measures, including air source heat pumps, central air conditioners, and ductless heat pumps, as high-impact measures for the PY16 evaluation. The PY16 evaluation plan specified to treat Energy Efficient Homes midstream HVAC channel as a high-impact measure in PY16, but Cadmus determined that, due to participation challenges, there would not be enough information to conduct a robust midstream HVAC channel NTG analysis and did not report an NTG ratio from PY16 primary research. Cadmus applied measure-level NTG ratios from the PY16 Downstream Equipment HVAC NTG research shown in Table C-7 below to Midstream Equipment stratum measures of the same measure categories. The NTG research for downstream equipment HVAC measure represents 37% of the total Residential Program verified gross energy savings in PY16.

Table C-7 presents NTG findings for high-impact measures studied in PY16.

Table C-7. PY16 High Impact Measure Net-to-Gross

High-Impact Measure	PYVTD kWh/yr	Free Ridership	Spillover	Net-to-Gross Ratio
Energy Efficient Homes - Downstream Equipment - Air-Source Heat Pump [1]	2,566,035	58%[2]	0%	0.42
Energy Efficient Homes - Downstream Equipment - Central Air Conditioner [1]	349,272	47%[2]	0%	0.53
Energy Efficient Homes - Downstream Equipment - Ductless Heat Pump [1]	15,196,154	47%[2]	0%	0.53
Total	**18,111,461**	**49%[3]**	**0%**	**0.51**

[1] Estimated from PY16 survey data.
[2] Weighted by the survey sample-verified program kWh/yr savings.
[3] The overall high-impact measure research free ridership estimate of 49% was weighted by each high-impact measure's verified kWh/yr population savings.

C.4. Program-Level Comparison of Performance to Approved EE&C Plan

Table C-8 presents PY16 expenditures, by program, compared to the budget estimates set forth in the EE&C plan for PY16.[23] All the dollars are presented in 2024 dollars.

Table C-8. Comparison of PY16 Expenditures to Phase IV EE&C Plan ($1,000)

Program	PY16 Budget from EE&C Plan(1)	PY16 Actual Expenditures(2)	Ratio (Actual/Plan)
Non-Residential	$35,192	$32,917	94%
Low-Income	$8,727	$10,225	117%
Residential	$12,399	$13,931	112%
Total Direct Program Costs(3)	**$56,318**	**$57,073**	**101%**
Common Portfolio Costs(4)	$8,620	$8,152	95%
Portfolio Total(3)	**$64,938**	**$65,225**	**100%**

(1) Budgets are from Table 6 of PPL Electric Utilities EE&C plan.
(2) Expenditures may not match the sum of incentives and program costs listed in the individual program cost-effectiveness tables due to rounding.
(3) Total may not match sum of rows due to rounding.
(4) Common costs include costs for SWE audit.

Table C-9 presents P4TD expenditures, by program, compared to the budget estimates set forth in the EE&C plan through PY16 (not the full phase). All the dollars are presented in 2024 dollars.

Table C-9. Comparison of P4TD Expenditures to Phase IV EE&C Plan ($1,000)

Program	Phase IV Budget from EE&C Plan through PY16(1)	PIVTD Actual Expenditures(2)	Ratio (Actual/Plan)
Non-Residential	$128,072	$102,703	80%
Low-Income	$33,951	$29,724	88%
Residential	$51,923	$46,448	89%
Total Direct Program Costs(3)	**$213,946**	**$178,875**	**84%**
Common Portfolio Costs(4)	$34,480	$26,302	76%
Portfolio Total(3)	**$248,426**	**$205,178**	**83%**

(1) Budgets are from Table 6 of PPL Electric Utilities EE&C plan.
(2) Expenditures may not match the sum of incentives and program costs listed in the individual program cost-effectiveness tables due to rounding.
(3) Total may not match sum of rows due to rounding. Total will not match infographics because they show expenditures compared to full Phase IV goal.
(4) Common costs include costs for SWE audit.

Table C-10 compares PY16 verified gross program savings compared to the energy savings projections set forth in the EE&C plan.

[23] PPL Electric Utilities Corporation. Revised March 27, 2025. *Energy Efficiency and Conservation Plan Act 129 Phase IV*. Docket No. M-2020-3020824.

Table C-10. Comparison of PY16 Actual Program Savings to EE&C Plan Projections for PY16

Program	EE&C Plan Projections for PY16 (MWh/yr)[1]	PY16 VTD Gross MWh/yr Savings[2]	Ratio (Actual/Plan)
Non-Residential[3]	210,698	234,987	112%
Low-Income[3]	14,571	15,530	107%
Residential[3]	33,017	49,074	149%
Total[3][4]	**258,286**	**299,591**	**116%**

[1] Projections from Table 4 of PPL Electric Utilities EE&C plan.
[2] Does not include PY15 unverified savings, verified in PY16.
[3] May not match totals in infographics due to rounding.
[4] Total may not match sum of rows due to rounding.

Table C-11 compares Phase IV actual program savings to the EE&C projections through Phase IV to date.

Table C-11. Comparison of Phase IV Actual Program Savings to EE&C Plan Projections for Phase IV To-Date

Program	EE&C Plan Through PY16[1]	VTD Gross MWh/yr Savings	Carryover MWh/yr	Total VTD Gross MWh/yr Savings	Ratio (Actual/Plan)
Non-Residential[2]	925,389	747,612	-	747,612	81%
Low-Income[2]	54,320	51,614	31,089	82,703	152%
Residential[2]	144,148	176,126	-	176,126	122%
Total[2][3]	**1,123,857**	**975,352**	**306,275 [4]**	**1,281,627 [5]**	**114%**

[1] Projections are from Table 4 of PPL Electric Utilities EE&C plan.
[2] May not match totals in infographics due to rounding.
[3] Total may not match sum of rows due to rounding. Total will not match infographics because they show savings compared to full Phase IV goal.
[4] Sum of Carryover column will not match total row because only 31,089 MWh/yr is attributed to a specific program. The remaining 275,186 MWh/yr is attributed to the portfolio.
[5] Sum of Total VTD Gross Savings column will not match total row because it includes portfolio-level carryover savings.

PPL Electric Utilities

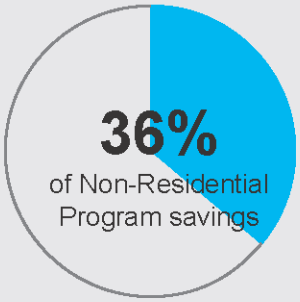
CADMUS

EFFICIENT EQUIPMENT

This component of the Non-Residential Program promotes the purchase and installation of high-efficiency equipment and lighting through four delivery channels by offering financial incentives to offset purchase costs and by providing information on efficiency features and benefits.

VERIFIED ENERGY SAVINGS

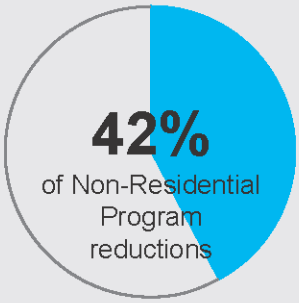
Phase IV has saved **370,288 MWh/yr**

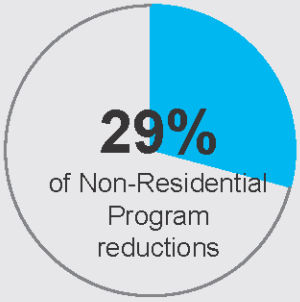


PY16 saved **84,727 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **61.98 MW/yr**





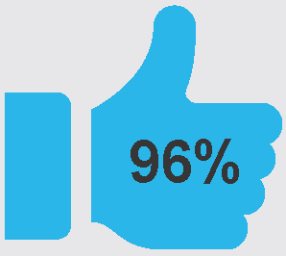
PY16 has reductions of **16.23 MW/yr**

PY16 PARTICIPATION

A total of **5,077** participants

- **4,753** Lighting
- **226** HVAC
- **38** Refrigeration
- **21** Motors
- **20** Agriculture
- **15** Other
- **4** Food Service

PARTICIPANT SATISFACTION



Satisfied with overall program component

Appendix D. Evaluation Detail Efficient Equipment Component

PPL Electric Utilities' Non-Residential Efficient Equipment component promotes the purchase and installation of a wide range of high-efficiency equipment, including lighting, HVAC, refrigeration, motors/drives, commercial kitchen, agricultural, equipment controls, and new construction projects.

The component offers incentives for lighting and equipment (non-lighting) through four delivery channels:

- **Downstream Rebates.** Customers, contractors, or trade allies submit applications for review and validation by the Non-Residential ICSP. The ICSP reviews and validates all submitted applications, processes eligible projects, and pays incentives upon project completion and final savings calculations.
- **Direct Discount.** This delivery channel is supported by a network of qualified contractors and higher incentives. The ICSP helps the contractor orchestrate the project from beginning to end on behalf of the customer. After the contractor completes and updates the application, the Non-Residential ICSP completes the verification and then reimburses the contractor with a check for the incentive.
- **Direct Install.** The Non-Residential ICSP targets hard-to-reach small C&I customers and provides a no-cost assessment to identify energy efficiency improvements and provide free LED bulbs and pre-rinse spray valves where needed.[24] After the assessment, the Non-Residential ICSP sends the customer an assessment report with additional recommendations to support the customer's overall energy efficiency and peak demand needs and goals, along with recommendations for qualified trade allies with whom they can work.
- **Midstream**. This delivery channel helps customers choose and procure certain high-efficiency products more quickly and easily than through typical downstream methods. Trade allies and customers may purchase high-efficiency products directly from participating and qualified midstream distributors and receive an immediate rebate at the point of purchase.

Cadmus uses "downstream" to collectively refer to projects in the downstream, direct discount, and direct install delivery channels of the Efficient Equipment component.

D.1. Gross Impact Evaluation

D.1.1. Gross Impact Methodology and Sampling Approach

Cadmus verified savings for the Efficient Equipment component from a sample of 31 PY16 downstream lighting projects, 23 PY16 midstream lighting projects, 24 PY16 downstream non-lighting projects, and nine PY16 midstream non-lighting projects.

[24] Product installations are limited to a maximum of two pre-rinse sprayers, 50 A19 bulbs, and 24 PAR30 bulbs.

Sampling Details

Due to the timing of the evaluation, Cadmus used records from Q1, Q2, and Q3 to create samples. Cadmus reviewed the records in Q4 and determined that the sampled projects for lighting and non-lighting already had a sufficient mix of projects to represent the population.

Downstream, Direct Discount, Direct Install, and Midstream Non-Lighting

The Pennsylvania Technical Reference Manual has established kilowatt-hour savings thresholds at the end-use category level to determine whether customer-specific information is required for estimating *ex ante* or *ex post* savings. Cadmus evaluated non-lighting projects below the PA TRM threshold with a basic level of rigor according to the Phase IV Evaluation Framework.[25] The Efficient Equipment component did not report non-lighting projects above the defined threshold in the PA TRM in PY16.

Table D-1 summarizes the impact evaluation sampling strategy. Cadmus adjusted the planned sample sizes during the evaluation period to meet precision targets. Due to relative PY16 population sizes and precision targets, Cadmus increased the sample size for downstream non-lighting and decreased the sample size for midstream non-lighting. Cadmus verified energy savings for the overall Efficient Equipment non-lighting subcomponent at 85% confidence with ±4.02% precision.

Table D-1. PY16 Efficient Equipment Non-Lighting Downstream and Midstream Subcomponent Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Non-Lighting				
Downstream	85/15; Cv of 0.50	~20	24	Desk review with optional phone interview and/or virtual site visit(1)
Midstream	85/15; Cv of 0.50	~13	9	Desk review with optional phone interview and/or virtual site visit
(1) Two virtual site visits were completed in the downstream strata.				

Downstream, Direct Discount, Direct Install, and Midstream Lighting

Lighting projects fell into three strata based on reported savings:

- More than 750 MWh per year (the lighting threshold in the PA TRM)
- 120 to 750 MWh per year
- Less than 120 MWh per year

Cadmus selected a random sample of projects from Q1, Q2, and Q3 in PY16 for all downstream and midstream lighting strata, evaluating lighting projects below the PA TRM threshold with a basic level of rigor and lighting projects at or above the threshold with an enhanced level of rigor.

[25] Pennsylvania Public Utility Commission. July 16, 2021. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc.

Table D-2 summarizes the impact evaluation sampling strategy. The gross impact evaluation activities resulted in verified energy savings estimates for the Efficient Equipment lighting subcomponent at 85% confidence with ±2.28% precision.

Table D-2. PY16 Efficient Equipment Lighting Subcomponent Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Lighting				
Downstream threshold (>750 MWh/yr)[1]	90/10	Up to 20	5	Enhanced Rigor: reviewed invoices, tech specs, rebate form, and *ex ante* documentation, conducted logger analysis
Downstream (120-750 MWh/yr)[1]		Up to 13	13	Basic Rigor: reviewed invoices, tech specs, rebate form, and *ex ante* documentation, optional interviews
Downstream (<120 MWh/yr)[1]		Up to 12	13	Basic Rigor: reviewed invoices, tech specs, rebate form, and *ex ante* documentation.
Midstream[2]		Up to 23	23	Basic Rigor: Conducted engineering analysis, reviewed invoices and tech specs, and conducted interviews.

[1] Assuming a Cv of 0.35 based on historical findings from Phase III.
[2] Assuming a Cv of 0.50.

Cadmus calculated annual sample sizes for the Efficient Equipment component to meet the Phase IV Evaluation Framework evaluation requirements of 85% confidence and ±15% precision. However, the sampling plan for the lighting subcomponent was designed to meet 90% confidence and ±10% precision (90/10) because lighting is a high-impact measure contributing 31% of reported energy savings and 28% of reported demand reductions to the Non-Residential Program.

Ex Post Verified Savings Methodology

Downstream, Direct Discount, and Direct Install Non-Lighting

Cadmus conducted desk reviews and virtual site visits on a sample of projects to verify installed equipment, operating conditions, and equipment details from project documentation, including invoices, specification sheets, and implementer calculation workbooks. Cadmus used these findings to calculate energy savings and demand reductions.

Midstream Non-Lighting

Cadmus conducted desk reviews on a sample of projects to confirm quantities, equipment eligibility, and operating conditions from project documentation, including invoices and specification sheets. Cadmus used these findings to calculate energy savings and demand reductions.

Downstream, Direct Discount, and Direct Install Lighting

Cadmus verified savings calculations, incorporated quantity and eligibility confirmation, and made adjustments to *ex ante* assumptions of lighting equipment specifications and operating conditions for the sample of projects selected for desk reviews and virtual site visits. Cadmus reviewed all relevant project documentation, including invoices, specification sheets, lighting plans, and implementer's files

for the PA TRM's Appendix C Lighting Audit and Design Tool for Commercial and Industrial Projects to evaluate savings.[26] For threshold projects, Cadmus conducted a lighting logger data analysis to verify hours of use and coincidence factors. For a subset of projects in the lighting sample, Cadmus conducted phone interviews to confirm reported parameters.

Midstream Lighting

Cadmus verified savings calculations, incorporated quantity and eligibility confirmation, and made adjustments to *ex ante* assumptions of lighting equipment specifications and operating conditions for the sample of projects selected for desk reviews and phone interviews. Cadmus reviewed customer invoices and the technical specifications of the reported installed equipment and verified these using the Design Lighting Consortium (DLC) or ENERGY STAR Qualified Products Lists. Cadmus also confirmed the correct application of the baseline and efficient lighting pairing using the midstream lighting protocol in the PA TRM and verified the hours of use for the building type based on interview responses.

Cadmus interviewed either the customer or the contractor who purchased and installed the rebated equipment for the customer. During the interview, Cadmus confirmed the interviewee's familiarity with the purchase and the installed location; verified the quantity of the reported lighting purchase, building type, hours of use, and space conditioning system against PPL Electric Utilities' tracking database, and gathered information regarding the *in situ* baseline fixtures and lamps.

D.1.2. Gross Impact Results

Cadmus calculated realization rates for non-lighting and lighting strata by dividing total evaluated savings by total reported savings for the sampled projects. To determine gross verified savings, Cadmus multiplied the reported savings of each project by the evaluated realization rate for the appropriate stratum and summed the results.

Table D-3 shows the verified gross energy savings and demand reductions for the Efficient Equipment component.

Table D-3. Efficient Equipment Component Savings

Savings	PY13 Verified	PY14 Verified[(1)]	PY15 Verified	PY16 Verified	Phase IV Verified[(2)]
MWh/yr	89,330	115,100	81,131	84,727	370,288
System-Level MW/yr	14.28	18.78	12.68	16.23	61.98

[(1)] Includes PY14 savings from the midstream non-lighting strata verified in PY15 (695 MWh/yr and 0.28 MW/yr).
[(2)] Phase IV verified savings may not match the sum of program years due to rounding.

[26] The PA TRM Appendix C Lighting Audit & Design Tool documents the pre- and post-installation cases of the lighting retrofit to facilitate the calculation of energy and demand reductions for large lighting installations.

In PY16, PPL Electric Utilities reported energy savings of 84,705 MWh per year (Table D-4) and demand reductions of 16.82 MW per year (Table D-5) for the Efficient Equipment component.

Table D-4. PY16 Efficient Equipment Component Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Non-Lighting Subcomponent					
Downstream HVAC	3,268	92%	0.04	2.7%	2,999
Downstream HVAC - Certainty	215	100%	0.00	0.0%	215
Downstream Motors	543	125%	0.61	41.2%	681
Downstream Motors - Certainty	38	100%	0.00	0.0%	38
Downstream Other[2]	1,351	86%	0.04	2.9%	1,163
Downstream Refrigeration	534	122%	0.15	13.7%	651
Downstream Refrigeration - Certainty	63	98%	0.00	0.0%	62
Midstream Agriculture Equipment	546	96%	0.04	1.9%	524
Midstream Food Service Equipment	58	79%	-	-	46
Non-Lighting Total[3], [4]	**6,616**	**96%**	**0.16**	**4.0%**	**6,377**
Lighting Subcomponent					
Downstream Threshold (>750 MWh/yr)	14,805	96%	0.17	9.7%	14,213
Downstream (120-750 MWh/yr)	18,948	98%	0.03	1.2%	18,542
Downstream (< 120 MWh/yr)	9,060	100%	0.11	4.5%	9,069
Midstream Lighting	35,277	104%	0.12	3.7%	36,526
Lighting Total[3], [4]	**78,090**	**100%**	**0.12**	**2.3%**	**78,350**
Component Total[3], [4]	**84,705**	**100%**	**0.14**	**2.1%**	**84,727**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] The Other stratum includes measures such as high-efficiency battery chargers, dishwashers, and heat pump water heaters.
[3] Savings may not match other tables or figures due to rounding.
[4] Totals may not sum due to rounding.

Table D-5. PY16 Efficient Equipment Component Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)[2]	System Level PYVTD (MW/yr)
Non-Lighting Subcomponent						
Downstream HVAC	0.81	84%	0.27	18.5%	0.68	0.74
Downstream HVAC - Certainty	0.02	100%	0.00	0.0%	0.02	0.02
Downstream Motors	0.06	100%	0.00	0.0%	0.06	0.07
Downstream Motors - Certainty	0.005	100%	0.00	0.0%	0.005	0.005
Downstream Other[3]	0.05	87%	0.06	4.9%	0.05	0.05
Downstream Refrigeration	0.07	122%	0.15	13.8%	0.09	0.10
Downstream Refrigeration – Certainty	0.01	98%	0.00	0.0%	0.01	0.01
Midstream Agriculture Equipment	0.21	96%	0.04	1.9%	0.20	0.22
Midstream Food Service Equipment	0.01	79%	-	-	0.01	0.01
Non-Lighting Total[4], [5]	**1.25**	**89%**	**0.38**	**9.9%**	**1.12**	**1.21**
Lighting Subcomponent						
Downstream Threshold (>750 MWh/yr)	2.09	92%	0.10	5.9%	1.92	2.03
Downstream (120-750 MWh/yr)	2.72	98%	0.03	1.2%	2.68	2.87
Downstream (< 120 MWh/yr)	1.62	100%	0.12	5.2%	1.62	1.74
Midstream Lighting	9.15	85%	0.33	10.3%	7.82	8.38
Lighting Total[4], [5]	**15.57**	**90%**	**0.28**	**5.7%**	**14.03**	**15.02**
Component Total[4], [5]	**16.82**	**90%**	**0.33**	**5.3%**	**15.15**	**16.23**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Cadmus applied realization rates to verified demand reductions before application of distribution losses.

[2] PYVTD in this column represents meter-level savings before the application of line losses.

[3] This includes measures such as high-efficiency battery chargers, dishwashers, and heat pump water heaters.

[4] Savings may not match other tables or figures due to rounding.

[5] Total may not sum due to rounding.

Realization Rate Findings

The following factors led to variation between the reported and verified energy savings and demand reductions and to the observed realization rates.

Downstream Non-Lighting

While the adjustments made to the HVAC stratum had the most significant impact on the realization rate, Cadmus also made adjustments that impacted the Other, Refrigeration, and Motors strata:

- **HVAC stratum projects.** Cadmus made several project-specific adjustments within the HVAC stratum. For three sampled HVAC tune-up projects, Cadmus adjusted savings to exclude sub-measures not implemented. For the two sampled ductless heat pump projects, Cadmus applied the IMP methodology and SWE guidance for calculating savings. Additionally, for one sampled HVAC systems project, Cadmus corrected the installed model and associated input parameters. These adjustments resulted in realization rates of 92% for energy savings and 84% for demand reduction for this stratum.
- **Other stratum projects.** During a virtual site visit for a high-frequency battery charger project, Cadmus found that six of 40 chargers were either installed at a different facility or were still in storage and not operational. This resulted in a realization rate of 86% for energy savings and a realization rate of 87% for demand reduction in this stratum.
- **Refrigeration stratum projects.** Cadmus made adjustments to horsepower inputs for four sampled evaporator fan motor projects based on provided pre- and post-inspection reports and photos, which resulted in energy and demand reduction realization rates of 122%.
- **Motors stratum projects.** The energy realization rate for this stratum was 125% because the facility type was incorrectly recorded as Industrial Manufacturing for one sampled VFD project instead of Education - College/University. This adjustment increased hours of use, which only impacts energy savings. As a result, it did not impact the demand reduction realization rate.

Midstream Non-Lighting

Cadmus made adjustments to Agriculture and Food Service sampled projects, resulting in 96% and 79% realization rates, respectively.

- **Agriculture stratum projects.** Cadmus corrected the fan size inputs for three sampled high-volume low-speed fan projects based on review of project documentation.
- **Food Service stratum projects**. Cadmus adjusted the installed idle steam and convection energy rates used in the calculations for a sampled combination oven project from kilowatts to watts per the IMP methodology. This reduced both energy savings and demand reductions.

Downstream and Midstream Lighting

Cadmus most frequently adjusted the fixture wattages and hours of use in the reported energy savings and demand reduction estimates. These adjustments contributed to realization rates of 100% for energy savings and 90% for demand reduction. Many fixture wattage updates involved minor changes due to rounding and alignment with DLC listings.

- **Downstream threshold stratum projects.** Cadmus adjusted hours of use based on findings from the logger data analysis.
- **Downstream non-threshold stratum projects.** Cadmus adjusted hours of use and coincidence factors as needed, based on facility type determined through the desk review or site contact interviews.
- **Midstream stratum projects.** After the adjustments to hours of use and coincidence factors, Cadmus most frequently updated fixture control and space condition types. One sampled project contained ineligible fixtures, so Cadmus assigned zero savings for this project.

Site Visit and Desk Review Findings

Downstream, Direct Discount, and Direct Install Non-Lighting

Cadmus included 24 equipment projects from the non-lighting downstream component in the PY16 gross impact evaluation sample. For these projects, Cadmus completed 24 desk reviews and two virtual site visits with phone interviews to verify the as-built conditions for each project and identify discrepancies with respect to reported savings inputs or methodologies. Cadmus incorporated site-specific data into verified savings.

The most significant adjustments to reported savings included corrections to the following:

- HVAC tune-up sub-measure savings factors (HVAC)
- Ductless heat pump calculation methodology (HVAC)
- High-efficiency battery chargers installed quantity (Other)
- Refrigeration evaporator fan motor horsepower (Refrigeration)
- Motor VFD facility type (Motors)

Cadmus found the adjustments to HVAC and Other stratum projects had the greatest impact on energy and demand savings. Adjustments within the Refrigeration and Motors stratum increased channel realization rates, but the lower realization rates in the HVAC and Other stratum offset those increases for an overall realization rate below 100%. The overall subcomponent demand realization rate remained lower than the energy realization rate because HVAC project discrepancies negatively impacted demand savings, while a Motors project discrepancy had a greater positive effect on energy savings.

Midstream Non-Lighting

Cadmus sampled nine equipment projects from the lighting midstream channel in the PY16 gross impact evaluation sample. For each project, Cadmus completed a desk review to verify as-built conditions and identify discrepancies in the reported savings inputs. Cadmus incorporated site-specific data into the

verified savings. The most significant adjustments to reported savings included corrections to the following:

- High-volume low-speed fan size (agriculture)
- Idle steam and convection energy rates for a combination oven (food service)

Downstream Lighting

Cadmus conducted desk reviews for 31 downstream lighting projects in the impact evaluation sample to verify as-built conditions for each project and identify any discrepancies in inputs and savings. For five threshold lighting projects in the impact evaluation sample, Cadmus analyzed logger data and calculated hours of use and coincidence factors. Cadmus used the results of the desk reviews to determine the verified savings for each of the sampled projects.

To verify downstream lighting savings, Cadmus conducted 31 desk reviews. Verified savings incorporated site- and equipment-specific data. Cadmus made adjustments to the following:

- Annual lighting hours of use calculated from metered logger data
- Fixture type and quantity
- Lighting control type
- Space cooling type
- Heating fuel type
- Fixture wattage
- Facility type

Cadmus most frequently adjusted reported lighting fixture or lamp wattage (25 of the 31 sampled projects), using DLC or ENERGY STAR data for evaluated savings. Cadmus also adjusted lighting controls in seven of the sampled projects where documentation did not support the fixtures reported as having controls. Cadmus adjusted quantities based on invoices and hours of use using TRM entries. Cadmus also adjusted metered hours of use for three projects where reported hours of use relied on a custom schedule (rather than directly referencing the results of the metered data) or misinterpreted metered data.

Midstream Lighting

In PY16, Cadmus conducted desk reviews and phone interviews to verify savings for the sample of 23 midstream lighting projects in PPL Electric Utilities' tracking database. Cadmus adjusted calculation inputs to reported savings that differed from verified conditions, as summarized in Table D-6. Since projects could involve multiple adjustments, the total number of adjustments is greater than the sample size.

Table D-6. PY16 Efficient Equipment Midstream Lighting Channel Verified Savings Adjustments Summary

Savings Adjustment Type	Number of Adjusted Projects	Percentage of Adjusted Projects[1]	Primary Reason for Adjustment
Facility Type	21	91%	For the midstream lighting program, hours of use, coincidence factors, and control types are assumed by the TRM. Cadmus interviewed each site to more accurately assign these values and calculate savings.
Fixture Control Type	23	100%	
Hours of Use	21	91%	
Coincidence Factor[2]	17	74%	
Energy Interactive Factor	21	91%	
Demand Interactive Factor	21	91%	
Post-Install Lamp/Fixture Wattage	1	4%	
Post-Install Lamp/Fixture Quantity	2	9%	
Pre-Install Lamp/Fixture Quantity	2	9%	
Ineligible Fixture	1	4%	

[1] Cadmus calculated the percentage of adjusted projects based on 23 verified sample projects.
[2] Coincidence factor does not have as many adjustments as facility type because some reported projects had an incorrect facility type, but the coincidence values were still correct.

D.2. Net Impact Evaluation

Net Impact Methodology

Cadmus applied the methods in the PA PUC's Evaluation Framework to estimate net savings for downstream, upstream, and midstream delivery channels.[27] The framework discusses the standard methods for determining free ridership and spillover. Cadmus did not conduct new primary research to assess net savings in PY16; instead, the team used historic NTG ratios. Additional methodological details for each section can be found in the PY14 Annual Report for downstream equipment and in the PY15 Annual Report for midstream equipment.[28, 29]

Cadmus calculated net savings to inform future planning of the Efficient Equipment component. Energy savings and demand reduction compliance targets are met using verified gross savings.

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27 PA PUC. Final version July 16, 2021. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc.

28 PPL Electric Utilities. November 15, 2023. *Phase IV of Act 129 Program Year 14 Annual Report (June 1, 2022–May 31, 2023).* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. https://www.puc.pa.gov/pcdocs/1800780.pdf

29 PPL Electric Utilities. November 15, 2024. *Phase IV of Act 129 Program Year 15 Annual Report (June 1, 2023–May 31, 2024).* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. https://www.puc.pa.gov/pcdocs/1851143.pdf

D.2.1. Net-to-Gross Results

Table D-7 shows the NTG ratio results for the strata of the Efficient Equipment component.

Table D-7. PY16 Efficient Equipment Component NTG Ratio Summary by Stratum

Stratum	PYVTD kWh/yr	Evaluation Years	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision
Downstream, Direct Discount, Direct Install Lighting	41,823,690	PY14	35%[1]	0%	0.65	10%[2]
Downstream, Direct Discount, Direct Install Non-Lighting	5,807,642	PY14	84%[1]	0%	0.16	84%[3]
Midstream Lighting	36,526,360	PY15	30%[1]	0%	0.70	10%[3]
Midstream Non-Lighting	569,791	PY15 Benchmarking	6%	0%	0.94	-
Component Total [4] [5]	**84,727,482**	**-**	**36%**	**0%**	**0.64**	**-**

[1] Cadmus weighted the free ridership by the verified kWh/yr savings. This method ensures that respondents who achieved higher energy savings through the component have a greater influence on the stratum-level free ridership estimate than do the respondents who achieved lower energy savings.
[2] At 90% confidence interval.
[3] At 85% confidence interval.
[4] Cadmus weighted stratum-level free ridership, spillover, and NTG estimates by each stratum's verified kWh/yr component population savings to arrive at the Efficient Equipment component NTG ratio of 0.64.
[5] Totals may not sum due to rounding.

D.3. Process Evaluation

Process activities in PY16 were generally consistent with planned activities, with one exception. At the request of PPL Electric Utilities, Cadmus conducted an additional online survey to measure customer satisfaction among participants. The results from these surveys are included in the Process Evaluation findings in this appendix, along with the overall Non-Residential Program satisfaction score found in Chapter 5, Section *Process Evaluation Key Findings* of this report.

The survey asked participants about their project outcomes, satisfaction with the program, and overall satisfaction with PPL Electric Utilities. Between November 2024 and January 2025, Cadmus made several attempts to reach participants through an initial email invitation, followed by two email reminders and several telephone calls. Twenty-seven participants responded to the survey: 18 from the downstream equipment channel and nine from the direct discounts. See *Appendix L. Survey Bias* for details about Cadmus' approach to reducing survey bias and contact instructions.

Sample sizes noted in this report may vary by survey question because respondents could skip questions they preferred not to answer. As a result, not all respondents provided answers to every question. Cadmus included all survey respondents who answered at least one question, even if they did not complete the survey.

Table D-8 lists the process evaluation sampling strategy.

Table D-8. Efficient Equipment Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Cv in Sample Design	Target Sample Size	Achieved Sample Size	Sample Frame	Percent Contacted [1]
PPL Electric Utilities Program and ICSP Staff	Key individuals from PPL Electric Utilities and ICSP	Telephone in-depth interview	2	N/A	2	2 [2]	2	100%
Downstream, direct discount	Participants	Online survey/Phone survey	2,318 [3]	N/A	All eligible	27	904[4]	100%
Total			**2,320**	**-**	**-**	29	**906**	100%

[1] Percent contacted means the percentage of the sample frame contacted to complete surveys and interviews.

[2] Two interviewees on one call.

[3] Population size includes the number of unique records available at the time of the survey or interview.

[4] The sample frame is a list of participants with contact information who have a chance to complete the survey or interview. The final sample frame includes unique records in the PPL Electric Utilities database at the time of the surveys and interviews. 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, had been selected for another survey, did not have valid contact information (email or telephone number), participated in an impact interview, was a residential customer, was on PPL Electric Utilities' "do not call" list, or opted out of the online survey in a previous survey instance.

D.3.1. Downstream, Direct Install, and Direct Discount

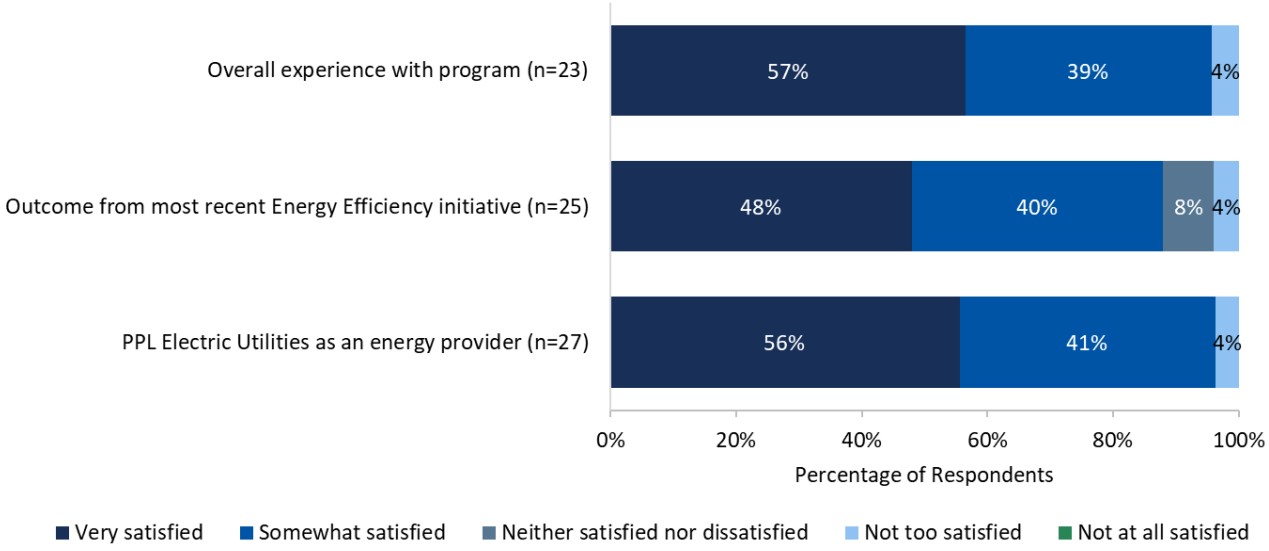
Program Component Experience

The survey asked downstream and direct discount participants a series of questions to assess their satisfaction with the program they participated in and with PPL Electric Utilities as an energy provider, the factors that impacted their satisfaction, and the outcomes of their most recent energy efficiency initiative. Respondents also rated how well the program met their expectations.

Program Component Satisfaction

The Efficient Equipment component achieved high satisfaction in PY16 (Figure D-1), with 96% of respondents *very* or *somewhat satisfied* with the component (22 of 23 respondents). Only 4% of respondents were *not too satisfied* (one respondent). Ninety-six percent of respondents (n=27) also gave *very* or *somewhat satisfied* ratings for their satisfaction with PPL Electric Utilities as an energy provider, and 88% were satisfied with the outcome of their most recent energy efficiency initiative (n=25).

Figure D-1. Efficient Equipment Component Satisfaction



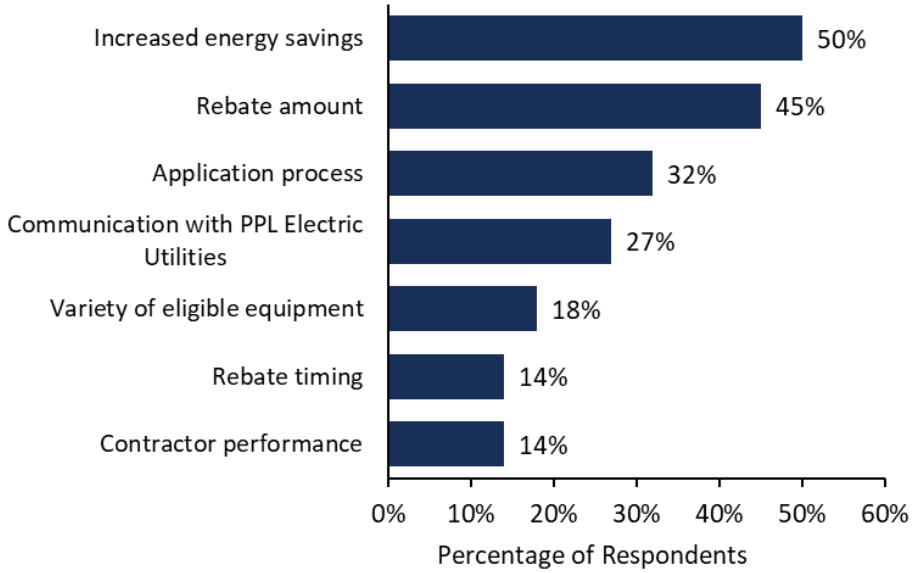
Source. Survey questions: "How would you rate your overall satisfaction with your experience in PPL Electric Utilities energy efficiency programs?", "How satisfied is your company with the outcomes achieved from its most recent energy efficiency initiative?", and "How would you rate your overall satisfaction with PPL Electric Utilities as your energy provider?" (Percentages may not appear to sum correctly due to rounding.)

Drivers of Program Component Satisfaction

To better understand what drives satisfaction, the survey asked participants what factor(s) most affected their satisfaction rating. Figure D-2 details the factors that most affected the overall experience rating reported by respondents who rated their satisfaction as *very* or *somewhat satisfied*. The most common drivers of high satisfaction were increased energy savings (50%, n=22) and the rebate amount (45%), followed by the application process (32%) and communications with PPL Electric Utilities (27%).

The one dissatisfied respondent who provided a low satisfaction rating cited the rebate amount and lack of variety of eligible equipment.

Figure D-2. Efficient Equipment Component Drivers of Satisfaction

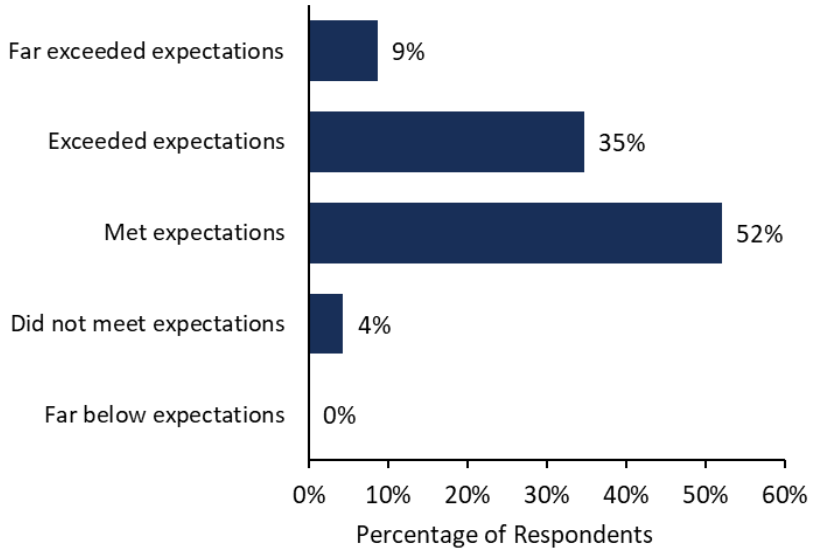


Source. Survey question: "What are the two most important factor(s) that most affected the overall experience rating you gave?" (Multiple responses allowed; satisfied respondents only; n=22)

Customer Expectations

The survey asked respondents whether their participation in PPL Electric Utilities' energy efficiency programs had met, exceeded, or fallen below their expectations (Figure D-3). Just over half (52%, n=23) said that their experience *met expectations*, while 44% said it either *exceeded expectations* or *far exceeded expectations*. Only one respondent said their experience *did not meet expectations,* and no respondent said it was *far below expectations*.

Figure D-3. Efficient Equipment Component Program Expectations



Source. Survey question: "How well did your participation in PPL Electric Utilities Business Energy Efficiency Program meet your expectations?" (n=23)

Participant Survey Attrition

Table D-9 lists the total number of records contacted for the survey via online and telephone attempts and the outcome (final disposition) of each record. Of 904 records in the sample frame, 27 participants responded to the survey, for a 3% response rate. Additional details on Cadmus' survey methodology are provided in *Appendix L. Survey Bias.*

Table D-9. Efficient Equipment Downstream Participant Sample Attrition

Description of Outcomes of Online and Telephone Participant Survey	Number of Records
Population (number of unique jobs)	**2,318**
Removed: inactive customer, residential sector, completed survey in past three months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list, or did not have accurate contact information	1,414
Survey Sample Frame	**904**
Not reached, left a message, or did not respond	683
Refused, opted out, bounce back, ineligible	194
Completed Surveys	**27**
Overall Response Rate	**3%**

PPL Electric Utilities

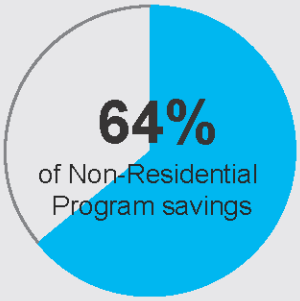
CADMUS

CUSTOM

This component of the Non-Residential Program offers financial incentives to customers who install equipment that is not offered elsewhere in PPL Electric Utilities' Non-Residential Program.

VERIFIED ENERGY SAVINGS

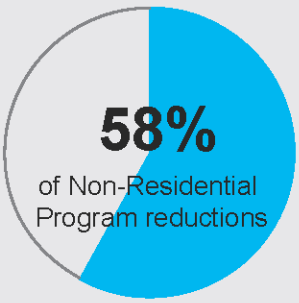
Phase IV has saved **377,323 MWh/yr**

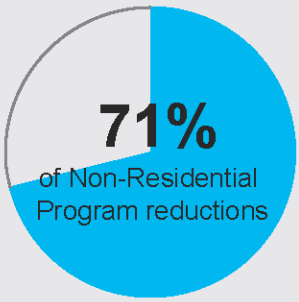


PY16 saved **150,260 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **85.09 MW/yr**





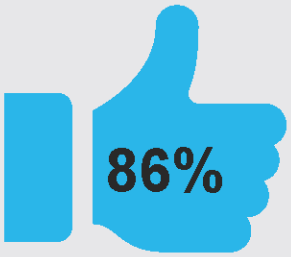
PY16 has reductions of **38.96 MW/yr**

PY16 PARTICIPATION

A total of **282** participants

- **138** Photovoltaic
- **57** Process
- **47** Motors
- **25** HVAC
- **7** Refrigeration
- **6** Lighting
- **2** Combined Heating and Power (CHP)

PARTICIPANT SATISFACTION



Satisfied with overall program component

Appendix E. Evaluation Detail – Custom Component

Through the Custom component, PPL Electric Utilities offers incentives to support the completion of complex and comprehensive projects that involve improvements not covered by the Efficient Equipment component. These improvements include operational process improvements, retro-commissioning, equipment optimization, CHP, solar, advanced lighting controls, compressed air, and other custom improvements.

PPL Electric Utilities' Custom component is offered through a downstream delivery channel. The Non-Residential ICSP, CLEAResult, works with customers and trade allies to identify and qualify custom projects. Customers or trade allies submit applications for review. The ICSP processes eligible projects and pays incentives upon project completion and final savings review.

A PY16 participant is defined as a project that was commercially operable between June 1, 2024, and May 31, 2025, and subsequently received an incentive payment.[30] An individual customer may have multiple participating projects. In PY16, there were 283 projects representing 263 unique customers.

E.1. Gross Impact Evaluation

E.1.1. Gross Impact Methodology and Sampling Approach

Cadmus evaluated all large stratum and CHP stratum projects, verifying savings at a high level of rigor and using approaches described in the International Performance Measurement and Verification Protocol (IPMVP). As indicated in the approved evaluation plan, savings for small stratum projects in PY15 and PY16 were verified in PY16. A discussion of the approach, by stratum, follows.

For the Custom component, Cadmus defined projects in three strata:

- **Large stratum.** Projects with expected energy savings greater than 2 million kWh/yr are assigned to the large stratum. In PY16, Cadmus verified savings for 27 large stratum projects.[31] Solar PV projects were included in the large stratum if their expected energy savings exceeded 1 million kWh/yr.[32] One large project was left unverified and will be verified in PY17.
- **CHP stratum.** All CHP projects were assigned to this stratum. In PY16, two CHP projects were verified.

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[30] As defined by the Phase IV Evaluation Framework, savings claimed by an electric distribution company (EDC) are determined by the date the equipment is "installed and energized." Equipment that is installed and not commissioned or is not operating as intended is not considered commercially operable.

[31] Five non-solar projects (all large stratum) were verified in PY16. Three of these large stratum non-solar projects had verified savings of approximately 1 million kWh/yr but were included in the large stratum because the expected savings exceeded 2 million kWh/yr.

[32] A total of 22 Large stratum solar projects were verified in PY16. Ten had expected savings above 2 million kWh/yr while the remaining twelve had expected savings over 1 million kWh/yr.

- **Small stratum.** All small stratum projects from PY15 Q1 through PY16 Q2 were included in the sampling population and were verified in PY16. A total of four projects in PY15 and four projects in PY16 were verified.

Table E-1 summarizes the impact evaluation sampling strategy.

Table E-1. PY16 Custom Component Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Large	Census	27	27[1]	Visual verification of improvement and site-specific conditions; M&V, including metering (in most cases); use of EMS or SCADA data
CHP	Census	2	2	
PY15/PY16 Small	85/15 Cv of 0.50	8	8	Most at high rigor, similar to large stratum projects (6); several qualified for a basic rigor approach in accordance with the Evaluation Framework (2).

[1] Cadmus evaluated fifteen projects in the large stratum with expected savings over two million kWh/yr (five non-solar and 10 solar projects) and 12 solar projects with expected savings above 1 million kWh/yr. Savings for small stratum projects from PY15 and PY16 were verified in PY16.

To calculate *ex post* savings with verified savings, Cadmus applied the sample-derived realization rate for each stratum to the respective population savings and then summed *ex post* and *ex ante* kWh savings across strata to calculate component-level realization rates and savings. Cadmus reported peak demand reductions (kW/yr) with the same approach.

Unverified savings do not factor into realization rates or into *ex ante* or *ex post* totals. In PY16, Cadmus verified PY15 unverified savings in the Custom component through the application of the small stratum realization rate and left one large PY16 project unverified.

E.1.2. Gross Impact Results

Table E-2 shows the Custom component's verified gross energy savings and demand reductions.

Table E-2. Custom Component Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified[1]	PY16 Verified	PY16 Unverified	Phase IV Verified [2]
MWh/yr	40,503	95,307	91,254	150,260	1,317	377,323
System-Level MW/yr	6.98	17.87	21.28	38.96	0.39 [3]	85.09

[1] PY15 verified savings include 36,146 MWh/yr and 10.15 MW/yr savings that were verified during the PY16 evaluation.
[2] Phase IV verified savings may not match sum of program years due to rounding.
[3] This does not include the application of line losses.

In PY16, PPL Electric Utilities reported 163,581 MWh/yr gross energy savings (Table E-3) and 38.83 MW/yr in demand reductions (Table E-4).

Table E-3. PY16 Custom Component Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Large	89,796	95%	0	0.0%	85,134
CHP	16,309	100%	0	0.0%	16,345
Small	56,159	87%	0.17	9.6%	48,781
Subtotal[2]	**162,264**	**93%**	**0.17**	**4.0%**	**150,260**
Unverified (Large)	1,317	-	-	-	-
Component Total[2]	**163,581**	**91%**	**0.17**	**4.0%**	**150,260**
Small (PY15 verified in PY16)	41,612	87%	0.17	9.6%	36,146

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Total may not match the sum of rows due to rounding.

Table E-4. Custom Component Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)	System-Level PYVTD (MW/yr)
Large	22.55	97%	0	0.0%	21.78	23.00
CHP	2.17	98%	0	0.0%	2.12	2.23
Small	13.71	93%	0.34	19.2%	12.80	13.73
Subtotal[2]	**38.44**	**95%**	**0.36**	**8.4%**	**36.70**	**38.96**
Large (unverified)	0.39	-	-	-	-	-
Component Total[2]	**38.83**	**95%**	**0.36**	**8.4%**	**36.70**	**38.96**
Small (PY15 verified in PY16)	10.08	93%	0.34	19.2%	9.41	10.15

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Cadmus applied realization rates to verified demand reductions before applying distribution losses.
[2] Total may not match the sum of rows due to rounding.

Large Stratum Projects

The following factors led to variation between reported and verified energy savings and demand reductions and to the observed realization rates:

- Six solar projects required more data than initially gathered to align with the Solar IMP. This additional data led to realization rates ranging from 94% to 107% for energy savings and demand reductions. These projects make up 12% of the PY16 verified savings.
- For one horticultural lighting project, the statewide evaluator (SWE) requested additional operating data. While the operation of the lighting system was fairly consistent, the use of additional data led to changes in the savings parameters that led to reductions in both energy and demand savings. Additionally, the SWE requested that a new waste heat factor be used. The SWE determined the standard factor used by Cadmus was not representative of the efficient cooling system at this site and said the waste heat factor in the IMP better represented site conditions. These adjustments resulted in realization rates of 88% for energy and 90% for

demand reductions. Operational changes such as average dimming and hours of operation had the largest impact on demand reductions, and the waste heat factor adjustment had the largest impact on energy savings. This project had a large impact on program component savings because it accounted for 20% of the PY16 verified energy savings.

- For one CHP project, SWE requested additional performance data beyond the original data collected for verified savings. Originally, the evaluation used one month of performance data because the project has no thermal component and very little seasonal variation. When additional data was included, the operation was largely consistent, but savings shifted slightly, resulting in an energy realization rate of 100% and a demand reduction realization rate of 96%.

Small Stratum Projects

Eight small stratum projects were also verified in PY16 (four PY15 and four PY16 projects). Cadmus made adjustments in seven of these projects, leading to realization rate changes. The small stratum accounted for 32% of the PY16 verified energy savings and 35% of the PY16 verified demand reductions and had a smaller impact on the realization rate for the component.

Below are the factors that led to a variation between reported and verified energy savings and demand reductions for seven small stratum projects:

- Motor and drive replacement project: Cadmus utilized a longer period of post-installation data for *ex post* savings, leading to a slightly lower energy realization rate and a slightly higher demand reduction realization rate.
- HVAC and refrigeration controls project: The *ex ante* calculations were based on site utility data from another location with the same owner. In addition, because other measures were implemented on-site in the same period, the Option C analysis had to be adjusted to eliminate the savings from measures outside the scope of the incentive.
- New compressor control system: Cadmus used four months of utility data because it covered a wider range of temperatures, while the *ex ante* savings used three months of data. Additionally, Cadmus revised the baseline period because it was a more stable period of operation.
- Solar project: Cadmus corrected the weather station and point of array, leading to increased verified savings. The *ex ante* savings used the Philadelphia International Airport (PHL) weather station for historical weather and typical meteorological year (TMY) plane of array (POA) data instead of weather from the actual location. Cadmus used the longitude and latitude of the installed PV system location to generate POA data from NREL's System Advisor Model (SAM) tool.
- Solar project: Cadmus adjusted the default losses to align with the IMP guidelines
- Pump replacement project: *Ex ante* savings assumed the entire facilities' energy usage was linear, but because there were existing VFDs on old pumps, the verified savings included only motor and pump efficiency improvement savings.
- Vacuum sealer project: Based on site visit findings, the customer installed four units instead of five units.

E.2. Net Impact Evaluation

E.2.1. Net Impact Methodology

The methods used to determine net savings for downstream, upstream, and midstream delivery channels are provided in the Evaluation Framework,[33] which discusses the common methods used to determine free ridership and spillover.

Cadmus did not conduct new primary research to assess net savings for the Custom component in PY16 and used a historic NTG ratio from PY14 evaluation results. Cadmus calculated net savings to inform future planning of the Custom component. Energy savings and demand reduction compliance targets are met using verified gross savings.

E.2.2. Net-to-Gross Results

Table E-5 shows the free ridership, spillover, and NTG ratio for the Custom component.

Table E-5. PY16 Custom Component NTG Ratio Summary

Stratum	PYVTD kWh/yr	Evaluation Years	Free Ridership (%)	Spillover (%)	NTG Ratio	Relative Precision
All	150,259,848	PY14	26%	0%	0.74	3%(1)

(1) At 90% confidence interval.

E.3. Process Evaluation

The approved evaluation plan did not include a participant survey, but PPL Electric Utilities added one to the PY16 evaluation. The results from these surveys are included in the Process Evaluation findings in this appendix, along with the overall Non-Residential Program section found in Chapter 5, Section *Process Evaluation Key Findings* of this report.

The participant survey asked questions about satisfaction with the program, the outcome of their project, and with PPL Electric Utilities overall. From November 2024 through January 2025, Cadmus made several attempts to reach participants through an initial email invitation, followed by two email reminders and several telephone calls. Seven participants responded to the survey. See *Appendix L. Survey Bias* for details about Cadmus' approach to reducing survey bias and contact instructions.

Sample sizes noted in this report may vary by survey question because respondents could skip questions they chose not to answer; therefore, not all respondents provided answers to every question. Cadmus

[33] PA PUC. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

included all survey respondents who answered at least one question, even if they did not complete the survey.

Table E-6 lists the process evaluation sampling strategy.

Table E-6. PY16 Custom Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Target Sample Size	Achieved Sample Size	Records in Sample Frame	Percent of Sample Frame Contacted to Achieve Sample[1]
Custom	Participants	Online and phone survey	489 [2]	N/A	All eligible	7[3]	199[4]	100%
Component Total			**489**	**-**	**-**	**7**	**199**	**100%**

[1] Percent contacted means the percentage of the sample frame contacted to complete surveys and interviews.
[2] Population size includes number of unique records available at the time of the survey field period.
[3] The achieved sample includes two manufacturing companies, two agricultural, one retailer, one property manager, and one grocery store.
[4] The sample frame includes 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 at the time of the survey. 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, had been selected for another program component survey, was a residential customer, did not have valid contact information (email or telephone number), was on the do not call list, or opted out of the online survey.

E.3.1. Component Experience

The survey asked respondents a series of questions to identify how satisfied they were with the program component and the factors that impacted their satisfaction levels.

The program component was delivered effectively in PY16, maintaining high levels of customer satisfaction. Most survey respondents indicated satisfaction with the custom program: three were *very satisfied* with the program, three were *somewhat satisfied*, and one was *neither satisfied nor dissatisfied* (n=7). Respondents each gave up to two reasons for their high satisfaction levels, and their top responses were the rebate amount and the application process (four mentions apiece), followed by the timeliness of the rebate payment (three mentions). Additionally, one respondent credited their contractor's performance, one mentioned increased energy savings, and one was satisfied with timely communications and a smooth participation process.

Most PY16 respondents were also satisfied with the outcomes their company achieved from participating in the custom program: three respondents were *very satisfied*, three were *somewhat satisfied*, and one was *neither satisfied nor dissatisfied* (n=7). When asked to rate how well participation in the Custom program component met their expectations, three respondents said it *met expectations,* and three said it *exceeded expectations*, though the respondent who was not satisfied with the Custom

program component or the outcome of their project said their experience was *far below expectations* (n=7). The participant who said their experience fell below expectations explained that the incentive they eventually received was far less than the initial estimate, and the requirement to install power recording devices "made this rebate pretty much a wash." Overall, survey respondents were highly satisfied with PPL Electric Utilities as an energy provider: five were *very satisfied*, one was *somewhat satisfied*, and one was *not too satisfied* (n=7).

E.3.2. Survey Sample Attrition

Table E-7 lists the total number of records contacted for the survey via online and telephone attempts and the outcome (final disposition) of each record. Of 199 records in the sample frame, seven participants responded to the survey, for a 4% response rate. See *Appendix L. Survey Bias* for additional details on survey methodology.

Table E-7. Custom Component Sample Attrition

Description of Outcomes of Online and Telephone Participant Survey	Number of Records
Population (number of unique jobs)	**489**
Removed: inactive customer, residential sector, completed survey in past three months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list, or did not have accurate contact information	290
Survey Sample Frame	**199**
Not reached, left a message, or did not respond	131
Refused, opted out, bounce back, ineligible	61
Completed Surveys	**7**
Overall Response Rate	**4%**

Appendix F. Evaluation Detail – Low-Income Component

F.1. Gross Impact Evaluation

PPL Electric Utilities provided four types of service (also known as job types) at no cost to the income-qualified customer: baseload, low-cost, full-cost, and welcome kits. The program offers baseload services to customers without electric heat and without an electric water heater, low-cost services to customers without electric heat but with electrically heated water, and full-cost services to customers with both electric heat and electrically heated water. The welcome kit is sent to any eligible customer who has not received a kit or participated in the program within the past three years.

Cadmus conducted the following activities to evaluate Low-Income Program participants:

- **Database Review.** Cadmus evaluated the census of projects in the welcome kit stratum for all welcome kit data using a combination of the PA TRM[34] inputs and data from PPL Electric Utilities' tracking database. We also used algorithms and inputs from sections 2.3.7 and 2.3.8 of the PA TRM and the 2023 Residential Baseline Study.[35]
- **Audit desk review.** Cadmus reviewed a random sample of 60 of the ICSP's assessment records for baseload, low-cost, and full-cost strata. Reviews of home assessment records involved verifying reported home and measure-level data from participant records in the ICSP's database and relevant inputs for savings calculations using the PA TRM. Cadmus verified all data fields in the assessment records against the PPL Electric Utilities' tracking database (e.g., home address, water heater fuel type, heating fuel type, reported quantities, count of home occupants, and baseline conditions).
- **Engineering analysis.** Cadmus conducted an engineering analysis for MMMF, baseload, low-cost, and full-cost strata and used the findings from the assessment records review as inputs to the engineering algorithms from the PA TRM, when available, and the IL TRM for algorithms (not inputs) not listed in the PA TRM.[36]
- **REA audio recordings review**. Cadmus reviewed 17 audio recordings from the ICSP's REAs with program participants to verify *in situ* baseline bulb information. The audio recordings consisted of an ICSP staff member calling the resident, giving an overview of the program, providing the resident with energy education, and guiding the resident through their residence to record the number, type, and wattage of currently installed light bulbs in each room. Cadmus primarily

[34] PA PUC. Revised February 2021. *Technical Reference Manual Volume 2: Residential Measures*. https://www.puc.pa.gov/pcdocs/1692531.docx

[35] PA PUC. March 21, 2024. *2023 Pennsylvania Statewide Act 129 Residential Baseline Study*. 2023_pa_residential_baseline_study.pdf

[36] Illinois Energy Efficiency Stakeholder Advisory Group. September 20, 2024. *2025 Illinois Statewide Technical Reference Manual for Energy Efficiency. Version 13.0. Volume 3: Residential Measures.* IL-TRM_Effective_010125_v13.0_Vol_3_Res_09202024_FINAL.pdf

reviewed recordings to verify the light bulb wattage and types installed in participants' homes to determine the baseline wattage for lighting savings calculations.

F.1.1. Gross Impact Methodology and Sampling Approach

In PY16, Cadmus coordinated with PPL Electric Utilities and the ICSP to collect the required data to verify energy savings and demand reductions for the Low-Income Program. The ICSP provided an extract of its tracking database of participant and energy assessment records, and Cadmus analyzed the census of projects for welcome kit installations. Cadmus selected a random sample of REA and in-home participants to verify that products were installed as reported.

Cadmus designed the verification sample for the Low-Income Program to meet 85% confidence with ±15% precision. To examine savings in detail, Cadmus stratified the population into baseload, low-cost, full-cost, and MMMF job types. Cadmus sampled the population by project number instead of by account number for simplicity and consistency with previous years.

The impact evaluation sampling strategy is summarized in Table F-1. Cadmus' energy evaluation produced results with ±6.90% precision at 85% confidence using a random sampling method to select a sample of homes for verification.

Table F-1. PY16 Low-Income Program Gross Impact Evaluation Sample Design

Sample Stratum	Population Size[1]	CP	Sampling Assumptions Cv in Sample Design	Target Sample Size	Achieved Sample Size[1]	Impact Evaluation Activity
Remote Energy Assessment[2]						
REA – Baseload	885	85/15	0.35	~12	12	Participant surveys, recordings, desk review, and engineering analysis
REA - Low-Cost	1,155			~12	12	
Direct Install						
In-home—Baseload	3,426	85/15	0.30	~9	9	Desk review and engineering analysis
In-home—Low-cost	2,831			~9	9	
In-home--Full-cost	5,227			~9	9	
In-home--MMMF (all job types)	1,731			~9	9	
Welcome Kits						
Welcome Kits	25,325	N/A	N/A	Census	N/A	Census and database review
Program Total	**40,660**	-	-	-	-	-

[1] Population size and sample size counts are based on unique job numbers, which differ slightly from unique households.
[2] Based on the evaluation plan, Cadmus did not sample REA-Full Cost jobs and applied the In-home Full Cost job realization rate.

At the end of the program year, within each stratum, Cadmus weighted and combined the realization rates for each sampled project into a single, stratum-level realization rate. To calculate verified savings, Cadmus applied each stratum-level realization rate to the respective population reported kW and kWh

savings represented by each stratum. Total verified savings for the population is the sum of these stratum-level savings.

Energy Education and Behavior Savings

Cadmus evaluated the impacts of electric consumption associated with behavior changes by program participants using calculations derived from a combination of engineering estimates, secondary research, and survey data. Cadmus selected three behavioral recommendations—adjust thermostats, wash clothes in cold water, and take shorter or fewer showers—that reasonably corresponded to energy-saving activities in the PA TRM.

Adjust Thermostat for Heating and Cooling Season

Cadmus assumed that participants who adjusted their thermostats saved energy similar to savings from a programmable thermostat and applied the PA TRM's algorithms accordingly.[37]

Wash More Loads of Laundry in Cold Water

Cadmus estimated the energy savings from participants washing clothes in cold water in two steps:

1. Estimated the energy usage of a clothes washer (using algorithms from the PA TRM)[38]
2. Weighted the results based on PY16 survey responses

Based on survey responses, Cadmus assigned an approximate percentage of time that clothes were washed in cold water (e.g., *always* indicated that 100% of laundry was washed in cold water, *more than half the time* assumed 75%, and so on). Cadmus then assessed the relative change before and after energy education was provided.

Take Shorter Showers

Cadmus assumed that participants who said they take short showers took a five-minute shower per their reported frequency (i.e., *always*, *more than half the time*, etc.). And, similar to the laundry behavior change, an associated percentage was applied to each frequency. To estimate shower energy use, Cadmus followed section 2.3.8 in the 2021 PA TRM and adjusted shower length from the 7.8-minute default based on the energy education recommendation.[39]

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[37] PA PUC. Revised February 2021. Technical Reference Manual Volume 2: Residential Measures. Section 2.2.11 https://www.puc.pa.gov/pcdocs/1692531.docx

[38] Section 2.3.5 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 energy consumption of a clothes washer.

[39] 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.

F.1.2. Gross Impact Results

Welcome Kit Findings

Findings from Cadmus' census evaluation are shown in Table F-2. These findings are the reasons for the differences between reported and verified savings.

Table F-2. PY16 Welcome Kits Findings

Product	Finding	Number of Jobs Impacted	Effect on Savings
Welcome Kits	PY16 participant survey data indicate that 76% of welcome kit recipients have electric water heat. Cadmus factored this into its PY16 analysis, which resulted in a lower realization rate (See TRM ELEC term)	25,118	Decreased
Welcome Kits	Recovery Efficiency (See TRM RE term) was estimated using a weighted average of the water heater based on data from the 2023 SWE baseline study. This resulted in a mild negative impact on the realization rate	25,118	Decreased
Welcome Kits	Cadmus observed 207 duplicates within the ICSP's dataset. Cadmus confirmed that these duplicate welcome kits were sent in error and omitted their associated savings. This resulted in a lower realization rate.	207	Decreased

Detailed Desk Review Findings

Findings from Cadmus' review of records are shown in Table F-3. These findings, along with in-service rates (ISRs) of products and energy education savings, are the reasons for differences between reported and verified savings.

Table F-3. PY16 REA and On-Site Desk Review Findings

Product	Finding	Number of Jobs	Effect on Savings
Bathroom Aerators	Number of occupants observed in home assessment data was greater than those assumed in TRM	11	Increased
Kitchen Aerators	Number of occupants observed in home assessment data was greater than those assumed in TRM	10	Increased
Showerheads	Number of occupants observed in home assessment data was greater than those assumed in TRM	16	Increased
TSRVs	Number of occupants observed in home assessment data was greater than those assumed in TRM	11	Increased
RAC Replacement and Recycling	TRM baseline EER value used in place of ICSP provided value.	6	Decreased
Ceiling Insulation	A default baseline R value of 5 was assumed in place of ICSP R-3 value	1	Decreased
LEDs	Direct install ISR value calculated from PY16 participant survey data (91%) is lower than observed in previous years within Phase IV	86	Decreased
	Halogen baseline bulb type assumed in instances where REA customer did not read bulb wattage and described the existing bulb as "hot" or "glass"	27	Decreased
Dehumidifiers	Appropriate deemed value per the latest IMP selected in place of "most efficient" deemed value.	2	Decreased

In-Service Rates

The participant survey asked questions about nine products—LEDs, LED nightlights, kitchen aerators, bathroom aerators, showerheads, tier 1 advanced power strips, thermostatic shower restriction valves, air purifiers, and dehumidifiers. Cadmus calculated the REA and on-site ISRs for these items, as shown in Table F-4.

Table F-4. PY16 In-Service Rates for Energy-Saving Items

Product	In-Service Rate	
	REA	On-Site
LEDs	98%	91%
LED Nightlights	100%	78%
Kitchen Aerators	76%	84%
Bathroom Aerators	73%	86%
Showerheads	62%	91%
Tier 1 Advanced Power Strips	96%	91%
Thermostatic Shower Restriction Valves	92%	67%
Air Purifiers	100%	88%
Dehumidifiers	50%	80%

Energy Education Savings Findings

Table F-5 shows the energy-savings recommendations considered in estimating energy education savings, any behavioral elements that energy education could change, PA TRM reference, and per-unit energy savings and demand reductions. The estimated PY16 per-household verified energy education savings is 37.24 kWh/yr; the *ex ante* assumption was 60 kWh/yr per PPL Electric Utilities' participant tracking database. Adjustment of the thermostat during colder months was the primary reason for the discrepancy in verified and *ex ante* savings. The reduction in energy savings from adjusting thermostats in the summer and winter months in Phase IV is attributed to a change in how participant data is categorized. On a recommendation from the SWE, the survey identified participants with central cooling and heating systems. In previous years, home heating fuel type and cooling served as a proxy for central air-based systems.

Table F-5. Low-Income Program Verified Energy Education Savings and Assumptions Summary

Energy Savings Recommendation	Behavioral Assumption	2021 PA TRM Reference	*Ex Post* Verified Savings	
			kWh/yr	kW/yr
Adjust Thermostats – Summer	Participants lower their thermostat in winter and raise it in summer	ENERGY STAR-Certified Connected Thermostats – Section 2.2.11	0.99	0.0004
Adjust Thermostats – Winter			27.49	0.0000
Wash Clothes in Cold Water	Participants increase the number of loads of laundry they wash in cold water	Water Heater Temperature Setback– Section 2.3.5	5.41	0.0004
Take Shorter Showers	Participants decrease the duration of each shower	Low Flow Showerheads – Section 2.3.8	3.35	0.0003
Total [(1)]			**37.24**	**0.0011**

[(1)] Each component is summed to get the total. Total may not sum due to rounding.

F.2. Process Evaluation

F.2.1. Survey Sample Attrition

The PY16 customer surveys collected demographic information about Low-Income Program participants. Most survey respondents reported they lived in a single-family detached residence (27%; n=197) or a multifamily apartment or condo building with four or more units (23%). Twenty-one percent reported they lived in an attached house (townhouse, row house, or twin), 15% reported they lived in a mobile or manufactured home, and 13% reported they lived in a different dwelling type.[40]

Table F-6 lists the total number of records contacted via online survey and the outcome (final disposition) of each record (all strata). *Appendix L. Survey Bias* includes additional detail on the survey methodology.

[40] The total does not sum to 100% due to rounding.

Table F-6. Low-Income Program Survey Sample Attrition

Description of Outcomes of Online Participant Survey	Number of Records	
	Survey	MMMF Interviews
Population (number of unique jobs at the time the sample was drawn)	**27,343**	**11**
Removed: inactive customer, completed survey in past three months, on "opt out" list, selected for a different survey, duplicate contact, on "do not contact" list	5,204	1
Removed: incomplete or invalid email address or phone number	2,666	0
Survey Sample Frame (records selected)	**19,473**	**10**
Not reached or non-working: Refused or opted out, email returned (bounce back), did not respond	7,601	9
Partially Completed Survey	369	**0**
Did not attempt because they were not needed to reach the plan	11,146	**0**
Completed Surveys (online)	**357**	**1**
Overall Response Rate	**4%**[(1)]	**10%**

[(1)] Excludes records not attempted in the selected sample frame from the denominator used to calculate response rate.

PPL Electric Utilities

CADMUS

APPLIANCE RECYCLING

This component of the Residential Program offers an incentive to customers who turn in eligible appliances and provides free pick-up and environmentally responsible recycling services.

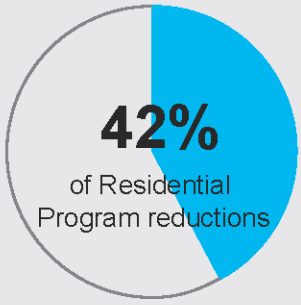
VERIFIED ENERGY SAVINGS

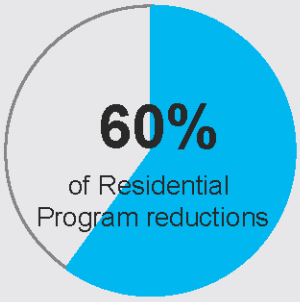
Phase IV has saved **35,998 MWh/yr**

PY16 saved **10,963 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **9.80 MW/yr**





PY16 has reductions of **3.53 MW/yr**

PY16 PARTICIPATION

A total of **10,136** customers recycled **18,204** units

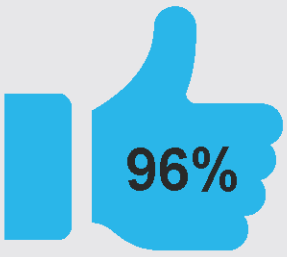
8,244 Refrigerators

5,145 Room air conditioners

3,072 Dehumidifiers

1,743 Freezers

PARTICIPANT SATISFACTION



Satisfied with overall program component

Note: This represents phase-to-date satisfaction as no new research was completed in PY16.

Appendix G. Evaluation Detail Appliance Recycling Component

In the Appliance Recycling component, PPL Electric Utilities offers an incentive to customers who turn in eligible appliances, while also providing free pick-up and environmentally responsible recycling services. The component 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. For evaluation purposes, Cadmus defined participants as unique appliances decommissioned through the Appliance Recycling component during the program year.

PPL Electric Utilities' energy efficiency program staff provides overall strategic direction and program management. The evaluation staff oversees evaluation activities and coordinates with the program component's delivery staff. In PY16, CLEAResult, the ICSP, delivered the Appliance Recycling component, along with its pick-up and recycling subcontractor.

During PY16, participating customers had the option of requesting in-person pick-up or contactless curbside pick-up. Refrigerators had to measure between 10 and 30 cubic feet to qualify for pick-up. Both primary and secondary refrigerators and freezers were eligible. Eligible appliances had to be functional at the time of pick-up. Previously, if customers recycled a refrigerator or freezer, they could also turn in room air conditioners and dehumidifiers as well. In PY16, the ICSP also offered customers the option to schedule pick-up of two or more room air conditioners and dehumidifiers without recycling a refrigerator or freezer, an expansion of the "neighborhood sweep" initiative the ICSP began in PY15 (e.g., scheduling pick-up of two or more small units is now allowed throughout PPL Electric Utilities territory and not just for specific times and places). During PY16, the ICSP also held four bulk recycling events to collect room air conditioners and dehumidifiers from customers without requiring them to schedule a pick-up.

Table G-1 shows the appliance eligibility parameters and incentives for PY16, which were unchanged from the end of PY15.

Table G-1. Eligible Equipment and Incentives for the Appliance Recycling Component

Equipment	Eligibility Rating	Incentive Range
Refrigerator	Working unit; > 10 cubic feet and ≤ 30 cubic feet	$50
Freezer	Working unit; > 10 cubic feet and ≤ 30 cubic feet	$50
Room Air Conditioner	Working unit removed from mounting	$10
Dehumidifiers	Working unit	$10

G.1. Gross Impact Evaluation

G.1.1. Gross Impact Methodology and Sampling Approach

Cadmus reviewed a census of records for room air conditioners and dehumidifiers and based savings for dehumidifiers and room air conditioners on a reference city in the PA TRM. Cadmus verified that each participant's ZIP code was mapped to the correct reference city and verified that the reported per-unit savings matched those listed in the PA TRM.

For refrigerators and freezers, Cadmus applied a historical realization rate from PY15 results to reported PY16 energy savings and demand reductions (Table G-2). See the PY15 evaluation report for details on the PY15 evaluation approach.[41]

Table G-2. Appliance Recycling Component Historic Realization Rates

Savings	Refrigerator/Freezer Historic Realization Rate	Room Air Conditioners and Dehumidifiers Historic Realization Rate
Energy Savings (MWh/yr)	91%	100%
Demand Reductions (MW/yr)	91%	100%

Table G-3 summarizes the impact evaluation sampling strategy. The impact evaluation activities produced results with ±15% precision at 85% confidence.

Table G-3. Appliance Recycling Component Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Target Sample Size	Achieved Sample Size	Impact Evaluation Activity
Room Air Conditioners and Dehumidifiers	N/A	Census	Census	Database review
Refrigerators and Freezers	N/A	N/A	N/A	Apply PY15 historical realization rate to PY16 reported savings

G.1.2. Gross Impact Results

Table G-4 shows the Appliance Recycling component's verified gross energy savings and demand reductions.

Table G-4. Appliance Recycling Component Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified	PY16 Verified	Phase IV Verified[(1)]
MWh/yr	7,900	8,569	8,565	10,963	35,998
System-Level MW/yr	1.90	2.09	2.28	3.53	9.80

[(1)] Phase IV verified savings may not match the sum of program years due to rounding.

[41] PPL Electric Utilities. September 30, 2024. *Phase IV of Act 129 Program Year 15 Annual Report (June 1, 2023–May 31, 2024).* Prepared by Cadmus. Presented to Pennsylvania Public Utility Commission.

Table G-5 shows verified energy savings and realization rates by stratum for PY16, and Table G-6 shows verified demand savings and realization rates.

Table G-5. Appliance Recycling Component Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Refrigerators and Freezers	8,596	91%	N/A	10.0%	7,822
Room Air Conditioners and Dehumidifiers	3,141	100%	N/A	N/A	3,141
Component Total[2]	**11,737**	**93%**	**-**	**7.1%**	**10,963**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Totals may not sum due to rounding.

Table G-6. Appliance Recycling Component Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)	System Level PYVTD (MW/yr)
Refrigerators and Freezers	1.39	91%	N/A	10.0%	1.26	1.37
Room Air Conditioners and Dehumidifiers	1.98	100%	N/A	N/A	1.98	2.16
Component Total[2]	**3.37**	**96%**	**-**	**3.9%**	**3.25**	**3.53**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Cadmus applied realization rates to verified demand reductions before applying distribution losses.
[2] Totals may not sum due to rounding.

G.2. Net Impact Evaluation

G.2.1. Net Impact Methodology

Cadmus did not conduct new primary research to assess net savings for the Appliance Recycling component in PY16 and used a historic NTG ratio of 0.50 from PY15.[42]

G.2.2. Net-to-Gross Results

Table G-7 shows NTG ratio results for the Appliance Recycling component.

Table G-7. Appliance Recycling Component NTG Ratio Summary

Stratum	PYVTD MWh/yr	Evaluation Year	Free Ridership and SMI (%)	Spillover (%)	NTG Ratio
Refrigerators and Freezers	10,963	PY15	50%	0%	0.50

[42] PPL Electric Utilities. September 30, 2024. *Phase IV of Act 129 Program Year 15 Annual Report (June 1, 2023–May 31, 2024).* Prepared by Cadmus. Presented to Pennsylvania Public Utility Commission.

G.3. Process Evaluation

In PY16, Cadmus conducted a limited process evaluation. Process evaluation activities were consistent with the planned activities, which included stakeholder interviews to inform program changes included in the program description at the beginning of this appendix. Table G-8 lists the process evaluation sampling strategy.

Table G-8. Appliance Recycling Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Cv in Sample Design	Target Sample Size	Achieved Sample Size	Sample Frame	Percent Contacted [1]
PPL Electric Utilities Program and ICSP Staff	Key individuals from PPL Electric Utilities, ICSP, and ICSP subcontractors	In-depth telephone interview	2	N/A	2	2[2]	2	100%
Program Total			**2**	**N/A**	**2**	**2**	**2**	**100%**

[1] Percent contacted means the percentage of the sample frame contacted to complete the survey or interviews.

[2] One interview with two stakeholders.

Appendix H. Evaluation Detail – Efficient Lighting

At the end of PY14, PPL Electric Utilities sunset this component and stopped offering upstream incentives to manufacturers due to changes in federal lighting efficiency standards. The final program LEDs were processed in the first quarter of PY15. There were no claimed savings in PY16 and none planned for PY17.

H.1.1. Gross Impact Results

Table H-1 shows the Efficient Lighting component's verified gross energy savings and demand reductions.

Table H-1. Efficient Lighting Component Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified	PY16 Verified	PY17 Verified	Phase IV Verified[1]
MWh/yr	4,349[2]	4,226	394	-	-	8,969
System-Level MW/yr	0.68[3]	0.66	0.06	-	-	1.41

[1] Phase IV verified savings may not match the sum of program years due to rounding.
[2] PY13 verified savings for the Efficient Lighting component were reduced by 3.65 MWh/yr to conform with the SWE's PY13 Annual Report findings.
[3] PY13 verified demand reductions for the Efficient Lighting component were reduced by 0.0001 MW/yr to conform with the SWE's PY13 Annual Report findings.

PPL Electric Utilities

CADMUS

ENERGY EFFICIENT HOMES

This component of the Residential Program provides a wide range of energy-efficient products, rebates, education, and services that give customers a variety of customizable and comprehensive solutions to increase their home's energy efficiency.

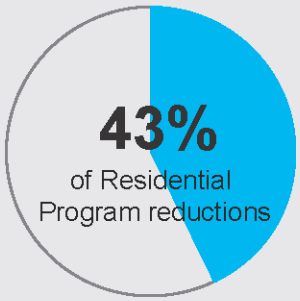
VERIFIED ENERGY SAVINGS

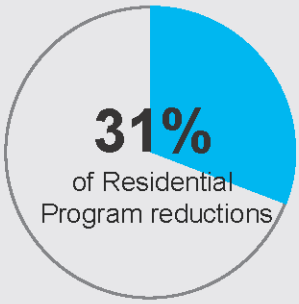
Phase IV has saved **103,381 MWh/yr**

PY16 saved **25,389 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **9.99 MW/yr**





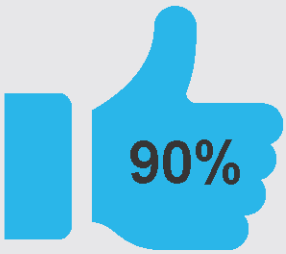
PY16 has reductions of **1.82 MW/yr**

PY16 PARTICIPATION

A total of **87,878** received rebates for

- **69,736** Instant Discount
- **10,631** Efficient Equipment (downstream and midstream)
- **3,723** Online Marketplace
- **1,920** New Homes
- **1,078** Weatherization
- **790** Online and in-home audit and energy conservation kits

PARTICIPANT SATISFACTION



Satisfied with overall program component

92% downstream equipment participants satisfied with program

82% in-home audit, online assessment, and weatherization participants satisfied with program

Appendix I. Evaluation Detail – Energy Efficient Homes Component

The Energy Efficient Homes component is designed for new construction and existing homes. The component offers a wide range of energy-efficient products, rebates, education, and services that give customers various customizable solutions to increase their homes' energy efficiency.

In PY16, the component had six subcomponents: Downstream Equipment, Midstream Equipment, the Online Marketplace, Audit and Weatherization, Instant Discount, and New Homes.

PPL Electric Utilities' energy efficiency program staff provides overall strategic direction and program management. CLEAResult, the ICSP, manages the Energy Efficient Homes component with the assistance of two subcontractors (New Homes and the Online Marketplace subcomponents). Retailers participating in the Instant Discount subcomponent include hardware and home improvement stores.

For all subcomponents of Energy Efficient Homes, a participant is defined as a rebated project, and each project is assigned a unique job number in PPL Electric Utilities' participant tracking database.

I.1. Gross Impact Evaluation

I.1.1. Gross Impact Methodology and Sampling Approach

In PY16, Cadmus used the findings from desk reviews, participant surveys, and database reviews to evaluate savings from the Downstream and Midstream Equipment, Audit and Weatherization and the spray foam measure in the Instant Discount subcomponent. Cadmus also verified PY15 savings for Instant Discount spray foam projects and Midstream Equipment in PY16.

Activities were consistent with the evaluation plan except Cadmus did not evaluate the New Homes subcomponent.

Activities are detailed below:

- The approach for evaluating savings for the **Audit and Weatherization** and **Downstream Equipment subcomponents** incorporated survey data and desk reviews in PY16.
- Cadmus also evaluated the **Midstream Equipment subcomponent** through desk reviews using a sample that spanned PY15 and PY16 projects.
- For the **Downstream Equipment subcomponent**, Cadmus attempted to survey a census of participants and used a nested stratified random sampling approach to select a subset of surveyed sites for desk reviews. Survey findings also contributed to the process evaluation.
- For the **Midstream Equipment subcomponent**, Cadmus used a simple random sampling approach to select projects for desk reviews. For the **Audit and Weatherization subcomponent**, Cadmus attempted to survey a census of participants and used a nested simple random sampling approach to select a subset of surveyed sites for desk reviews for weatherization measures. The participant survey findings contributed to both the process and impact evaluations.

Cadmus used a variety of approaches for various individual measures. For the air sealing and insulation measures, Cadmus used desk review documentation and survey data for the existing cooling and heating system type to determine the *ex post* savings. For the virtual and in-home audit measures, Cadmus conducted a database review for all rebated products and used the participant survey to calculate an in-service rate (ISR) for individual measures. For measures in which Cadmus could not calculate an ISR due to limited survey data, the team used TRM ISR values. Survey findings also contributed to the process evaluation.

All PY15 and PY16 savings for the **Deep Energy Retrofits** pilot were left unverified and will be verified in PY17. In a change from the evaluation plan, Cadmus did not verify savings for the New Homes subcomponent to allow time for additional review of demand reductions. These savings will be verified in PY17.

Additionally, Cadmus applied a historical realization rate from PY15 results to reported PY16 energy savings and demand reductions for the **Online Marketplace subcomponent**, **High Performance Homes pilot**, and all measures in the **Instant Discount subcomponent** except spray foam (Table I-1). See the PY15 report for details on the PY15 evaluation approach for these subcomponents.[43] The final PY16 realization rates differ from those in PY15 due to differences in the measure mix.

Table I-1. Energy Efficient Homes Historical Realization Rates

Subcomponent	Historic Realization Rate	
	Energy Savings (MWh/yr)	Demand Reductions (MW/yr)
Online Marketplace Kits	127%	139%
Online Marketplace Other	95%	104%
Online Marketplace Weatherization	197%	715%
High Performance Homes	97%	101%
Instant Discount (non-spray foam)	90%	85%

Table I-2 summarizes the evaluation sampling strategy. Cadmus evaluated the subcomponents with basic levels of rigor and used different sampling approaches for each subcomponent.

[43] PPL Electric Utilities. September 30, 2024. *Phase IV of Act 129 Program Year 15 Annual Report (June 1, 2023–May 31, 2024).* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus.

Table I-2. Energy Efficient Homes Component Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Planned Sample Size	Achieved Sample Size[(1)]	Impact Evaluation Activity
Audit and Weatherization	85/15 (Cv=0.50)	≥23	38	Participant survey, attempted census, desk reviews. Sample included 21 audit measures and 17 weatherization measures.
New Homes	N/A	N/A	N/A	No activities: savings for PY16 will be verified in PY17
Downstream Equipment	85/15 (Cv=0.50)	≥ 40	40	Participant survey, attempted census, desk reviews
		40	40	Nested stratified random sample for desk reviews
Online Marketplace	N/A	N/A	N/A	Applied PY15 historical realization rate to PY16 reported savings
Instant Discount Spray Foam	Convenience	N/A	N/A	Combined two-year PY15/PY16 general population survey
Instant Discount (all other measures)	N/A	N/A	N/A	Applied PY15 historical realization rate to PY16 reported savings
Midstream HVAC Equipment	85/15 (Cv=0.50)	23	23	Combined two-year PY15/PY16 sampling approach, documentation review, and engineering analysis
High Performance Homes	N/A	N/A	N/A	Applied PY15 historical realization rate to PY16 reported savings
Deep Energy Retrofits	N/A	N/A	N/A	No activities: savings for PY15 and PY16 will be verified in PY17

[(1)] The number of respondents who answered questions about the ISR may not equal the total number of survey respondents used in the process section of the report, infographics, or net savings analysis.

The impact evaluation activities verified energy savings with ±8.0% precision at 85% confidence and demand reductions with ±6.7% precision at 85% confidence.

Ex Post Savings Calculation

Downstream Equipment

Cadmus weighted and combined the realization rates for each sampled project for each stratum into a single stratum-level realization rate. To calculate *ex post* savings for each stratum, Cadmus applied the sample-derived realization rate for each stratum to the respective population savings and then summed *ex post* and *ex ante* kWh savings across strata to calculate component-level realization rates and savings.

Cadmus verified savings per the PA TRM and relied on inputs from PPL Electric Utilities' participant tracking database, project documentation, participant surveys, 2023 PA Residential Baseline Study[44],

[44] NMR Group Inc., March 21, 2024. *2023 Pennsylvania Statewide Act 129 Residential Baseline Study.* Submitted to Pennsylvania Public Utility Commission. 2023_pa_residential_baseline_study.pdf

third-party sources such as ENERGY STAR, AHRI, and product manufacturer websites, or deemed inputs from the PA TRM, where relevant.

Midstream Equipment

Cadmus weighted and combined the realization rates for each sampled project into a single stratum-level realization rate. Cadmus only sampled HVAC projects; thus, the team only applied the HVAC stratum realization rate to all Midstream Equipment measures. To calculate *ex post* savings for each stratum, Cadmus applied the sample-derived realization rate to the respective population savings and then summed *ex post* and *ex ante* kWh savings across strata to calculate component-level realization rates and savings.

Cadmus verified savings per the PA TRM and relied on inputs from PPL Electric Utilities' participant tracking database, project documentation, 2023 PA Residential Baseline Study, third-party sources such as ENERGY STAR, AHRI, and product manufacturer websites, or deemed inputs from the PA TRM, where relevant.

Audit and Weatherization

For each strata where sampling was applied, Cadmus calculated a single, stratum-level realization rate, weighted by each sampled project's evaluated savings. To calculate *ex post* savings for each stratum, Cadmus applied the sample-derived realization rate for each stratum to the respective population savings and then summed *ex post* and *ex ante* kWh savings across strata to calculate subcomponent-level realization rates and savings.

Cadmus verified savings per the PA TRM and relied on inputs from PPL Electric Utilities' tracking database, project documentation, participant surveys, or deemed inputs from the PA TRM, where relevant.

Instant Discount

Cadmus applied a historical realization rate from PY15 results to reported PY16 energy savings and demand reductions (Table I-1) for all measures except for spray foam. Cadmus verified savings for spray foam per the PA TRM and relied on inputs from PPL Electric Utilities' tracking database, participant surveys, 2018 PA Residential Baseline Study, or deemed inputs from the PA TRM, where relevant.

I.1.2. Gross Impact Results

Table I-3 shows the verified gross energy savings and demand reductions for Energy Efficient Homes.

Table I-3. Energy Efficient Homes Component Savings

Savings	PY13 Verified	PY14 Verified	PY15 Verified	PY15 Unverified	PY16 Verified	PY16 Unverified	Phase IV Verified[1]
MWh/yr	17,556 [2]	25,763	34,673 [3]	17	25,389	6,145	103,381
System-Level MW/yr	1.87 [4]	2.83	3.47 [5]	0.0004[6]	1.82	1.34[6]	9.99

[1] Phase IV verified savings may not match the sum of program years due to rounding and do not include PY15 or PY16 unverified savings.

[2] PY13 verified savings for the Energy Efficient Homes component were increased by 0.19 MWh/yr to conform with the SWE's PY13 Annual Report findings.

[3] PY15 verified savings for the Energy Efficient Homes component were increased by 3,481 MWh/yr to conform with the SWE's PY15 Annual Report findings. Includes verified savings of 1,115 MWh/yr for Instant Discount spray foam and 6 MWh/yr for Midstream Equipment left unverified in PY15.

[4] PY13 verified demand reductions for the Energy Efficient Homes component were increased by 0.0005 MW/yr to conform with the SWE's PY13 Annual Report findings.

[5] PY15 verified demand reductions for the Energy Efficient Homes component were decreased by 0.14 system-level MW/yr to conform with the SWE's PY15 Annual Report findings. Includes verified savings of 0.01 MW/yr for Instant Discount spray foam and 0.001 MW/yr for Midstream Equipment left unverified in PY15.

[6] Line loss adjustments are applied to savings after verification.

Table I-4 shows incentive costs, verified electric savings, and demand reductions by subcomponent.

Table I-4. PY16 Incentives and Verified Energy Savings and Demand Reductions by Subcomponent

Parameter	Downstream Equipment[1]	Midstream Equipment[2]	Online Marketplace	New Homes[3]	Audit and Weatherization[1]	Instant Discount[4]	Total[5]
PY16 Participants	10,600	31	3,723	1,920	1,868	69,736	87,878
PYRTD (MWh/yr)	18,796	65	558	6,144	733	5,300	31,596
PYRTD (MW/yr)	1.09	0.01	0.06	1.34	0.05	0.68	3.21
PYVTD (MWh/yr)	20,137	65	631	3	531	4,021	25,389
PYVTD (MW/yr)	0.98	0.01	0.07	0.001	0.05	0.57	1.67
System-Level PYVTD (MW/yr)	1.07	0.01	0.07	0.002	0.05	0.62	1.82
PY16 Incentives ($1,000)	$2,671	$13	$142	$2,024	$472	$759	$6,082

[1] Downstream Equipment includes 2 MWh/yr and 0.0002 MW/yr reported savings attributed to Deep Energy Retrofits. Audit and Weatherization includes 2 MWh/yr and 0.00005 MW/yr reported savings attributed to Deep Energy Retrofits. These savings will be verified in PY17.

[2] This does not include PY15 savings verified in PY16.

[3] The High Performance Homes pilot is included with New Homes totals in this table. Cadmus applied the PY15 historical realization rate to High Performance Homes pilot.

[4] This does not include PY15 spray foam savings verified in PY16. Cadmus applied the PY15 historical realization rates to non-spray foam savings to verify PY16.

[5] Column sums may not add up to the total column due to rounding.

In PY16, the Energy Efficient Homes component reported energy savings of 31,596 MWh/yr, as shown in Table I-5, and demand reduction of 3.21 MW/yr, as shown in Table I-6.

Table I-5. Energy Efficient Homes Component Gross Impact Results for Energy

Stratum	PYRTD (MWh/yr)	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Downstream Equipment HVAC	17,846	107%	0.33	10.7%	19,160
Downstream Equipment Other	948	103%	0.05	1.6%	977
Downstream Subtotal[2]	**18,794**	**107%**	**0.44**	**10.0%**	**20,137**
Weatherization	646	64%	1.34	48.8%	411
Audit	85	141%	0.18	5.8%	120
Audit and Weatherization Subtotal[2]	**731**	**73%**	**1.43**	**36.7%**	**531**
Online Marketplace Kits	310	127%	0.00	0.0%	394
Online Marketplace Other	247	95%	0.00	0.0%	234
Online Marketplace Weatherization	2	197%	0.00	0.0%	3
Online Marketplace Subtotal[2], [3]	**558**	**113%**	**0.00**	**0.0%**	**631**
Instant Discount Spray Foam	935	10%	0.00	0.0%	93
Instant Discount Other [3]	4,365	90%	0.00	0.0%	3,928
Instant Discount Subtotal[2]	**5,300**	**76%**	**0.00**	**0.0%**	**4,021**
High Performance Homes Subtotal[2], [3]	**4**	**97%**	**0.00**	**0.0%**	**3**
Midstream Equipment Subtotal[2]	**65**	**101%**	**0.02**	**0.8%**	**65**
Component Subtotal[2]	**25,451**	**100%**	**0.40**	**8.0%**	**25,389**
Unverified Deep Energy Retrofit	4 [4]	-	-	-	-
Unverified New Homes	6,140	-	-	-	-
Unverified Subtotal[2] [3]	**6,145**	**-**	**-**	**-**	**-**
Total (Verified + Unverified) [2] [3]	**31,596**	**80%**	**0.40**	**8.0%**	**25,389**
Instant Discount (spray foam) (PY15 verified in PY16)	11,206	10%	0.00	0.0%	1,115
Midstream Equipment (PY15 verified in PY16)	6	101%	0.02	0.8%	6

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Total may not match the sum of rows due to rounding.
[3] Cadmus used the PY15 historical realization rates for the Online Marketplace subcomponent, non-spray foam savings in the Instant Discount subcomponent, and the High Performance Homes pilot.
[4] Includes 2 MWh/yr for Downstream Equipment and 2 MWh/yr for audit and weatherization improvements.

Table I-6. Energy Efficient Homes Component Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)	System Level PYVTD (MW/yr)
Downstream Equipment HVAC	0.99	89%	0.67	21.9%	0.88	0.95

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)	System Level PYVTD (MW/yr)
Downstream Equipment Other	0.10	99%	0.12	4.3%	0.10	0.11
Downstream Subtotal[2]	**1.09**	**90%**	**0.81**	**19.3%**	**0.98**	**1.07**
Weatherization	0.04	101%	0.05	2.0%	0.04	0.04
Audit	0.01	143%	0.19	6.3%	0.01	0.01
Audit and Weatherization Subtotal[2]	**0.05**	**107%**	**0.08**	**1.9%**	**0.05**	**0.05**
Online Marketplace Kits	0.03	139%	0.00	0.0%	0.04	0.04
Online Marketplace Other	0.03	104%	0.00	0.0%	0.03	0.03
Online Marketplace Weatherization	0.00002	715%	0.00	0.0%	0.0001	0.0001
Online Marketplace Subtotal[2], [3]	**0.06**	**120%**	**0.00**	**0.0%**	**0.07**	**0.07**
Instant Discount Spray Foam	0.01	12%	0.00	0.0%	0.001	0.001
Instant Discount Other [3]	0.67	85%	0.00	0.0%	0.57	0.62
Instant Discount Subtotal[2]	**0.68**	**84%**	**0.00**	**0.0%**	**0.57**	**0.62**
High Performance Homes Subtotal[2], [3]	**0.001**	**101%**	**0.00**	**0.0%**	**0.001**	**0.002**
Midstream Equipment Subtotal[2]	**0.01**	**93%**	**0.15**	**5.3%**	**0.01**	**0.01**
Component Subtotal[2]	**1.88**	**89%**	**0.41**	**6.7%**	**1.67**	**1.82**
Unverified Deep Energy Retrofit	0.0002[4]	-	-	-	-	-
Unverified New Homes	1.34	-	-	-	-	-
Unverified Subtotal[3]	**1.34**	**-**	**-**	**-**	**-**	**-**
Total (Verified + Unverified)[3]	**3.21**	**52%**	**0.41**	**6.7%**	**1.67**	**1.82**
Instant Discount (spray foam) (PY15 verified in PY16)	0.08	12%	0.00	0.0%	0.01	0.01
Midstream Equipment (PY15 verified in PY16)	0.001	93%	0.15	5.3%	0.001	0.001

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings. Cadmus applied the realization rates to verified demand reductions before applying distribution losses.
[2] Total may not match the sum of rows due to rounding.
[3] Cadmus used the PY15 historical realization rates for the Online Marketplace subcomponent, non-spray foam savings in the Instant Discount subcomponent, and the High Performance Homes pilot.
[4] Includes 0.0002 MW/yr for Downstream Equipment and 0.00005 MW/yr for audit and weatherization improvements.

The following sections describe the factors that led to discrepancies between the reported and verified savings and the observed realization rates.

Downstream Equipment

Energy and demand realization rates for the HVAC end-use in the Downstream Equipment subcomponent differ from 100% because of discrepancies between the efficiency ratings recorded in the tracking database and those in the AHRI database. All of the ductless heat pump, air source heat

pump, and central air conditioning projects had discrepancies in SEER or HSPF, or both, even in cases where the project documentation included the AHRI certificate. In many cases, equipment efficiency was recorded in the tracking database as SEER and heat pump HSPF converted from SEER2/HSPF2 values despite SEER/HSPF being available on the AHRI certificate. Cadmus evaluated all equipment using SEER and HSPF values from the AHRI database per TRM guidance memos.

There were additional deviations due to differences in reported and survey-verified baseline heating and cooling equipment:

- For one ductless heat pump project, reported savings used an air source heat pump baseline for heating and cooling. However, the verification survey found that the baseline equipment was a natural gas furnace with no cooling.
- For another ductless heat pump project, reported savings used non-electric heating and central air conditioning as the baseline equipment. However, the verification survey found that the baseline equipment was an air source heat pump.
- For another ductless heat pump project, reported savings used a ductless heat pump as the baseline for heating and cooling. However, the verification survey found that the baseline equipment was an electric furnace and central air conditioning.
- For two additional ductless heat pump projects, reported savings used a room/window AC unit as the baseline cooling equipment. However, the verification survey found that the baseline conditions did not include cooling systems. Inversely, reported savings for another project were based on no existing cooling, yet the survey found that the baseline equipment was a room/window AC unit.
- For one air source heat pump project, reported savings used an air source heat pump for baseline conditions. However, the verification survey found that the existing equipment was a natural gas furnace and central air conditioning.
- For another air source heat pump project, reported savings used a room/window AC unit as the baseline cooling system, while the verification survey found no existing cooling system.

Overall, these factors led to realization rates higher than 100% for energy and lower than 100% for demand.

Cadmus also identified discrepancies in the other measures. For three heat pump water heater projects, the energy factor provided in the tracking database did not match the specifications of the equipment models provided in the project documentation. For one of these projects, the tank size also did not match. Two out of three smart thermostat projects were reported as self-installed; however, the survey respondents said contractors installed them. Overall, the other measures had much fewer discrepancies than HVAC, and correspondingly, the realization rates were close to 100%.

Midstream Equipment

Energy and demand realization rates for the Midstream Equipment subcomponent are, overall, close to 100%, but differ from 100% from project to project because of differences in inputs between *ex ante* and *ex post* calculations. Cadmus sourced all impact inputs from AHRI certificates for each model

number in the tracking database; however, the AHRI number was not always present in the project documentation. HVAC system capacity and efficiency values can vary for an outdoor unit based on the indoor unit it is paired with. Without the AHRI number, Cadmus could not identify the indoor unit. Since the tracking data does not include *ex ante* assumptions for these parameters, slightly different values were likely chosen, which led to small increases or decreases in savings at the measure level. Cadmus evaluated all equipment as SEER and HSPF per TRM guidance memos.

Audit and Weatherization

Energy and demand realization rates for the Audit and Weatherization subcomponent varied greatly from measure to measure. They were less than 100% due to survey-verified inputs, such as in-service rates (ISRs) and findings from reviewing project documentation during desk reviews.

Audit Measures

Cadmus made the following adjustments to savings for audit measures.

- Cadmus updated ISRs for globe LEDs, reflector LEDs, nightlights, and advanced power strips using data from the PY16 participant survey. For kit measures with insufficient survey responses, Cadmus applied either a historical ISR or the PA TRM default. Table I-7 shows comparisons between *ex ante* and *ex post* realization rates.

Table I-7. Audit Measure *Ex Ante* to *Ex Post* ISR Comparison

Measure	*Ex Ante* ISR	*Ex post* ISR
Globe LED	92%	77%
Reflector LED	92%	75%
Nightlight	45%	80%
Weatherstripping	72%	72%
Outlet Gasket	24%	24%
Advanced Power Strip	45%	71%
Bathroom Aerator	28%	28%
Kitchen Aerator	28%	28%
Pipe Insulation	62%	62%
Showerhead	35%	35%
Water Heater Setback	27%	27%

- Cadmus also used survey-verified values for electric water heating saturation, heating fuel saturation, cooling saturation, and climate region weights. The team derived these values from a combination of the PY16 participant survey and the participant tracking database for customer ZIP code mapping. Updating the electric water heater saturation, heating fuel type, and cooling saturation had a positive impact on both energy and demand realization rates.
- For advanced power strips, Cadmus used survey data to determine end-use (home entertainment or home office) and weighted evaluated savings accordingly. The verified power strip use resulted in slightly lower energy savings relative to the unspecified end-use value the PA TRM used for *ex ante,* and therefore had a slightly negative impact on the realization rate.

The verified power strip use demand savings were the same as the unspecified end-use value listed in the PA TRM, which had no impact on the demand savings realization rate.

- Cadmus noted that *ex ante* savings for several products within audit kits had varying values due to ISR changes that occurred throughout the program year. Products included advanced power strips, nightlights, outlet gaskets, low-flow showerheads, and kitchen and bathroom aerators, with the lower ISRs in effect for majority of the program year. Some *ex post* ISRs were higher and others lower than the *ex ante* ISRs, which leveled out the realization rates overall, with lower realization rates for globe and reflector LED measures, and higher realization rates for nightlight and advanced power strip measures.

Weatherization

Cadmus compared survey responses to the participant tracking data and reviewed application forms and contractor invoices as part of the desk review process for weatherization measures. The team adjusted savings for eight out of 17 sampled projects, as detailed below:

- Six projects showed HVAC system types in the participant tracking database that did not match survey data. Cadmus evaluated these projects using the customer-provided HVAC system types for both heating and cooling systems. For two projects, the participant tracking database showed air source heat pumps as the heating system. However, the customer specified electric baseboard heating and a natural gas furnace as the installed type in the survey. In one of these two projects, the tracking data noted an air source heat pump as the cooling system type, but the customer specified central air conditioning as the installed type in the survey. For two other projects, the participant tracking database showed electric resistance as the heating type. However, the customer specified a natural gas furnace and wood/pellet stove as the installed type in the survey. For another project, the participant tracking database showed electric furnace as the heating type, while the customer specific electric baseboard/cadet as the installed type in the survey. Another project showed an air-source heat pump as the heating system type, while the customer specified mini-split heat pump in the survey data. Although there was a wide variance in differences between the participant tracking database details and the survey responses, there was an overall negative impact on the savings realization rates. The participant tracking database did not include the project's square footage as a parameter. Due to limited information in the invoices and project documentation, Cadmus accepted the provided square footage and insulation values provided by the implementer for the sampled projects as accurate. For some sampled projects, the team compared these values against the available project documentation and found them to be correct. Therefore, no discrepancies in square footage impacted the savings realization rates. The application for one project indicated that no pre-existing insulation was installed due to a fire in the building. The participant tracking database showed the total R-value of existing insulation was 5.24, which was higher than the R-value for an uninsulated attic per the TRM. Therefore, Cadmus evaluated this project using an R-value of 5 for 0 inches of insulation for the baseline scenario per the TRM.
- Two of the 14 sampled insulation projects were for basement insulation. In one case, only cooling savings applied, and in the other, only heating savings applied, due to the existing

cooling and heating equipment verified from survey responses. These updates resulted in a positive impact on the energy savings realization rates.

Instant Discount – Spray Foam

Energy and demand realization rates for spray foam were largely driven by ISR. The *ex ante* ISR was assumed to be 59% and a 12-ounce can was assumed to contain 161 linear feet of foam, meaning 95 linear feet of insulation per can. Cadmus estimated the ISR as 5% and a 12-ounce can was assumed to contain 200 linear feet of foam, meaning 10 linear feet of insulation per can.

Cadmus estimated the spray foam ISR by including spray foam questions in four different surveys (general population, customer satisfaction, Downstream Equipment, Audits and Weatherization) asking respondents if they had purchased spray foam within the last 12 months and, if so, asking them to estimate how many linear feet they used to seal windows, doors, or gaps/cracks in conditioned spaces. Cadmus found the average across these four surveys to be approximately 10 linear feet of insulation per can purchased.

I.2. Net Impact Evaluation

I.2.1. Net Impact Methodology

Cadmus applied methods outlined in the Evaluation Framework to determine free ridership, spillover, and net savings for downstream, upstream, and midstream programs.[45] Cadmus used online self-report surveys to assess free ridership and spillover for the Downstream Equipment stratum. Due to participation challenges for the Midstream Equipment stratum (in which only 31 total units received incentives in PY16), Cadmus applied measure-level PY16 NTG ratios estimated from self-report survey data collected through the Downstream Equipment subcomponent.

Cadmus calculated net savings to inform future program planning. Energy savings and demand reduction compliance targets are measured using verified gross savings.

Table I-8 summarizes the methods and sampling strategy used to determine net savings for the Downstream Equipment stratum in PY16. Cadmus assigned an NTG ratio of 1.0 for pilot projects in High Performance Homes.

[45] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

Table I-8. Energy Efficient Homes Component Net Impact Evaluation Sample Design

Stratum	Evaluation Year	Stratum Boundaries	Population Size[1]	Achieved Sample Size[2]	NTG Activity
Downstream Equipment – Refrigerator	PY16	Participants (Customers)	1,619	44[3]	Participant online survey
Downstream Equipment – Dehumidifier	PY16		702	27[3]	
Downstream Equipment – Central Air Conditioner	PY16		966	26[3]	
Downstream Equipment – Air-Source Heat Pump	PY16		1,232	36[3]	
Downstream Equipment – Ductless Heat Pump	PY16		2,435	85[3]	
Downstream Equipment - Smart Thermostat	PY16		1,075	25[3]	
Downstream Equipment – Heat Pump Water Heater	PY16		376	23[3]	
Downstream Equipment – Other	PY16		140	0[3]	

[1] The population sizes differ among impact, process, and net savings analyses.

[2] The number of respondents used in the net savings analysis differs from the number used in the gross impact and process evaluation.

[3] Achieved sample size is based on the number of survey respondents answering the first free ridership question, "Which of the following would have happened if you had not received the $[Field-REBATE] to purchase your [MEASURE]?" and answering at least of one of the questions, "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 on your decision. The $[REBATE] for the [MEASURE], PPL Electric Utilities' information about energy efficiency.

Free Ridership

Cadmus summed the intention and influence free ridership components to estimate the average total intention and influence free ridership by stratum, weighted by verified gross kWh/yr savings.

Table I-9 summarizes the intention, influence, and free ridership scores for the Downstream Equipment stratum.

Table I-9. Energy Efficient Homes Component Intention, Influence, and Free Ridership Score by Stratum

Stratum	Number of Respondents	Intention Score	Influence Score	Free Ridership Score
Downstream Equipment – Refrigerator	44	42%	17%	59%
Downstream Equipment – Dehumidifier	27	36%	17%	53%
Downstream Equipment – Central Air Conditioner	26	29%	18%	47%
Downstream Equipment – Air-Source Heat Pump	36	33%	25%	58%
Downstream Equipment – Ductless Heat Pump	85	31%	16%	47%
Downstream Equipment – Smart Thermostat	25	26%	16%	42%
Downstream Equipment – Heat Pump Water Heater	23	23%	13%	36%

Spillover

Table I-10 lists the quantity of spillover energy-efficient equipment types that the respondents for the Downstream Equipment stratum attributed to PPL Electric Utilities. The table also lists the per-unit energy savings and the source of the estimated energy savings used in the spillover analyses.

Table I-10. Energy Efficient Homes Component Spillover Calculation

Spillover Product	Respondent Quantity	Per-Unit Savings (kWh/yr)	Savings Source
Downstream Equipment			
Air Source Heat Pump	1	1,234	PY16 PPL Electric Utilities Gross Verified Savings
Central Air Conditioner	3	271	PY16 PPL Electric Utilities Gross Verified Savings
Clothes Dryer	5 [(1)]	25	2021 PA TRM
Clothes Washer	4 [(1)]	95	2021 PA TRM
Dishwasher	5 [(2)]	23	2021 PA TRM
Insulation	1 project	387	PY16 PPL Electric Utilities Gross Verified Savings
Refrigerator	2 [(2)]	55	PY16 PPL Electric Utilities Gross Verified Savings

[(1)] 50% of per-unit savings kWh/yr applied to two units due to a maximum PPL Electric Utilities 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 Electric Utilities influence rating of three, on a 1 to 5 scale, with 1 meaning not at all influential and 5 meaning extremely influential.

Table I-11 shows the spillover results for the PY16 evaluated equipment categories of the Downstream Equipment and Online Marketplace strata.

Table I-11. Energy Efficient Homes Component Spillover Calculation for Downstream Equipment Category

Variable	Variable Description	Downstream Equipment	Source
A	Survey Sample Size (n)	266	Survey Data
B	Total Survey Sample Spillover kWh/yr Savings	3,004	Survey Data/Engineering Estimates
C	Average Spillover kWh/yr Savings Per Survey Respondent	11.3	Variable B ÷ Variable A
D	Program Participant Population	8,405 [(1)]	Program Tracking Data
E	Spillover kWh/yr Savings Extrapolated to the Participant Population	94,931	Variable C × Variable D
F	Evaluated Program Population kWh/yr Savings	19,872,691	Evaluated Gross Impact Analysis
G	Spillover Percentage Estimate	0%	Variable E ÷ Variable F

[(1)] 8,405 unique PY16 participants.

I.2.2. Net-to-Gross Results

Table I-12 shows the Downstream Equipment strata free ridership, spillover, and NTG ratios by equipment category.

Table I-12. Energy Efficient Homes Component – Downstream Equipment Net Impact Evaluation Results

Equipment Category	PYVTD kWh/yr	Evaluation Year	Free Ridership (%)[1]	Spillover (%)	NTG Ratio
Refrigerator	112,285	PY16	59%	0%	0.41
Dehumidifier	97,526	PY16	53%	0%	0.47
Central Air Conditioner	349,272	PY16	47%	0%	0.53
Air Source Heat Pump	2,566,035	PY16	58%	0%	0.42
Ductless Heat Pump	15,196,154	PY16	47%	0%	0.53
Smart Thermostat	784,261	PY16	42%	0%	0.58
Heat Pump Water Heater	767,158	PY16	36%	0%	0.64
Subtotal	**19,872,691**	**-**	**48%**	**0%**	**0.52**
Other	263,934	PY16	48%[4]	0%[4]	0.52[2]
Total[3],[4]	**20,136,625**	**-**	**48%**	**0%**	**0.52**

[1] Free ridership estimates were weighted by the survey sample-verified component kWh/yr savings. This method ensures that respondents who achieved higher energy savings through the component have a greater influence on the equipment-level free ridership estimate than do respondents who achieved lower energy savings.
[2] The overall Downstream Equipment Stratum NTG ratio of 0.52, which was based on equipment-level free ridership, spillover, and NTG estimates, was weighted by the product's verified kWh/yr component population savings. Cadmus applied population savings to the "other" equipment category, where there were no PY16 survey respondents.
[3] Equipment- level free ridership, spillover, and NTG estimates were weighted by the product's verified kWh/yr component population savings to arrive at the Downstream Equipment stratum NTG ratio of 0.52.
[4] Total may not match the sum of rows due to rounding.

Cadmus did not conduct primary NTG research for the Midstream Equipment stratum in PY16 due to small sample sizes. Cadmus applied measure-level NTG ratios from the PY16 Downstream Equipment NTG research for measures similar to Midstream Equipment stratum measures. Table I-13 shows the NTG ratios and the source of the NTG ratios applied to PY16 Midstream Equipment stratum measures, along with the overall PY16 Midstream Equipment stratum NTG ratio that is based on weighting the measure level NTG ratios by PY16 gross verified kWh/yr savings.

Table I-13. Midstream Equipment Stratum Measures

Midstream Equipment Stratum Measure	PYVTD kWh/yr	Free Ridership (%)	Spillover (%)	NTG Ratio	NTG Ratio Source
Air Source Heat Pump	11,565	58%	0%	0.42	PY16 Downstream Equipment
Central Air Conditioner	565	47%	0%	0.53	PY16 Downstream Equipment
Ductless Heat Pump	52,978	47%	0%	0.53	PY16 Downstream Equipment
Overall	**65,107**	**49%**	**0%**	**0.51**	

Table I-14 shows the NTG ratio results for each stratum of the Energy Efficient Homes component. The overall Energy Efficient Homes component NTG ratio of 0.57 is heavily weighted towards the Downstream Equipment stratum NTG ratio of 0.52, as this stratum represents 79% of the Energy Efficient Homes component verified gross population energy savings.

Table I-14. Energy Efficient Homes Component NTG Ratio Summary

Stratum	PYVTD kWh/yr	Evaluation Year	Free Ridership (%)[1]	Spillover (%)	NTG Ratio
Audit and Weatherization	531,078	PY14	52%	14%	0.62
Downstream Equipment	20,136,625	PY16	48%	0%	0.52
Online Marketplace	631,344	PY15	20%	8%	0.88
Instant Discount	4,021,199	PY15	25%	0%	0.75
High Performance Homes	3,467	Deemed	0%	0%	1.00
Midstream Equipment	65,107	PY16[2]	49%	0%	0.51
Component Total[3],[4]	**25,388,820**	**-**	**43.74%**	**0.49%**	**0.57**

[1] Stratum-level free ridership estimates were weighted by the survey sample-verified component kWh/yr savings. This method ensured that respondents who achieved higher energy savings through the component products had a greater influence on the equipment-level free ridership estimate than did the respondents who achieved lower energy savings.
[2] Due to low participation, Cadmus applied downstream NTGRs as approved by the SWE in the evaluation plan.
[3] The stratum-level free ridership, spillover, and NTG ratio estimates were weighted by the component population's verified kWh/yr savings to arrive at the final Energy Efficient Homes component NTG ratio of 0.57.
[4] Total may not match the sum of rows due to rounding.

I.3. Process Evaluation

Cadmus conducted a process evaluation of the Energy Efficient Homes component using data collected through online participant surveys and interviews with participating distributors, contractors, and staff from PPL Electric Utilities, the ICSP, and the ICSP's subcontractors. The research objectives for the process evaluation were to assess participant satisfaction, review component changes and performance, assess component design and market actor experience, and make recommendations for improvement.

Process activities were consistent with planned activities. A total of 304 respondents—260 in Downstream Equipment and 44 in Audit and Weatherization subcomponents—completed the online survey from April through May 2025. The results from the participant survey produced a measure of component satisfaction with ±10% precision at 90% confidence. See *Appendix L. Survey Bias* for details on Cadmus' approach to reduce survey bias and contact instructions.

Cadmus also completed interviews with a distributor and a contractor participating in the midstream equipment program. The team made multiple outreach attempts via email and telephone to distributors (two records) and contractors (three records), completing one interview with each group. Interviews assessed program experience and satisfaction, challenges to participation, program influence on sales and stocking practices, and gathered feedback for improvement.

Sample sizes noted in this report may vary by survey or interview question because respondents could skip questions they chose not to answer; therefore, not all respondents provided answers to every question. Cadmus included all survey and interview respondents who were eligible and answered at least one question, regardless of whether they completed the survey or interview.

Table I-15 shows the sampling strategy for the process evaluation.

Table I-15. Energy Efficient Homes Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Proportion or Cv in Sample Design	Planned Sample Size	Achieved Sample Size	Records in 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, ICSP, and the ICSP's subcontractors	Telephone in-depth interview	3	N/A	3	3	N/A	100%
Component Participants	Downstream Equipment	Online survey	6,822[3]	85/15	≥ 40	260[4]	5,375	100%
	Weatherization	Online survey	938	85/15	≥ 23	19[4]	720	100%
	Audit	Online survey				25[4]		
Midstream Equipment	Participants	Distributors	2	N/A	2	1	2	100%
		Contractors	3	N/A	2	1	3	100%
Component Total			**7,768**	**-**	**-**	**309**	**6,100**	**-**

[1] A sample frame is a list of participants and stakeholders with contact information who had a chance to complete the survey or interview. The final sample frame includes unique records in the PPL Electric Utilities database at the time of the surveys. After selecting all unique records, Cadmus removed any records from the population that lacked 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/interviews.

[3] Number of participants in the PPL Electric Utilities' tracking database at the time of the PY16 survey, which occurred before the end of the program year.

[4] The achieved sample size shows the number of respondents who completed the survey. When reporting, Cadmus included all responses in the analysis, even if the respondent did not complete the survey. The number of respondents used in the process evaluation differs from the numbers used in the gross impact and net impact analysis.

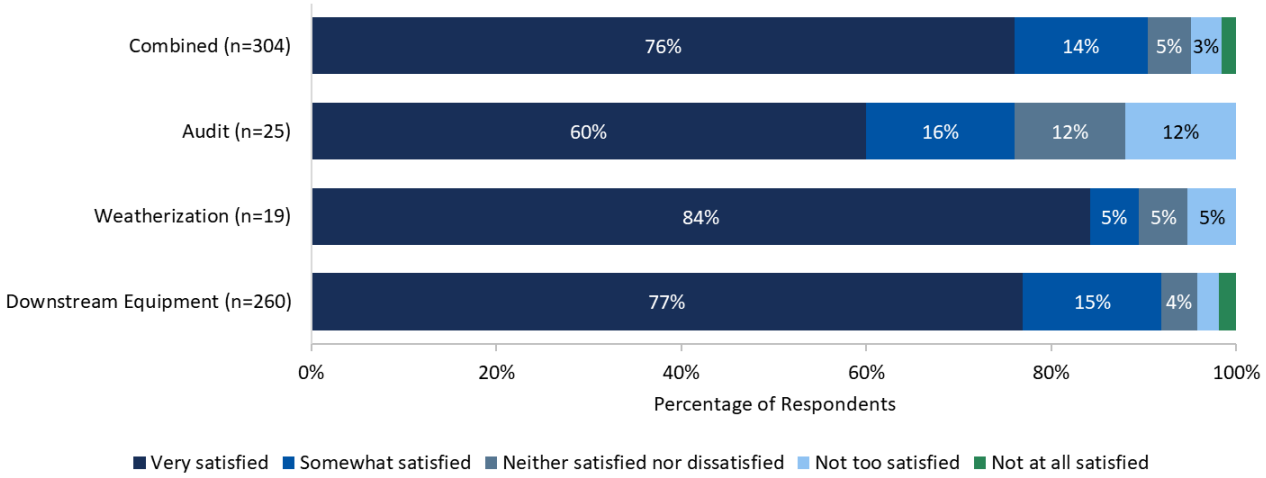
I.3.1. Program Component Experience

Downstream Equipment and Audit and Weatherization survey respondents rated their satisfaction with different aspects of the Energy Efficient Homes component, provided insights about their satisfaction ratings, and rated the effect of their participation on their opinion of PPL Electric Utilities.

Program Component Satisfaction and Customer Effort

Across all subcomponents, a large majority of respondents (90%) were satisfied with their experience (Figure I-1), with overall satisfaction rated at either *very (76%)* or *somewhat satisfied (14%)*.

Figure I-1. PY16 Overall Satisfaction with Energy Efficient Homes by Subcomponent



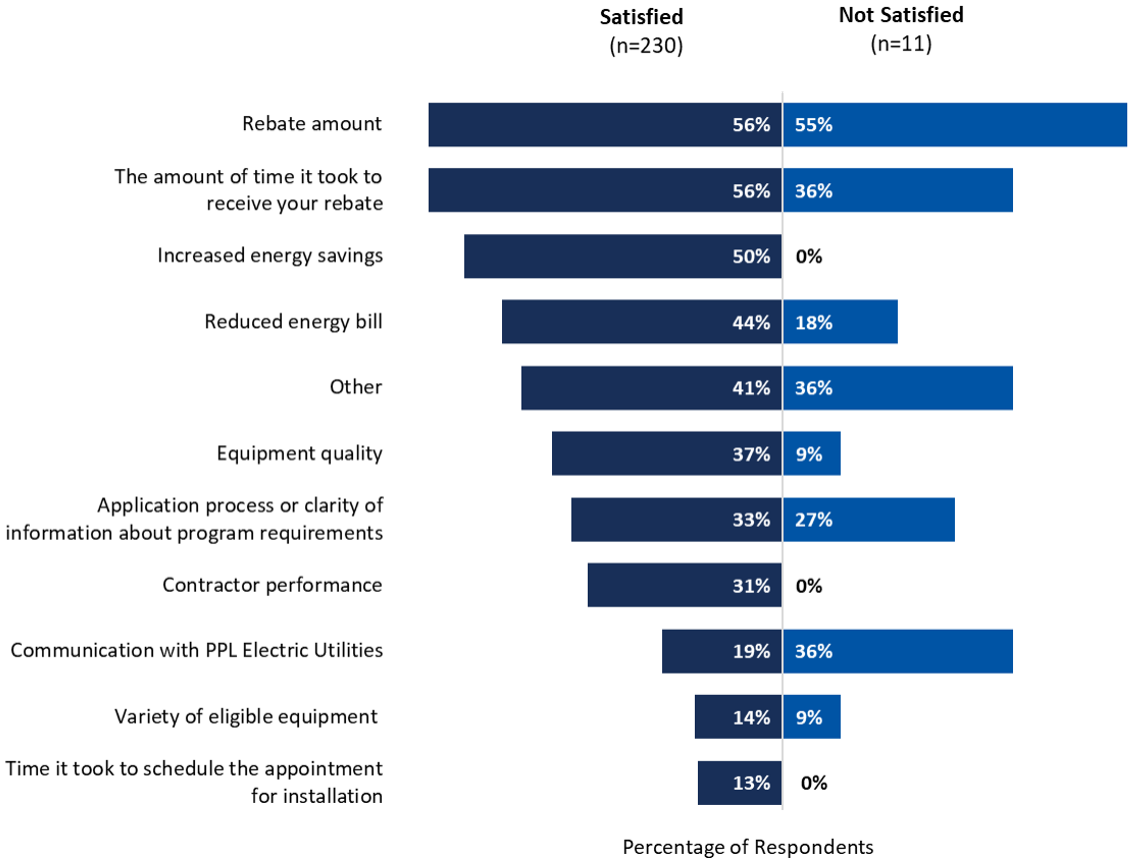
Source: Downstream Equipment and Audit and Weatherization Participant Survey, "Thinking about your overall experience with the PPL Electric Utilities [program], how would you rate your satisfaction?" Note: Unlabeled segments represent 2% or less of respondents. Totals may not sum due to rounding and may not match the totals in the infographic. Sample sizes reflect partially completed surveys.

Drivers of Program Component Satisfaction

To better understand what drives satisfaction, the survey asked participants of the Downstream Equipment and Audit and Weatherization subcomponents what factor(s) led to their satisfaction rating. In Downstream Equipment, as shown in Figure I-2, top drivers of positive experiences were the rebate amount (56%), the amount of time it took to receive the rebate (56%), and increased energy savings (50%).

Eleven of the Downstream Equipment respondents who were *not too satisfied* or *not at all satisfied* with their overall experience with the rebate provided a reason for their dissatisfaction (Figure I-1). Rebated equipment in this group included ductless heat pumps, smart thermostats, dehumidifiers, air-source heat pumps, refrigerators, central air conditioners, fuel switch water heaters, and heat pump water heaters. The main reasons these participants cited as impacting their experience were the rebate amount (six respondents), the amount of time it took to receive rebates (four respondents), and communication with PPL Electric Utilities (four respondents).

Figure I-2. Drivers of High and Low Satisfaction for Downstream Equipment

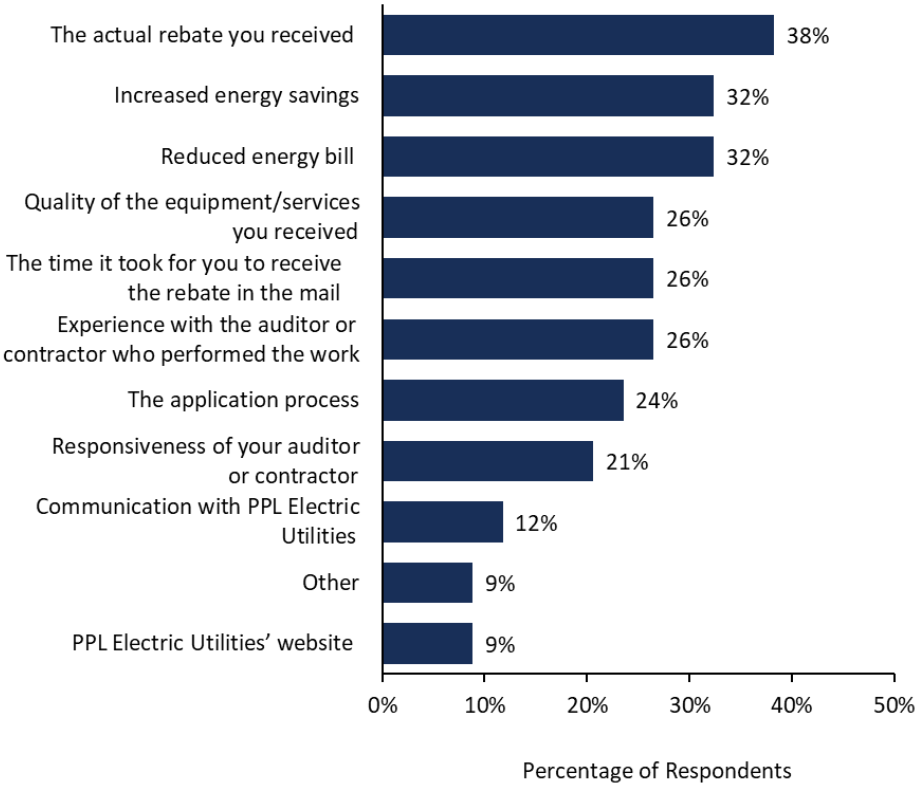


Source: Downstream Equipment Participant Survey, "What factor(s) most affected the overall experience rating you gave?" (n=241; multiple responses allowed) Note: *Neither satisfied nor dissatisfied* (n=8) responses not included in this chart.

As shown in Figure I-3, the top drivers of high satisfaction for the Audit and Weatherization respondents were the rebate they received (38%), increased energy savings (32%), and reduced energy bill (32%).

Four Audit and Weatherization respondents were *not too satisfied* with their overall experience with the program and none were *not at all satisfied*. The drivers for their low ratings were related to the quality of the equipment or services they received (one respondent), the time it took for them to receive a rebate in the mail (one respondent), a lack of clarity on why part of their weatherization project did not receive a rebate (one respondent), and wanting the audit to be in-person rather than over the phone (two respondents). The respondent who identified the time it took to receive the rebate also cited not receiving a rebate and not being informed about the rebate by the contractor who filed it for them.

Figure I-3. Audit and Weatherization Drivers of High Satisfaction



Source: Audit and Weatherization Participant Survey, "What factor(s) most affected the overall experience rating you gave?" (n=34; multiple responses allowed)
Note: *Not too satisfied* (n=4) and *Neither satisfied nor dissatisfied* (n=4) responses not included in this chart.

Opinion of PPL Electric Utilities

Offerings in the Downstream Equipment and Audit and Weatherization subcomponents impacted how customers view PPL Electric Utilities. Fifty percent of Downstream Equipment respondents (n=256) and 44% of Audit and Weatherization respondents (n=41) said their opinion of PPL Electric Utilities had improved. Less than 10% in either subcomponent said their opinion of PPL Electric Utilities had decreased, and the rest said their opinion had not changed.

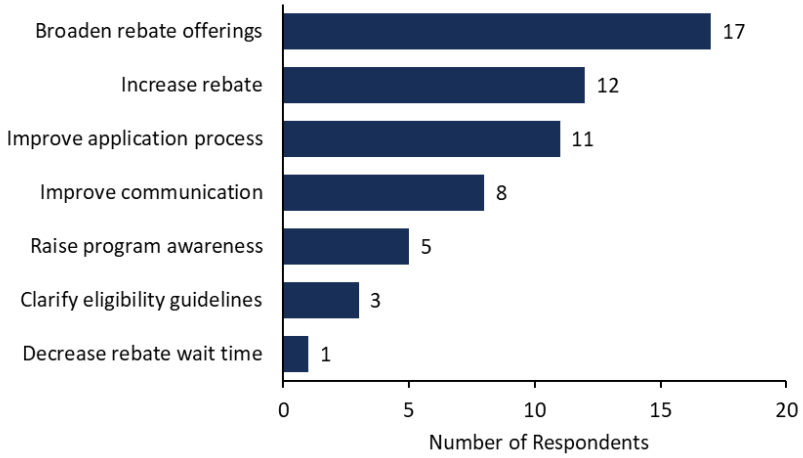
When asked why their opinion of PPL Electric Utilities decreased since participating in the program, eight Downstream Equipment respondents provided reasons. Three ductless heat pump purchasers reported issues with applying for rebates. One smart thermostat purchaser cited a rebate issue. Three air source heat pump purchasers cited application or rebate issues, and one was confused with equipment qualifications, saying that their "thermostat should be covered" in addition to their heat pump.

Improvement Suggestions

The survey asked respondents what PPL Electric Utilities could do to improve the Energy Efficient Homes component. Not all respondents had a suggestion.

For the Downstream Equipment subcomponent, 57 respondents (22%; n=260) suggested improvements, as shown in Figure I-4. The most common suggestion was for PPL Electric Utilities to broaden rebate offerings, with 17 respondents. Several respondents suggested, for example, that rebates should *"*include more types of equipment,*"* including dishwashers. One respondent said that their *"*new heat pump just missed one requirement*"* to receive a rebate. Another 12 respondents suggested an increased rebate, and 11 wanted an improved application process. One respondent said that PPL Electric Utilities should *"*clarify what needs to be submitted at the time of submission,*"* so that they are not required to resubmit their application later, an issue echoed by two others. Additionally, two respondents who suggested improved communication said that they needed more guidance from customer service on how to scan and submit paperwork.

Figure I-4. Downstream Equipment Improvement Suggestions

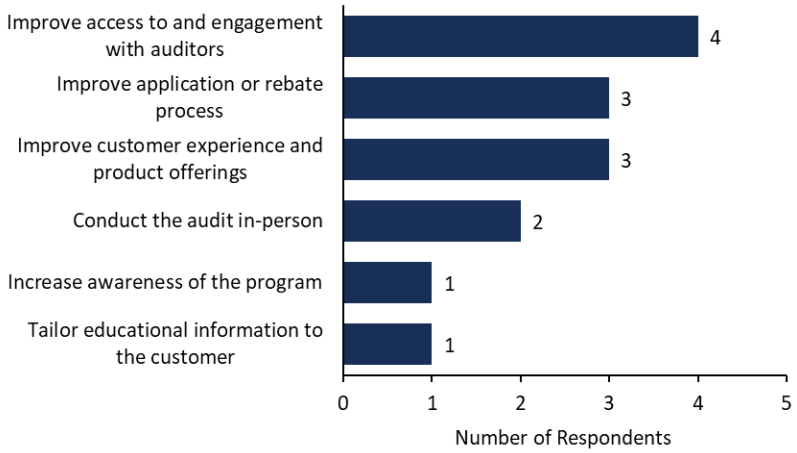


Source: Participant Survey, "What is the one thing PPL Electric Utilities could change about the program to improve it?" (n=57)

For the Audit and Weatherization subcomponent, 14 respondents (32%; n=44) offered suggestions, as shown in Figure I-5. The most common suggestions were to improve access to and engagement with auditors (four respondents), improve the application or rebate process (three respondents), and improve customer experience and product offerings (three respondents). Two respondents struggled with getting application approval, with one requiring their contractor to reach out to PPL Electric Utilities on their behalf. The other only had one application approved out of the two they completed for different efficiency projects. Respondents suggested several additional offerings be covered by the

program, including doors and windows. Others suggested that program cover measures that are already included, such as insulation and lightbulbs, suggesting some confusion about the program.

Figure I-5. Audit and Weatherization Improvement Suggestions



Source: Participant Survey, "What is the one thing PPL Electric Utilities could change about the program to improve it?" (n=14)

I.3.2. Midstream Equipment

Cadmus interviewed one of two participating distributors and one of three purchasers in the Midstream Equipment component to assess their satisfaction with the offering, identify what was working well and what challenges they faced, assess how the program impacts sales and stocking practices, and probe for recommendations. Purchasers in the midstream program are contractors who source the equipment for projects from the distributors.

For the Midstream Equipment subcomponent, the interviewed distributor said that they sold directly to contractors in addition to manufacturing HVAC equipment that they sell. They reported having "two or three" distribution centers in the PPL Electric Utilities service area. The interviewed contractor said that they had one location in Pennsylvania, and around 90% of their customers were residential. Of the program-qualifying equipment, both the distributor and contractor said that they sold more ducted and ductless air source heat pumps than central air conditioners and did not sell any heat pump water heaters.

Cadmus asked each respondent why they did not sell any heat pump water heaters, though they qualify for program incentives. The contractor said that there is "not really much customer demand" for the product, and the distributor, who only distributes equipment that they manufacture themselves, said they did not manufacture heat pump water heaters without providing insights as to why they did not.

The distributor said that they took a $25 portion of the rebate and requested that contractors pass the rest of the rebate onto their customers. The contractor said that they passed on 100% of the rebate they received to their customers.

Program Experience and Satisfaction

When asked about their experience with joining the program and submitting applications for the rebate, the contractor and distributor reported having an easy time with few issues. The distributor cited a portal they have for their contractors to submit claims that takes only "about three to five minutes" for contractors to use. The contractor said that "the only drawback is that [the portal] seems to freeze" frequently, taking up time during the submission process. The contractor said they encountered another challenge with some equipment that they expected to qualify, but did not. The distributor could not think of any obstacles they encountered in the process.

The distributor found the information and materials provided by a PPL Electric Utilities program manager "helped [them] better understand the program," whereas the contractor did not have any interaction with educational materials from PPL Electric Utilities.

Asked why they decided to participate in the program, the distributor said that participation helps increase sales and "opened a new market" for them in Pennsylvania. The contractor said that the rebate was an attractive thing to advertise and that involvement with a utility program "legitimizes the system" for customers. In summary, both the interviewed distributor and contractor rated themselves as *somewhat satisfied* with their experience.

Program Influence on Sales and Stocking Practices

The contractor said that their sales of ducted and ductless heat pumps increased since participating in the program by "roughly 35%." Overall, they reported that Midstream Equipment was *very important* for their 2024 sales of eligible equipment. The contractor said that of their current stock of equipment, "at least 80%" qualified for Midstream Equipment. Before participation, however, they said that the proportion of their equipment in stock that was high efficiency was only around "50% to 60%."

The distributor did not have specific data on how the program influenced sales or stocking practices, but said that their company participates in midstream programs like PPL Electric Utilities' across the country because "energy-efficient systems are more expensive when selling to an end user" and anything that makes them more affordable "does help [their] sales." The distributor rated the program as *somewhat important* for their 2024 sales.

Customer and Trade Ally Feedback

Cadmus asked the distributor what feedback they have received from their contractor trade allies about the program. The distributor said that contractors have "responded well" to the program, but they wanted higher awareness among contractors. They specifically said that "drawbacks with [their experience with] downstream programs…makes contractors not want to participate in midstream." Cadmus also asked the interviewed contractor about the feedback they had received from customers. Overall, they said that they "don't hear too much as long as they get their [rebate] check," but also said that some customers who do not have internet access or do not want to fill out paperwork do not apply for the rebate despite encouragement from the contractor.

Suggested Changes

Cadmus asked the distributor and contractor respondents what they would like PPL Electric Utilities to change about the program if they could change one thing. The contractor said that they would like there to be fewer questions asked of homeowners in applications, which is something their customers have complained about. The distributor suggested that smart thermostats be added to Midstream Equipment to entice more contractors to participate, since thermostats are often part of full system replacements, which include equipment that currently qualifies.

I.3.3. Other Findings

Participant Profile and Survey Sample Attrition

Downstream Equipment and Audit and Weatherization

The PY16 surveys collected demographic information about participants in the Energy Efficient Homes component.[46] Figure I-6 shows the characteristics of the respondents.

Figure I-6. Energy Efficient Homes Participant Profile

Attribute	Downstream Equipment	Audit and Weatherization
Housing type – percent living in a single-family detached home	86%	80%
Average household size	2.2 people	2.3 people
Average age	67 years of age	61 years of age
Completed some college education or more	78%	93%
Household income of $50,000 or more	78%	90%

Table I-16 lists the total number of records contacted via online survey and the outcome (final disposition) of each record. Additional details on the survey methodology are in *Appendix L. Survey Bias*.

[46] Includes data on Downstream Equipment and Audit and Weatherization.

Table I-16. Energy Efficient Homes Online Participant Survey Sample Attrition

Description of Outcomes of Online Participant Survey	Number of Records	
	Downstream Equipment	Audit and Weatherization
Population (number of unique jobs)	**6,822**	**938**
Removed: inactive customer, completed survey in past three months, on "opt out" list, selected for a different survey, duplicate contact, on “do not contact” list	1,447	218
Removed: incomplete or invalid email address or phone number	0	0
Survey Sample Frame (records attempted)	**5,375**	**720**
Not reached or non-working: Opted out, email returned (bounce back), did not respond	5,011	647
Partially completed survey; ineligible for survey	104	29
Completed Surveys (online)	**260**	**44**
Overall Response Rate	**5%**	**6%**

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STUDENT ENERGY EFFICIENT EDUCATION

This component of the Residential Program provides a school-based energy efficiency education curriculum through classroom presentations to students and classroom materials for teachers.

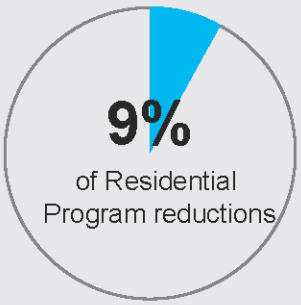
VERIFIED ENERGY SAVINGS

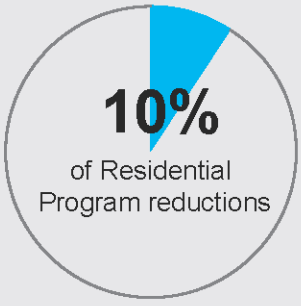
Phase IV has saved **20,215 MWh/yr**

PY16 saved **5,160 MWh/yr**

VERIFIED DEMAND REDUCTIONS

Phase IV has reductions of **2.07 MW/yr**





PY16 has reductions of **0.56 MW/yr**

PY16 PARTICIPATION

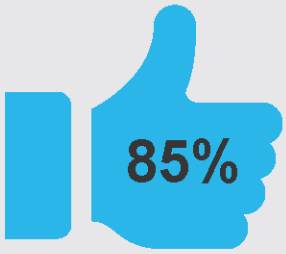
A total of **20,204** participants

5,328 Bright Kids (2nd – 3rd grades)

10,531 Take Action (5th – 7th grades)

4,345 Innovation (9th – 12th grades)

PARTICIPANT SATISFACTION



Satisfied with overall program component

93% Bright Kids (2nd – 3rd grades)

83% Take Action (5th – 7th grades)

78% Innovation (9th – 12th grades)

100% Teachers

Appendix J. Evaluation Detail – Student Energy Efficient Education Component

The Student Energy Efficient Education (SEEE) component provides a school-based energy efficiency education curriculum through classroom presentations to students and classroom materials for teachers. The component includes a poster contest for elementary and middle grades to submit posters illustrating how they would save energy and help the environment. The SEEE component invites participating students at the high school level to participate in an Innovation Challenge to communicate innovative ideas about increasing energy and water efficiency, communicated through artwork, a science project, an essay, literature, photography, music, a service project, video, website project, or any other work of innovation. The curriculum is offered once during the school year, typically in the fall. Students receive educational materials and a take-home kit of energy-saving items to install at home with a trusted adult. PPL Electric Utilities updated the component in PY16 to replace Take Action videos with an interactive ChangeMaker Challenge game where two teams answer quiz questions.

The SEEE component provides kits to students in three cohorts:

- Bright Kids (2nd – 3rd grades)
- Take Action (5th – 7th grades)
- Innovation (9th – 12th grades)

The kits are tailored to each grade level participating in the component. Table J-1 shows the kit items by cohort. Each kit included installation instructions and a cross-promotional insert of other program components that PPL Electric Utilities offers residential customers. There were no changes to the kit contents in PY16 compared to the prior year.

Table J-1. Student Energy Efficient Education Energy-Savings Items by Cohort

Cohort	Kit Items
Bright Kids	LED nightlight, 8W A19 LED light bulb, two 15W A21 LED light bulbs, Tier 1 advanced power strip
Take Action	LED nightlight, 8W A19 LED light bulb, two 15W A21 LED light bulbs, showerhead, kitchen faucet aerator, Tier 1 advanced power strip, furnace whistle, water heater setback card
Innovation	8W A19 LED light bulb, two 15W A21 LED light bulbs, showerhead, kitchen faucet aerator, bathroom faucet aerator, Tier 1 advanced power strip, furnace whistle, water heater setback card

CLEAResult distributes and records each kit as a participant in the residential ICSP database and PPL Electric Utilities tracking database with an identifier for school, classroom, and teacher. PPL Electric Utilities did not collect or record the utility account numbers of classroom students who received a kit.

The ICSP also develops home energy worksheets (HEWs), which students may complete and submit online or in hard copy. The HEWs ask questions to track installation rates of the items in the kits and collect information about participant demographics and component satisfaction. The program offers small grants as incentives for teachers to return 25% or more of HEWs, with amounts starting at $10 and going up to $50 for response rates of 80% or more. Teachers are also requested to complete evaluation forms following their participation.

The ICSP subcontracted with the National Energy Foundation to recruit schools and teachers, with a focus on disadvantaged communities, create curricula correlated with Pennsylvania academic standards, and secure support of the component by the Pennsylvania Department of Education. As in prior years, Energy Federation Incorporated assembled and delivered kits to schools. The ICSP provided oversight and direction to its subcontractors.

PPL Electric Utilities collaborated with the ICSP on the SEEE component's strategic direction while maintaining overarching responsibility for Act 129 administration, program component support, evaluation, and data management.

J.1. Gross Impact Evaluation

J.1.1. Gross Impact Methodology and Sampling Approach

Cadmus planned to apply historical realization rates from the PY15 Annual Report to derive verified savings for PY16.[47] However, upon review with the Statewide Evaluator (SWE), Cadmus confirmed that PPL Electric Utilities-reported savings incorporated verified measure-level installation rates (ISRs) from the PY15 evaluation report. Because ISRs are the primary drivers of realization rates, the SWE agreed that applying historical realization rates after reported savings had already been adjusted to account for updated ISRs would double-count the measure-level adjustments. Instead, Cadmus and the SWE agreed to pass through the reported savings for PY16 as verified savings, effectively resulting in realization rates of 100% for PY16.

J.1.2. Gross Impact Results

Table J-2 shows the SEEE component's verified gross energy savings and demand reductions.

Table J-2. Student Energy Efficient Education Component Savings

Savings	PY13 Verified	PY14 Verified(1)	PY15 Verified	PY16 Verified	Phase IV Verified(2)
MWh/yr	4,797	5,037(3)	5,221(4)	5,160	20,215
System-Level MW/yr	0.47	0.48(5)	0.56(6)	0.56	2.07

(1) PY14 savings were verified in PY15.
(2) Phase IV verified savings may not match the sum of program years due to rounding.
(3) PY14 verified savings for the SEEE component were decreased by 115 MWh/yr to conform with the SWE's PY15 Annual Report findings.
(4) PY15 verified savings for the SEEE component were decreased by 116 MWh/yr to conform with the SWE's PY15 Annual Report findings.
(5) PY14 verified demand reductions for the SEEE component were decreased by 0.01 system-level MW/yr to conform with the SWE's PY15 Annual Report findings.
(6) PY15 verified demand reductions for the SEEE component were decreased by 0.02 system-level MW/yr to conform with the SWE's PY15 Annual Report findings.

[47] PPL Electric Utilities. November 30, 2022. *Phase IV of Act 129 Program Year 13 Annual Report (June 1, 2021–May 31, 2022).* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus.

In PY16, the SEEE component reported energy savings of 5,160 MWh/yr (Table J-3) and demand reductions of 0.52 MW/yr (Table J-4).

Table J-3. Student Energy Efficient Education Component
Gross Impact Results for Energy

Stratum	PYRTD MWh/yr	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Bright Kids	794	100%	0.07	0.5%	794
Take Action	2,971	100%	0.32	1.7%	2,971
Innovation	1,395	100%	0.09	1.1%	1,395
Component Total[2]	**5,160**	**100%**	**0.26**	**1.0%**	**5,160**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Total may not match the sum of rows due to rounding.

Table J-4. Student Energy Efficient Education Component
Gross Impact Results for Demand

Stratum	PYRTD MW/yr	Demand Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MW/yr)	System-Level PYVTD (MW/yr)
Bright Kids	0.07	100%	0.07	0.5%	0.07	0.08
Take Action	0.30	100%	0.35	1.9%	0.30	0.32
Innovation	0.15	100%	0.10	1.1%	0.15	0.16
Component Total[2]	**0.52**	**100%**	**0.28**	**1.1%**	**0.52**	**0.56**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate does not accurately reflect the final verified savings. Cadmus applied realization rates are applied to verified demand reductions before application of distribution losses.
[2] Total may not match the sum of rows due to rounding.

J.2. Net Impact Evaluation

The SEEE component is explicitly offered to schools. The program provides kits free of charge to teachers, who include the kits as part of the school's curriculum and give them to their students to take home. Cadmus did not evaluate free ridership, as there is no expectation that teachers or households will voluntarily purchase and provide the items in the kits to students in the absence of the component. Spillover is also not measured. The SEEE component is assumed to have an NTG ratio of 1.0.

J.3. Process Evaluation

Cadmus conducted a process evaluation of the SEEE component in PY16 to assess student and teacher satisfaction with both the kits and energy efficiency presentation, and to understand what worked well, as well as areas in need of improvement. The evaluation activities were consistent with the planned activities. Table J-5 lists the process evaluation sampling strategy. Completed HEWs produced a measure of component satisfaction with ±0.50% precision at 85% confidence. Sample sizes noted in this report may vary by survey question because respondents could skip questions they chose not to answer; therefore, not all respondents provided answers to every question. Cadmus included all survey respondents who answered at least one question, even if they did not complete the survey.

Table J-5. Student Energy Efficient Education Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Cv in Sample Design	Target Sample Size	Achieved Sample Size	Sample Frame	Percent Contacted [1]
PPL Electric Utilities Program and ICSP Staff	Key individuals from PPL Electric Utilities and CLEAResult	Telephone in-depth interview	2	N/A[2]	Up to 2	2	N/A	100%
Students	Bright Kids, Take Action, Innovation	ICSP subcontractor-administered paper and online HEWs	20,204	N/A[2]	All surveys returned	15,083[3]	All available	100%
Teachers	Bright Kids, Take Action, Innovation	ICSP subcontractor-administered Teacher evaluation forms	702[4]	N/A[2]	All surveys returned	166	All available	100%
Component Total			**20,908**	**-**	**-**	**15,251**	**-**	**100%**

[1] Percent contacted means the percentage of the sample frame contacted to complete surveys and interviews.
[2] The SEEE component evaluation did not include sampling; thus, Cv and target precision are not meaningful and are noted as N/A.
[3] Sample size represents the number of returned HEWs, which may differ from the number of HEWs used for the impact evaluation or the number of responses received for a given HEW question in other process results.
[4] Quantity reflects the number of unique teachers, where each unique teacher is identified by the participant code.

J.3.1. Participant Satisfaction

Students and teachers participate in the SEEE component by receiving kits, presentations, and curriculum. The student HEW and the evaluation form distributed to participating teachers included a satisfaction question. Both questionnaires measure overall satisfaction via a five-point rating scale (*very satisfied*, *somewhat satisfied*, *neither satisfied nor dissatisfied*, *not very satisfied*, or *not at all satisfied*). Overall, 85% of participants were satisfied with their experience with the SEEE component in PY16, as shown in Table J-6. Though a higher proportion of teachers were satisfied than students, student experience accounts for most of the satisfaction score due to the much higher number of students who participated than the smaller number of teachers. While teacher satisfaction increased (99% in PY15 and 100% in PY16), there was no change in overall satisfaction across participating teachers and students compared to PY15 (85% each year).

Table J-6 PY16 Satisfaction for the SEEE Component

Stratum	Overall Satisfaction[(1)]
Students (n=14,913)	85%
Teachers (n=166)	100%
Overall Satisfaction (n=15,079)	**85%**

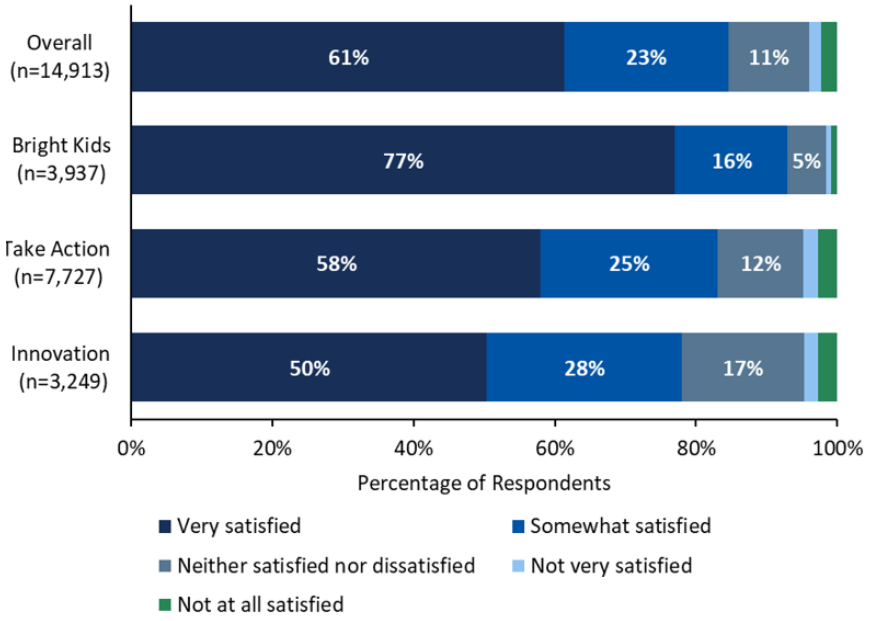
[(1)] As measured by a rating of *very* or *somewhat satisfied*

Student Satisfaction

Teachers received a HEW template they could copy and distribute, which allowed students to complete the HEW on paper or online. Of the 20,204 student population, 15,083 (75%) completed HEWs, and 14,913 answered the satisfaction question. Figure J-1 summarizes the results by cohort. Of the students who responded to the question, 85% said they were *very satisfied* (61%) or *somewhat satisfied* (23%) with the component overall.[48] By cohort, satisfaction ranged from 78% *very satisfied* or *somewhat satisfied* for Innovation students to 93% for Bright Kids students. Overall satisfaction of participating students in PY16 was the same as PY15 (85%).

[48] The sum of *very* and *somewhat satisfied* do not match the overall percentage due to rounding.

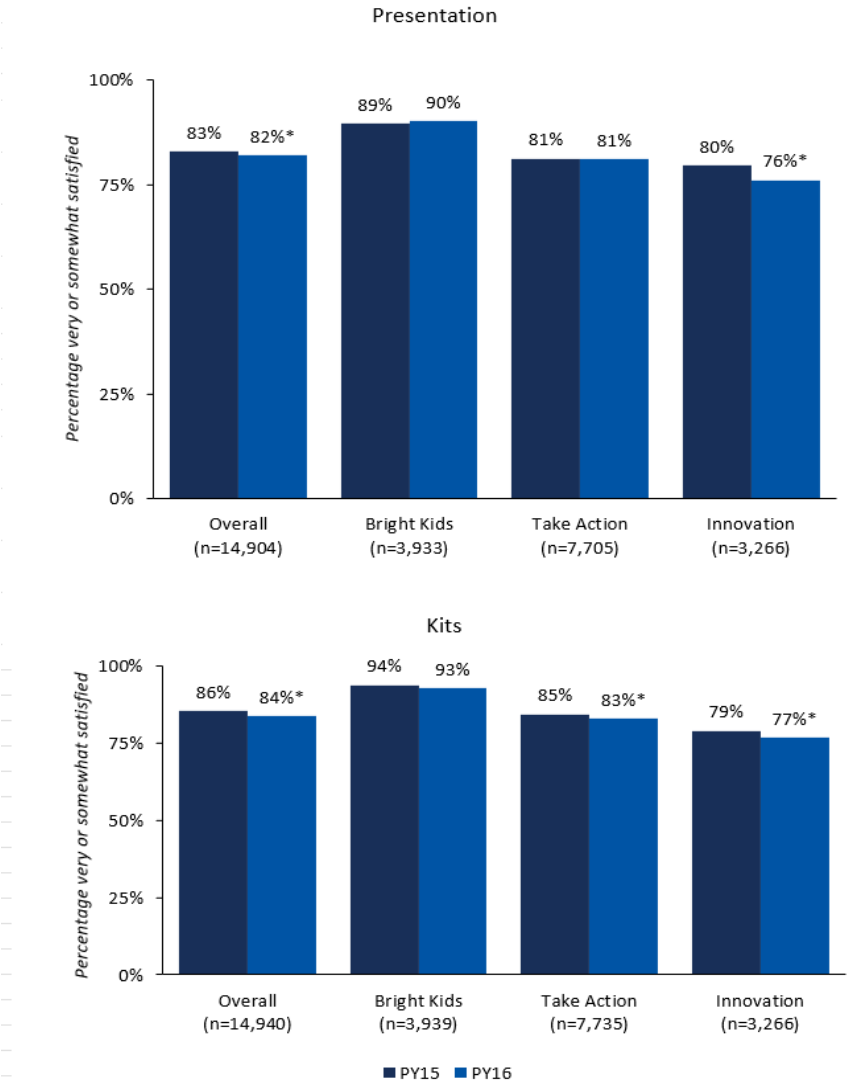
Figure J-1. PY16 Overall Student Satisfaction by Cohort



Source: Home Energy Worksheet: "Please rate your overall satisfaction with the Think! Energy program."
Totals may not sum to 100% due to rounding. The sum of *very* and *somewhat satisfied* may not match the percentage reported on the infographic or in the report text due to rounding.
Unlabeled segments represent 3% or less of respondents.

The HEWs included separate questions to assess student satisfaction for both the presentation and the kit. As shown in Figure J-2, overall satisfaction with the presentation was slightly lower in PY16 compared to PY15. Specifically, among Innovation students, satisfaction with the presentation decreased by four percentage points in PY16 compared to PY15. Similarly, satisfaction with the kits also declined in PY16, with Take Action and Innovation students reporting two percentage-point decreases in the proportion of those who were *very* or *somewhat satisfied* with kits, although the kits did not change between years.

Figure J-2. PY16 Student Satisfaction with Presentations and Kits by Cohort



Source: Home Energy Worksheet:
"How satisfied are you with the presentation?" and "How satisfied are you with the energy efficiency kit?" Not all HEW respondents answered each question.
* Statistically significant difference between years, p<0.05.

Teacher Satisfaction

After participating in the teacher's classroom presentation, presenters asked teachers to rate the delivery of the SEEE component. Of 702 participating teachers in PY16, 24% (166 teachers) completed evaluation forms, and all teachers provided a rating.

Figure J-3 summarizes the results of the teacher satisfaction survey. Nearly all teachers who responded to the survey rated the component as either *very satisfied* (95%) or *somewhat satisfied* (5%; n=166). This is similar to results from PY15 (data not shown), with a slight increase in the rate of *very satisfied*

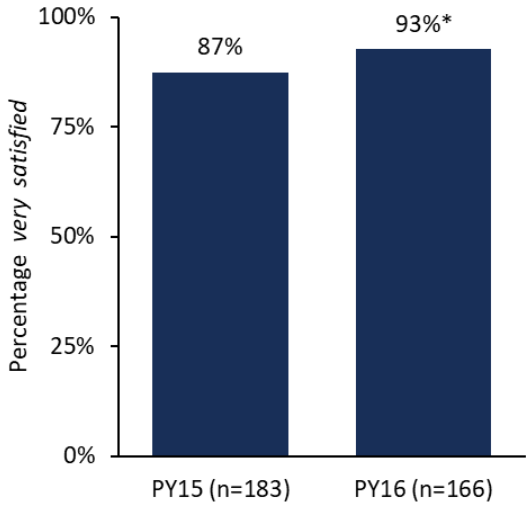
teachers (92% in PY15, p<0.05). Teachers of the Bright Kids cohort rated their impression of the component as *very satisfied* (98%), more often than did teachers of the Innovation cohort (82%, p<0.05).

Figure J-3. PY16 Participating Teacher Satisfaction with Student Energy Efficient Education Component Overall

Source: Teacher Evaluation: "Please share your impression of Think! Energy – Overall Experience."

The teacher evaluation forms included separate satisfaction ratings questions for aspects of the program, including the presentation. As shown in Figure J-4, teacher satisfaction with the presentation was higher in PY16 compared to PY15 (p<0.10).

Figure J-4. PY16 Teacher Satisfaction with Presentations by Program Year



Source: Teacher Evaluation:
"Please share your impression of Think! Energy—Presentation."
* Statistically significant difference between years, p<0.10.

Teacher Feedback

The evaluation forms invited teachers to provide open-ended comments about their experience with the component, and teachers left overwhelmingly positive comments, which were in line with their high satisfaction ratings for the program. In PY16, teachers continued to provide positive feedback on the quality of the presentations, specifically noting the engaging structure of the presentation.

> "This program is fabulous—kid friendly and informative at the same time. The students loved it, and they love getting the kits. This helps their families also conserve energy and use energy wisely."
> *--Bright Kids Teacher*

They also expressed the value of the content covered in the presentations, along with the free kit contents:

- "The students love the presentation. The parents love the home energy kit." (Bright Kids)
- "The presenters were fabulous, fun, and related very well to the students!" (Take Action)
- "It is a fun and engaging presentation that makes students want to become 'Game Changers' in their homes and community!" (Take Action)
- "Thank you for your continued support! Our school has participated in this program since its inception over a decade ago, and it keeps getting better every year. Our students love the lively presentation and the free kit they receive at the end of the day. We also hear great stories of how they used the products in their homes and what they liked the best about using them. We look forward to participating again next year!" (Innovation)

> "Thank you so much for this program. Not only are my students excited to teach others but they have also begun to make sure that the lights in our classroom are turned off before leaving."
> *-Bright Kids Teacher*

- "I think it's a fantastic program that helps us jump-start an energy conversation with the students. We have some great learning time discussing the pieces of the kit and the information they get from the presentation." (Innovation)
- "This is such a great experience for my students. The presenters did an amazing job. All my students were engaged and couldn't wait to come back to the classroom to play the Kahoot on what they learned. I think this is great for my students' families as well because I teach in a low-income school. A lot of students were provided items that could help lower their energy bills, which they may not have been able to get on their own. Such a great program!" (Take Action)

Suggested Improvements

While most comments on the PY16 presentations were quite positive, a subset of teachers in PY16 had a variety of suggestions to improve the program. A total of 14 teachers had suggestions, with the majority from the Bright Kids cohort, even though the cohort accounts for only a quarter of all participants, while Take Action accounts for around half.

The suggestions for improvement provided by the teachers fell into three categories: presentation, kits, and program implementation. Unlike last year, when some feedback focused on videos, this year's suggestions for the presentations emphasized ideas for increasing engagement more generally:

- "More engaging presentation." (Innovation)
- "More questions during presentation for students to answer." (Innovation)
- "During the games, maybe keeping score on each side to have it be more of a friendly competition would engage them even more." (Bright Kids)
- "More small giveaways during the presentation will inspire greater audience participation. Additional shared resources that can continue the program in the classroom would be helpful." (Bright Kids)

With regard to kits, teachers offered a few suggestions for making them as relevant as possible for their students:

- "Thank you, though, try to find more universal items. The furnace whistle doesn't help people in apartments or baseboard heat." (Innovation)
- "The bag for the students should have included something more interesting for the students, like a bee pal or something to that effect. The materials are useful and great; however, there should be something fun for the kids, in my opinion." (Bright Kids)
- "They appreciate the power strip, but is there one that is more modern? This generation needs one that allows a game system to be always on, then turn everything else on when it powers up, or USB plugs." (Bright Kids)

Survey Participant Profile

The PY16 HEWs collected demographic information about participants in the SEEE component. Respondents had the following characteristics:

- Lived in a single-family detached residence (78%; n=14,944)
- Had an average household size of 4.6 people (n=14,986)

Appendix K. Net Savings Impact Evaluation

K.1. Self-Report Survey Methodology

K.1.1. 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.

Following methods defined in the Phase IV Evaluation Framework,[49] Cadmus assessed free ridership. This assessment involves two components: the *intention* to implement an energy-efficient project without a rebate and the *influence* of the program on 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.

Cadmus summed the intention and influence components to estimate the total intention/influence method free ridership average by product or stratum. Free ridership estimates by product or stratum are weighted by *ex post* gross kWh/yr savings.

Intention Score

Cadmus assessed intention by asking questions to determine how the participant's decisions would have differed in the absence of the program. For example, the survey asked the following key question to determine how the residential participant's ductless heat pump project-related decisions would have differed in the absence of a program:

- "Which of the following would have happened if you had not received the $[Field-REBATE] ductless heat pump rebate from PPL Electric Utilities?"
- Response Options
    - Canceled or postponed purchasing a ductless heat pump at least one year
    - Not purchased anything
    - Purchased a less expensive ductless heat pump
    - Purchased a less efficient ductless heat pump
    - Purchased the same exact ductless heat pump without the $[REBATE]
    - Don't know

[49] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

Cadmus used the responses to determine a participant's final intention score, in accordance with the methods defined in the Phase IV Evaluation Framework, which we multiplied by the participant's 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 (*extremely influential*)—various program elements had on the customer's decision to purchase energy-efficient equipment. 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 various program components. Cadmus assessed program influence from participants' ratings of how important various program elements were in their decision to purchase energy-efficient equipment.

K.1.2. Spillover

Following methods defined in the Phase IV Evaluation Framework,[50] Cadmus estimated spillover. To estimate spillover, surveys included questions to determine whether participants installed specific additional high-efficiency products and, if so, whether participation in the 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. Typically, the data collected through the non-residential surveys do not provide enough information to reliably quantify spillover; therefore, potential spillover activity is reported qualitatively.

In presenting interview and survey data in the report, 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.

[50] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* Prepared by NMR Group, Inc., Demand Side Analytics, LLC, Brightline Group, and Optimal Energy, Inc. Final version July 16, 2021.

Appendix L. Survey Bias

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
- Employ stratified random sampling when relevant

The SWE team and PPL Electric Utilities reviewed and approved surveys that Cadmus fielded.

L.1. Survey Contact Instructions

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 and customers who were selected for another survey. This cleaning and survey sample preparation process reduced the available sample.

For online surveys, Cadmus sent email invitations to the remaining contacts with email addresses and followed up with one reminder email invitation. For telephone surveys, Cadmus attempted each record up to five times at different times of the day and weekend, if applicable, and left messages with voicemail where possible.

For multimode surveys, Cadmus first contacted all participants with email addresses to complete an online survey, sent two reminder email invitations, and 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 programs with limited populations.

Appendix M. Non-Energy Benefits

Cadmus quantified non-energy benefits in accordance with the Phase IV TRC order.[51]

M.1. Non-Energy Benefits of Water-Saving Measures

Non-energy benefits associated with water-saving products include the gallons of water saved. According to the recommendation in the SWE Guidance Memo of 2018, Cadmus assumed $0.01 in avoided cost, per-gallon saved, in TRC testing (after gross-up for distribution losses). Cadmus assumed 24.5% losses on water distribution, based on guidance. The avoided cost of water is escalated over the TRC test horizon using the same inflation/escalation assumption embedded elsewhere in the TRC model.

M.2. Non-Energy Benefits of Fossil Fuel Savings

Cadmus calculated fossil fuel benefits in accordance with the direction provided by the 2021 TRC Order. The Pennsylvania Public Utility Commission directed that EDCs should continue to include fossil fuel benefits, consistent with the 2016 TRC Test and the 2018 guidance memo.[52]

M.3. Lighting Interactive Effects

Cadmus calculated lighting interactive effects according to the TRC order, which states:

> "Interactive effects from efficient lighting installations in businesses with electric heat have been captured in the Pennsylvania Technical Reference Manual since the 2009 TRM and interactive effects from homes with electric heat were added in the 2014 TRM. The objective of the TRM is to capture the electric impacts of EE&C measures. The impact of EE&C measures on fossil fuel consumption is a TRC matter, *… Phase IV Act 129 programs will utilize a simplifying approach of monetizing all fossil fuel impacts using the avoided cost of natural gas rather than requiring a separate avoided cost forecast for fuel oil and propane and tracking heating fuel distributions among EE&C plan participants with fossil fuel heat.*"

[51] 2021 TRC Test Final Order - Final order on the TRC Test for Phase IV of Act 129. From the Public Meeting of December 19, 2019, at Docket No. M-2019-3006868. Entered December 19, 2019.

[52] SWE. Guidance on the Inclusion of Fossil Fuel and H_2O Benefits in the TRC Test. March 25, 2018.

PPL Electric Utilities

CADMUS

HOME ENERGY REPORT

This component of the Residential Program encourages customers to save energy by sending them home energy reports that provide information about their energy use, tips for saving energy, and product recommendations.

VERIFIED ENERGY SAVINGS

Phase IV has saved **7,562 MWh/yr**

PY16 saved **7,562 MWh/yr**

VERIFIED DEMAND REDUCTIONS

There are no demand reductions because the component launched after the peak period.

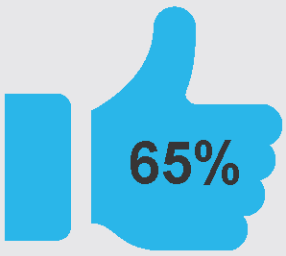
0%
of Residential
Program Savings

0%
of Residential
Program Savings

PY16 PARTICIPATION

A total of **427,592** participants received home energy reports

PARTICIPANT SATISFACTION



Satisfied with the home energy reports

Appendix N. Evaluation Detail - Home Energy Report (HER)

The Home Energy Report component of the Residential 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 (e.g., turning off lights and taking short showers) and product recommendations (e.g., power strips and appliances). These reports also guide customers to PPL Electric Utilities' online energy management portal, also referred to as the energy analyzer portal, where they can update their home profile by entering detailed information about their home to increase the accuracy of the tool.

PPL Electric Utilities' energy efficiency program staff provides overall strategic direction and program management. CLEAResult, the ICSP, manages the Home Energy Report component with the assistance of a subcontractor that is responsible for developing and distributing the program's educational offerings: the home energy reports and the online energy analyzer portal.

In PY16, the component mailed 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 analyzer portal to view usage information, review energy savings recommendations, and suggestions for other program offerings. 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 and were not 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.

None of the customers in the treatment or control groups were carried over from Phase III. The Home Energy Report component ICSP subcontractor identified new treatment and control group customers to expand the program for Phase IV, and Cadmus reviewed the random assignments of these additional customers in PY16.

N.1. Gross Impact Evaluation

N.1.1. Gross Impact Methodology and Sampling Approach Overview

Cadmus conducted the PY16 impact evaluation of the Home Energy Report component using a randomized controlled trial with a large treatment and control group, enabling accurate intent-to-treat estimates. Cadmus conducted panel regression analyses on monthly billing data, including all treatment customers regardless of opt-out status.

To ensure methodological alignment, Cadmus reviewed the gross savings results and modeling process with SWE. While Cadmus and the SWE found discrepancies in the estimates from the Lagged Dependent Variable (LDV, post-only) models, the SWE's LDV results were statistically equivalent to Cadmus' Difference-in-Difference (D-in-D) model results. Because the evaluation plan specified that savings

would be derived with an LDV model, the verified unadjusted savings are based on the SWE's LDV model results.

Additionally, Cadmus adjusted savings for uplift (i.e., additional savings from increased participation in other PPL Electric Utilities residential programs driven by the reports) by estimating and subtracting these savings to avoid double-counting.

Table N-1 summarizes the evaluation sampling strategy.

Table N-1. Home Energy Report Component Gross Impact Evaluation Sample Design

Stratum	Sampling Assumptions	Planned Sample Size (population)	Achieved Sample Size	Impact Evaluation Activity
Treatment	Census	361,810	361,810	• Implemented as a randomized controlled trial • Applied regression analysis with monthly billing data from customers in the treatment and control groups to assess impact and validate results
Control	Census	94,542	94,542	

The impact evaluation activities verified energy savings with ±42% precision at 85% confidence.

N.1.2. Data Preparation

Cadmus worked with PPL Electric Utilities and the ICSP to acquire the data necessary for the Home Energy Report component evaluation in PY16. To prepare for the analysis, Cadmus cleaned and compiled the program tracking data, billing consumption data, and weather data. This section describes the steps Cadmus took to process the data and verify customers in the tracking and billing data. Cadmus also reviewed SWE's data preparation steps and found they were largely consistent with Cadmus' approach, and found both approaches reasonable and defensible.

Program Tracking Data

Cadmus received Home Energy Report component program tracking data from the ICSP at the close of PY16. These data included treatment group customers who received home energy reports and control group customers who were tracked since the program's inception. Because the Home Energy Report component was implemented as a randomized 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. It is important to note that the ICSP did not send reports to all designated treatment customers due to some customers having solar installations, lacking billing data, or having invalid "Neighborhood IDs" for identifying comparison customer clusters. Additionally, treatment customers received their initial reports—either by mail or email—in different months. To maintain the original randomization assignment, Cadmus included all treatment customers in the analysis and defined the treatment start date as the "earliest report received date" among the treatment customers.

Table N-2 shows customer attrition in PY16, by treatment and control groups, and as originally randomized and active at the beginning of treatment. The attrition process identified customers whose accounts closed (became inactive) after the launch of the program. It removed any accounts with inactive dates prior to November 2023 to ensure only relevant participants were included. In PY16, all customers either did not have an inactive date or had inactive dates that occurred within the baseline or evaluation periods.

Table N-2. PY16 Customer Attrition

	Originally Randomized		Active at the Beginning of Treatment in PY16 [1]	
	Treatment	Control	Treatment	Control
Program Total	361,810	94,542	361,810	94,542

[1] Customers active at the beginning of PY16 were not necessarily included in the billing data analysis if they had insufficient billing data.

Billing Data

Cadmus collected customer monthly billing data from PPL Electric Utilities. To clean the billing data, Cadmus followed these steps:

2. Dropped customers whose accounts went inactive before the delivery of the first energy reports.
3. Cleaned and calendarized bills, including dropping bills that covered more than 65 days, those with negative consumption, and those dated earlier than one year prior to the delivery of the first energy reports; trued up bills by replacing estimated consumption values with corrected values based on actual reads; corrected mismatched ZIP codes; and removed duplicated billing cycles.
4. Dropped customers with less than 11 months of pre-treatment bills.

Table N-3 provides the attrition in the PY16 analysis sample from data cleaning steps. The final modeling sample included customers in the program tracking dataset from ICSP who were successfully matched to customers in the billing data and ultimately used in the final billing analysis.

Table N-3. Summary of PY16 Sample Attrition from Data Cleaning

Step in Attrition	Treatment	Control
Originally randomized customers	361,810 (100%)	94,542 (100%)
Included in billing data	358,999 (99%)	93,813 (99%)
Non-missing ZIP code	358,999 (99%)	93,813 (99%)
At least one post-treatment month	353,038 (98%)	92,109 (97%)
At least 11 pre-treatment months	349,583 (97%)	91,163 (96%)
Final Modeling Sample	**349,583 (97%)**	**91,163 (96%)**

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.

N.1.3. 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. The ICSP conducted the randomization for the PY16 program component. Cadmus verified the randomization using the cleaned billing data, comparing the pre-program average annual and monthly consumption from before the launch of the program.

Table N-4 provides the results of the tests for significant differences in treatment and control group pre-treatment consumption. Cadmus found that pre-period months January, February, June, July, and August are significant at ±10% significance, indicating the treatment and control groups are not fully balanced for those months. All other months in the pre-period were balanced at ±10% significance. When examining the average difference across all pre-period months, no statistically significant difference was observed between the treatment and control groups (p-value=0.721), indicating that the treatment and control groups are generally balanced overall.

Table N-4. PY16 Tests for Differences in Pre-Period Electricity Use between Treatment and Control

Pre-Period Month	Average Daily Electricity Use per Customer (kWh)			p-value
	Treatment Group	Control Group	Difference	
December 2023	41.3310	41.4444	-0.1134	0.1127
January 2024	44.2090	44.3601	-0.1511	0.0346
February 2024	40.0299	40.1519	-0.1220	0.0879
March 2024	34.8664	34.9414	-0.0750	0.2941
April 2024	30.0109	30.0002	0.0107	0.8808
May 2024	29.6513	29.5591	0.0922	0.1971
June 2024	37.5387	37.3824	0.1563	0.0289
July 2024	42.3188	42.1473	0.1714	0.0165
August 2024	35.7727	35.6175	0.1552	0.0300
September 2024	29.0782	28.9661	0.1120	0.1185
October 2024	27.0775	27.0373	0.0402	0.5770
November 2024	33.9168	33.9683	-0.0515	0.4765

N.1.4. *Ex Post* Verified Savings Methodology

Energy Savings Model Specification

The following section describes the approach taken by Cadmus for the LDV and D-in-D fixed effects model. The SWE confirmed they followed the same methodology.

Cadmus conducted regression analyses of monthly billing data from customers in the treatment and control groups to estimate the Home Energy Report component's energy savings. The billing analysis

conformed to IPMVP Option C, whole facility,[53] and the approach described in the Uniform Methods Project.[54,55] Cadmus also followed the methods included in the Phase IV Evaluation Framework for behavioral programs.[56]

Specifically, Cadmus used a multivariate regression to analyze the energy use of customers who had been randomly assigned to treatment and control groups, employing two general model specifications to ensure the robustness of savings results: (1) an LDV or (post-only) model and (2) a D-in-D fixed effects model.

The LDV (post-only) model regresses customer average daily consumption on a treatment indicator variable and includes as regressors the customers' pre-treatment energy use, month-by-year fixed effects, and weather.[57] The model is estimated only with post-treatment customer bills. Cadmus clustered the standard errors on customers to account for arbitrary correlation in customer consumption over the analysis period. Cadmus used the D-in-D model to check sensitivity and robustness. The D-in-D model regresses average daily consumption on a treatment indicator variable, month-by-year fixed effects, customer fixed effects, and weather. The model was estimated with pre-treatment and post-treatment customer bills.

Cadmus used the results from the LDV model as the final evaluated results, consistent with what was proposed in the evaluation plan.

The following sections provide additional details about the modeling approaches.

Lagged Dependent Variable Model

The LDV model was specified assuming the average daily consumption (ADC_{it}) of electricity of customer 'i' in month 't' as given by Equation N-1.

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53 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/

54 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

55 Stewart, Jim, and A. Todd. 2020. *The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures*. "Chapter 17: Residential Behavior Protocol." Prepared for National Renewable Energy Laboratory, Golden, Colorado. NREL/SR-7A40-77435. https://www.nrel.gov/docs/fy21osti/77435.pdf

56 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs.* July 16, 2021.

57 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.

Equation N-1

$$ADC_{it} = \beta_1 part_i + \sum_{m=1}^{12} \delta_m pre\_adc_{im} \times M_m + W'\gamma + \tau_t + \varepsilon_{it}$$

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).
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_usage_i	=	Mean household energy consumption of customer 'i' across all pre-treatment months.
M_m	=	Variable indicating the month of the calendar year for months m=1, 2, …, 12
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	=	The month-by-year fixed effects, which reflect unobservable factors that affect the consumption of all households during the month 't'.
ε_{it}	=	Error term for customer 'i' in month 't.'

Difference-in-Difference 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 N-2:

Equation N-2

$$ADC_{im} = \alpha_i + \tau_m + W'\gamma + \beta_1 part_i \times post_m + \epsilon_{im}$$

Where:

α_i	=	Average energy use for 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_m	=	Average energy use in month and year *m* reflecting unobservable factors specific to the month and year; the analysis controlled for these effects with month-by-year fixed effects
W	=	Vector using HDD and CDD variables to control for weather impacts on energy use

γ = Vector of coefficients representing the average impact of weather variables on energy use

β_1 = Coefficient representing the product's conditional average treatment effect on electricity use (kilowatt-hours per customer per day)

$part_i$ = Indicator variable for product participation (which equals 1 if customer *i* was in the treatment group and 0 otherwise)

$post_m$ = Indicator variable for whether month *m* is pre- or post-treatment (which equals 1 if month *m* was in the treatment period and 0 otherwise)

ϵ_{it} = Error term for customer *i* in month and year *m*

Annual Program Energy Savings

Cadmus estimated program savings in PY16 for treated customers as the product of average daily savings per participant and the number of days these customers were treated in PY16, shown in Equation N-3.

Equation N-3

$$Savings_h = -\hat{\beta}_1 * \sum_{i=1}^{N} Treatment\ Days_i$$

Where:

$\hat{\beta}_1$ = Average daily savings (kWh) per treatment group customer, estimated from Equation N-1.

$Treatment\ Days_i$ = The number of days customer 'i' was treated in PY16.

Cadmus estimated realization rates as the ratio of verified program savings to reported program savings (estimated by the ICSP).

Table N-5 shows the LDV (post-only) model estimate of average daily savings per customer and the total savings in PY16. The estimated average daily savings per customer are 0.11 kWh based on the LDV model, as computed by SWE. Cadmus' D-in-D fixed effects model produced estimated average daily savings that were within the confidence interval of the SWE's estimate and not statistically different. The close alignment between these two models demonstrates the robustness of the estimated treatment effects.

Table N-5. PY16 Home Energy Report Program Savings Estimate

Model	Savings Estimate (kWh/day)	Standard Error of Savings Estimate	Treatment Days	Total Evaluated MWh	85% Confidence Interval (Lower Bound)	85% Confidence Interval (Upper Bound)
LDV Model[1]	0.1117	0.0329	65,487,610	7,312.16	4,206.99	10,417.32

Notes: The LDV model results were computed by SWE.

Ex Post Verified Savings Across Time

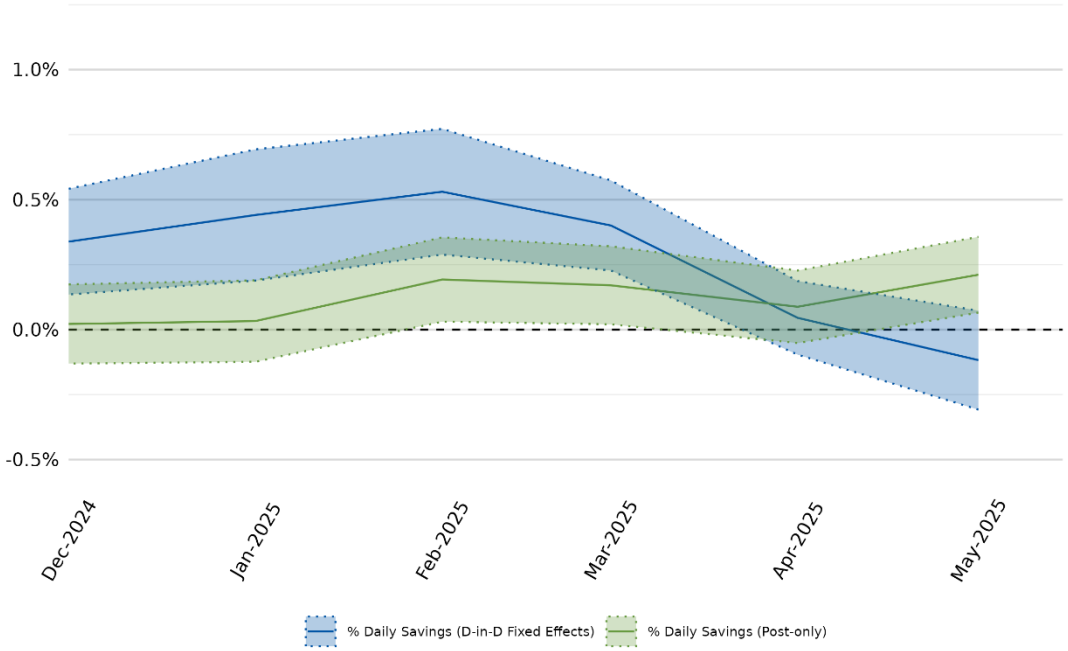
Cadmus also estimated monthly savings. The treatment variable, $part_i$, in equation N-1 was interacted with the month indicator binary variables to produce a monthly estimate of the average daily savings per customer. Because Cadmus included only the current program year and pre-treatment period billings in the regressions, the estimated treatment effect reflects the monthly average treatment effect in the current treatment year, PY16. The average daily savings per customer are the negative of the treatment effect and can be used to estimate total monthly savings in each month.

LDV model monthly regression results show statistically significant savings begin to emerge in February and March 2025 (p value less than 0.1). May savings ramped up and are statistically significant at the 5% level. This pattern is consistent with a ramp-up period and seasonal variation in responsiveness.

D-in-D fixed effects were significant for the months December 2024 through March 2025. All remaining post-periods, April 2025 through June 2025, remained insignificant. Cadmus evaluated average daily savings per customer of 0.013 (p value of 0.64), -0.031 (p value of 0.375), and -0.047 (p value of 0.422) for April, May, and June, respectively. This pattern may reflect the dilution of measured post-period impacts, as customers received treatment at different times and monthly averages; therefore, combined participants were at varying points after treatment initiation. Figure N-1 provides the percentage daily savings across time for each month in PY16. Cadmus calculated the percentage daily savings as the ratio of average daily savings to the monthly average control group consumption.

The blue line in Figure N-1 shows monthly savings resulting from the LDV (post-only) and D-in-D models, with the surrounding shaded area representing the range of statistical uncertainty. Both models show positive savings in the early post-treatment months, though the D-in-D model estimates are higher. The D-in-D model estimates indicate that prior to April 2025, the treatment group showed savings on average daily consumption of between 0.53% and 0.33%. Beginning in April 2025, the D-in-D estimates declined and became statistically insignificant, while the LDV (post-only) model indicates modest positive savings. The wider confidence intervals in later months highlight increased uncertainty as the analysis period progresses.

Figure N-1. Percentage of Monthly Savings Across Time



Demand Reduction Evaluation Methodology

Cadmus did not evaluate peak demand because the Home Energy Report component was not implemented during the peak period as defined in the Pennsylvania TRM.[58] The component launched after December 2024, and the evaluation period ends before June 2025.

N.1.5. Uplift Analysis Methodology

Savings from the Home Energy Report component 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 water-saving equipment. In PY16, some customers who installed efficient products because of the Home Energy Report may have received rebates from PPL Electric Utilities through other Act 129 programs. As a result, these savings could be counted in both the Home Energy Report component and PPL Electric Utilities' other efficiency programs.

To avoid double-counting of cross-program savings caused by the Home Energy Report component, Cadmus subtracted cross-participation savings from the component savings. To do this, Cadmus conducted an uplift analysis to estimate the impacts of the Home Energy Report component on customer participation in PPL Electric Utilities' residential and low-income efficiency programs, as well as the energy savings resulting from that participation. Cadmus refers to any difference in the rate of participation and savings as "participation uplift" and "savings uplift," respectively.

[58] The Pennsylvania TRM defines peak demand impacts as the average reduction in electric consumption from 2:00 p.m. to 6:00 p.m. Eastern Daylight Time on non-holiday weekdays during June, July, and August.

The following sections provide details on uplift results.

Cross-Participation in Downstream Residential Rebate Programs

Cadmus used the experimental design of the Home Energy Report component 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 both groups receive the same marketing and are eligible for incentives from the utility for Product A. The impact of energy reports on the adoption of Product A can then be estimated as the difference in adoption of Product A—and resulting savings—between the randomized treatment and control groups. Any differences can be attributed to the Home Energy Report component.

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 Report component 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 PY16.

Home Energy Report component treatment and control customers could also participate in PPL Electric Utilities' downstream programs in PY16, which includes the Appliance Recycling and Energy Efficient Homes component, and the Low-Income Program.

Participation Uplift

After matching tracking data to Home Energy Report component 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 PY16, divided by the total number of control group customers. If the cross-program participation rate was greater for treatment customers than it was for control customers, the Home Energy Report component had an additive effect on participation in those other programs.

Table N-6 shows the PY16 participation rate uplift results for the Home Energy Report component, 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 Energy Efficient Home Program had the highest cross-program participation in PY16.

Table N-6. Participation Uplift by Program (Per 1,000 Customers)

Program	Participation Uplift per 1,000 Customers	Percentage Participation Uplift
Appliance Recycling	0.0028	0.09%
Energy Efficient Homes	0.3221	16.20%
Low-Income	0.7504	8.21%

Savings Uplift

The savings uplift analysis followed a simple-differences approach. 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 Report 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 PY16. 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 PY16.
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 PY16 yielded the estimate of the total Home Energy Report component savings from participation in other PPL Electric Utilities energy efficiency programs and counted by the other efficiency programs.

The uplift analysis excluded upstream components, whose participation is not tracked at the customer level. Since there were no upstream lighting installations after the launch of the Home Energy Reports component, the default upstream reduction factor from the Phase IV Evaluation Framework is not applicable. Given the expected small treatment effect, conducting a large-scale customer survey to capture small uplift savings is not worthwhile.

Table N-7 shows energy savings uplift results for PY16 resulting from PPL Electric Utilities' downstream programs. The negative uplift savings indicate that the Home Energy Report component did not lead to

additional energy savings in these downstream programs. Per SWE's feedback, in calculating verified adjusted savings, Cadmus net out the negative uplift values.

Table N-7. Home Energy Report Component Uplift Energy Savings Summary

	Average Cross-Program Savings per Customer (kWh/yr)			Total Uplift Savings (MWh/yr)
	Treatment Group	Control Group	Difference	
Program Total	3.43	4.12	-0.69	-250.04

Although uplift savings were negative, participation uplift (presented in an earlier section) was positive. This suggests that the Home Energy Report component encouraged customers to participate in other efficiency programs, but those participants did not generate the expected incremental savings. It is likely that treatment customers adopted additional energy efficiency measures through downstream programs; however, the measured savings attributable to these actions were relatively low.

N.2. Gross Impact Results

Table N-8 shows the verified gross energy savings, adjusted by uplift savings, for the Home Energy Report component. As mentioned earlier, Cadmus did not evaluate peak demand because no treatment occurred during the peak period as defined in the Pennsylvania TRM.

Table N-8. Home Energy Report Component Savings

Savings	PY16 Verified[1]	Phase IV Verified[1]
MWh/yr	7,562[2]	7,562
System-Level MW/yr	0.00	0.00

[1]Verified savings in this table reflect the removal of energy-savings uplift (double-counting) in the component.
[2]Includes uplift.

In PY16, the Home Energy Report component reported energy savings of 6,215 MWh/yr, as shown in Table N-9. Cadmus verified 118% of the reported savings. The evaluated savings confidence interval (85%) ranged from 4,457 MWh/yr to 10,667 MWh/yr, which does encompass the reported savings estimate. The variance is likely attributable to the low statistical significance of results and limited precision in the underlying calculations. Many treatment customers received their first report later than the planned treatment start date. Using the planned date as a universal proxy for treatment introduced measurement error in treatment timing.

Table N-9. Home Energy Report Component Gross Impact Results for Energy

Stratum	PYRTD (MWh/yr)	Energy Realization Rate[1]	Sample Cv or Error Ratio	Relative Precision at 85% C.L.	PYVTD (MWh/yr)
Treatment	6,215	118%	0.29	42.48%	7,312
Total (Verified)[2]	**6,215**	**118%**	**0.29**	**42.48%**	**7,312**
Adjustment for Double-Counted Savings (uplift)	-	-	-	-	-250[3]
Adjusted Savings[2]	**6,215**	**122%**	**0.29**	**42.48%**	**7,562**

[1] Due to rounding, multiplying the PYRTD savings by the realization rate will not accurately reflect the final verified savings.
[2] Total may not match the sum of rows due to rounding.
[3] Per SWE guidance, negative uplift savings are still applied as a subtraction from the unadjusted savings. When there are differences in energy efficiency program participation between the treatment and control groups, the incremental savings from that differential uptake are already captured in the regression-based estimate. In this case, applying the correction increases the PY16 verified savings by 250 MWh.

N.3. Net Impact Evaluation

The Home Energy Report component 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.

N.4. Process Evaluation

Cadmus conducted a full process evaluation of the Home Energy Report component using data collected through an online participant survey and interviews with staff from PPL Electric Utilities, the ICSP, and the ICSP's subcontractor. The research objectives for the process evaluation were to assess participant satisfaction, review component changes and performance, assess component design and customer experience, and make recommendations for improvement. Table N-10 shows the sampling strategy for the process evaluation. The results from the participant survey produced a measure of component satisfaction with ±10% precision at 90% confidence.

See Appendix L for details on Cadmus' approach to reduce survey bias and contact instructions. A total of 1,280 customers responded to the online survey from May 2 through June 4, 2025, of whom 1,133 respondents passed screening questions and were thus eligible to complete the survey. In total, 997 respondents (475 treatment customers and 522 control customers) completed the survey, defined as providing an answer for at least one demographic question at the end of the survey. The evaluation was consistent with the approved evaluation plan.

Sample sizes noted in this report may vary by survey or interview question because respondents could skip questions they chose not to answer; therefore, not all respondents provided answers to every question. Cadmus included all survey and interview respondents who answered at least one question, even if they did not complete the survey or interview.

Table N-10. Home Energy Report Component Process Evaluation Sampling Strategy

Stratum	Stratum Boundaries	Mode	Population Size	Assumed Cv in Sample Design	Target Sample Size	Achieved Sample Size	Sample Frame[1]	Percent Contacted [2]
PPL Electric Utilities Program and ICSP Staff	Key individuals from PPL Electric Utilities, ICSP, and the ICSP's subcontractors	Telephone in-depth interview	3	n/a	Up to 3	3	3	100%
Customers	Treatment	Online survey	361,810	0.50	400	475[3]	55,000	100%
	Control	Online survey	94,542	0.50	400	522[3]	35,000	100%
Component Total			**456,355**	**-**	**About 803**	**1,000**	**90,003**	**100%**

[1] The sample frame is a list of participants and program staff with contact information who had a chance to complete the survey or interview. The final sample frame includes unique records in the PPL Electric Utilities database at the time of the surveys. After selecting all unique records, Cadmus removed any records from the population that 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 via telephone or email to complete surveys/interviews.

[3] Achieved sample size shows the number of respondents who completed the survey. When reporting, Cadmus included all responses in the analysis, even if the respondent did not complete the survey. The number of respondents used in the process evaluation differs from the numbers used in the gross impact analysis.

N.4.1. Home Energy Report Survey

The Home Energy Report survey was administered online to both treatment and control group respondents. There were two purposes for this survey: first, to gauge customer experience based on the treatment group's interactions with the reports, and second, to provide comparisons between treatment and control group customers on indicators of program performance.

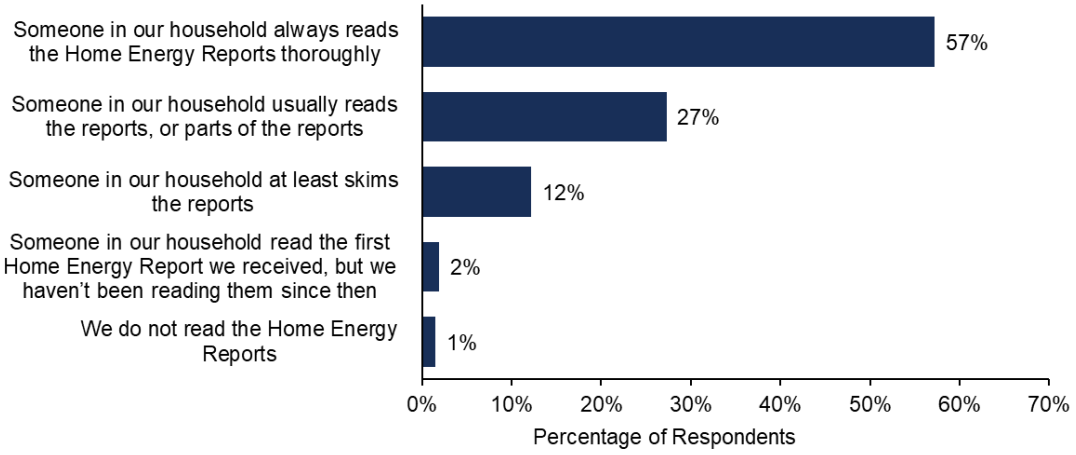
Experience with Home Energy Reports

One of the primary objectives of the survey was to gather feedback on customer experience regarding the design of the program component, as well as participation rates, effectiveness of, and satisfaction with the reports from those who receive them (i.e., the treatment group).

Readership of Home Energy Reports

The survey asked treatment respondents if they recalled seeing the home energy reports, and 89% answered yes (n=585). Treatment respondents who did not recall receiving reports were informed that they were not qualified to take the survey. Among those who recalled receiving reports, they were asked the extent to which they read through them, with 57% saying that someone in their household always read the report thoroughly (n=484). Only 3% of treatment respondents said that they either do not read the reports or that they had read the first one but none after that, indicating that almost all respondents who recalled receiving reports at least skim the reports they receive (Figure N-2).

Figure N-2. PY16 Level of Readership of Home Energy Reports



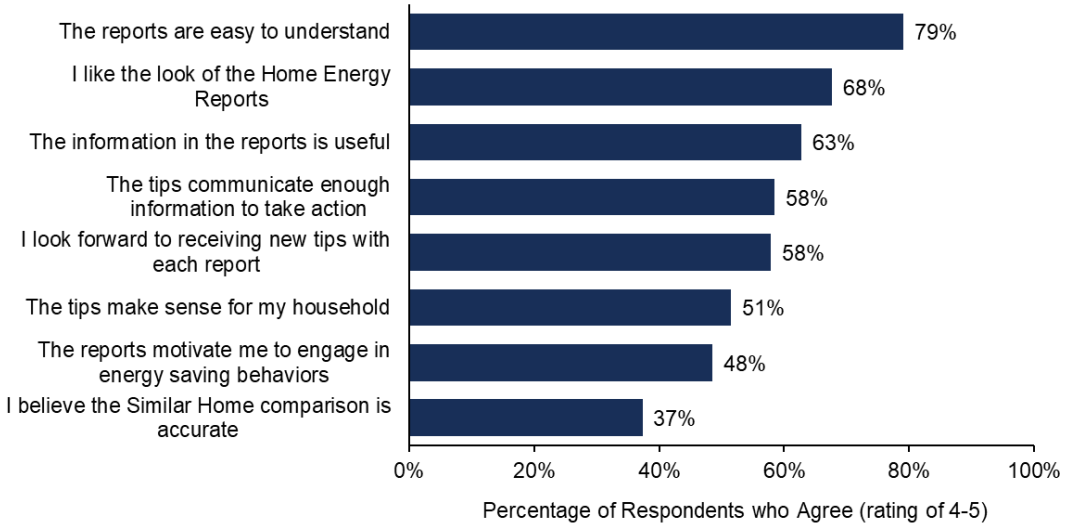
Source: Home Energy Report Treatment Survey, "Which of the following statements best describes what you do with the Home Energy Reports you received from PPL Electric Utilities?" (n=484)

Perceptions of the Home Energy Reports

The survey asked treatment respondents to indicate their level of agreement with eight positive statements about the helpfulness and relevance of the reports. Figure N-3 shows that more than half of respondents agreed with six of the eight statements, with the highest percentage of agreement for the statement "*The reports are easy to understand*" (79%). The fewest percentage of respondents agreed with the statement "*I believe the Similar Home comparison is accurate*" (37%). About half of the

respondents agreed that the reports motivated them to engage in energy-saving behaviors (48%) and that the tips included with reports made sense for their household (51%).

Figure N-3. PY16 Agreement with Statements about Home Energy Reports

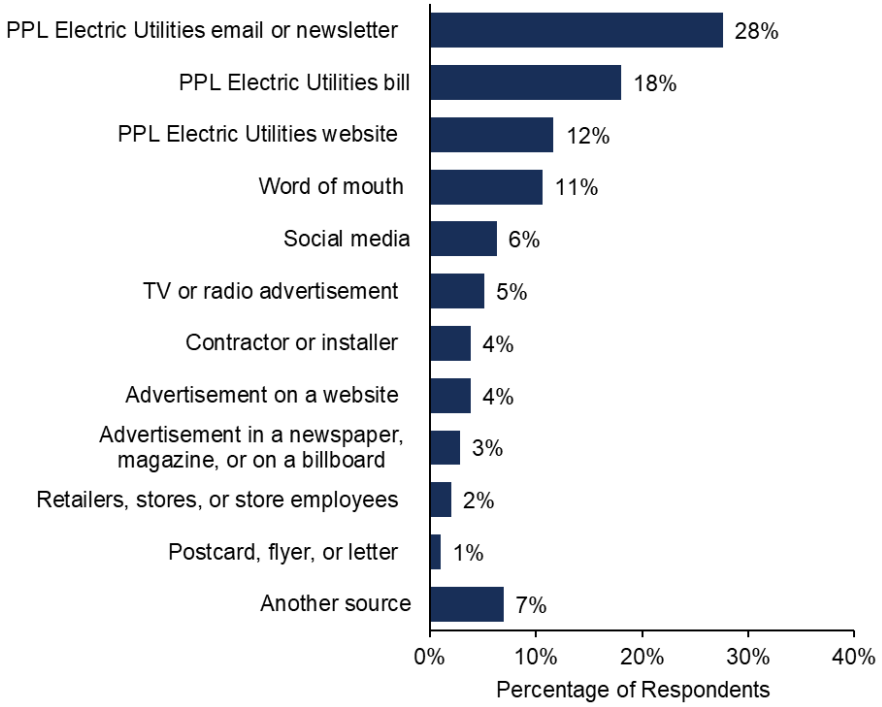


Source: Home Energy Report Treatment Survey, "To what extent do you disagree or agree with the following statements about the Home Energy Reports?" (n=494)

Control Group Baseline Comparison of Information Seeking Behavior

To establish a baseline for energy-saving information-seeking behavior, the survey asked respondents in the control group how frequently they sought or heard about information regarding home energy-saving strategies or products. Among this group, 27% said they sought or heard relevant information *very often* or *often*, whereas 44% said *sometimes,* and 29% said they either *rarely* or *never* sought or heard of this type of information (n=548). Respondents were then asked to identify the sources from which they sought or heard home energy saving strategies and products. The most frequently cited source was PPL Electric Utilities emails or newsletters (see Figure N-4).

Figure N-4. PY16 Sources of Information on Saving Energy Among Control Group Customers

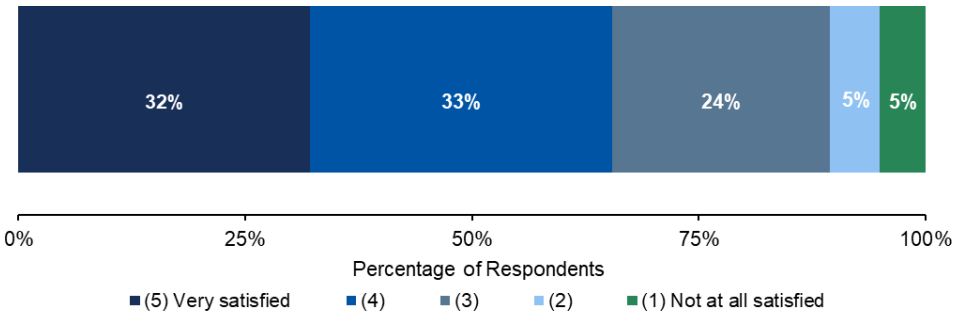


Source: Home Energy Report Control Survey, "How do you seek out or hear about information regarding home energy saving strategies or products?"; Multiple responses allowed (n=489)

Satisfaction with Home Energy Reports (Treatment Group)

The survey asked treatment group customers to rate their satisfaction with the PPL Electric Utilities home energy reports on a 5-point scale, where 1 means *not at all satisfied* and 5 means *very satisfied*. As shown in Figure N-5, most respondents rated themselves as being satisfied with the reports (65% gave 4 or 5 ratings) and only 10% were not satisfied (gave 1 or 2 ratings).

Figure N-5. PY16 Satisfaction with Home Energy Reports Overall



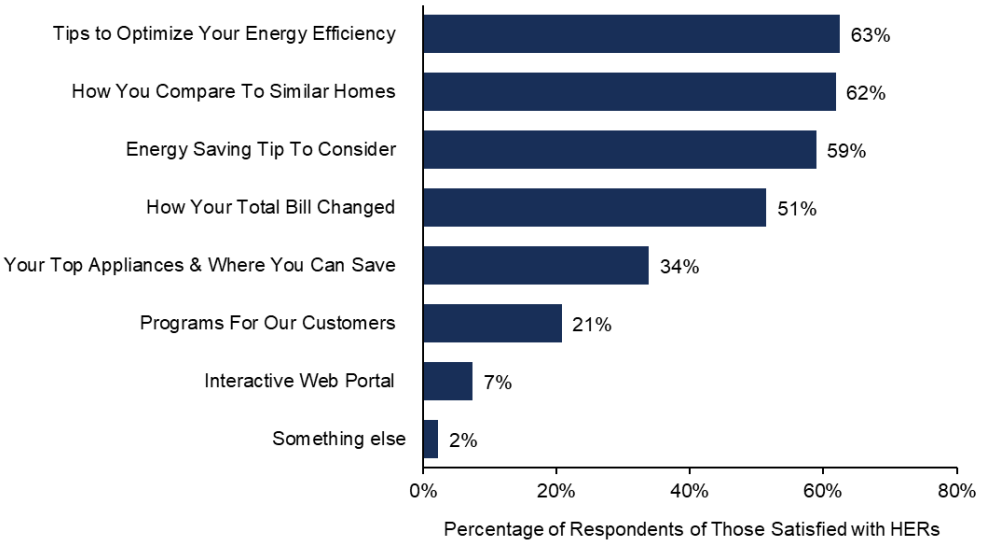
Source: Home Energy Report Treatment Survey, "How would you rate your overall satisfaction with the Home Energy Reports?" (n=492)

Drivers of High and Low Satisfaction with Home Energy Reports

The survey asked treatment respondents who were satisfied with their reports to identify which aspects of the reports they were particularly satisfied with. Figure N-6 shows a breakdown of the percentage of

respondents who rated each aspect of the report as contributing to their satisfaction. The most frequently cited aspects were tips to optimize energy efficiency (63%), similar homes comparisons (62%), and energy saving tips to consider (59%).

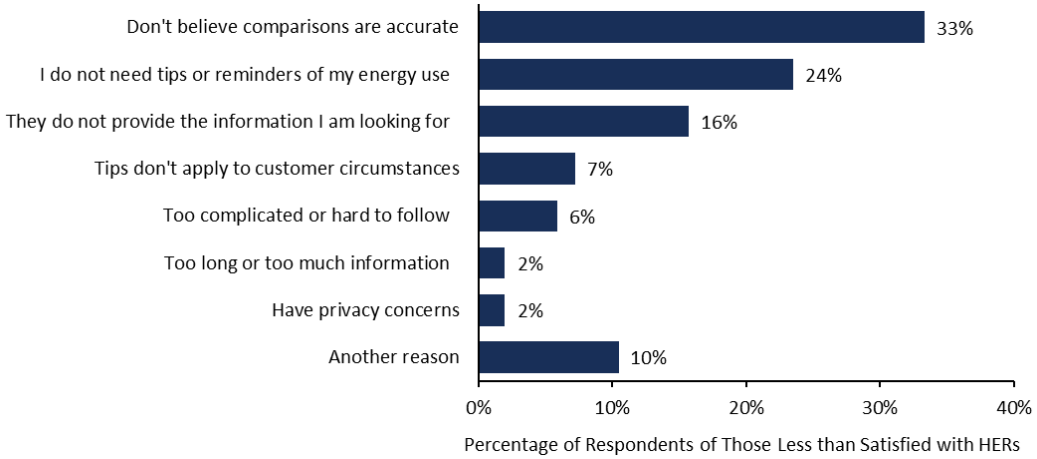
Figure N-6. PY16 Drivers of High Satisfaction with Home Energy Reports



Source: Home Energy Report Treatment Survey, "What aspects of the Home Energy Reports were you particularly satisfied with?"; Multiple responses allowed (n=307)

Conversely, respondents who were less than satisfied with their reports were asked for specific reasons why they provided their satisfaction rating. As shown in Figure N-7, the most frequently cited reasons were that respondents didn't believe the comparisons to be accurate (33%) and that they didn't need tips or reminders about their energy use (24%). For those who said that the reports did not provide the information they were looking for, respondents were asked to state the information that they were looking for. Four requested more information explaining how the "similar homes" comparisons worked, and five others said that the reports were not specific enough to their situation or that they were missing key information relevant to their individual situations.

Figure N-7. Drivers of Low Satisfaction for Home Energy Reports

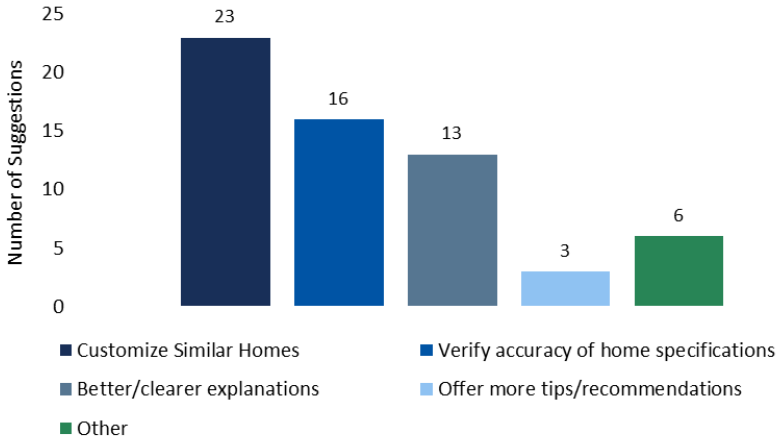


Source: Home Energy Report Treatment Survey, "Why are you less than satisfied with the Home Energy Reports?" Multiple responses allowed (n=153)

Suggestions on How to Improve the Home Energy Reports

Treatment group respondents were given the opportunity to say whether there was anything about the reports that they would change to improve and to provide suggestions on how to do so. Of the 475 respondents who answered the question, 18% said they would change something about the report to improve it. However, only 61 respondents (13%) offered constructive suggestions for improving the reports. Cadmus excluded several comments that indicated disinterest rather than suggestions for improvement (e.g., "don't send [me these reports]") or were not pertinent to the reports from the analysis. Among the suggestions provided, there were a few common themes that emerged. The most common themes included suggestions related to improving the customization of the "similar home comparisons," followed by suggestions to improve the verification process for home specifications, as well as a call for better or clearer explanations as to how the reports work and the data used. Figure N-8 includes a breakdown of the selected responses.

Figure N-8. Suggestions on How to Improve Home Energy Reports



Source: Home Energy Report Treatment Survey, "Is there anything about the Home Energy Reports that you would change to improve them? - If yes, please describe (n=61)

Verbatim quotes from respondents are provided by theme below:

- Better customization of similar homes
  - "Improve home comparisons to account for homes that are 100% electric with no other utilities."
  - "My house [is] completely electric and the winter comparison doesn't reflect the source of heating to similar homes."
  - "I have an ENERGY STAR home. Need to compare to similar homes."
- More detailed verification of home specifications
  - "Accurately reflect my home's square footage and age."
  - "Ask residents to specifically identify conditions that may impact energy utilization."
  - "Consider household size. Consider if an occupant needs medical equipment running on electric[ity]."
- Better or clearer explanation for how the report works
  - "You need to provide a detailed explanation of what you are using for a comparable home."
  - "I would like some more detail on comparison to know more precisely how we compare."
  - "Report says always on. What are you referring to so that I can change what is always on?"

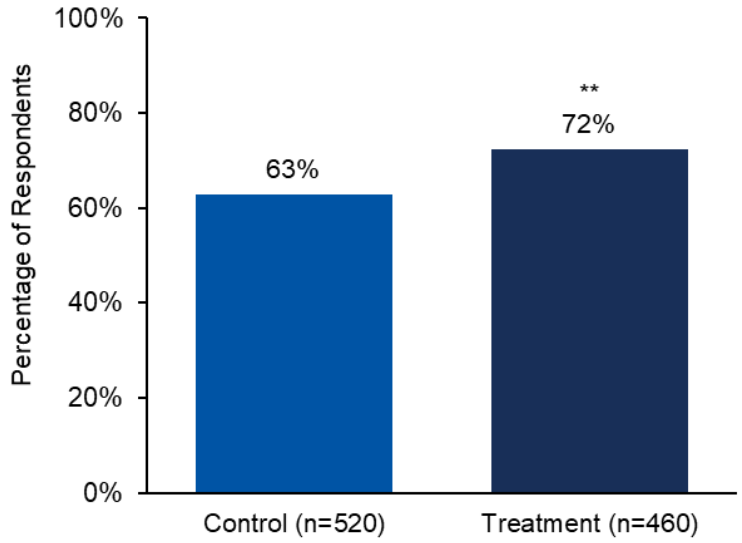
Treatment and Control Group Comparisons

The Home Energy Report survey also assessed respondents on several key metrics, including awareness of PPL Electric Utilities programs and rebates, engagement with the utility's website, engagement in energy-saving behaviors and home improvement, barriers preventing engagement with energy-saving behaviors, confidence to overcome challenges, and perceptions of and satisfaction with PPL Electric Utilities. Cadmus analyzed responses between the treatment and control groups on relevant measures and assessed statistical significance at the 90% and 95% confidence levels.

Awareness of PPL Electric Utilities Programs and Rebate Offers

Although treatment and control groups had access to the same online resources where they could discover energy efficiency details and information about other programs offered by PPL Electric Utilities, the reports that treatment group customers received included promotions for other PPL Electric Utilities energy efficiency programs, as well as energy-saving related reminders and tips. When asked about their general familiarity with energy efficiency programs and rebates offered by PPL Electric Utilities to reduce energy use and save money on energy bills, significantly more treatment (72%) than control (63%) group respondents reported having heard about such programs over the past six months ($p \leq 0.05$; Figure N-9).

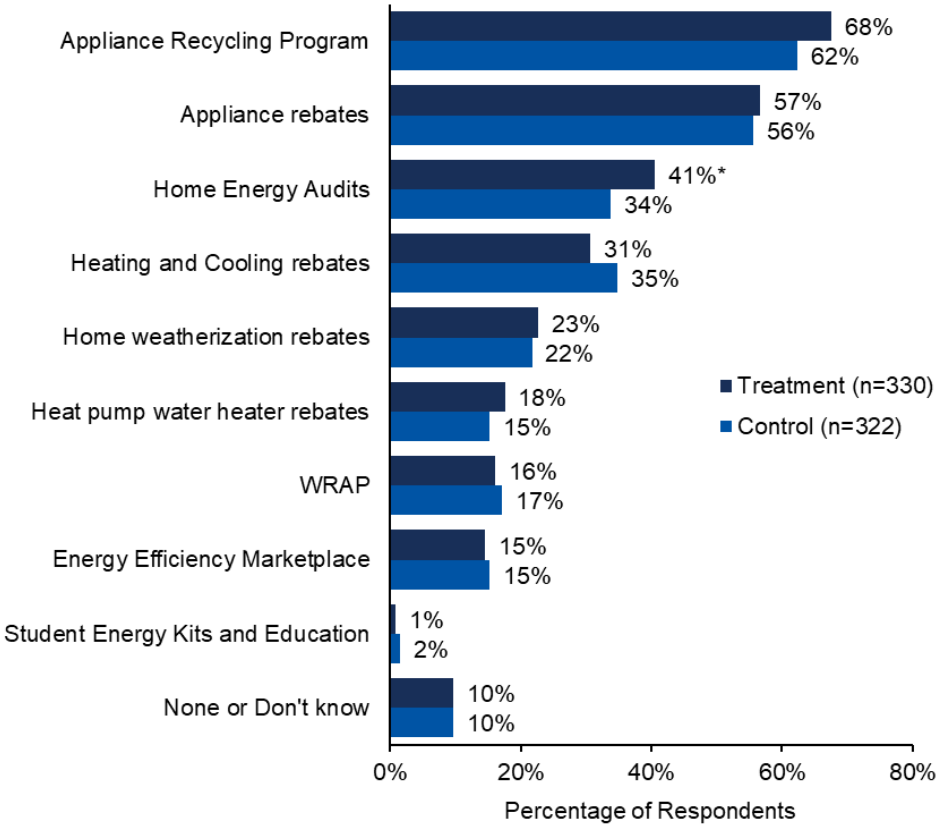
Figure N-9. Awareness of PPL Electric Utilities Energy Efficiency Programs



Source: Home Energy Report Treatment Control Survey, "Over the past six months, have you heard anything about PPL Electric Utilities programs that provide rebates on the purchase of energy efficient equipment, or that help you to save energy and money on energy bills in other ways?"
**Indicates a significant difference between groups (p≤0.05).

Survey respondents who said they were aware of programs offered by PPL Electric Utilities answered a follow-up question to identify the energy efficiency programs they had heard of from a list of programs. Overall, program awareness was highest for Appliance Recycling, and lowest for Student Energy Efficiency Education, heat pump water heater rebates, WRAP, and the Energy Efficiency Marketplace (Figure N-10). The treatment group was more likely than the control group to be aware of Home Energy Audits offered by PPL Electric Utilities ($p<0.10$). Of treatment group customers, 55% reported that the home energy reports were helpful in familiarizing them with (4 or 5 on a 5-point scale, where 5 means *Familiar*) the PPL Electric Utilities program components that they mentioned (n=192).

Figure N-10. Programs Recognized by Customers Aware of Programs from PPL Electric Utilities

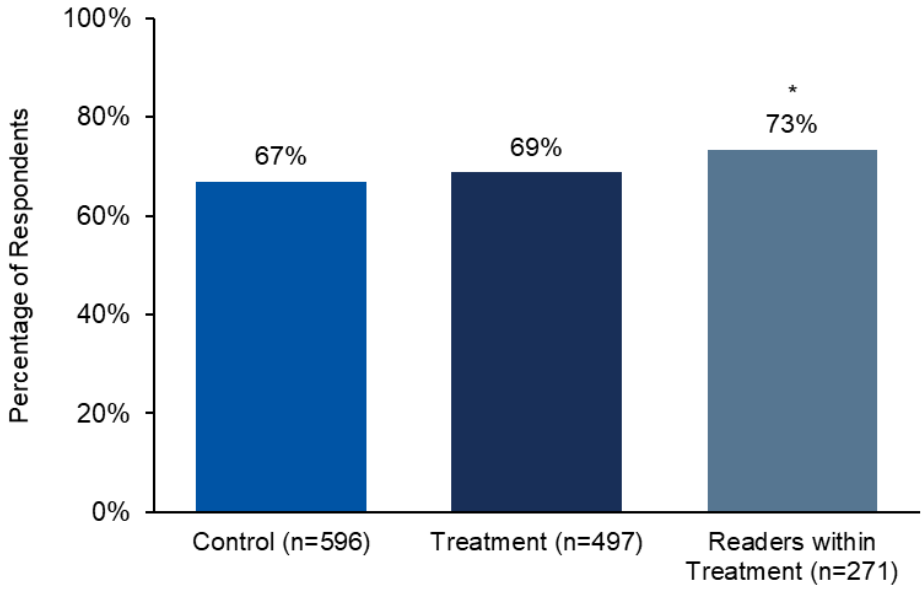


Source: Home Energy Report Treatment Control Survey, "Which PPL Electric Utilities rebate or energy efficiency programs have you heard about over the past six months? Select all that apply."
*Indicates a significant difference between groups (p≤0.10).

Engagement with the PPL Electric Utilities Website

Treatment and control group survey respondents shared whether they had visited the PPL Electric Utilities website in the past six months. Figure N-11 shows that treatment and control group respondents visited the PPL Electric Utilities website to look for ways to save money on their utility bills in the past six months at similar rates. However, when isolating treatment group respondents who said they read the reports thoroughly, there was a statistically significant difference compared to the control group; treatment group respondents who read the reports thoroughly were more likely to visit the website in the past six months (p<.10).

Figure N-11. Self-Reported Visits to the PPL Electric Utilities Website in the Past Six Months



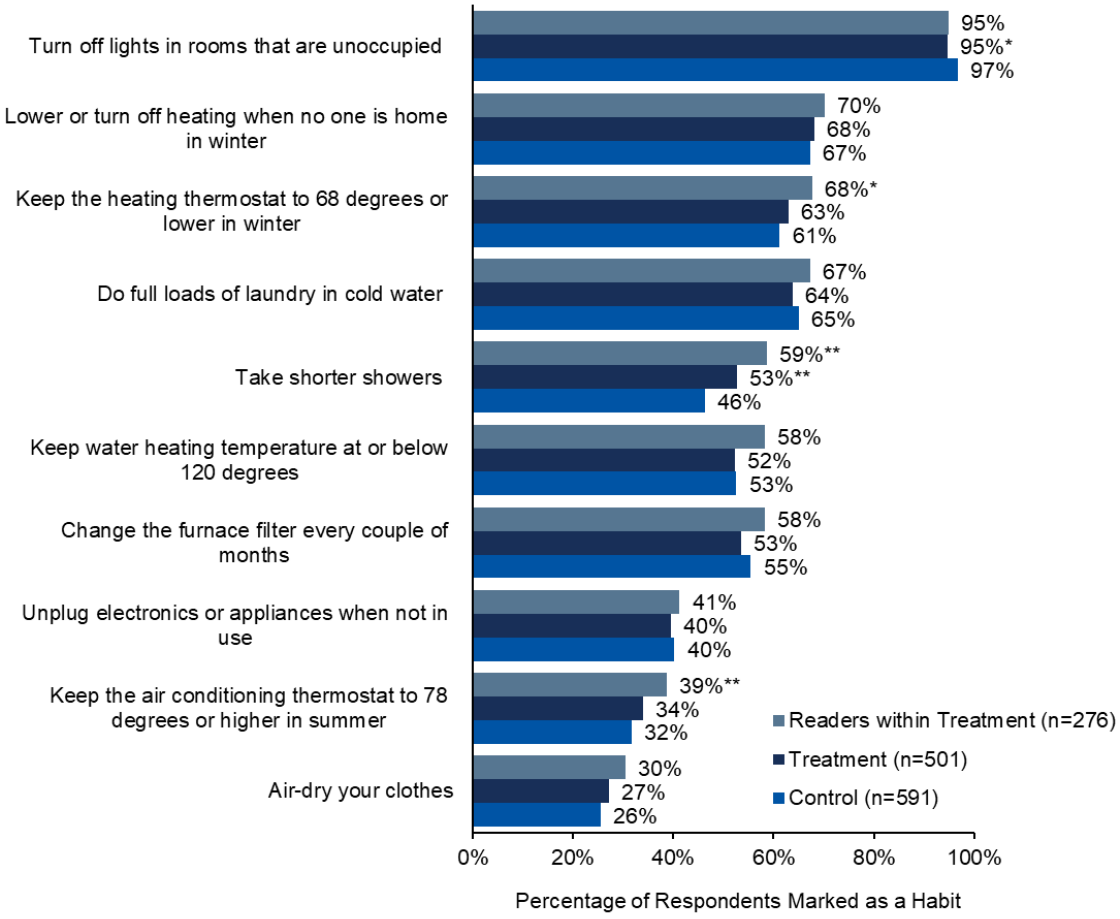
Source: Home Energy Report Treatment Control Survey, "Have you visited the PPL Electric Utilities' website in the past six months?"
*Indicates a significant difference between control and treatment customers who read reports thoroughly (based on their response to "Which of the following statements best describes what you do with the Home Energy Reports you received from PPL Electric Utilities?"); (p≤0.10).

Engagement in Energy Saving Behaviors and Home Improvement

Survey respondents provided information about the everyday habits they practice that could help them save energy, as well as home improvement measures that they have completed within the past six months. Overall, the vast majority of respondents said that they habitually turned off lights in unoccupied rooms, while far fewer respondents said that they regularly air-dried their clothes or kept their air conditioning temperatures at 78°F or higher during the summer.

In terms of between-group differences, treatment respondents were statistically significantly more likely to take shorter showers than control respondents (p<.05). When comparing treatment readers to the control group, Home Energy Report readers were more likely to keep the air conditioning at 78°F or higher (p<.05), keep the heating thermostat at 68°F or lower in the winter (p<.10), and take shorter showers (p<.05; Figure N-12).

Figure N-12. Energy-Saving Habits



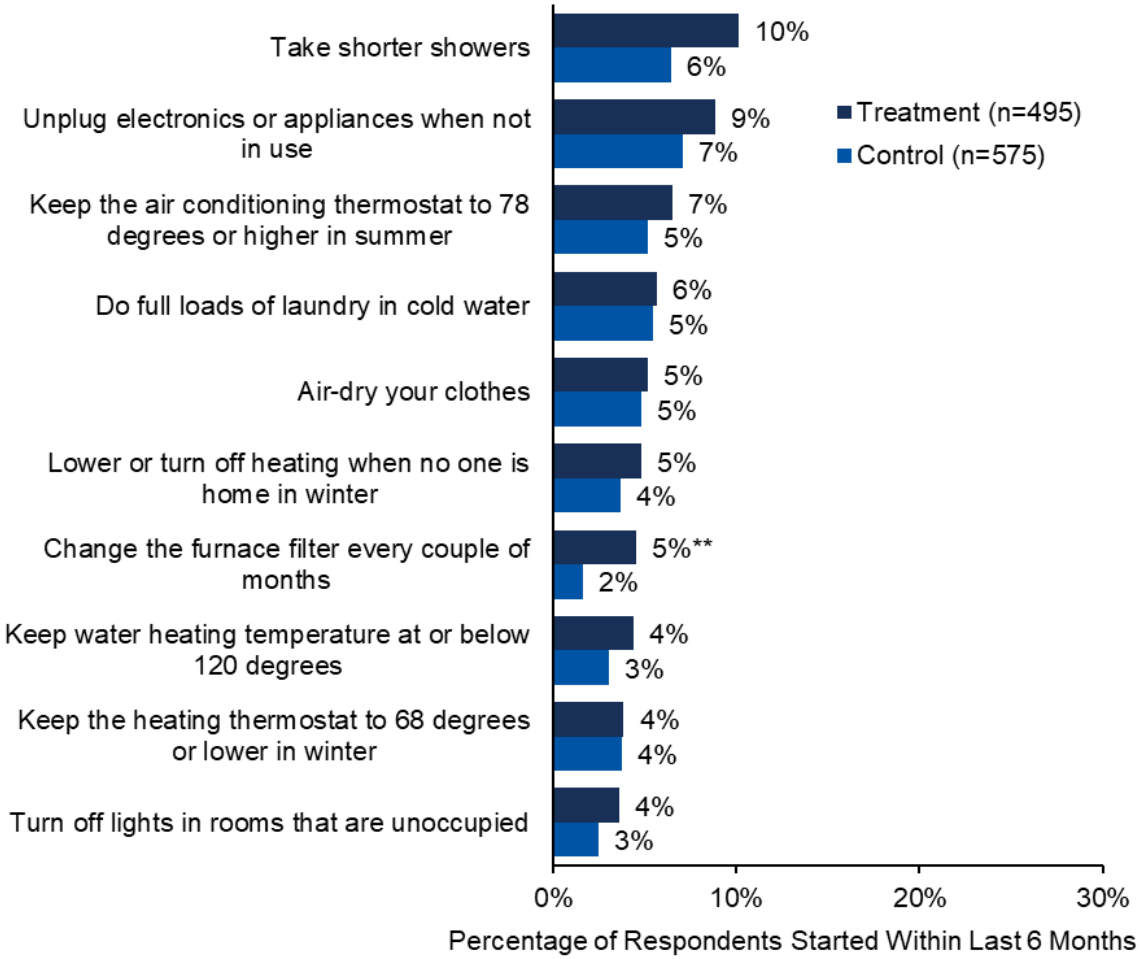
Source: HER Treatment Control Survey, "Below is a list of everyday habits that can save energy. Please check all the items your household tries to make a habit of."

*Indicates a significant difference between groups (p≤0.10).

**Indicates a significant difference between groups (p≤0.05).

The survey also asked respondents whether they had started practicing each habit that they reported engaging in within the past six months or prior to six months. Overall, respondents appear to have been engaged in habits longer than the six-month period in which the reports were disseminated. When comparing groups, treatment respondents had an incrementally higher rate of increasing practice for every habit compared to the control group; however, the only statistically significant difference was the uptick in changing furnace filters every couple of months (p<.05; Figure N-13)

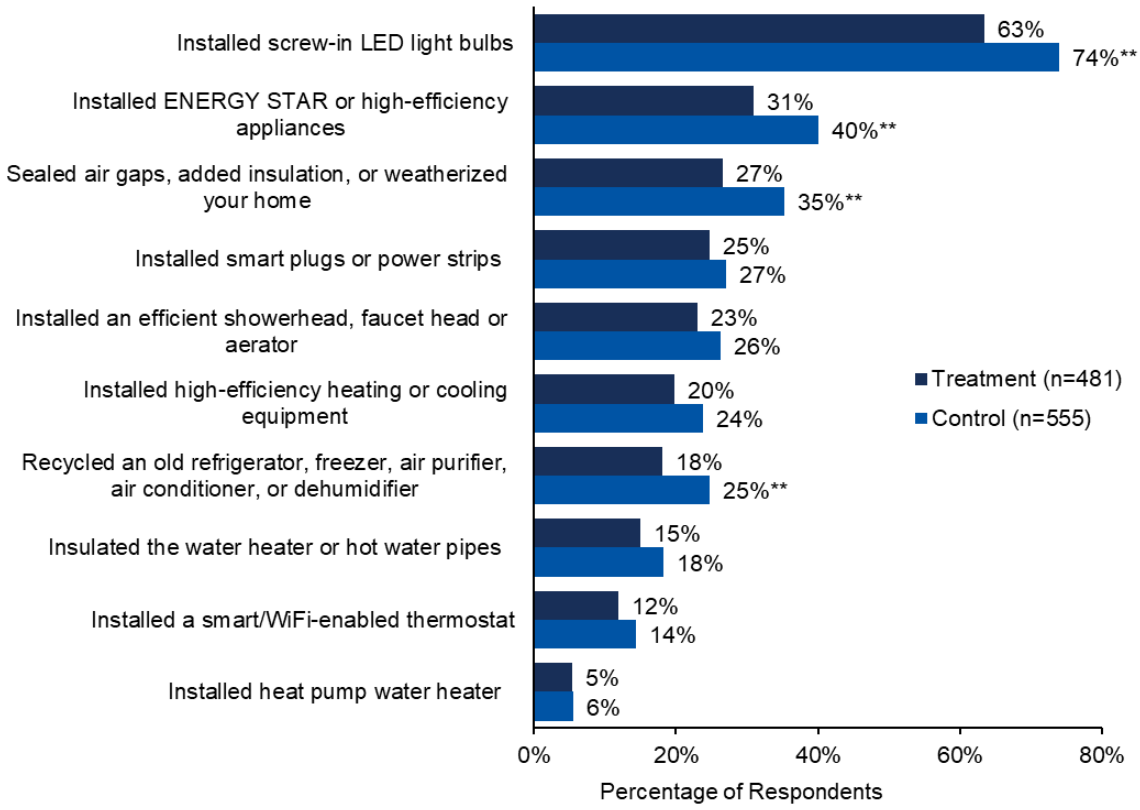
Figure N-13. Adoption of Energy-Saving Practices within the Past Six Months



Source: HER Treatment Control Survey, "For each of the habits that you selected, please indicate whether you started doing this within the past six months or if you started doing this more than six months ago."
**Indicates a significant difference between groups (p≤0.05).

Survey respondents then indicated whether they had completed any items from a list of 10 home improvement actions over the past six months. Overall, respondents were most likely to report that they had installed LED lighting and ENERGY STAR high-efficiency appliances. The home improvements that respondents mentioned the least were installing heat pump water heaters and smart/Wi-Fi-enabled thermostats. Counter to expectations, the control group respondents reported undergoing home improvements, including installing LED light bulbs, ENERGY STAR appliances, weatherization, and recycling old appliances, significantly more often than treatment respondents (Figure N-14).

Figure N-14. Energy-Saving Home Improvements Made in the Past Six Months



Source: HER Treatment Control Survey, "Below is a list of energy-saving home improvements. Please check all the items your household has done in the past six months."
**Indicates a significant difference between groups (p≤0.05).

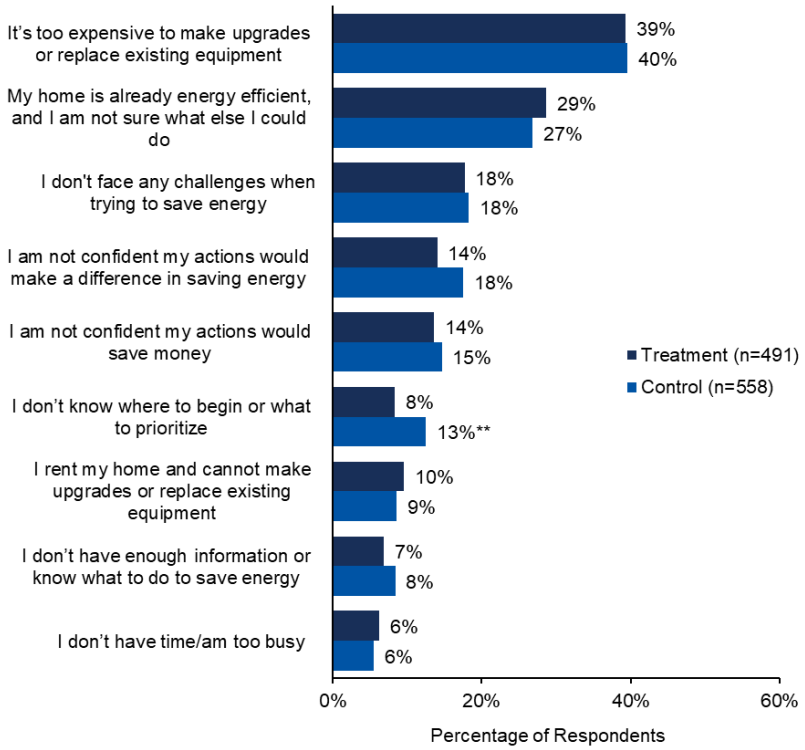
Barriers to Engaging in Energy Saving Behaviors and Overcoming Challenges

Survey respondents were asked to rate their pre-existing knowledge of different ways to save energy, barriers that they might encounter while trying to practice energy-saving behaviors, and their abilities to overcome challenges that they may face. In terms of self-reported knowledge, treatment respondents (77%; n=496) were significantly more familiar (4 or 5 on a 5-point scale, where 1 means *not at all familiar* and 5 means *very familiar*) with different ways to save energy in their homes than control respondents (72%; n=567; p<.05).

Respondents were then provided with a list of potential challenges and asked to select the challenges that apply to their households. Overall, the most frequently cited challenge was that it was *too*

expensive to upgrade or replace equipment (40%). A large proportion of respondents also stated that they don't face any challenges when trying to save (18%) or that their homes were already efficient, and that they were not sure what else they could do (28%). The only statistically significant difference between groups was in prioritizing energy-saving strategies; control respondents were more likely to state that they didn't know where to begin or what to prioritize compared to treatment respondents ($p<.05$; Figure N-15).

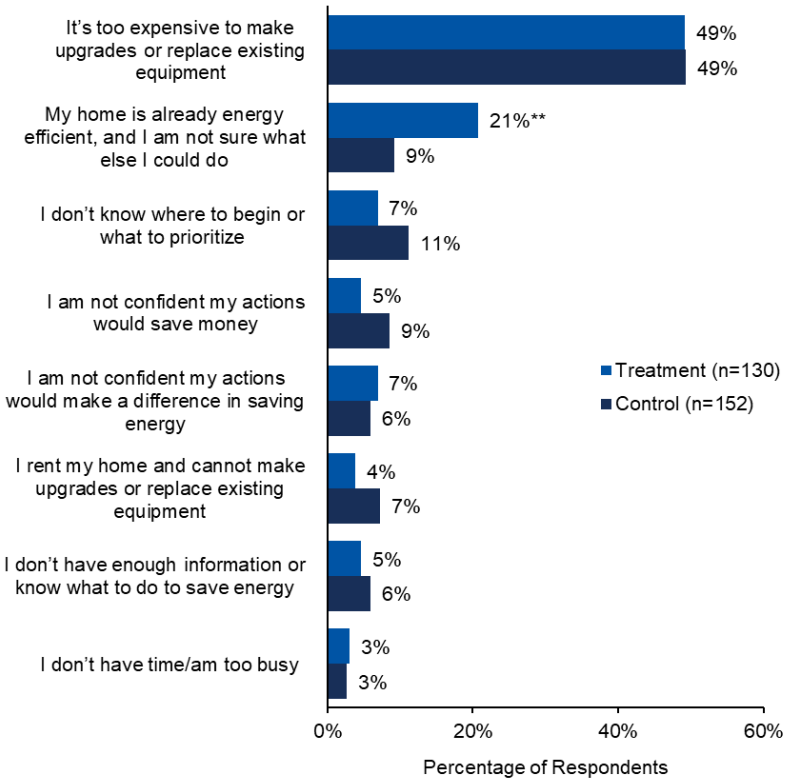
Figure N-15. Challenges to Saving Energy in the Home



Source: HER Treatment Control Survey, "Below is a list of potential challenges that people might face when trying to save energy in their homes. Please check all the items that you think apply to your household."
**Indicates a significant difference between groups ($p \leq 0.05$).

As a follow-up, respondents who selected multiple challenges were asked to identify the biggest challenge they face (Figure N-16). Respondents identified that it was too expensive to make upgrades or replacements (49%) as the biggest barrier preventing people from saving energy. The only statistically significant difference between groups was that treatment respondents (21%) said their homes were already energy efficient, and they were not sure what else they could do, compared to control respondents (9%).

Figure N-16. Most Significant Challenge to Saving Energy



Source: HER Treatment Control Survey, "Which of the challenges you selected would you say is the biggest challenge to your household?" (among those who selected multiple challenges)
**Indicates a significant difference between groups (p≤0.05).

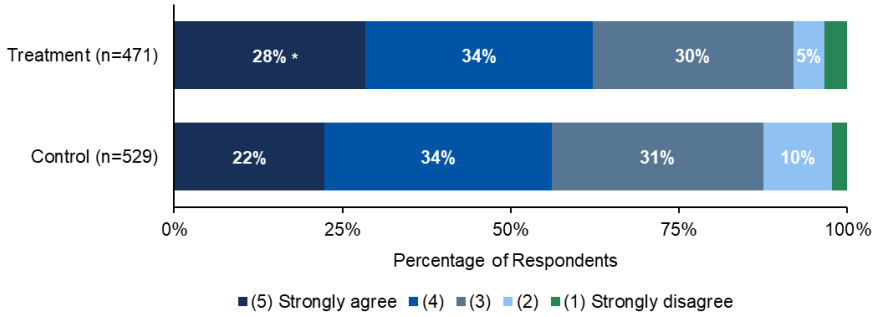
After identifying the challenges that they face in saving energy, respondents reported their confidence in overcoming these challenges. Overall, confidence in overcoming challenges was low for both groups, with only 43% of control and 42% of treatment respondents selecting a 4 or 5 on a 5-point scale (where 1 means *not at all confident* and 5 means *very confident*). Respondents were then asked their likelihood to engage in more energy-saving behaviors if the challenges faced were removed; both control (75%) and treatment respondents (76%) reported they would be more confident in their abilities to engage if challenges were removed.

Customer Perceptions of PPL Electric Utilities

Reliability of PPL Electric Utilities as a Source for Energy Efficiency Information

Cadmus asked both control and treatment group customers to rate the extent to which they view PPL Electric Utilities as a source of information on energy efficiency or rebate offerings. Treatment customers (62%) were more likely than control customers (56%) to agree that PPL Electric Utilities is a source of energy efficiency information and rebate information (4 or 5 on a scale from 1 to 5, where 5 means *strongly agree*; p<.10) (Figure N-17).

Figure N-17. PPL Electric Utilities as a Source for Energy Efficiency Information or Rebates

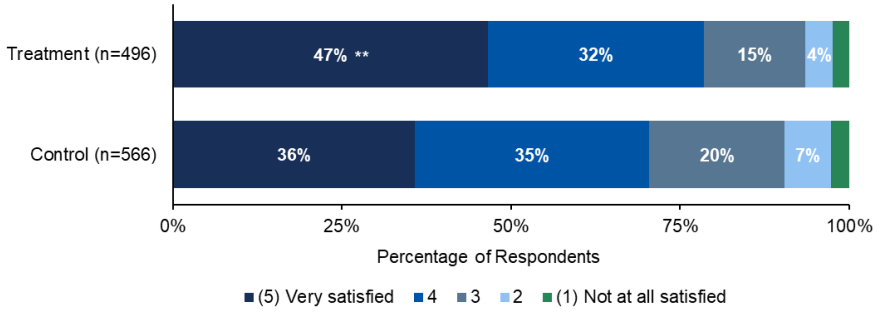


Source: Home Energy Report Treatment Control Survey, "To what extent do you disagree or agree with the following statement: I view PPL Electric Utilities as a source for energy efficiency information or rebates."
*Indicates a significant difference on 4 and 5 (combined rating) between groups (p≤0.10).

Satisfaction with PPL Electric Utilities

To assess group differences in customer satisfaction with PPL Electric Utilities, the survey asked both control and treatment group customers about their overall satisfaction with PPL Electric Utilities. There was a statistically significant difference in customer satisfaction (p<.05), with treatment customers reporting greater overall satisfaction with PPL Electric Utilities (79% selected either 4 or 5 on a scale from 1 to 5, where 5 means *very satisfied*) compared to control group customers (71%; Figure N-18)

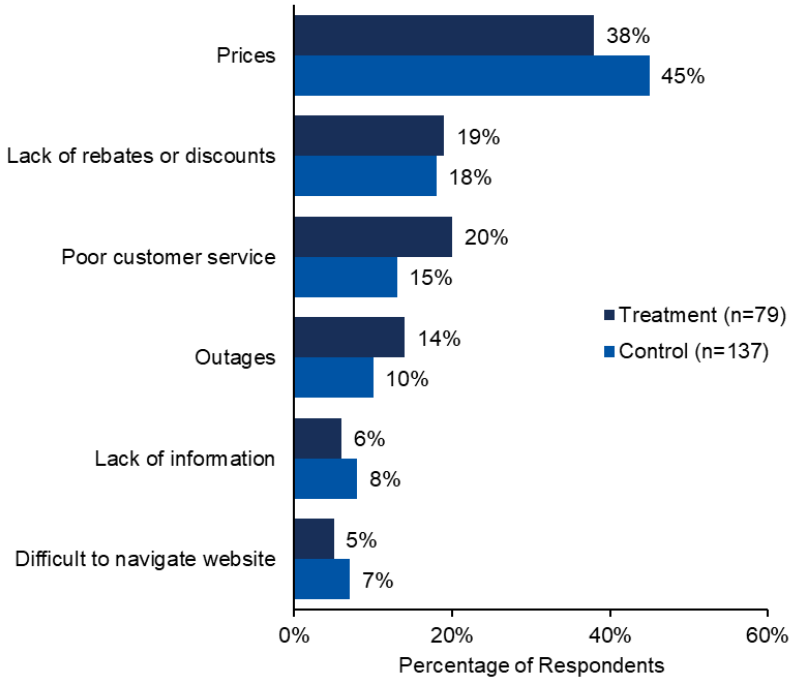
Figure N-18. Satisfaction with PPL Electric Utilities



Source: Home Energy Report Treatment Control Survey, "How would you rate your overall satisfaction with PPL Electric Utilities?"
**Indicates a significant difference on 4 and 5 (combined rating) between groups (p≤0.05).

Customers who reported being less than satisfied with PPL Electric Utilities were asked to provide additional context for their satisfaction rating of PPL Electric Utilities. Of the provided options, poor customer service and lack of rebates or discounts were cited most frequently. However, an examination of write-in responses revealed that issues regarding pricing and frequency or length of power outages were also commonly reported by customers (Figure N-19).

Figure N-19. Reasons for Being Less than Satisfied with PPL Electric Utilities



Source: Home Energy Report Treatment Control Survey, "Why are you less than satisfied with PPL Electric Utilities (select all that apply)?"

N.4.2. Other Findings

Participant Profile and Survey Sample Attrition

The PY16 surveys collected demographic information about participants in the Home Energy Report component. Table N-11 shows the characteristics of the respondents.

Table N-11. Home Energy Report Participant Profile

Attribute	Treatment	Control
Housing type – percentage living in a single-family detached home	75%	76%
Average household size	2.2	2.3
Average age	67 years of age	63 years of age
Completed some college education or more	80%	75%
Household income of $50,000 or more	69%	72%

Table N-12 lists the total number of records contacted via online survey and the outcome (final disposition) of each record. Additional details on the survey methodology are in *Appendix L. Survey Bias*.

Table N-12. Home Energy Report Online Participant Survey Sample Attrition

Description of Outcomes of Online Participant Survey	Number of Records	
	Treatment	Control
Population (number of selected households)	**361,810**	**94,542**
Removed: Not selected for the sample frame	306,810	59,542
Survey Sample Frame (records attempted)	**55,000**	**35,000**
Not reached or non-working: Opted out, email returned (bounce back), did not respond	54,365	34,355
Ineligible for survey (disqualified)	102	21
Partially completed survey	58	102
Completed Surveys (online)	**475**	**522**
Overall Response Rate	**0.9%**	**1.5%**

N.4.3. Logic Model

Home Energy Reports

Cadmus reviewed the logic model for the behavioral subprogram known as the Home Energy Report component of the Residential Program. The model is based on the approved evaluation plan, interviews with PPL Electric Utilities staff and program implementers (CLEAResult), and secondary research.

Table N-13 shows the logic model for the Home Energy Report component.

Table N-13. Logic Model: HERs

Barriers	Component Activities	Output Produced by Component Activities	Short-Term Outcomes	Intermediate Outcomes	Long-Term Outcomes
• Customers lack awareness of PPL Electric Utilities' programs and offers • Customers face challenges practicing energy-efficient habits and making energy-saving home improvements • Customers are unaware of how their energy consumption compares to that of other households • General marketing or messaging from PPL Electric Utilities lacks specificity and relevance for some customers	• Identify customers for participation • Develop customized report content • Send monthly and seasonal reports to customers • Allow customers to opt out of receiving reports • Identify a control group to quantify energy impacts	• Customers are aware of how their household's energy consumption compares to similar homes • Customers are aware of PPL Electric Utilities' rebates and offerings • Customers engage with online tools, such as an interactive web portal • Customers respond to tips and recommendations by modifying their behavior and/or installing energy - efficient products	• Increased uptake in participation in energy efficiency programs • Customers become better informed about their energy consumption and more confident in their abilities to overcome barriers to reducing their energy consumption • Customers become capable of developing and implementing strategies to reduce their energy consumption • Customers engage in energy-saving behaviors promoted in their Home Energy Reports • Customers purchase and install energy-efficient equipment to improve their home's ability to realize savings • Increased customer satisfaction	• Lower electric bills for component participants • Energy and peak demand savings accrue and contribute to PPL Electric Utilities' savings plan and regulatory requirements	• Continued energy savings for the participants • PPL Electric Utilities achieves long-term energy savings and peak demand reductions, moving the market toward improved energy efficiency • Increase in PPL Electric Utilities' knowledge and experience operating this type of component • Environmental benefits are achieved • More engagement from PPL Electric Utilities customers using other energy-saving behaviors and programs

Cadmus reviewed the logic model and determined that the Home Energy Report component is operating as expected in most cases. Table N-14 shows the outcome of the logic model review.

Table N-14. Home Energy Reports Component Logic Model Review

Topics	Logic Model Components/ Plan	Status	PY16 Outcomes
Component Activities	• Identify customers for participation • Develop customized report content • Send monthly and seasonal reports to customers • Allow customers to opt out of receiving reports • Identify and recruit a control group to quantify energy impacts	Achieved	• Conducted all activities as planned • In PY16, PPL Electric Utilities sent out four paper reports (two seasonal and two non-seasonal), as well as a monthly email to approximately 360,000 households
Outputs Produced by Component Activities	• Customers are aware of how their household's energy consumption compares to similar homes • Customers are aware of PPL Electric Utilities' rebates and offerings • Customers engage with online tools, such as an interactive web portal • Customers respond to tips and recommendations by modifying their behavior or installing energy-efficient products	Partially achieved	• Participating customers (treatment) were significantly more aware of programs and rebates than nonparticipants (control) • Participating customers reported having read and engaged with reports • Home Energy Report recipients used less kWh per day (0.33% to 0.53% by month) in the first months after PPL Electric Utilities sent them reports, though their results were not statistically different from the control group in April through June 2025
Short-Term Outcomes	• Increased uptake in participation in energy efficiency programs • Customers become better informed about their energy consumption and more confident in their abilities to overcome barriers preventing desired behaviors • Customers become capable of developing and implementing strategies to reduce their energy consumption • Customers engage in energy-saving behaviors promoted in their Home Energy Reports • Customers purchase and install energy-efficient equipment to improve their home's ability to realize savings • Increased customer satisfaction	Partially achieved	• Participating customers were better informed about their energy use and more confident in their abilities to overcome certain barriers compared to the nonparticipant control group • Awareness and knowledge of programs and strategies to reduce energy use and save money increased for participants • The majority of participating customers were satisfied with their Home Energy Reports and reported higher overall satisfaction with PPL Electric Utilities compared to the nonparticipant control group • Although uplift savings were negative, participation uplift suggested that the Home Energy Report component encouraged customers to participate in other efficiency programs, but those participants did not generate the expected incremental savings.

Topics	Logic Model Components/ Plan	Status	PY16 Outcomes
Intermediate Outcomes	• Lower electric bills for component participants • Energy and peak demand savings accrue and contribute to PPL Electric Utilities' savings plan and regulatory requirements	Unable to assess	• In PY16 (Year 4), the Home Energy Report component contributed 7,562 MWh/yr of verified savings to the component • Due to the launch of the component in December 2024, no demand reductions were generated in PY16 but will be generated in PY17.
Long-Term Outcomes	• Continued energy savings for the participants • PPL Electric Utilities achieves long-term energy savings and peak demand reductions, moving the market toward improved energy efficiency • Increasing PPL Electric Utilities' knowledge and experience in operating this type of component • Environmental benefits are achieved • More engagement from PPL Electric Utilities customers using other energy-saving behaviors and programs	Unable to assess	• Unable to assess at this time