
SWE Final Annual Report: Act 129 Program Year 16

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SUBMITTED TO:
Pennsylvania Public Utility Commission

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The Phase IV SWE also thanks the staff of the Pennsylvania Public Utility Commission's (PUC's) Bureau of Technical Utility Services (TUS) for their assistance and support in all aspects of the SWE's work during Phase IV.

This SWE Phase IV Program Year 16 Final Report presents the findings, conclusions, and recommendations of the Phase IV SWE only and, as such, is not necessarily agreed to by the EDCs or the Commission. The Commission, while not adopting the findings, conclusions, and recommendations contained in this annual report, may consider and adopt some or all of them in appropriate proceedings.

Acronyms

ACC	Avoided Costs Calculator
AECs	Alternative Energy Credits
AEPS	Alternative Energy Portfolio Standards
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ARCA	Appliance Recycling Centers of America, Inc.
ATE	Average Treatment Effect
ATI	Appliance Turn-In
BRA	Base Residual Auction
C&I	Commercial and Industrial
CAC	Central Air Conditioner
CF	Coincidence Factor
CHP	Combined Heat and Power
CI EMNC	Commercial and Industrial Energy Management and New Construction
CI MF	Commercial and Industrial Master-Metered Multifamily Direct Install
CSP	Conservation Service Provider or Curtailment Service Provider
CV	Coefficient of Variation
DDR	Dispatchable Demand Response
DEER	Database for Energy Efficiency Resources
DHW	Domestic Hot Water
DLC	Design Lights Consortium
DRIPLE	Demand Reduction Induced Pricing Effects
EDC	Electric Distribution Company
EDT	Eastern Daylight Time
EE&C	Energy Efficiency and Conservation
EFLH	Equivalent Full Load Hours
EEPDR	Energy Efficiency and Peak-Demand Reduction
EM&V	Evaluation, Measurement, and Verification
EUL	Effective Useful Life
FCM	Forward Capacity Market
FE	FirstEnergy
FYSATE	First-Year Savings Average Treatment Effect
FERC	Federal Energy Regulatory Commission
GNI	Government, Non-Profit, Institutional
GSLs	General Service Lamps
HER	Home Energy Report
HEWs	Home Energy Worksheets
HIM	High Impact Measure
HOU	Hours of Use
HVAC	Heating, Ventilating, and Air Conditioning
IDI	In-Depth Interview
IMPs	Interim Measure Protocols
IPMVP	International Performance Measurement and Verification Protocol
ISR	In-Service Rate

kW	Kilowatt
kWh	Kilowatt-Hour
LDV	Lagged Dependent Variable
LED	Light-Emitting Diode
LI	Low-Income
LIEEP	Residential LI Energy-Efficiency Program
LLF	Line Loss Factor
LMPs	Locational Marginal Prices
LS	Lagged Seasonal
M&V	Measurement and Verification
MW	Megawatt
MWh	Megawatt-Hour
NEF	National Energy Foundation
NPV	Net Present Value
NTG	Net-to-Gross
NTGR	Net-to-Gross Ratio
P4TD	Phase IV to Date
PA PUC	Pennsylvania Public Utility Commission
PDR	Peak-Demand Reductions
PSA	Phase IV to Date Preliminary Savings Achieved; equal to VTD + PYRTD
PSA+CO	PSA savings, plus Carryover from Phase III
PV	Photovoltaic
PY	Program Year: e.g., PY16, from June 1, 2022, to May 31, 2023
PYRTD	Program Year Reported to Date
PYVTD	Program Year Verified to Date
RARP	Residential Appliance Recycling Program
RCT	Randomized Control Trial
RDIP	Residential Downstream Incentives Program
REA	Remote Energy Assessment
RMIP	Residential Midstream Incentive Program
ROB	Replace on Burnout
RTD	Phase IV to Date Reported Gross Savings
RUIP	Residential Upstream Incentive Program
SBDI	Small Business Direct Install
SEEE	Student Energy Efficient Education
SO	Spillover
SOW	Scope of Work
SSL	Solid State Lighting
SWE	Statewide Evaluator
TRC	Total Resource Cost
TRM	Technical Reference Manual
TUS	Technical Utility Services
VCx	Virtual Commissioning
VTD	Phase IV to Date Verified Gross Savings
WACC	Weighted Average Cost of Capital

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 provider (CSP) 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 (TRM) provides algorithms and assumptions to calculate annual savings; 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. PYRTD 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 (PYTD). PSA savings are an important metric in semi-annual reports when activity from the current program year has not yet been verified.

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.

Executive Summary

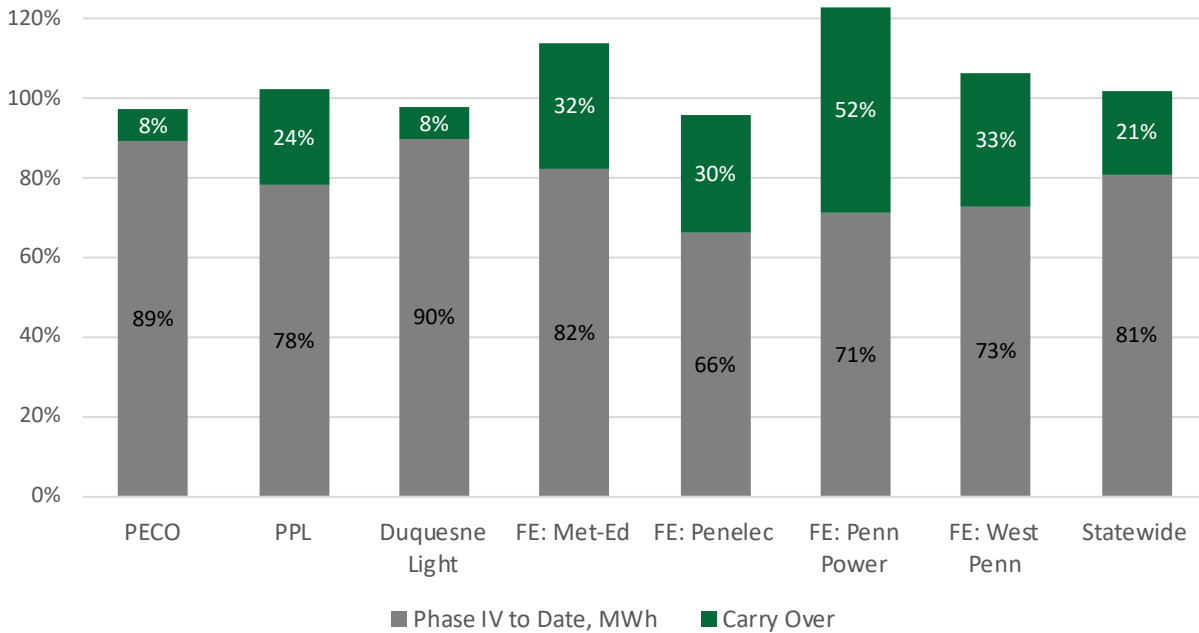
Program Year 16 (PY16), June 1, 2024, to May 31, 2025, is the fourth year of Phase IV of Pennsylvania's Act 129 Energy Efficiency and Conservation (EE&C) program. Phase IV goals were established on an incremental annual basis, meaning that progress toward goals is assessed by summing the annual energy savings of new measure installations in a program year. Over the five-year phase, the Electric Distribution Companies (EDCs) subject to Act 129 have a total incremental annual energy savings goal of 4.5 million MWh/year and 809 MW/year of peak-demand reductions.¹ Act 129 programs are expected to achieve nearly a 3.1% cumulative reduction in annual electricity use statewide during the five-year phase.

In their PY16 annual reports to the Public Utility Commission (PUC), the EDCs claimed a total of 1,160,271 MWh/year of verified gross energy savings for PY16 (approximately 26% of the statewide Phase IV target) and 219.44 MW of peak-demand reductions (approximately 27% of the statewide Phase IV target). The Statewide Evaluator (SWE) performed a detailed review of the research methods, assumptions, and calculations utilized by EDC evaluation contractors to determine verified gross savings for PY16. The SWE audit validated most of the savings calculations. Errors were discovered in some of the EDC-verified savings calculations that led to increases in the MWh and MW totals, and a net increase statewide in savings resulting in a revised PY16 gross verified statewide total of 1,160,694 MWh/year (approximately 26% of the statewide Phase IV target) and 219.63 MW/year of peak-demand reductions (approximately 27% of the statewide Phase IV target).

PROGRESS TOWARD PHASE IV ENERGY EFFICIENCY COMPLIANCE TARGETS

Progress toward the individual EDC Phase IV compliance targets to date in verified gross energy savings ranged from 66% (Penelec) to 90% (Duquesne Light) (see [Figure 1](#) and [Table 1](#)). Including carryover savings from Phase III, total progress toward Phase IV targets ranged from 96% (Penelec) to 123% (Penn Power). Additional summary tables of progress toward Phase IV targets can be found in [Section 2](#) and [Appendix A.1](#) and the EDC's program-level impacts can be found in [Section 3](#).

¹ The EDCs subject to Act 129 are PECO, PPL Electric Utilities (PPL), Duquesne Light, and FirstEnergy Pennsylvania (FirstEnergy). FirstEnergy was granted approval for consolidation by the PUC, at the December 7, 2023, Public Meeting, of the four independent EDCs it owned: Metropolitan Edison Company (Met-Ed), Pennsylvania Electric Company (Penelec), Pennsylvania Power Company (Penn Power), and West Penn Power Company (West Penn). These former four EDCs are now Rate Districts that comprise the FirstEnergy EDC. The SWE reports all findings by the FirstEnergy Rate Districts throughout this report.

Figure 1: P4TD Verified Savings Progress Toward Phase IV Energy Efficiency Compliance Targets, by EDC and Statewide**Table 1: Performance Toward Phase IV Energy Efficiency Compliance Targets¹**

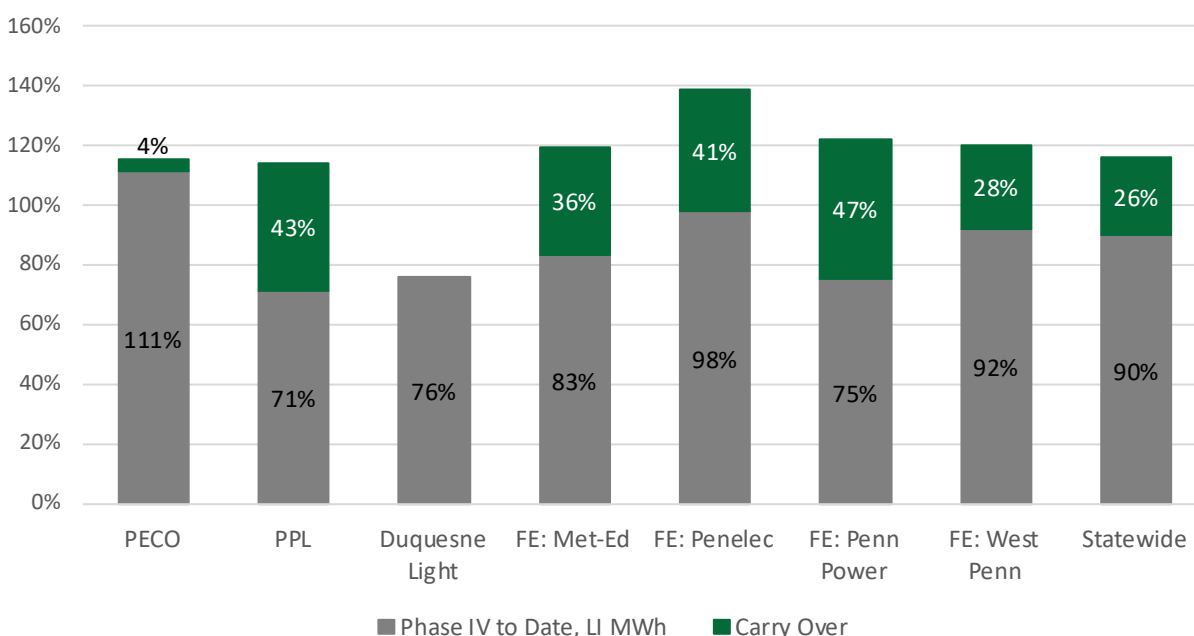
EDC	VTD (MWh/yr)	Phase III CO	VTD + CO (MWh/yr)	% of Goal	Phase IV Compliance Target (MWh/yr)
PECO	1,233,910	106,218	1,340,128	97%	1,380,837
PPL	975,545	306,275	1,281,820	103%	1,250,157
Duquesne Light	311,736	28,137	339,873	98%	348,126
FE: Met-Ed	379,912	147,303	527,215	114%	463,215
FE: Penelec	290,211	130,025	420,236	96%	437,676
FE: Penn Power	92,022	66,577	158,599	123%	128,909
FE: West Penn Power	368,007	168,480	536,486	106%	504,951
Total	3,651,343	953,015	4,604,357	102%	4,513,871

¹ Totals may not equal the sum of columns or rows due to rounding.

Progress Toward Phase IV Low-Income Targets

Each EDC must obtain energy consumption reductions from programs solely directed at low-income (LI) customers or LI-verified participants in multifamily housing programs (see [Table 2](#)). [Figure 2](#) reports EDC P4TD progress toward their targets. Progress toward the LI target ranged from 71% (PPL) to 111% (PECO) in P4TD verified gross savings and 76% (Duquesne Light) to 139% (Penelec) when Phase III carryover savings are included (EDC totals may not equal the sum of the components of the bar due to rounding).

Figure 2: P4TD Progress Toward Phase IV LI Targets

Table 2: Performance Toward Phase IV LI Targets¹

EDC	LI VTD (MWh/yr)	Phase III CO	VTD + CO (MWh/yr)	% of Goal	Phase IV Compliance Target (MWh/yr)
PECO	89,028	3,452	92,480	115%	80,089
PPL	51,614	31,089	82,703	114%	72,509
Duquesne Light	14,115	-	14,115	76%	18,566
FE: Met-Ed	22,370	9,782	32,152	120%	26,866
FE: Penelec	24,821	10,466	35,287	139%	25,385
FE: Penn Power	5,625	3,504	9,129	122%	7,477
FE: West Penn Power	26,972	8,270	35,242	120%	29,287
Total	234,545	66,563	301,108	116%	260,179

¹ Totals may not equal the sum of columns or rows due to rounding.

Low-Income Measure Proportionality Analysis

The Phase IV Implementation Order also directed EDCs to offer conservation measures to the LI customer segment based on the proportion of electric sales attributable to LI households.² This “Low-Income Measure Proportionality” requirement directs each EDC to include in their programs a number of energy-efficiency measures for households at, or below, 150% of the federal poverty income guidelines that is proportionate to each EDC’s total LI consumption relative to the total

² 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.
<https://www.puc.pa.gov/pdocs/1666981.docx>

energy usage in the service territory. An LI measure is defined as a measure that is targeted to LI customers and is available at no cost to LI customers. The SWE found that each EDC complied with the LI proportionality requirement in PY16. [Table 3](#) reports the required minimum proportions and results of the SWE's verification analysis. The SWE's verification analysis can be found in [Appendix A.2](#).

Table 3: LI Measure Proportionality Targets and SWE Verification Results, PY16

EDC	Proportionate Number of Measures, Target	PY16 Proportionate Number of Measures, Reported	PY16 Proportionate Number of Measures, SWE Verified
PECO	8.80%	30.6%	31.0%
PPL	9.95%	23.4%	23.4%
Duquesne Light	8.40%	37.8%	37.8%
FE: Met-Ed	8.79%	21.3%	21.3%
FE: Penelec	10.23%	21.3%	21.3%
FE: Penn Power	10.64%	21.3%	21.3%
FE: West Penn Power	8.79%	21.3%	21.3%

Phase IV Performance, Multifamily Housing

[Table 4](#) reports the Phase IV to date (P4TD) verified energy savings from multifamily households and low-income multifamily households. Multifamily housing accounts for a range of savings for the residential and low-income customer segments from 2% (Met-Ed and Penn Power) to 9% (PPL), while low-income multifamily housing accounts for a range of savings for the low-income segment from 12% (Met-Ed and Penn Power) to 28% (PPL).

Table 4: Summary of PY16 Verified Energy Savings for Multifamily Housing by EDC

EDC	VTD (MWh/yr)	% of VTD Residential and LI Segments	VTD, LI Households (MWh/yr)	% of VTD LI Segment
PECO	28,031	8%	12,162	16%
PPL	21,132	9%	14,183	28%
Duquesne Light	2,477	3%	1,838	13%
FE: Met-Ed	3,116	2%	2,555	12%
FE: Penelec	4,281	4%	3,987	18%
FE: Penn Power	917	2%	658	12%
FE: West Penn Power	4,541	4%	3,789	15%
Statewide	64,495	6%	39,173	18%

PROGRESS TOWARD PHASE IV PEAK-DEMAND COMPLIANCE TARGETS

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. Eastern Daylight Time (EDT) on non-holiday weekdays from June to August. The peak-demand impacts from energy efficiency in this report are presented at the system level, reflecting adjustments for transmission and distribution losses.

Progress toward the individual EDC Phase IV compliance targets to date in verified peak-demand savings ranged from 65% (Penelec) to 95% (Duquesne Light) (Figure 3 and Table 5). Phase III of Act 129 did not have a peak-demand reduction target from energy efficiency, so EDCs do not have carryover savings toward this target.

Figure 3: Phase IV EDC Performance Toward Peak-Demand Compliance Target

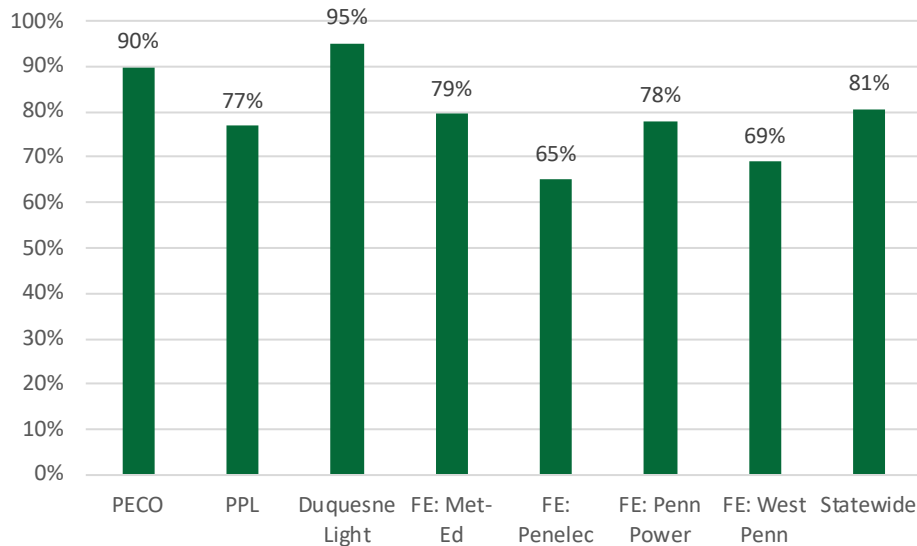


Table 5: Performance Toward Phase IV Peak-Demand Compliance Target¹

EDC	VTD (MW/yr)	% of Goal	Phase IV Compliance Target (MW/yr)
PECO	229.99	90%	256
PPL	176.33	77%	229
Duquesne Light	58.95	95%	62
FE: Met-Ed	60.39	79%	76
FE: Penelec	52.01	65%	80
FE: Penn Power	15.61	78%	20
FE: West Penn Power	59.28	69%	86
Total	652.57	81%	809

¹ Totals may not equal the sum of columns or rows due to rounding.

Planned FCM Nominations by Program Year and PJM Delivery Year

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 (FCM).³ If the resources clear, the proceeds flow back to the rate class that generated the Act 129 savings to

³ <https://www.pjm.com/>

offset cost recovery via riders. In September 2024, PJM filed a proposal⁴ with the Federal Energy Regulatory Commission (FERC) to no longer allow EE resources to participate in PJM's wholesale capacity market beginning with the Base Residual Auction associated with the 2026/2027 delivery year. In November 2024, FERC issued an order⁵ accepting PJM's revisions to its tariff to prospectively sunset EE resource participation in the wholesale capacity market.

Table 6 summarizes each EDC's PY16 verified gross demand savings and the estimated for wholesale recognition of those capacity savings for the final delivery year, 2025–2026, for which they are eligible at PJM. Approximately 15% of the peak-demand savings acquired by the EDCs in PY16 was nominated to PJM's FCM with most of the MW coming from PECO.

Table 6: Planned FCM Nominations by EDC and PJM Delivery Year for PY16

EDC	PY16 Verified Gross Demand Savings (MW/yr)	Estimated PY16 MW Acquisition for FCM in Delivery Year 2025-2026
PECO	62.10	23.40
PPL	63.00	5.90
Duquesne Light	13.54	1.00
FE: Met-Ed	27.35	0.60
FE: Penelec	20.90	0.70
FE: Penn Power	5.60	0.60
FE: West Penn Power	27.13	0.90
Statewide	219.63	33.10

Proceeds from resources that clear in the FCM flow back to the rate class that generated the savings to offset cost recovery. Table 7 shows the proceeds received in PY16 and P4TD net of CSP fees and other administrative costs for each EDC and Statewide.

Table 7: FCM Proceeds from Recognized Peak-Demand Reductions (\$1,000)

EDC	PY16 Proceeds	P4TD Proceeds	P4TD Expected
PECO	\$959.00	\$1,549.00	\$4,569.00
PPL	\$65.00	\$99.36	\$871.51
Duquesne Light	\$0.27	\$0.27	\$0.27
FE: Met-Ed	\$162.67	\$283.45	\$677.45
FE: Penelec	\$176.52	\$255.83	\$580.83
FE: Penn Power	\$26.56	\$39.85	\$216.85
FE: West Penn Power	\$103.17	\$182.70	\$872.70
Statewide	\$1,493.19	\$2,410.46	\$7,788.61

Based on the reported EE&C Plan expenditures from each EDC, at the portfolio level, statewide PY16 cost recovery requirements were lowered by 0.57% due to the FCM proceeds received

⁴ https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20240906-5122&optimized=false

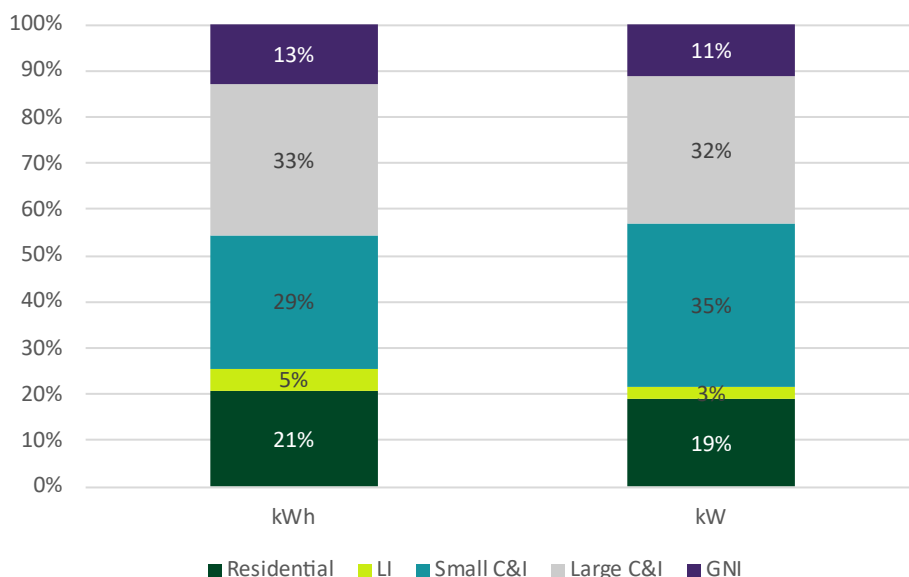
⁵ https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20241105-3046

from recognition of demand savings. Statewide P4TD cost recovery requirements have been lowered by 0.27% due to the FCM proceeds received. An additional 5.3 million dollars in proceeds from recognition of peak-demand reductions are expected by the end of Phase IV. Most of the demand reductions and associated proceeds statewide come from non-residential rate classes and therefore flow back to the same classes.

PHASE IV PERFORMANCE BY CUSTOMER SEGMENT

Figure 4 presents the phase-to-date verified gross savings by customer segment. The residential, small commercial and industrial (C&I), and large C&I segments were defined by EDC tariff, and the LI and government, non-profit, institutional (GNI) segments were defined by statute (66 Pa. C.S. § 2806.1).⁶ Non-residential customers (small C&I, large C&I, and GNI) accounted for 74% of verified gross kWh savings and 78% of verified gross kW savings in PY16 (the non-residential totals may not equal the sum of the components of the bar due to rounding).

Figure 4: PY16 Verified Gross Savings by Customer Segment, Statewide



TOP SAVINGS PROGRAM OFFERINGS

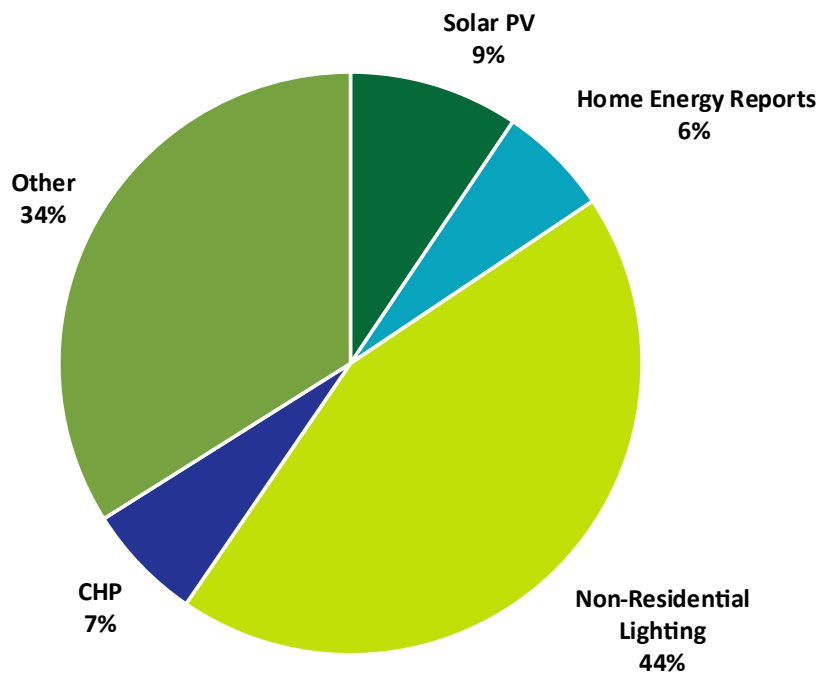
The Pennsylvania EDCs support a wide range of energy-efficient equipment and technologies in their Phase IV EE&C plans. In PY16 savings from the Solar PV measure shifted from a limited portion of verified savings to the second biggest measure in the programs after non-residential lighting. The top offerings, which include CHP and HERs, accounted for 66% of all gross verified

⁶ The LI segment is almost entirely a subset of the residential customer class but can include a limited number of LI-qualified residents in master-metered buildings in the small C&I and large C&I sectors. The GNI segment is almost entirely composed of customers who are part of the small C&I or large C&I rate classes but can include a limited number of residential customers.

MWh statewide in PY16 (Figure 5). For the first time since top offerings have been tracked, residential lighting was not among the top offerings.

Non-residential lighting accounted for 44% of PY16 verified gross energy savings. While changing baselines have nearly eliminated the savings opportunity from residential lighting, code changes have affected the non-residential sector far less. Solar photovoltaic (PV) projects accounted for 9.4% of all gross verified MWh statewide in PY16, so it replaced residential lighting as a top offering.⁷ CHP projects accounted for 7% of all gross verified MWh statewide in PY16, while HERs accounted for another 6%

Figure 5: Top Savings Program Types in PY16



Appendix J explores each of these core programs and technologies in detail. Based on a statewide review, the SWE compares the different ways EDCs delivered these programs and technologies in PY16. The SWE also examined the rapidly changing non-residential lighting market that EDC programs are working to transform and the implications that these market changes have on program delivery.

⁷ Residential lighting, delivered through direct install and kit offerings, still accounted for nearly 4% of statewide energy savings in PY16.

COST-EFFECTIVENESS SUMMARY

Pennsylvania has adopted the Total Resource Cost (TRC) test as its specified approach to benefit-cost assessment. The TRC test examines cost-effectiveness from the perspective of the utility, participants, and non-participants. Over time, the Commission customized the Pennsylvania TRC test to reflect the policy priorities of the Commonwealth. In preparation for Phase IV, the PUC issued the 2021 TRC Test Order⁸ to document the methodology and assumptions EDCs should use when calculating the costs and benefits of Phase IV EE&C portfolios.

Table 8 shows the Net Present Value (NPV) costs and benefits for each EDC portfolio in PY16, as well as the TRC ratio (benefits divided by costs). The table presents TRC results on both a gross and net savings basis. Per the 2021 TRC Test Order, incremental participant costs and benefits from free riders are excluded from the calculation of the net TRC ratio. The NPV of future energy savings is calculated using a 3% real discount rate (5% nominal discount rate) for all EDCs.⁹ On a gross basis, PY16 programs saved the Commonwealth an estimated \$205.3 million (benefits minus costs). On a net basis, statewide savings from PY16 programs are estimated at \$127.7 million. The statewide PY16 TRC ratio is 1.38.

Table 8: PY16 TRC Test Results by EDC¹

EDC	Gross Benefits (\$1000)	Gross Costs (\$1000)	Gross TRC	Net Benefits (\$1000)	Net Costs (\$1000)	Net TRC
PECO	\$189,432	\$152,265	1.24	\$130,464	\$109,326	1.19
PPL	\$237,449	\$184,462	1.29	\$171,265	\$140,215	1.22
Duquesne Light	\$41,782	\$20,497	2.04	\$35,890	\$18,508	1.94
FE: Met-Ed	\$95,249	\$71,324	1.34	\$62,542	\$48,453	1.29
FE: Penelec	\$79,131	\$47,664	1.66	\$56,972	\$36,292	1.57
FE: Penn Power	\$20,328	\$14,458	1.41	\$14,730	\$11,053	1.33
FE: West Penn Power	\$84,441	\$53,054	1.59	\$59,569	\$39,911	1.49
Statewide	\$747,812	\$543,725	1.38	\$531,432	\$403,758	1.32

¹ Totals may not equal the sum of columns or rows due to rounding.

COMPARISON OF SAVINGS AND EXPENDITURES TO PLAN

In preparation for Phase IV, each EDC filed an EE&C plan with detailed projections of program spending, savings, incentive levels, and other key metrics. In the SWE-prepared EDC annual report template, the SWE requested EDCs to compare their actual P4TD expenditures and verified gross energy savings to the EE&C plan projections. Figure 6 compares actual P4TD

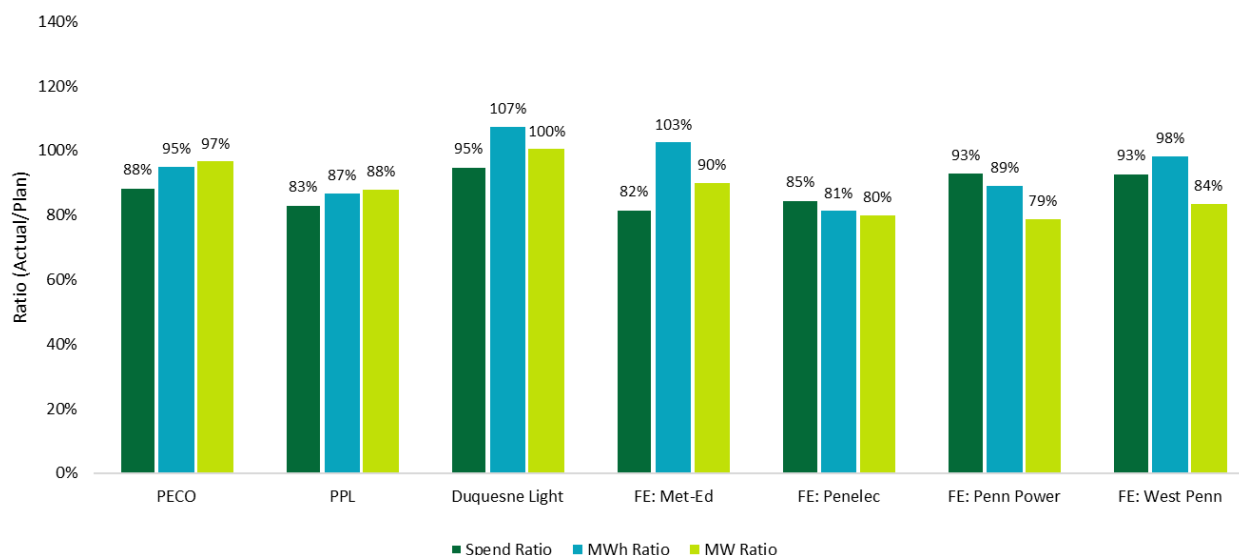
⁸ Pennsylvania Public Utility Commission, *2021 TRC Test Final Order*. From the Public Meeting of December 19, 2019, at Docket No. M-2019-3006868 (*2021 TRC Test Order*). Entered December 19, 2019.

<https://www.puc.pa.gov/pcdocs/1648126.docx>

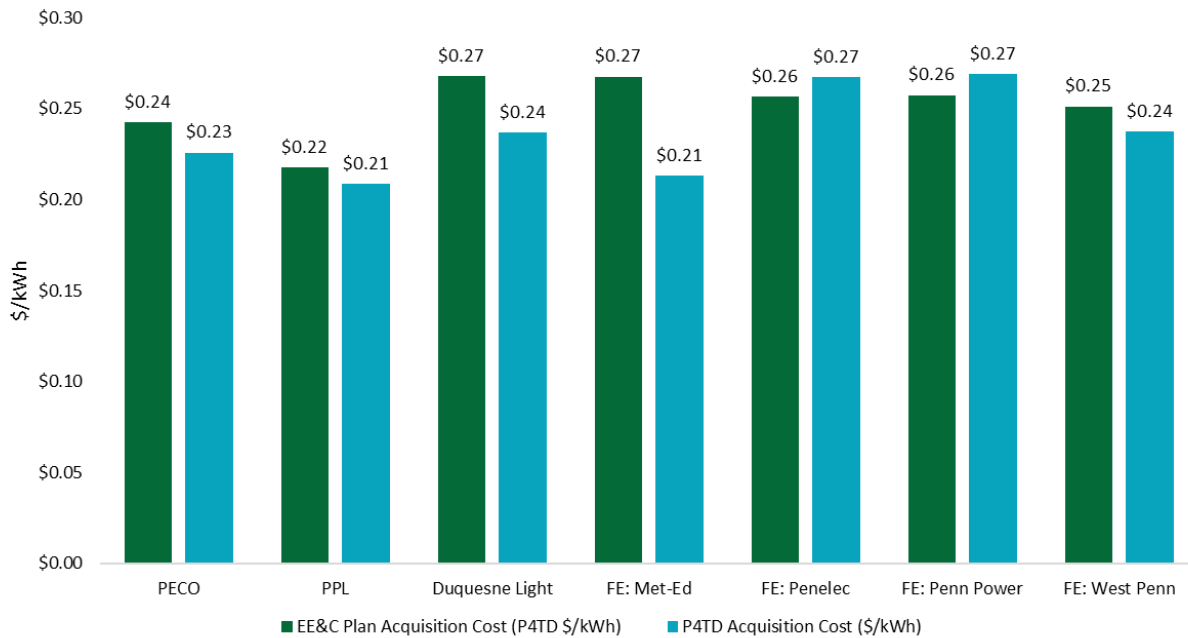
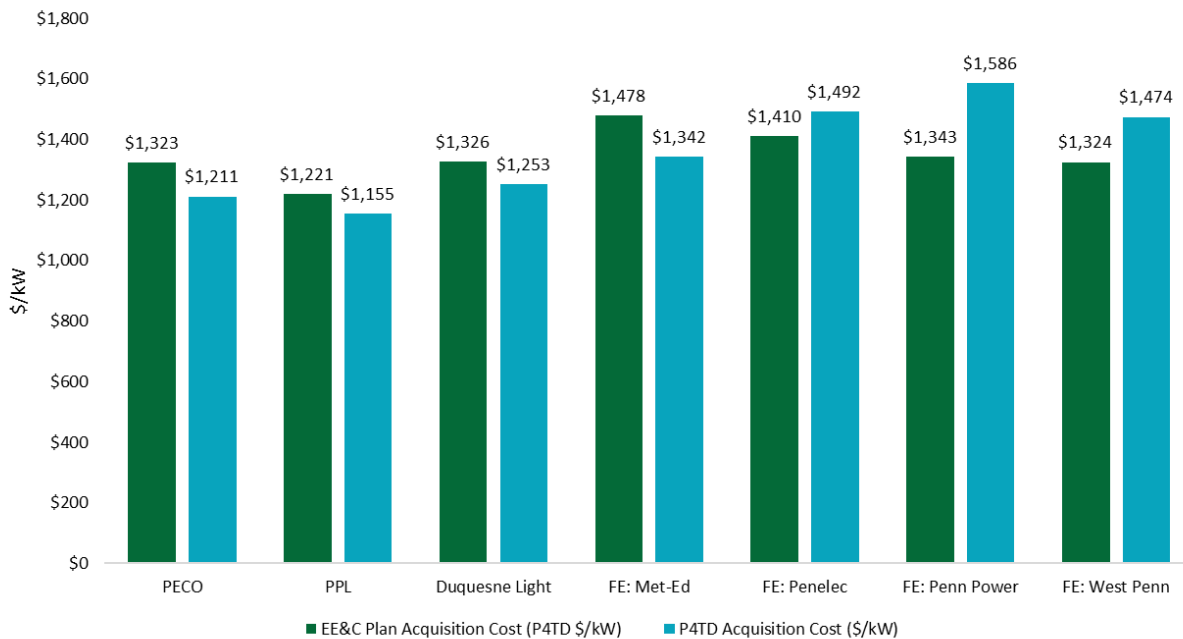
⁹ 2021 TRC Test Order. Pages 17-21.

spending and verified savings to their EE&C plan projections for the first four years of Phase IV. PECO and PPL have unverified savings from PY16, which lower the MWh and MW ratios. Statewide, actual P4TD expenditures were 87% of EE&C Plan projections. The EDCs achieved 93% of the projected energy savings and 91% of the projected peak-demand savings across the first four years of Phase IV. The EDCs will need to accelerate both their spending and resource acquisition in the final year of Phase IV to reach the planned savings totals for the phase.

Figure 6: P4TD Spending and Savings Compared to EE&C Plan



Because of the emphasis on Act 129 goal achievement and the fact that EDC budgets are fixed, acquisition cost is an important metric for EDCs subject to Act 129. Acquisition cost is a performance metric of dollars per first-year kWh (energy) or first-year kW (capacity). [Figure 7](#) compares the projected phase-to-date energy acquisition cost from the Phase IV EE&C plan to actual phase-to-date verified energy acquisition costs. [Figure 8](#) presents the same information for peak demand, or capacity. Statewide, the EDCs deliver energy and capacity savings at a slightly lower unit cost than planned. Unverified savings from plan components at PECO and PPL raise acquisition costs slightly because the costs are incurred but the verified savings are not.

Figure 7: Planned vs. Actual P4TD Energy Acquisition Cost**Figure 8: Planned vs. Actual P4TD Capacity Acquisition Cost**

Section 2.3 presents similar performance metrics for PY16 in table format.

REDUCTION IN EMISSIONS

Electric power generation is a major source of carbon emissions, so the energy conservation programs implemented by the Pennsylvania EDCs have a direct impact on the amount of carbon

dioxide produced. Although the Pennsylvania TRC test does not place a monetary value on emission reductions, it is an important benefit to some stakeholders because of links between CO₂ emissions and climate change. The team compiled Table 9 using the gross verified first year and lifetime MWh savings in PY16, EDC-specific line loss factors (LLFs); an average of the June 2024–May 2025 load-weighted marginal CO₂ emissions rates was calculated with data from PJM's DataMiner2¹⁰ for each of the Pennsylvania EDCs. The average marginal emissions rate for PY16 is 1,148 lbs/MWh—higher than the marginal emissions rate of 1,132 lbs/MWh in PY15.

Table 9: PY16 Carbon Dioxide Emission Impacts

Performance Metric	Value
PY16 Verified Gross MWh/yr	1,160,694
PY16 Verified Gross Lifetime MWh	14,096,980
Weighted Average Measure Life (years)	12.15
Pennsylvania Zone Marginal CO ₂ Emissions Rate (lbs/MWh)	1,148
First-Year Avoided Short Tons of CO ₂	716,859
Lifetime Avoided Short Tons of CO ₂	8,708,117

The lifetime emission impacts in Table 9 are calculated using the June 2024–May 2025 marginal CO₂ emission rates and do not include the emissions associated with secondary fossil fuel impacts caused by EE&C measures. If the generation fuel mix in the region becomes cleaner over the life of the measures installed in PY16, the emissions rate would decrease, thus lowering the lifetime CO₂ impacts. These emissions reductions could impact the TRC ratio if the Act 129 TRC Test assigned financial value to avoided CO₂ emissions. For example, if the Act 129 TRC test valued CO₂ emissions at the interim social cost of carbon adopted by the U.S. Environmental Protection Agency (EPA) under the previous presidential administration—\$46 per short ton—the statewide PY16 gross TRC ratio would increase from the 1.38 value shown in Table 8 to approximately 1.95. The EPA proposed in 2023 to increase the social cost of carbon to \$172 per short ton. Implementing this value would increase the value of avoided emissions almost four times, raising the hypothetical TRC ratio to 3.51.

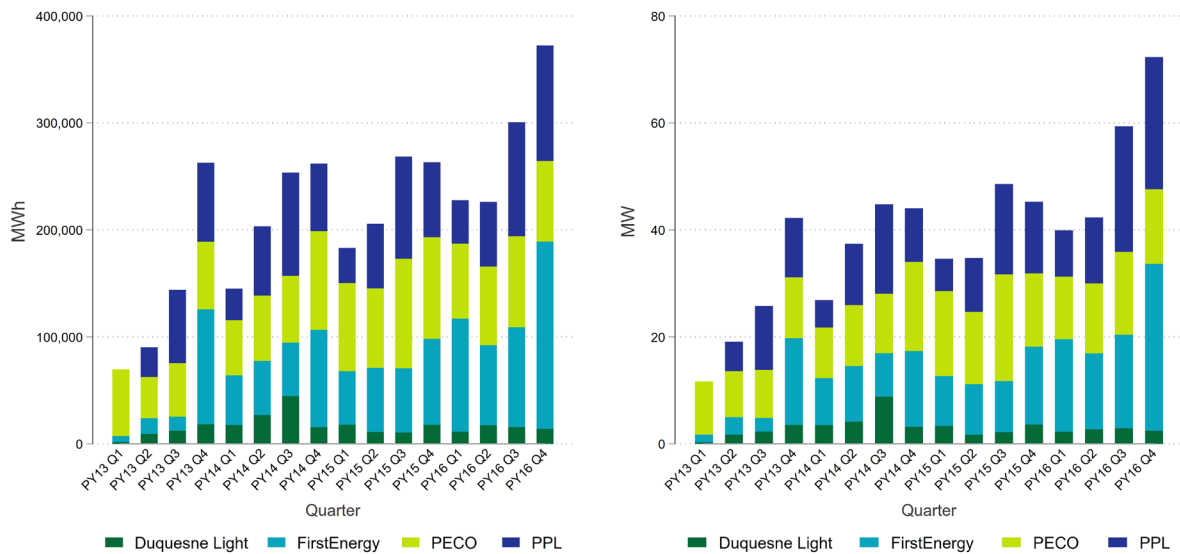
SUMMARY OF SWE FINDINGS

- Finding:** Through the first four years of Phase IV, the EDCs collectively achieved 81% of the statewide peak-demand reduction target of 809 MW. This is a notable increase from the 52% statewide progress toward goal at the end of PY15 thanks to strong production in PY16. Penelec (65%) and West Penn Power (69%) are the furthest from goal after four years and will each need to accelerate program implementation in the final year of Phase IV to meet their peak-demand reduction targets. Since Phase III of Act 129 did not include coincident demand reduction targets from EE, the EDCs do not have carryover savings for peak demand like they do for portfolio and low-income energy savings.

¹⁰ <https://dataminer2.pjm.com/list>

- Finding:** The Phase IV Implementation Order directed the EDCs to nominate a portion of the expected peak-demand savings in their Phase IV EE&C Plans into PJM's FCM and to use the proceeds from those nominations to lower Act 129 cost recovery requirements. EDCs nominated 15% of the peak-demand savings acquired in PY16 to the FCM. While the limited nominations are a disappointing outcome from a policy standpoint, the low level of FCM involvement lessens EDC exposure to recent changes to the eligibility of EE at PJM. In September 2024, PJM proposed a tariff change eliminating EE nominations from the FCM. This change was approved in November 2024 and prevents the EDCs from nominating any Act 129 MW beginning with the 2026/2027 delivery year. As of PY16, capacity auctions have been completed for all years in which EE remains eligible in the FCM. Over the course of Phase IV to date, proceeds from FCM nominations have reduced cost recovery requirements by 0.27%. Since the EDCs will be unable to realize any FCM proceeds beyond the 2025/2026 delivery year, Act 129 cost recovery will need to be adjusted to make up for the shortfall. Most EDCs only nominated or planned to nominate a small subset of their Phase IV peak-demand savings, meaning the impacts to cost recovery will be small but still should be considered moving forward. EDCs will also need to adjust their CSP contracts to remove any fees associated with FCM support services in any future program years.
- Finding:** Phase IV implementation was slow to ramp up in PY13 but finished with a strong PY13Q4. PY14 and PY16 saw a similar trajectory with more savings acquired in the second half of the program year. [Figure 9](#) shows the breakdown of reported gross energy and peak-demand savings by quarter. Savings attributable to HER programs are not included. PY16Q3 and PY16Q4 were the largest quarters to date in Phase IV with respect to reported gross MWh and MW savings claims. The strong finish to PY16 helped the EDCs close the gap between EE&C Plan projections and actual P4TD performance.

Figure 9: Reported Gross MWh and MW by Quarter



- Finding:** Statewide energy savings continued to shift away from the residential sectors and into the non-residential sectors in PY16. Non-residential savings accounted for 74% of statewide MWh savings in PY16, compared to 71% in PY15, 70% in PY14, 66% in PY13 and 49% of savings in Phase III. Non-residential lighting accounted for the bulk of the PY16 savings (44% statewide). Penn Power had the highest share of residential MWh savings in PY16 at 38% and PPL and West Penn Power had the lowest residential shares at 21%.
- Finding:** In PY16 savings from the Solar PV measure shifted from a limited portion of verified savings to the second biggest measure, after non-residential lighting, accounting for over 9% of energy savings statewide. Solar PV projects' contributions ranged from 2% (Penn Power) to 23% (PPL) of portfolio energy savings for the EDCs.
- Finding:** Residential Lighting continued to account for a smaller share of portfolio savings compared to Phase III. In PY16, Residential Lighting accounted for 4% of statewide MWh savings while it accounted for 5% in PY15, 9% in PY14 and 30% of statewide MWh during Phase III. Residential Lighting will likely decline further in PY17 as point-of-sale and downstream lighting measures that meet the U.S. Department of Energy's (DOE) definitions of General Service Lamps (GSLs) are no longer eligible. While direct-install and kit-delivered lighting measures are still eligible, direct install savings opportunities may be diminishing with declining numbers of existing inefficient bulbs.
- Finding:** The SWE issued a series of "Codes and Standards" memos in 2022 to reflect changes to federal standards, state building codes, and ENERGY STAR specifications since the release of the 2021 TRM. In most cases, the EDCs and their evaluation contractors reflected these changes in the verified savings calculations for PY16. One update that was missed by all seven EDCs was recessed downlight fixtures in commercial midstream lighting programs. Due to the U.S. Department of Energy's changes to general service lighting requirements, screw-based lamps and recessed downlights, which replace screw-based lamps were no longer eligible for Act 129 savings beginning June 1, 2023. In PY16, the EDCs continued to incentivize midstream delivery of recessed downlights. The SWE identified this issue and worked with the EDC evaluation contractors to zero out savings from ineligible products in the PY16 verified savings analyses. This led to a small reduction (1-2%) in verified energy and demand savings from commercial midstream lighting programs.
- Finding:** Actual acquisition costs in PY16 were 0.4% higher than EE&C plan projections statewide for energy (\$/kWh) and 1% higher than EE&C plan projections for capacity (\$/kW) statewide, comparable to EE&C plan projects. [Table 10](#) shows that PY15 was the first year of Phase IV where actual acquisition costs were materially higher than EE&C plan projections and in PY16 actual acquisition costs were closer to project costs. EE&C plans generally assume that targets will be exceeded without using 100% of the spending cap so the EDCs have built in some buffer on this key metric.

Table 10: Planned Versus Actual Acquisition Cost by Program Year

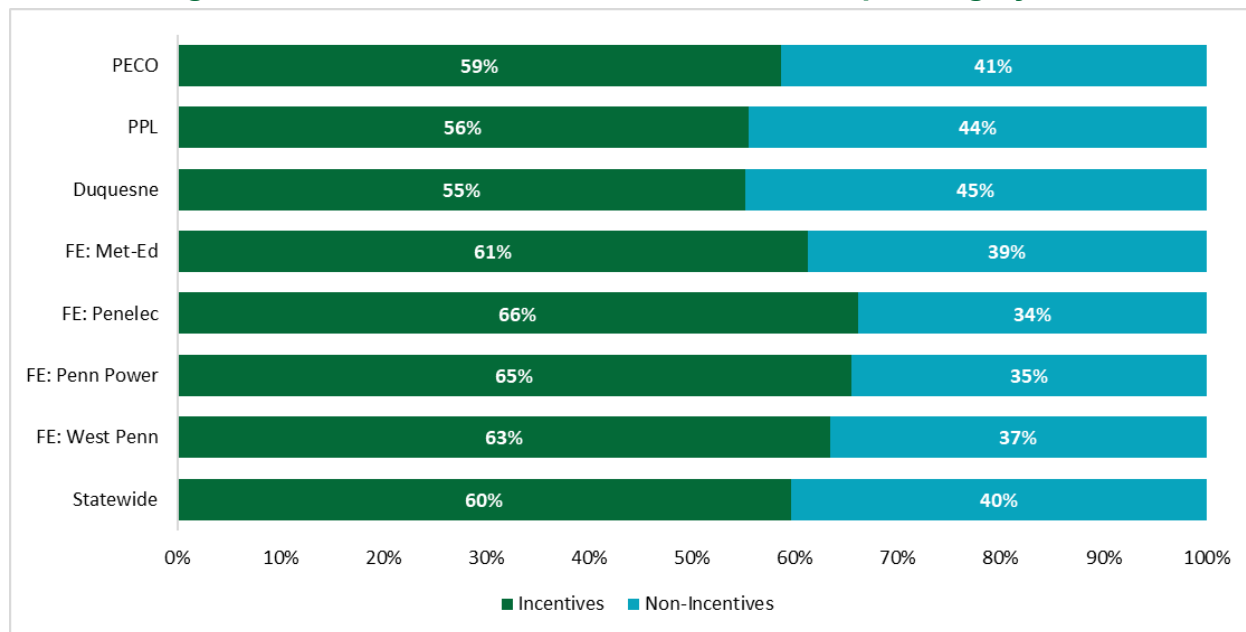
Program Year	Forecast \$/kWh	Actual \$/kWh	Forecast \$/kW	Actual \$/kW
PY13	\$0.25	\$0.22	\$1,386	\$1,357
PY14	\$0.24	\$0.23	\$1,320	\$1,327
PY15	\$0.25	\$0.29	\$1,335	\$1,647
PY16	\$0.23	\$0.23	\$1,210	\$1,222

- Finding:** Avoided Alternative Energy Portfolio Standards (AEPS) compliance costs are a component of the value of avoided energy in the TRC Test. Since the Commission issued its 2021 TRC Test Order in 2019, the value of AEPS credits has increased by almost a factor of seven. While the increased value of AEPS credits is large on a relative basis, they are a small component of the overall avoided cost of electric energy. In line with these findings, the 2026 TRC Order incorporates the higher values of AEPS credits in recent years into the Avoided Cost Calculator that will be used by the EDCs to plan for Act 129 programming in Phase V.
- Finding:** Each year, SWE conducts a comparison of market conditions to the Phase IV avoided cost forecast. Wholesale market prices for energy were higher than the avoided energy cost forecast for PY16. Auction clearing prices for generation capacity have fluctuated significantly over the course of Phase IV. The avoided cost of generation capacity forecast overstated the value of peak savings for the initial years of Phase IV but will understate the value of peak savings beginning in PY17 based on the much higher clearing price results of PJM's Base Residual Auction for the 2025/2026 and 2026/2027 delivery years.¹¹ Despite this volatility, the *average* Base Residual Auction results over the phase are well-aligned with the forecasted generation capacity costs.
- Finding:** In the 2026 TRC Test Order, the Commission directs the Pennsylvania EDCs to include the value of Demand Reduction Induced Price Effects (DRIPE) in cost effectiveness testing for Phase V. The SWE conducted a study to quantify the value of DRIPE for each EDC in the future years of Phase V and beyond for both energy and capacity. In preparation for this annual report, the Commission requested that the SWE conduct a sensitivity analysis on the value of including DRIPE in cost effectiveness testing. To do so, the SWE calculated what the value of DRIPE benefits would have been for both energy and capacity in PY16 had they been included. If the benefits from DRIPE were included in cost effectiveness testing in PY16 the statewide TRC ratio of 1.38 would increase to 1.64. While price suppression effects will make up only a piece of both avoided energy and avoided capacity when they are officially included in cost effectiveness testing in Phase V, the value added to benefits will increase overall cost effectiveness substantially.
- Finding:** EDC cost categorization is an area of emphasis for the Commission as the Phase IV Implementation Order required that EDCs "*submit an EE&C Plan which shows at least 50% of all spending allocated to incentives and less than 50% of all spending allocated to non-*

¹¹ <https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2025-2026/2025-2026-base-residual-auction-report.ashx> and <https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2026-2027/2026-2027-bra-report.pdf>

*incentive cost categories.*¹² While this was an EE&C Plan requirement and not an actual program delivery target, the SWE sees value in reviewing the actual breakdown of expenditures. The statewide share of spending on incentives as a percentage of total EDC expenditure was 60% in PY16. Figure 10 shows the division of spending between incentive and non-incentive cost centers by EDC and statewide. Our TRC audit activities found that EDC cost categorization was well-aligned with the directives of the 2021 TRC Test Order in PY16 with respect to energy-efficiency kits and directly installed equipment.

Figure 10: PY16 Incentive and Non-Incentive Spending by EDC



Finding: The accounting methodology for behavioral HERs changed significantly in Phase IV. Instead of assuming all measured savings are incremental first-year savings, the 2021 TRM adopted a multi-year measure life perspective that reduces compliance savings beginning in the third year of program delivery. The EDCs implemented this new framework in different ways. PECO, FirstEnergy, and Duquesne Light moved to a rotating model where legacy waves are paused and then restarted once the assumed persistence has declined. PPL waited until PY16 to launch its HER program so they will not face persistence adjustments in Phase IV. FirstEnergy reintroduced ten HER cohorts in PY16 after a three-year pause, which allowed for most of its measured savings to be treated as incremental and claimed towards compliance targets. HER programs contributed more MWh in PY16 than any prior year of Phase IV, largely because of the addition of nearly 350,000 households at PPL and the reintroduction of ten cohorts by FirstEnergy. HERs accounted for approximately 6% of portfolio MWh savings and 9% of progress towards low-income targets statewide.

- **Finding:** In general, the SWE found that the EDCs' cost-effectiveness reporting was well documented and aligned with the 2021 TRC Test Order. One area of weakness was fossil

¹² Phase IV Implementation Order. Pages 119-127.

fuel impacts. Both PPL and PECO had issues with the units used (therms versus MMBtu), that caused fossil fuel benefits to be misstated by a factor of ten for certain measure categories. Duquesne Light included the fossil fuel penalty from LED lighting measures in its TRC model but ignored the fuel savings from weatherization and low-flow devices installed in buildings with fossil fuel space heating or domestic water heating. The handling of fossil fuel savings from smart thermostats was also inconsistent across EDCs, with the FirstEnergy EDCs and PPL quantifying the fossil fuel heating savings from Wi-Fi connected smart thermostats and PECO and Duquesne Light ignoring the fossil fuel heating benefits.

- **Finding:** Gross TRC ratios at the portfolio level ranged widely from 1.24 for PECO to 2.04 for Duquesne Light. Incremental measure cost is by far the largest TRC cost. [Table 11](#) compares the assumed incremental measure cost per MWh of lifetime savings acquired in PY16. The EDCs with lowest assumed IMC per lifetime MWh showed the highest TRC ratios for PY16.

Table 11: Incremental Measure Cost per Lifetime MWh

EDC	Lifetime MWh	IMC (\$1,000)	IMC per Lifetime MWh
PECO	3,005,434	\$119,486	\$39.76
PPL	4,052,474	\$155,231	\$38.31
Duquesne Light	889,695	\$12,994	\$14.61
FE: Met-Ed	2,107,734	\$59,222	\$28.10
FE: Penelec	1,464,116	\$37,565	\$25.66
FE: Penn Power	396,286	\$11,653	\$29.41
FE: West Penn Power	2,181,241	\$41,406	\$18.98
Statewide	14,096,979	\$437,557	\$31.04

- **Finding:** Appliance recycling programs were active again for several EDCs (PECO, Duquesne Light and FirstEnergy) in PY16 after being interrupted in PY15 due to the implementation contractor being unable to fulfill their contract obligations.

Recommendations

- All seven EDCs have spent less money than projected in their EE&C Plan through the first four years of Phase IV. Actual spending as a percentage of EE&C Plan projected spending ranges from 82% (Met-Ed) to 95% (Duquesne Light). In each case, the EE&C budget is lower than the statutory budget limit established by the Act. EDCs who are behind schedule in attainment of their low-income consumption or peak-demand reduction targets have the available funds to ramp up implementation in PY17. The SWE recommends the EDCs explore increased marketing and elevated incentive levels framed as “limited time offers” to stimulate the market and increase participation in PY17.
- The shift in EE&C program activity from the residential to the non-residential sector continued in PY16, in large part due to the diminished savings opportunity for residential lighting. The shift does not create an equity issue because Act 129 cost recovery occurs at the class level. However, EDCs and their CSPs should continue to explore new conservation opportunities in the residential sector to ensure a balanced portfolio across customer classes.

- EDCs should be mindful of using limited Act 129 budgets to incentivize ineligible products that cannot claim compliance savings. The recessed downlight issue identified in the commercial midstream lighting programs in PY16 revealed incomplete adoption of the Codes and Standards updates to the 2021 TRM. EDCs should work closely with their CSPs and raise eligibility questions to the SWE if there is uncertainty regarding product eligibility or the effective dates of Code and Standard changes.
- Each year of Phase IV, the annual avoided cost review described in [Section 2.4](#) and [4.9.2](#) revealed several notable departures from the forecast in the actual market conditions for key TRC benefit streams. This included energy and AEPS credits increasing and, most recently, generation capacity auction prices exceeding forecast values. For PY15 and PY16, natural gas prices and, in turn, wholesale electric prices largely returned to the levels projected in Phase IV EE&C Plans. The SWE recommends the Commission continue to monitor market conditions and consider a TRC sensitivity analysis at the end of Phase IV.
- The market price of Tier II AEPS credits (which include EE) increased dramatically over the course of Phase IV. Given the sharp increase in the value of Tier II (energy efficiency) credits, the SWE suggests EDCs explore a process to facilitate AEPS registration in PY17 as a “value add” element of Act 129 participation to help C&I participants to register their EE projects and take advantage of the elevated market prices. The Commission adopted this recommendation in its Phase V Implementation Order, directing that *“Each EDC shall propose in their EE&C plan a process to help facilitate AEPS Act registration for C&I participants of Act 129 programs to register their EE projects and take advantage of the elevated AEC pricing.”*¹³ PY17 offers a useful test period for EDCs and CSPs to experiment with and refine their proposed processes prior to the beginning of Phase V.

¹³ Phase V Final Implementation Order. Entered June 18, 2025, at Docket No. M-2025-3052826. Page 184.

Section 1 Act 129 and Summary of PUC Orders

1.1 EE&C PROGRAM – PHASE IV IMPLEMENTATION ORDER REQUIREMENTS

Act 129 requires the PUC to establish an EE&C program that includes the following characteristics:

- Adopts an “energy-efficiency and conservation program to require electric distribution companies¹⁴ to adopt and implement cost-effective energy-efficiency and conservation (EE&C) plans to reduce energy demand and consumption within the service territory of each electric distribution company (EDC) in this commonwealth”¹⁵
- Adopts additional incremental reductions in consumption if the benefits of the EE&C program exceed its costs
- Evaluates the costs and benefits of the Act 129 EE&C programs in Pennsylvania by November 30, 2013, and every five years thereafter
- Ensures that the EE&C program includes “an evaluation process, including a process to monitor and verify data collection, quality assurance, and results of each plan and the program”¹⁶

Based on findings from the Phase IV Market Potential Study dated February 2020, the PUC determined that the benefits of a Phase IV Act 129 program would exceed its costs, and therefore adopted additional incremental reductions in consumption and peak demand for another EE&C program term of June 1, 2021, through May 31, 2026 (program years 13, 14, 15, 16, and 17). In its Phase IV Implementation Order, the PUC established targets for those consumption and peak-demand reductions (PDRs) for each of the seven EDCs in Pennsylvania; established the standards each plan must meet; and provided guidance on the procedures to be followed for submittal, review, and approval of all aspects of the EDC EE&C plans for Phase IV.¹⁷

1.1.1 EDC Cost Recovery for Act 129 EE&C Programs

Pennsylvania Act 129 allows each EDC to recover all prudent and reasonable costs relating to the provision or management of its EE&C Plan but limits such costs to an amount not to exceed 2% of the EDC’s total annual revenue as of December 31, 2006, excluding LI Usage Reduction Programs established under 52 Pa. Code § 58. 66 Pa. C.S. § 2806.1(g). The cost-recovery

¹⁴ This Act 129 requirement does not apply to EDCs with fewer than 100,000 customers.

¹⁵ See House Bill No. 2200 of the General Assembly of Pennsylvania, An Act Amending Title 66 (Public Utilities) of the Pennsylvania Consolidated Utilities, October 7, 2008, page 50.

¹⁶ See House Bill No. 2200 of the General Assembly of Pennsylvania, An Act Amending Title 66 (Public Utilities) of the Pennsylvania Consolidated Utilities, October 7, 2008, page 51.

¹⁷ 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.

<https://www.puc.pa.gov/pcdocs/1666981.docx>

mechanism also ensures that approved measures are financed by the customer class that receives the direct energy and conservation benefit of the measure.

The Act also requires that each EDC's plan includes a proposed cost-recovery tariff mechanism, in accordance with 66 Pa. C.S. §1307 (relating to adjustments and sliding scale of rates), to fund all measures and ensure a full and current recovery of prudent and reasonable costs, including administrative costs, as approved by the Commission.

1.1.2 Phase IV Conservation Targets for Each EDC

The PUC's Phase IV Implementation Order explained that it was required to establish electric energy consumption reduction compliance targets for Phase IV of Act 129.¹⁸ In addition, while Phase III had dispatchable demand response (DDR) reduction targets, the Commission excluded DDR targets from Phase IV and replaced them with PDR targets. The final Phase IV Implementation Order stated that the Commission found that the merits of a PDR strategy focused on long-lasting everyday reductions from energy-efficiency measures outweigh the features of a design that includes both PDR from EE and DDR. EDCs are also directed to offer an unspecified number of energy-efficiency resources into the PJM market. The peak-demand impacts from energy efficiency in this report are presented at the system level, reflecting adjustments for transmission and distribution losses.

Table 12 contains portfolio budgets, consumption reduction targets and PDR targets for Phase IV for each of the seven EDCs.

Table 12: Act 129 Phase IV Five-Year Energy Efficiency Reduction Compliance Targets

EDC	Portfolio Budget Allocation (Million \$)	Phase IV Consumption Reduction (MWh/yr)	Phase IV PDR (MW/yr)
PECO	\$427.4	1,380,837	256
PPL	\$307.5	1,250,157	229
Duquesne Light	\$97.7	348,126	62
FE: Met-Ed	\$124.3	463,215	76
FE: Penelec	\$114.9	437,676	80
FE: Penn Power	\$33.3	128,909	20
FE: West Penn Power	\$117.8	504,951	86
Statewide	\$1,222.9	4,513,871	809

1.1.2.1 Standards Each EDC's Phase IV EE&C Plan Must Meet

The PUC requires that each EDC's EE&C plan for Phase IV meet several standards, including the following:

- EDCs must obtain the given amount of consumption reduction as stated in Table 13 from programs solely directed at low-income customers or low-income-verified participants in multifamily housing programs. Savings from non-low-income programs, such as general

¹⁸ Phase IV Implementation Order at <https://www.puc.pa.gov/pdocs/1666981.docx>

residential programs, will not be counted for compliance. More details about the low-income targets and requirements are provided in [Section 1.1.3](#). Act 129 also includes legislative requirements to include a number of energy-efficiency measures for households at or below 150% of the federal poverty income guidelines that is proportionate to each EDC's total low-income consumption relative to the total energy usage in the service territory. The SWE has advised that EDCs should consider the definition of a low-income measure to include a measure that is targeted to low-income customers and is available at no cost to low-income customers.

- EDCs will be awarded credit for all new, first-year, incremental savings delivered in each year of the phase, as was done in Phase III.
- EDC plans should be designed to achieve the most lifetime energy savings per expenditure.
- EDC plans should be designed to achieve at least 15% of the target amount in each program year.
- EDCs are to include at least one comprehensive program for residential customers and at least one comprehensive program for non-residential customers.
- EDCs should determine the initial mix and proportion of energy-efficiency programs, subject to PUC approval. The PUC expects the EDCs to provide a reasonable mix of energy-efficiency programs for all customers. However, each EDC's Phase IV EE&C Plan must ensure that the utility offers each customer class at least one energy-efficiency program.
- EDCs should nominate a portion of the expected peak-demand savings in their Phase IV EE&C Plans into PJM's FCM. Cost recovery from the customer class providing the capacity should be adjusted to reflect the proceeds or penalties from this activity.
- EDCs should report savings achieved for the GNI sector in Phase IV and highlight in their EE&C plans how the GNI sector will be served.
- EDCs should report savings achieved in multifamily housing, both for the low-income carve-out and for their portfolio of programs.

1.1.3 Low-Income Customer Savings

As noted in [Section 1.1.2.1](#), each EDC Phase IV EE&C Plan must obtain consumption reduction requirements from programs solely directed at low-income customers or low-income-verified participants in multifamily housing programs (see [Table 13](#) for a summary of the low-income carve-out information). Savings from non-low-income programs, such as general residential programs, will not be counted for compliance. Low-income customers are defined as households at or below 150% of the federal poverty income guidelines. As noted in [Section 1.1.4](#), low-income carryover for Phase IV was only permitted if the EDC's entire portfolio had carryover savings and the EDC had low-income specific savings in excess of their Phase III low-income target.

1.1.3.1 Proportionate Number of Measures and Low-Income Savings Targets

Act 129 also includes legislation to ensure specific measures are available for and provided to low-income customers. The compliance criteria for this metric require the EDCs to include energy-efficiency measures proportionate to each EDC's total low-income consumption, relative to the total energy usage in the service territory, for households at or below 150% of the federal poverty income guidelines. The SWE has advised that EDCs should consider the definition of a low-income measure to include a measure that is targeted to low-income customers and is available to them at no cost.

Act 129 defines an EE&C measure (in the definitions section; 66 Pa.C.S. 2806.1[m]) as follows:

Energy efficiency and conservation measures.

(1) Technologies, management practices, or other measures employed by retail customers that reduce electricity consumption or demand if all of the following apply:

(i) The technology, practice, or other measure is installed on or after the effective date of this section at the location of a retail customer.

(ii) The technology, practice, or other measure reduces consumption of energy or peak load by the retail customer.

(iii) The cost of the acquisition or installation of the measure is directly incurred in whole or in part by the EDC.

(2) EE&C measures shall include solar or solar photovoltaic panels; energy efficient windows and doors; energy efficient lighting, including exit sign retrofit, high bay fluorescent retrofit, and pedestrian and traffic signal conversion; geothermal heating; insulation; air sealing; reflective roof coatings; energy efficient heating and cooling equipment or systems; and energy efficient appliances; and other technologies, practices, or measures approved by the commission.

The SWE recommends that EDCs refer to the PA TRM when determining the appropriate level of granularity at which to list measures when calculating the "proportionate number of measures." The EDCs should not further subdivide technologies that a single algorithm section in the TRM addresses. They should base measure divisions on equipment types, not differences in equipment efficiency or sizing of the same type of equipment. For example, EDCs should not separate LED bulbs into multiple measures based on wattage. For measures that are not addressed in the PA TRM, the EDCs should employ a grouping approach that distinguishes between equipment types but not sizes or efficiency levels.

Regarding how to classify which measures as specific low-income measures, the legislation states the following:

The plan shall include specific energy-efficiency measures for households at or below 150% of the federal poverty income guidelines. The number of measures shall be proportionate to those households' share of the total energy usage in the service territory. The electric distribution company shall coordinate measures under this clause with other programs administered by the commission or another federal or state agency. The expenditures of an electric distribution

company under this clause shall be in addition to expenditures made under 52 Pa. Code Ch. 58 (relating to residential low-income usage reduction programs).

A summary of the low-income carve-out information is provided in [Table 13](#).

Table 13: Act 129 Phase IV Low-Income Carve-Out Information

EDC	Proportionate Number of Measures	2021-2026 Potential Savings (MWh/yr)	Low-Income Savings Target (MWh/yr)
PECO	8.80	1,380,837	80,089
PPL	9.95	1,250,157	72,509
Duquesne Light	8.40	348,126	18,566
FE: Met-Ed	8.79	463,215	26,866
FE: Penelec	10.23	437,676	25,385
FE: Penn Power	10.64	128,909	7,477
FE: West Penn Power	8.79	504,951	29,287
Statewide	-	4,513,871	260,179

1.1.4 Carryover Savings from Phase III

The PUC's Phase IV Implementation Order specifies that Phase III consumption reductions in excess of an EDC's Phase III targets can be applied as carryover toward that same EDC's Phase IV electric consumption reduction targets. Note that only savings achieved in Phase III can count toward carryover. The Phase IV Implementation Order states, "for example, assume an EDC had a Phase III target of 1,000 MWh and had 100 MWh of carryover savings from Phase II. To have carryover into Phase IV, the EDC must have attained over 1,000 MWh in Phase III alone, not including the 100 MWh of Phase II carryover." Carryover should be determined based on Phase III verified savings (see [Table 1](#) for Phase III carryover for each EDC).

Low-income carve-out savings carryover are only permitted if an EDC has carryover savings for the entire portfolio of programs in Phase III and if the EDC has low-income carve-out savings from Phase III in excess of the Phase III low-income carve-out savings targets (see [Table 2](#) for Phase III low-income carryover for each EDC).

Carryover of Phase III peak-demand savings into Phase IV of Act 129 will not be permitted since the nature of the Phase III and Phase IV PDR targets are *inherently different*. Phase III of Act 129 included a PDR target that could only be met with DDR programs. Phase IV of Act 129 includes a PDR target that can only be met with coincident reductions in peak demand from energy-efficiency programs. EDCs could not accumulate savings in excess of a Phase III energy-efficiency and peak-demand reduction (EEPDR) target because no such target existed.

1.1.5 Incremental Annual Accounting

As in Phase III, EDCs will be awarded credit for all new, first-year, incremental savings delivered in each year of the phase. Each program year, the new first-year savings achieved by an EE&C program are added to an EDC's progress toward compliance. Unlike in Phase I and Phase II of Act 129, whether a measure reaches the end of its expected useful life (EUL) before the end of the phase does not impact compliance savings.

1.1.6 Net-to-Gross Ratio (NTGR)

The PUC's Phase IV Implementation Order specifies that compliance will be based on gross verified savings rather than net savings, and that EDCs will continue to perform Net-to-Gross (NTG) research. Results of the NTG evaluations should be used to inform program modifications and program planning (e.g., program design, modifying program incentive levels, and eligibility requirements), as well as determinations of program cost-effectiveness.

1.1.7 Statewide Evaluator

Act 129 requires the Commission to establish an evaluation process that monitors and verifies data collection, quality assurance, and the results of each EDC EE&C Plan and the program as a whole. See 66 Pa. C.S. § 2806.1(a)(2). While Section 2806.1(b)(1)(i)(C) requires each plan to explain how quality assurance and performance will be measured, verified, and evaluated, it is apparent that Section 2806.1(a)(2) requires the Commission to monitor and verify this data. This evaluation process is to be conducted every year. Each EDC will submit an annual report documenting the effectiveness of its EE&C Plan, energy savings measurement and verification, an evaluation of the cost-effectiveness of expenditures, and any other information the Commission requires. See 66 Pa. C.S. § 2806.1(i)(1).

The Phase IV SWE was selected by the Commission, as in prior phases, to provide credible impact verification via a transparent evaluation process. The SWE provides expertise in evaluations and remains independent from EDC evaluators. The SWE responsibilities include evaluating the EDC programs, identifying whether further cost-effective savings can be obtained in future EE&C programs, developing an updated evaluation framework, conducting annual audits of EDC programs, conducting a market potential study on energy efficiency and a market potential study on DR.

1.1.8 Annual Reporting Requirements

The Phase IV SWE contract specifies that *“The contractor provide a final annual report on each EDC plan and the program, as a whole, to the Project Officer by November 30. Final Annual Reports will be provided to the Commission by November 30, except for the fifth (final) annual report of the phase, which will be rolled into the Final Five-Year Energy Efficiency and Conservation Program Assessment Report. The annual reports may form the basis for Commission annual reports required to be provided to the legislature each year.”*

This report provides detailed information on the findings of the SWE's audit activities of the Act 129 EE&C programs implemented by seven EDCs in Pennsylvania and reports the status of EDC compliance with Phase IV energy efficiency and peak-demand targets.

The SWE contract specifies that the Final Annual Reports and the Final Five-Year Report will include, but are not limited to, the following:

- An analysis of each EDCs' plan expenditures and an assessment of the program's expenditures.
- An analysis of each EDCs' protocol for measurement and verification of energy savings attributable to its plan, in accordance with the Commission adopted TRM and approved custom measures.

- An analysis of the cost effectiveness of each EDCs' expenditures in accordance with the Commission adopted Total Resource Cost (TRC) Test Order.
- A review of TRM information and savings values with suggestions for possible revisions and additions.
- A review of the TRC test with suggestions for possible revisions and additions.
- A review of any proposed revisions and updates to EDC plans.

1.2 2021 TRC TEST ORDER

Act 129 requires that the cost-effectiveness of each EDC's EE&C plan be assessed annually to demonstrate its viability. The TRC test, which weighs the net present values of future benefits and costs over the effective life of any given energy-efficiency measure, is the standard used to measure cost-effectiveness. The purpose of using a TRC test to evaluate EE&C programs is to track the relationship between the benefits to the Commonwealth and the costs incurred to obtain those benefits. Section 2806.1(m) of Act 129 states that a TRC test be used to determine whether ratepayers received more benefits (in reduced capacity, energy, transmission, and distribution costs) than the implementation costs of the EE&C plans.

Before each prior phase, a TRC Test Order was published to explain how the TRC test process should be applied to Pennsylvania. Each iteration of the TRC Test Order has customized the Act 129 TRC Test by taking lessons learned from the prior phase to refine the process. The Commission released the 2021 TRC Test Tentative Order at the Public Meeting held on September 19, 2019. After receiving comments and reply comments from stakeholders, the 2021 TRC Test Final Order was adopted at the Public Meeting held on December 19, 2019. Some of the topics addressed in the TRC Test Order include:

- Frequency of review of the TRC test assumptions
- Aggregation level of TRC test results
- Setting a common discount rate for calculation of future benefits and costs
- The methodology for forecasting avoided costs of electric energy, generation capacity, and transmission and distribution capacity.
 - The Commission also released an Avoided Cost Calculator (ACC) to help the EDCs develop their Phase IV avoided cost forecasts.
- Line losses
- Quantifying and monetizing both water and fossil fuel impacts
- Societal benefits
- TRC cost classification
- Treatment of increased fossil fuel consumption due to fuel switching
- Net-to-Gross Issues

In 2024, the SWE supported the Commission with development of the 2026 TRC Test Order in preparation for Phase V of Act 129. The 2026 TRC Test Final Order was approved at the Public Meeting of November 7, 2024, at Docket No. M-2024-3048998.¹⁹

1.3 2021 TRM ORDER

First adopted in June 2009 at the beginning of the Act 129 implementation, the Pennsylvania TRM was used to define the savings algorithms and assumptions for individual energy-efficiency measures. The Commission charged that the TRM be implemented, maintained, and periodically updated when needed. For the start of Phase IV, an updated TRM was proposed by the 2021 TRM Tentative Order on April 11, 2019. The 2021 TRM Final Order was adopted by the PUC on August 8, 2019. The 2021 TRM was later modified by Secretarial Letter in September 2020 to correct errata, then Tentative and Final 2021 Amendment Orders in October 2020 and February 2021, respectively. The 2021 TRM Amendment Order added peak-demand savings protocols for several measures in response to the Commission's decision to establish compliance targets for peak-demand reduction from energy efficiency.

In the 2021 TRM Final Order, the Commission set forth several changes intended to improve the accuracy, applicability, and coverage of the TRM. The changes were based partially on recent research, reviews of the TRMs from other states, and the needs and experiences of the EDCs. The other category of changes came from the SWE's comprehensive review of the 2016 TRM, which identified general improvements to the organization and internal consistency of the manual. The adopted changes focus on improving assumptions for key parameters, algorithms, and deemed savings values, as well as accounting for new codes and standards for residential and non-residential EE&C measures. The changes adopted were intended to make the TRM a more effective and professional tool for validating energy savings and providing support for the Act 129 goals.

Some of the topics covered in the 2021 TRM Order updates are listed below:

- Climate related assumptions
- Consistent taxonomy of C&I building types across measures
- Updated equivalent full load hour and coincidence factor assumptions for residential HVAC measures
- Adjustments to the definitions of peak and off-peak periods
- Adoption of new Residential and Non-Residential measures
- Removal of some Residential and Non-Residential measures

The 2026 Technical Reference Manual Final Order was approved at the Public Meeting of September 12, 2024, at Docket No. M-2023-3044491. [Section 4.1](#) discusses the development and release of the 2026 TRM in preparation for Phase V of Act 129.

¹⁹ <https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/total-resource-cost-test/>

Section 2 Portfolio and Program-Level Savings by Program Year

2.1 SUMMARY OF PY16 ENERGY SAVINGS

2.1.1 Summary of PY16 Energy Savings Statewide and by EDC

Table 14 provides a summary of PY16 reported and verified energy savings by EDC. Realization rates in PY16 ranged from 92% (Penelec) to 109% (Duquesne Light).

Table 14: Summary of PY16 Reported and Verified Energy Savings by EDC¹

EDC	PY16 Reported (MWh/yr) ²	PY16 Verified Gross (MWh/yr)	Realization Rate
PECO	333,763	321,861	96%
PPL	313,933	299,784	95%
Duquesne Light	66,024	72,031	109%
FE: Met-Ed	169,065	163,063	96%
FE: Penelec	120,057	110,670	92%
FE: Penn Power	34,093	32,615	96%
FE: West Penn Power	173,673	160,670	93%
Statewide	1,210,608	1,160,694	96%

¹ Totals may not equal the sum of columns or rows due to rounding.

² Reported savings exclude unverified savings

2.1.2 Summary of PY16 Energy Savings by Sector

Table 15 presents the PY16 verified gross savings by customer segment. The residential, small commercial and industrial (C&I), and large C&I segments were defined by EDC tariff, and the LI and GNI segments were defined by statute (66 Pa. C.S. § 2806.1).²⁰ Residential customers (including LI customers) accounted for 296,318 MWh of verified gross savings in PY16 (26% of PY16 energy savings) whereas non-residential customers accounted for 864,374 MWh of verified gross savings.

²⁰ The LI segment is almost entirely a subset of the residential customer class but can include a limited number of LI-qualified residents in master-metered buildings in the small C&I and large C&I sectors. The GNI segment is almost entirely composed of customers who are part of the small C&I or large C&I rate classes but can include a limited number of residential customers.

Table 15: Summary of PY16 Verified Savings by Customer Segment^{1,2}

EDC	Residential (MWh/yr)	LI (MWh/yr)	Small C&I (MWh/yr)	Large C&I (MWh/yr)	GNI (MWh/yr)	Total ² (MWh/yr)
PECO	74,104	18,792	107,821	75,326	45,816	321,861
PPL	49,071	14,964	83,820	113,456	38,474	299,784
Duquesne Light	21,749	3,308	5,623	23,446	17,904	72,031
FE: Met-Ed	36,301	5,952	32,250	87,470	1,090	163,063
FE: Penelec	21,360	5,216	51,325	30,813	1,957	110,670
FE: Penn Power	11,417	1,020	11,145	8,483	550	32,615
FE: West Penn Power	27,980	5,083	42,090	40,779	44,737	160,670
Statewide	241,983	54,335	334,074	379,773	150,527	1,160,694

¹ Does not include carryover savings.

² Totals may not equal the sum of columns or rows due to rounding.

2.1.3 Summary of PY16 Energy Savings for Multifamily Housing

Multifamily savings account for a range of 2% of savings for the residential and low-income customer segments (Duquesne Light and Met-Ed) to 12% (PPL), while low-income multifamily housing accounts for a range of 6% of savings for the low-income segment (Duquesne Light) to 42% (Penn Power; see [Table 16](#)).

Table 16: Summary of PY16 Verified Energy Savings for Multifamily Housing by EDC

EDC	PY16 VTD (MWh/yr)	% of PY16 Residential and LI Segments	PY16 VTD, LI Households (MWh/yr)	% of PY16 LI Segment
PECO	6,464	7%	2,169	12%
PPL	7,378	12%	3,867	26%
Duquesne Light	469	2%	195	6%
FE: Met-Ed	1,007	2%	971	16%
FE: Penelec	1,604	6%	1,475	28%
FE: Penn Power	676	5%	424	42%
FE: West Penn Power	1,387	4%	787	15%
Statewide	18,985	6%	9,886	18%

2.2 SUMMARY OF PY16 PEAK-DEMAND REDUCTIONS

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. on non-holiday weekdays from June to August. The peak-demand impacts from energy efficiency in this report are presented at the system level, reflecting adjustments for transmission and distribution losses.

2.2.1 Summary of PY16 Peak-Demand Reductions Statewide and by EDC

[Table 17](#) provides a summary of PY16 reported and verified peak-demand savings by EDC. Realization rates in PY16 ranged from 74% (Penn Power) to 109% (Duquesne Light).

Table 17: Summary of PY16 Reported and Verified Peak-Demand Reduction by EDC¹

EDC	PY16 Reported (MW/yr)	PY16 Verified Gross (MW/yr)	Realization Rate
PECO	59.68	62.10	104%
PPL	62.9	63.00	100%
Duquesne Light	12.4	13.54	109%
FE: Met-Ed	31.97	27.35	86%
FE: Penelec	26.41	20.90	79%
FE: Penn Power	7.60	5.60	74%
FE: West Penn Power	33.74	27.13	80%
Statewide	234.70	219.63	94%

¹ Totals may not equal the sum of columns or rows due to rounding.

2.2.2 Summary of PY16 Peak-Demand Savings by Sector

Compared to energy savings, non-residential customers account for a slightly higher percentage of peak-demand reductions (78%). Residential customers (including LI customers) accounted for 22% of PY16 peak-demand savings ([Table 18](#)).

Table 18: Summary of PY16 Verified Peak-Demand Reduction by Customer Segment^{1,2}

EDC	Residential (MW/yr)	LI (MW/yr)	Small C&I (MW/yr)	Large C&I (MW/yr)	GNI (MW/yr)	Total ² (MW/yr)
PECO	16.18	2.22	23.85	13.33	6.53	62.10
PPL	6.09	1.66	23.03	23.85	8.37	63.00
Duquesne Light	3.21	0.38	1.03	5.17	3.75	13.54
FE: Met-Ed	5.29	0.71	7.27	13.87	0.21	27.35
FE: Penelec	3.68	0.33	11.18	5.33	0.38	20.90
FE: Penn Power	1.33	0.17	2.59	1.44	0.08	5.60
FE: West Penn Power	5.58	0.76	8.30	7.26	5.23	27.13
Statewide	41.35	6.23	77.25	70.26	24.54	219.63

¹ Does not include carryover savings.

² Totals may not equal the sum of columns or rows due to rounding.

2.3 COMPARISON OF PY16 EXPENDITURES AND APPROVED EE&C PLAN BUDGET ESTIMATES

[Table 19](#) provides an overview of the EDC's planned and actual expenditures for EE&C programs in PY16. In PY16, statewide, the EDCs increased their spending compared to PY14, when six of seven EDCs spent less than their approved budget. In PY16, six of seven EDC's spending exceeded their approved budgets, and statewide spending was slightly above approved budgets.

Table 19: Comparison of PY16 Statewide Energy Efficiency Budgets and Expenditures¹

EDC	Actual PY16 Expenditures (\$1000)	Approved EE&C Plan Budget for PY16 (\$1000)	Difference Between Actual and EE&C Plan	Percent Difference from EE&C Plan
PECO	\$88,650	\$68,950	\$19,700	29%
PPL	\$64,829	\$63,938	\$891	1%
Duquesne Light	\$16,139	\$17,361	-\$1,222	-7%
FE: Met-Ed	\$30,544	\$25,066	\$5,478	22%
FE: Penelec	\$29,121	\$23,189	\$5,932	26%
FE: Penn Power	\$7,915	\$6,695	\$1,220	18%
FE: West Penn Power	\$31,242	\$23,714	\$7,528	32%
Statewide	\$268,440	\$228,913	\$39,527	17%

¹Totals may not match EE&C plan totals due to rounding.

Table 20 provides an overview of the EDC's planned and actual energy acquisition costs in PY16 and Table 21 presents the same comparison for PY16 capacity savings.

Table 20: Planned Versus Actual Energy Acquisition Costs in PY16

EDC	PY16 Verified Savings (MWh/yr)	Forecasted PY16 Acquisition Cost per First-Year kWh Saved	Actual PY16 Acquisition Cost per First-Year kWh Saved	Percent Change from Forecasted Acquisition Cost ²
PECO	321,861	\$0.19	\$0.28	42%
PPL	299,784	\$0.24	\$0.22	-10%
Duquesne Light	72,031	\$0.26	\$0.22	-13%
FE: Met-Ed	163,063	\$0.26	\$0.19	-29%
FE: Penelec	110,670	\$0.26	\$0.26	3%
FE: Penn Power	32,615	\$0.26	\$0.24	-6%
FE: West Penn Power	160,670	\$0.25	\$0.19	-22%
Statewide	1,160,694	\$0.23	\$0.23	0.4%

¹ The actual PY16 acquisition costs for PECO and PPL are overstated because program costs include the costs for savings that were unverified in PY16 but will be verified in PY17.

² Due to rounding of the forecasted and actual acquisition costs to the nearest cent, the percent change can vary dramatically.

Table 21: Planned Versus Capacity Acquisition Costs in PY16

EDC	PY16 Verified Savings (MW/yr)	Forecasted PY16 Acquisition Cost per First-Year kW Saved	Actual PY16 Acquisition Cost per First-Year kW Saved	Percent Change from Forecasted Acquisition Cost
PECO	62.10	\$1,079	\$1,427	32%
PPL	63.00	\$1,211	\$1,029	-15%
Duquesne Light	13.54	\$1,094	\$1,192	9%
FE: Met-Ed	27.35	\$1,462	\$1,117	-24%
FE: Penelec	20.90	\$1,406	\$1,394	-1%
FE: Penn Power	5.60	\$1,342	\$1,412	5%
FE: West Penn Power	27.13	\$1,323	\$1,151	-13%
Statewide	219.63	\$1,210	\$1,222	1%

¹ The actual PY16 acquisition costs are overstated for PECO and PPL because program costs include the costs for savings that were unverified in PY16 but will be verified in PY17. .

2.4 COST-EFFECTIVENESS SUMMARY

Pennsylvania utilizes the Total Resource Cost (TRC) test for all benefit-cost analysis. The TRC test examines cost-effectiveness from the perspective of the utility, participants, and non-participants. Over time, the Commission has customized the Pennsylvania TRC Test to reflect the policy priorities of the Commonwealth. In preparation for Phase IV, the PUC issued the 2021 TRC Test Order²¹ to document the methodology and assumptions EDCs should use when calculating the costs and benefits of Phase IV EE&C portfolios.

Table 22 shows the NPV costs and benefits for each EDC portfolio in PY16, as well as the TRC ratio (benefits divided by costs). TRC results are presented on both a gross and net savings basis. Per the 2021 TRC Test Order, incremental participant costs and benefits from free riders are excluded from the calculation of the net TRC ratio. The NPV of future energy savings is calculated using a 3% real discount rate (5% nominal discount rate) for all EDCs.²² On a gross basis, PY16 programs saved the Commonwealth an estimated \$205.3 million (benefits minus costs). On a net basis, statewide savings from PY16 programs are estimated at \$127.7 million. The statewide PY16 TRC ratio is 1.38.

²¹ Pennsylvania Public Utility Commission, *2021 TRC Test Final Order*. From the Public Meeting of December 19, 2019, at Docket No. M-2019-3006868 (*2021 TRC Test Order*). Entered December 19, 2019.

<https://www.puc.pa.gov/pdocs/1648126.docx>

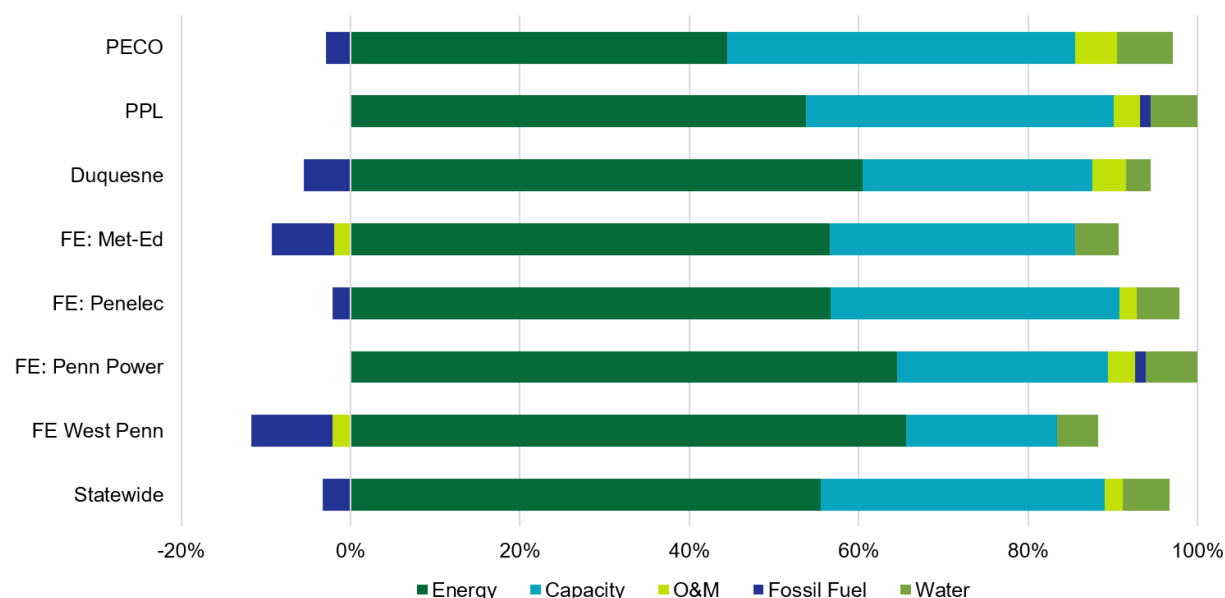
²² 2021 TRC Test Order. Pages 17-21.

Table 22: PY16 TRC Test Results by EDC¹

EDC	Gross Benefits (\$1000)	Gross Costs (\$1000)	Gross TRC	Net Benefits (\$1000)	Net Costs (\$1000)	Net TRC
PECO	\$189,432	\$152,265	1.24	\$130,464	\$109,326	1.19
PPL	\$237,449	\$184,462	1.29	\$171,265	\$140,215	1.22
Duquesne Light	\$41,782	\$20,497	2.04	\$35,890	\$18,508	1.94
FE: Met-Ed	\$95,249	\$71,324	1.34	\$62,542	\$48,453	1.29
FE: Penelec	\$79,131	\$47,664	1.66	\$56,972	\$36,292	1.57
FE: Penn Power	\$20,328	\$14,458	1.41	\$14,730	\$11,053	1.33
FE: West Penn Power	\$84,441	\$53,054	1.59	\$59,569	\$39,911	1.49
Statewide	\$747,812	\$543,725	1.38	\$531,432	\$403,758	1.32

¹ Totals may not equal the sum of columns or rows due to rounding.

Figure 11 shows the distribution of TRC benefits by EDC and statewide for PY16. Each series sums up to 100%, but the negative benefits are allowed to offset to the positive benefits categories. Energy is the largest benefit category statewide, followed by capacity, and then water. Fossil fuel and O&M benefits vary in direction and magnitude by EDC. West Penn Power and Met-Ed showed negative O&M benefits, while the other five EDCs showed positive O&M benefits. While O&M benefits are positive in PY16 at the statewide portfolio level, the aggregate O&M benefits were negative this year for Met-Ed and West Penn Power due to an assumed annual O&M expense of \$6.50 per installed kW of solar PV. Only FirstEnergy assumes that solar PV projects have a recurring annual maintenance cost. Only PPL and Penn Power reported positive fossil fuel benefits in PY16. For the other five EDCs, the aggregate fossil fuel benefits were negative—largely due to the interactive effects of LED lighting measures.

Figure 11: Breakdown of TRC Benefits

Finally, Table 23 presents a summary of statewide portfolio finances on a gross basis. The incremental cost of efficient equipment is the largest cost category. In PY16, EDC incentives covered 35% of incremental measure costs and participants paid the other 65%.

Table 23: Summary of Statewide Portfolio Finances

Row #	Cost Category*	PY16 (\$1000)	
1	IMCs	\$437,556	
2	Rebates to Participants and Trade Allies	\$95,935	
3	Upstream / Midstream Incentives	\$26,322	
4	Material Cost for Self-Install Programs (EE&C Kits)	\$12,664	
5	Direct Installation Program Materials and Labor	\$19,509	
6	Participant Costs (Row 1 minus the sum of Rows 2 through 5)	\$283,127	
		EDC	CSP
7	Program Design	\$89	\$43
8	Administration and Management	\$29,875	\$30,212
9	Marketing	\$3,065	\$11,130
10	Program Delivery	\$747	\$20,494
11	EDC Evaluation Costs	\$9,063	
12	SWE Audit Costs	\$1,452	
13	Program Overhead Costs (Sum of rows 7 through 12)	\$106,168	
14	Total NPV TRC Costs (Sum of rows 1 and 13)	\$543,725	
15	Total NPV Lifetime Electric Energy Benefits	\$444,026	
16	Total NPV Lifetime Electric Capacity Benefits	\$268,563	
17	Total NPV Lifetime O&M Benefits	\$16,815	
18	Total NPV Lifetime Fossil Fuel Impacts	(\$26,096)	
19	Total NPV Lifetime Water Impacts	\$44,503	
20	Total NPV TRC Benefits (Sum of rows 15 through 19)	\$747,812	
21	Statewide TRC Ratio (Row 20 divided by Row 14)	1.38	

* Rows 1-13 are presented in nominal dollars (PY13 = 2021, PY14 = 2022, PY16 = 2023, PY16 = 2024, PY17 = 2025)

2.4.1 Summary of the Alternative Energy Portfolio Standards Costs

The 2021 TRC Test Order²³ directed the Phase IV SWE to include a summary of the Alternative Energy Portfolio Standards (AEPS) costs in its Annual Report and to produce a comparison of how these costs have changed over time. What follows is a brief introduction to the AEPS values, how they are used, and their historic fluctuations.

²³ From the Public Meeting of December 19, 2019, at Docket No. M-2019-3006868. Entered December 19, 2019. <https://www.puc.pa.gov/pdocs/1648126.docx>

Alternative Energy Portfolio Standards Costs are electric cost adders included to reflect the cost of purchasing Alternative Energy Credits (AECs) as required by the AEPS Act.²⁴ The AECs are categorized into three tiers: Non-Solar Tier I, Tier II and Solar. The AEPS Act requires that AECs be purchased at a fixed percentage of EDC retail sales each year. EDCs must procure 10% of their retail MWh sales as Tier II credits, 8% of retail MWh sales as Non-Solar Tier I credits and 0.5% as Solar credits.

In the Act 129 Phase IV Avoided Energy and Capacity Cost Calculator,²⁵ AEPS avoided costs are a benefit as any reduction in retail sales associated with energy efficiency will decrease the total number of credits required to be procured. To simplify modeling, a single, weighted, AEPS cost was constructed. The total cost to purchase these credits to offset 1,000 MWh of retail sales is \$834 in nominal dollars, which amounts to \$4.51/credit and \$0.83/MWh.

The SWE was instructed to investigate AEPS cost changes and provide a recommendation on whether these values should be updated. To assess the degree to which AEPS costs fluctuate over time, the SWE collected historic²⁶ and current AEPS bid and offer prices and constructed the cost per MWh and per credit from 2008 onwards. Using current Marex Spectron prices, the weighted average cost of the AECs is \$29.55 per credit, or \$5.47 per MWh. Compared to the values originally included in the 2021 TRC Test Final Order and Phase IV ACC, the current value of credits is up by almost a factor of seven. AEPS credit values originally made up about 3% of the avoided cost of energy and now it would be approximately 20%.

When looking at the historical trend, three things are clear. First, the AEPS cost incorporated in 2019 represented a time when prices were at a historic low. Second, there has always been fluctuation in AEPS prices, and third, the current prices show a slowing of the trend toward increased AEPS costs over the last five years. The overall increase in costs over Phase IV has roots in policy changes that originated in the amending of the AEPS Act by Act 40²⁷ of 2017 and Act 114²⁸ of 2020. Act 40 requires that Solar AECs come from solar facilities within the Commonwealth while Act 114 implements the same location requirement for Tier II credits. In line with these findings, the 2026 TRC Order incorporates the higher values of AEPS credits in recent years into the Avoided Cost Calculator that will be used by the EDCs to plan for Act 129 programming in Phase V. In the 2026 TRC Order, the Commission also states that it plans to direct the SWE to continue including a summary of the AEPS costs over time in Phase V. The SWE agrees that continued monitoring of the cost of AEPS credits over time is a valuable exercise for understanding trends in the marketplace.

²⁴ See 73 P.S. §§ 1648.1–1648.8 and 66 Pa. C.S. § 2814. See also 52 Pa. Code §§ 75.1–75.72.

²⁵ <https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/total-resource-cost-test/>

²⁶ See AEPS Act Historical Pricing reports at <https://www.pennaeps.com/reports/>.

²⁷ See PA Act 40 of 2017, Section 2804

²⁸ See PA Act 114 of 2020, Section 1799.10-E

2.4.2 Annual Comparison of Phase IV Avoided Costs with Actual Market Conditions

Section B.1 of the 2021 TRC Test Final Order called for a single forecast of avoided costs to be used in Phase IV EE&C Plans and EDC Annual Reports. The Industrials²⁹ commented that EDCs should use actual experienced market prices rather than forecasted prices in annual and phase reporting. PA-EEFA³⁰ comments recommended an annual review of market conditions by the SWE to assess whether an update to the avoided costs forecast was warranted. The Commission agreed and directed the SWE *“to include in its Final Annual Reports a comparison of forecasted avoided costs of electricity to load weighted real time locational marginal prices (LMPs) for each EDC service area.”* According to the 2021 TRC Test Order, the Commission may reconsider the appropriateness of a static forecast of avoided costs or make changes in the methodology currently used to develop the avoided costs forecast based on the results of this exercise.

The original Phase IV forecasts of avoided costs were developed in summer 2020, at the height of the COVID-19 pandemic. During this time, the energy markets were facing low prices and uncertainty about the future regarding the pandemic. In summer 2022, the first review of avoided costs was undertaken by the SWE for PY13. Using LMP data from PJM’s DataMiner2, it was determined that the forecasted avoided costs had been underpredicted in comparison to experienced prices. The largest divergence from predictions was seen in the shoulder months. In PY14, much of the year experienced similarly high prices as seen in PY13, but the overall trend in LMPs was lower towards the end of the year, reaching similar levels to those of the forecast. In PY16, LMPs remained low, much nearer forecasted levels than in PY13 and PY14. LMPs rose again in PY16 and were further from forecasted levels than in PY15.

A review of the avoided cost of generation capacity forecasts was conducted in parallel to the review of forecasted avoided energy costs. The actual clearing prices from the Base Residual Auction (BRA) auctions for PY14, PY15, and PY16, for Phase IV generation capacity were lower than forecasted, prior to Phase IV, for all EDCs. However, the BRAs for PY17 and PY18 saw clearing prices for generation capacity increase to levels significantly higher than forecasted. Overall, the forecasted avoided cost of capacity overstated the value of peak savings for PY13, PY14, PY15, and PY16, but will understate the value of peak savings for PY17 and PY18 based on auction results. Despite this fact, when looking at all years of PJM BRA results and ACC forecasted generation capacity costs, the forecasts correctly estimate actual capacity price on average for Phase IV. In PY16 the forecasted avoided cost of energy slightly underestimated avoided energy benefits. No forecast model is perfect and there will always be some difference between forecasted and actual market conditions. When combining forecasts for multiple

²⁹ The Met-Ed Industrial Users Group, the Penelec Industrial Customer Alliance, the Philadelphia Area Industrial Energy Users Group, the PP&L Industrial Customer Alliance, the West Penn Power Industrial Intervenors, and the Pennsylvania Energy Consumer Alliance

³⁰ Green and Healthy Homes Initiative, Housing Alliance of Pennsylvania, Keystone Energy Efficiency Alliance, Natural Resources Defense Council, National Housing Trust, Pennsylvania Utility Law Project, and Regional Housing Legal Services (collectively, the Pennsylvania Energy Efficiency for All Coalition (PA-EEFA))

resources, however, differences should be expected to even out unless there is a systematic bias in the forecast.

Over Phase IV, the forecasted avoided costs have at times overpredicted and at other times underpredicted the actual costs of energy and capacity in the marketplace. While this is generally the expected outcome when comparing actual values to forecasted values, the SWE believes that the exercise of comparing forecast avoided costs to actual market conditions is a valuable exercise to keep up to date with actual market values. The SWE recommends that forecast avoided costs should still be reviewed annually in Phase V for deviations from actual market conditions.

This does not, however, change the SWE's position that a single avoided cost forecast should be used across Phase V to align benefits from program implementation with planning values. Even though the EDCs will have newly developed forecasts of avoided costs as part of their Phase V EE&C plans, the SWE recommends that PY17 benefit-cost modeling rely on the forecast that was used to plan Phase IV and report the cost-effectiveness of Act 129 programming in prior years of the phase.

2.4.3 DRIPE Sensitivity Analysis

In the 2026 TRC Test Order, the Commission directs the Pennsylvania EDCs to include the value of Demand Reduction Induced Price Effects (DRIPE) in cost effectiveness testing for Phase V of Act 129. DRIPE, or price suppression effects, captures the value of changes in wholesale electricity prices caused by a shift in the demand curve in a market. In relation to Act 129 activities, this means that DRIPE is meant to capture the value of overall decreased energy or capacity prices that result from avoided energy purchases or avoided capacity demand.

The SWE conducted a study to quantify the value of price suppression effects for each EDC in the future years of Phase V and beyond for both energy and capacity. In preparation for this annual report, the Commission requested that the SWE conduct a sensitivity analysis on the value of including DRIPE in cost effectiveness testing. To do so, the SWE calculated what the value of DRIPE benefits would have been for PY16 had they been included. [Table 24](#) shows the amount the PY16 benefits would increase if both energy and capacity DRIPE were included in the TRC test.

Table 24: Hypothetical DRIPE Benefits from PY16 by EDC

Category	PY16 Energy DRIPE (\$1,000)	PY16 Capacity DRIPE (\$1,000)
PECO	\$28,889	\$14,486
PPL	\$23,028	\$18,132
Duquesne Light	\$6,451	\$1,182
FE: Met-Ed	\$13,272	\$7,386
FE: Penelec	\$9,536	\$5,677
FE: Penn Power	\$2,393	\$278
FE: West Penn Power	\$13,239	\$2,312
Statewide	\$96,808	\$49,452

* Values are in present value (PY16 = \$2024). Totals may not equal the sum of columns or rows due to rounding.

If the benefits from DRIPE were included in cost effectiveness testing in PY16 the statewide TRC ratio of 1.38, shown in [Table 22](#), would increase to 1.64. While price suppression effects will make up only a portion of both avoided energy and avoided capacity when they are officially included in cost effectiveness testing in Phase V, the additional benefits stream will increase overall cost effectiveness substantially. Including the value of DRIPE in future cost effectiveness testing will provide a more comprehensive picture of the value provided of Act 129 EE&C programs to the Commonwealth.

Section 3 Portfolio and Program-Level Savings by EDC

This chapter provides a summary of the portfolio and program-level energy impacts, peak-demand impacts, DR performance, and Total Resource Cost (TRC) benefit-cost ratios for each EDC.

Table 25 presents a statewide overview of PY16 and phase-to-date savings.

Table 25: Summary of Statewide PY16 Impacts and Phase IV Impacts: Gross and Net Annual and Lifetime Savings

Savings Category	Statewide Total
Phase IV Reported Gross Savings (MWh/yr)	3,714,361
Phase IV Verified Gross Savings (MWh/yr)	3,651,343
Phase IV Net Savings (MWh/yr)	2,630,056
Phase IV Gross Lifetime Savings (MWh)	42,882,241
Phase IV Net Lifetime Savings (MWh)	30,066,670
PY16 Reported Gross Savings (MWh/yr)	1,210,608
PY16 Verified Gross Savings (MWh/yr)	1,160,694
PY16 Net Savings (MWh/yr)	825,899
PY16 Gross Lifetime Savings (MWh)	14,096,979
PY16 Net Lifetime Savings (MWh)	9,735,852

3.1 PECO

3.1.1 Impact Evaluation

Table 26 summarizes PECO's energy impacts by program for PY16. The Non-Residential Program accounted for 71% of the verified savings in PY16 while the Residential Program accounted for 16% of verified savings.

Table 26: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – PECO

Program	PYRTD (MWh/yr) ²	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Residential	59,476	85%	50,296	0.49	24,605
Income-Eligible	13,943	119%	16,559	1.00	16,559
Residential HER	28,911	90%	26,156	1.00	26,156
Income-Eligible HER	1,465	55%	807	1.00	807
Non-Residential	229,969	99%	228,042	0.69	156,764
Portfolio Total¹	333,763	96%	321,861	0.70	224,891

¹ Totals may not equal the sum of columns or rows due to rounding.

² PYRTD excludes unverified savings.

A summary of phase-to-date energy impacts by program is presented in [Table 27](#). Consistent with PY16, the bulk of savings (70%) in the phase is attributable to the Non-Residential Program.

Table 27: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – PECO

Program	RTD (MWh/yr) ²	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Residential	208,613	91%	188,900	0.66	123,740
Income-Eligible	73,413	101%	74,358	1.00	74,358
Residential HER	108,558	97%	105,303	1.00	105,303
Income-Eligible HER	3,421	72%	2,473	1.00	2,473
Non-Residential	858,760	100%	862,875	0.68	590,336
Portfolio Total¹	1,252,766	98%	1,233,910	0.73	896,210

¹ Totals may not equal the sum of columns or rows due to rounding.

² RTD excludes unverified savings.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 are presented in [Table 28](#), while [Table 29](#) shows the phase-to-date peak-demand performance by program.

Table 28: PY16 Peak-Demand Savings by Program (MW/Year) – PECO

Program	PYRTD (MW/yr) ²	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Residential	7.83	112%	8.79	0.49	4.37
Income-Eligible	1.60	116%	1.84	1.00	1.84
Residential HER	4.70	164%	7.73	1.00	7.73
Income-Eligible HER	0.24	83%	0.20	1.00	0.20
Non-Residential	45.31	96%	43.54	0.69	30.06
Portfolio Total¹	59.68	104%	62.10	0.71	44.20

¹ Totals may not equal the sum of columns or rows due to rounding.

² PYRTD excludes unverified savings.

Table 29: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – PECO

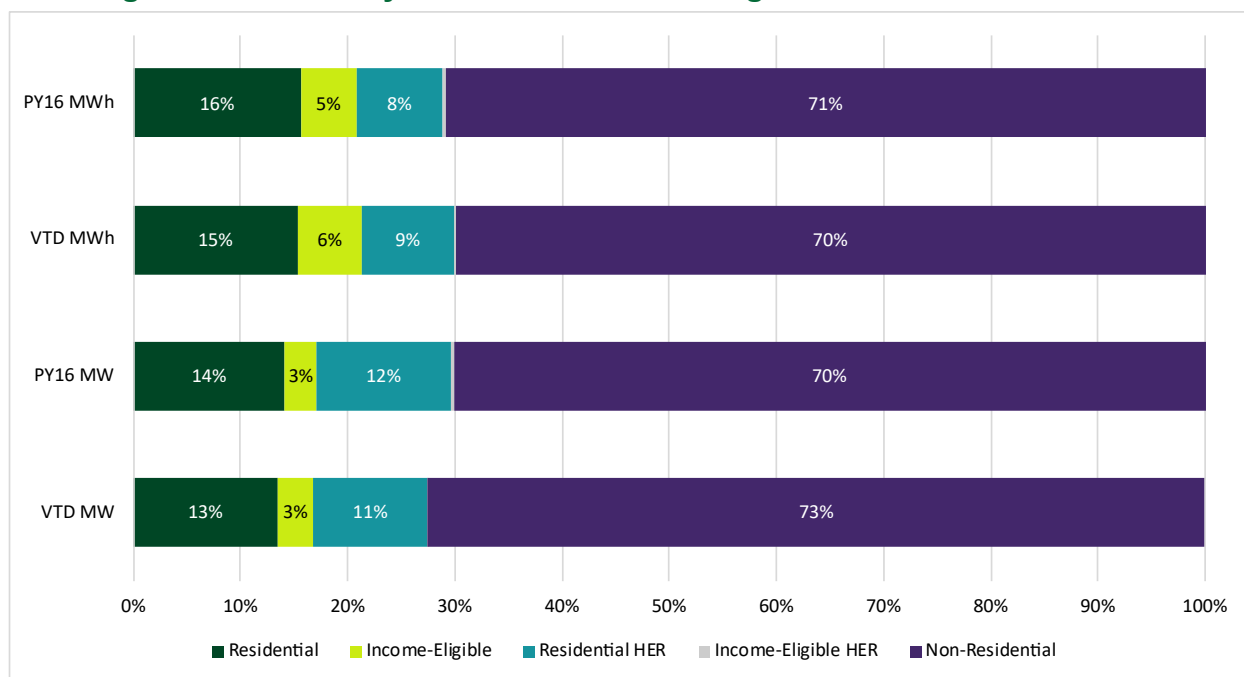
Program	RTD (MW/yr) ²	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Residential	31.15	99%	30.94	0.63	19.57
Income-Eligible	7.73	99%	7.66	1.00	7.66
Residential HER	17.67	139%	24.51	1.00	24.51
Income-Eligible HER	0.56	21%	0.12	1.00	0.12
Non-Residential	167.75	99%	166.75	0.69	114.91
Portfolio Total¹	224.86	102%	229.99	0.73	166.77

¹ Totals may not equal the sum of columns or rows due to rounding.

² RTD excludes unverified savings.

Figure 12 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis.

Figure 12: Summary of PY16 and P4TD Program Contributions – PECO



3.1.2 Cost-Effectiveness

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

Table 30 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which was 1.24 in PY16, lower than 1.59 in PY15. The benefits were calculated using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table 30: PY16 Gross TRC Ratios by Program (\$1,000) – PECO¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Residential EE	\$42,337	\$41,473	1.02	\$863
Income-Eligible EE	\$18,259	\$5,317	3.43	\$12,943
Residential HER	\$9,119	\$2,217	4.11	\$6,902
Income-Eligible HER	\$249	\$97	2.57	\$152
Residential Subtotal	\$69,964	\$49,104	1.42	\$20,860
Non-Residential Subtotal	\$119,468	\$92,755	1.29	\$26,713
Common Portfolio Costs	--	\$10,406		(\$10,406)
Portfolio Total	\$189,432	\$152,265	1.24	\$37,166

3.1.3 Process Evaluation

Guidehouse reported on PY16 process evaluations for the following PECO programs and target market segments ([Table 31](#)).

Table 31: PECO PY16 Process Evaluations Conducted for Program Components

Programs and Program Components	
Residential EE Program ³¹	Non-Residential Program ³²
Rebates and Marketplace - Downstream	Downstream
Rebates and Marketplace - Point of Purchase	

For PY16, Guidehouse conducted and reported on full process evaluations for three components and sub-components within the PECO residential and non-residential programs. The Residential EE Program has five components: Rebates and Marketplace, In-Home Assessment, Multifamily, Appliance Recycling, and New Construction; a full process evaluation was only conducted for the Rebates and Marketplace component in PY16. The Rebates and Marketplace component of the Residential EE Program also contains four sub-components: Downstream, Trade Ally and Distributor Network, Point of Purchase, and Online Marketplace; a full process evaluation was only conducted for the Downstream and Point of Purchase sub-components in PY16. The Income-Eligible EE Program has four components: Single-Family, Appliance Recycling, Multifamily, and Long-Term Savings; a full process evaluation was not conducted for any components of this program in PY16. Finally, the Non-Residential Program also contains four components: Downstream, Midstream, New Construction, and Small Business Direct Install; a full process evaluation was only conducted for the Downstream component in PY16.

From these evaluations, the results produced process evaluation findings regarding program satisfaction from participants. Participant satisfaction information was collected for the Downstream and Point of Purchase sub-components of the Rebates and Marketplace component of the Residential EE Program, and the Downstream (customer) component of the Non-Residential Program. On average, across these participant surveys, 84% of Residential EE Program participants and 100% of Non-Residential Program participants were satisfied with the programs overall.

³¹ As described in the Phase IV Evaluation Plan approved by the SWE, Guidehouse did not complete any in-depth process evaluation activities for the Distributor Network or Online Marketplace sub-components of the Rebates and Marketplace component. Guidehouse also did not complete any in-depth process evaluation activities for the In-Home Assessment, Multifamily, Appliance Recycling, or New Construction components of the Residential Program in PY16.

³² As described in the Phase IV Evaluation Plan approved by the SWE, Guidehouse did not complete any in-depth process evaluation activities for the Midstream Rebates, New Construction, or Small Business Direct Install components of the Non-Residential Program in PY16. The evaluation plan mentioned conducting in-depth interviews with distributors for the Midstream Rebates component in PY16, but the team plans to continue these efforts and report results in PY17.

For the *PECO Residential EE Program*, the PY16 process evaluation provided two key findings and two recommendations. One recommendation was in progress, and one was under consideration. The evaluation conducted a participant survey for two sub-components of the Rebates and Marketplace component (Downstream and Point of Purchase). Additionally, the evaluation conducted interviews with retail store managers for the Point of Purchase sub-component. The evaluation also consisted of interviews for program and CSP staff, but no findings were reported on these interviews for PY16. Findings for this program addressed other topics beyond satisfaction, including the following:³³

- Likelihood of recommending the program
- Awareness of the program
- Ease of participating in the program
- Drivers of program component satisfaction

For the *PECO Income-Eligible EE Program*, the PY16 process evaluation consisted of interviews for program and CSP staff, but neither satisfaction results nor findings were reported on these interviews for PY16. No other process evaluation activities were conducted for this component in PY16. Future findings for this program will address other topics beyond satisfaction, including the following:³⁴

- Likelihood of recommending the program
- Awareness of the program
- Ease of participating in the program
- Drivers of program component satisfaction

For the *PECO Non-Residential EE Program*, the PY16 process evaluation provided three findings and three recommendations. Two recommendations were in progress, and one was under consideration. The evaluation conducted a participant survey for the Downstream Rebates component of the non-residential program. Additionally, the evaluation team attempted to survey non-lighting distributors for the Midstream Rebates component of the non-residential program. Due to a low response rate, process results were not reported in PY16 and will be reported in the future. The evaluation also consisted of interviews for program and CSP staff, but neither satisfaction results nor findings were reported on these interviews for PY16. Findings for this program addressed other topics beyond satisfaction, including the following:³⁵

- Likelihood of recommending the program
- Awareness of the program
- Ease of participating in the program
- Drivers of program component satisfaction

³³ The PECO annual report provides further detail regarding these topics.

³⁴ The PECO annual report provides further detail regarding these topics.

³⁵ The PECO annual report provides further detail regarding these topics.

3.1.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the PECO PY16 Annual Report and the supporting detail provided by PECO's evaluation contractor. The detailed audit findings can be found in [Appendix B](#).

- The SWE's review of verified savings for residential components, which include income-eligible programs, found that, overall, the verification process followed proper TRM protocols and followed Guidehouse's EM&V plans. For education measures, the SWE found some savings calculation errors as well as the use of an incorrect verification ratio. Correcting these errors increased the total residential and low income verified savings by 0.25%.
- PECO's Phase IV EM&V Plan calls for an intermediate savings quantity between reported and verified gross savings referred to as "adjusted database savings." The ratio of verified savings to "adjusted database savings" is called the "verification ratio." The adjusted database savings are computed for every program component annually, even in program years when no impact evaluation was conducted. The documentation improved further for PY16, allowing the SWE to more easily replicate the expansion process and verified savings calculations for all program components.
- Adjusted database savings are the result from Guidehouse's review of every measure to identify systematic patterns or errors in applying TRM algorithms, constants, or deemed values. The adjusted database savings differed only slightly from the reported savings in PY16, with adjusted database MWh and MW approximately 0.4% lower than reported MWh and MW at the portfolio level. While the SWE has questioned the usefulness of this intermediate quantity, it provided a natural place to zero out savings from ineligible products incentivized through the commercial midstream channel. This systematic issue should not persist; therefore, separating it from the broader realization rates is reasonable.
- The dataset used in the sample expansion and realization rate calculations differs from PECO's annual report values for the Downstream component of the Non-Residential program because the sample frame includes 3,192 MWh of unverified PY15 savings that were verified in PY16 and excludes 746 MWh of unverified PY16 savings that will be evaluated in PY17. This difference is a natural consequence of unverified savings and does not create any sampling or expansion issues, given the limited contribution of unverified savings to overall program totals.
- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific Measurement and Verification (M&V) activities, and applied TRM protocols correctly. Minor revisions included updating the operational schedule for the demand calculation of one air compressor project to align with data collected.
- PECO has a portfolio TRC ratio of 1.24 in PY16, lower than PY15's TRC ratio of 1.59. The SWE's TRC audit led to an adjustment of the fossil fuel benefits from low-flow water savings devices, such as faucet aerators and showerheads. Guidehouse's TRC model monetized per-unit therm savings estimates on a \$/MMBtu basis, meaning the fossil fuel benefits of these measures were overstated by a factor of 10 in PECO's PY16 annual

report. Guidehouse also updated the assumed domestic hot water fossil fuel share for these devices to align with TRM defaults for the PECO service territory. The corrections lowered the portfolio TRC benefits by approximately \$20 million. All TRC values in this report reflect corrected fossil fuel impacts for low-flow devices. The SWE thoroughly audited the TRC model and found all other elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.

- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in PECO's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and incentives. The SWE was unable to replicate participant counts exactly using the tracking data, but the SWE did not expect to be able to do so.
- PECO had eleven active behavioral HER cohorts in PY16, with approximately 540,000 treated households. Ten of eleven cohorts were mature enough to require persistence calculations to separate incremental savings from persisting savings from prior exposure. Over half of the MWh savings measured at the meter were attributed to prior HER exposure and therefore not eligible to count towards Phase IV compliance targets. Approximately 8% of all gross verified MWh savings came from HER programs in PY16, and 4.3% of PECO's progress towards its low-income compliance target came from the Income-Eligible HER program. The SWE was able to replicate the verified energy and demand savings values.
- The Income-Eligible HER program delivered 807 MWh of verified gross savings in PY16, thanks to improved performance from Wave 8. In PY15, the Income-Eligible HER program contributed -237 MWh of verified gross savings, causing a setback for PECO in terms of progress toward its Phase IV low-income compliance target. It is unclear what led to the lack of performance of Wave 8 in PY15, but the positive savings in PY16 are an encouraging trend.
- Non-residential project document reviews were conducted for 30 projects across five non-program components. Overall, project documentation was thorough and provided the data needed to inform savings analyses. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of PECO's residential and income-eligible components in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data. The SWE notes that while PECO's Residential Appliance Recycling program component was active in PY16 there were no project files submitted for review in PY16. Project files should be submitted for the Appliance Recycling program component in the PY17 quarterly data request responses.
- Overall, Guidehouse estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and applied historic NTG according to the approved EM&V plan.
- For the process evaluations, Guidehouse completed all the PY16 activities detailed in the approved evaluation plan and sampling memos, and the reporting followed the SWE

guidelines. The process evaluation discussion was succinct and highlighted findings that should be of value to PECO and its CSPs.

3.2 PPL

3.2.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 32](#). Over three-quarters of the savings (78%) are attributable to the Non-Residential Energy-Efficiency Program, which comprises two distinct program components – Efficient Equipment and Custom. The Custom component is designed to give customers the option to save electricity across lighting and non-lighting end-uses including those measures that are not covered by other programs.

Table 32: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – PPL

Program	PYRTD (MWh/yr) ²	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Low-Income	18,402	0.84	15,530	1.00	15,530
Residential	48,563	1.01	49,267	0.66	32,721
Non-Residential	246,969	0.95	234,987	0.70	165,410
Portfolio Total¹	313,933	0.95	299,784	0.71	213,662

¹ Totals may not equal the sum of columns or rows due to rounding.

² PYRTD excludes unverified savings

A summary of phase-to-date energy impacts by program is presented in [Table 33](#).

Table 33: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – PPL

Program	RTD (MWh/yr) ²	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Low-Income	53,840	0.96	51,614	1.00	51,614
Residential	188,195	0.94	176,319	0.66	116,467
Non-Residential	754,356	0.99	747,612	0.67	502,830
Portfolio Total¹	996,391	0.98	975,545	0.69	670,911

¹ Totals may not equal the sum of columns or rows due to rounding.

² RTD excludes unverified savings

A summary of the peak-demand impacts for each energy-efficiency program for PY16 and P4TD are presented in [Table 34](#) and [Table 35](#) respectively.

Table 34: PY16 Peak-Demand Savings by Program (MW/Year) – PPL

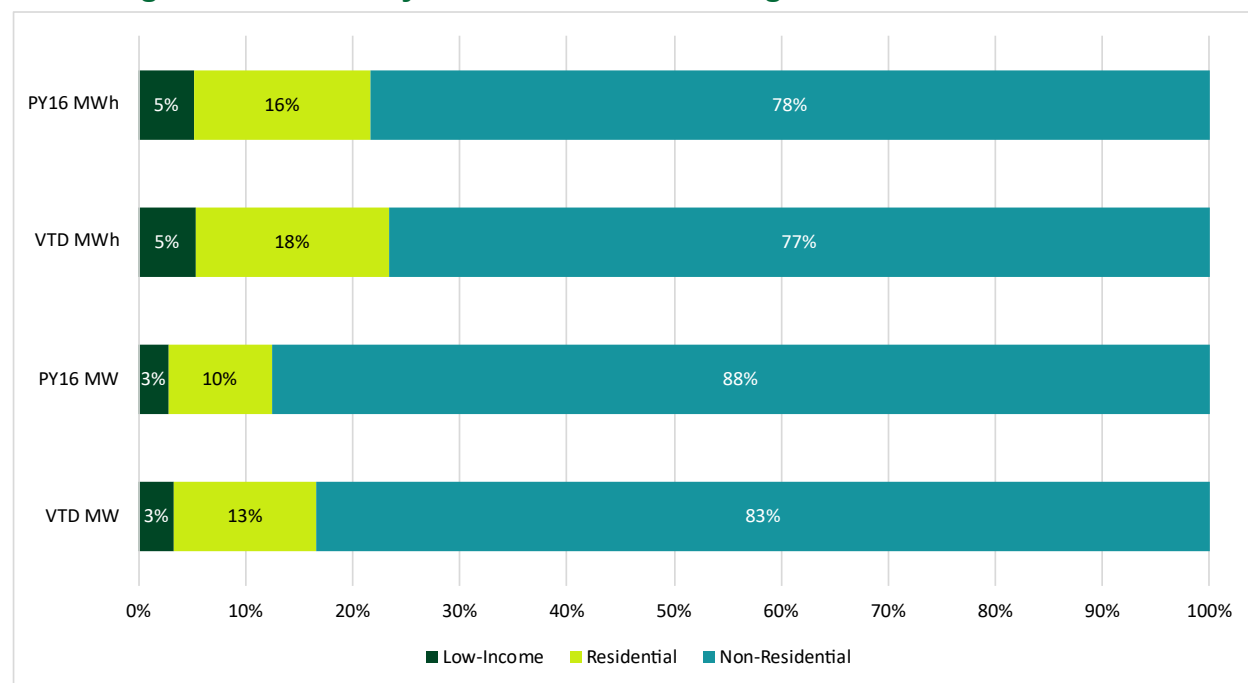
Program	PYRTD (MW/yr) ²	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Low-Income	1.87	93%	1.73	1.00	1.73
Residential	5.76	106%	6.08	0.58	3.55
Non-Residential	55.26	100%	55.19	0.71	39.38
Portfolio Total¹	62.9	100%	63.00	0.71	44.66

¹ Totals may not equal the sum of columns or rows due to rounding.² PYRTD excludes unverified savings**Table 35: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – PPL**

Program	RTD (MW/yr) ²	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Low-Income	5.75	1.01	5.82	1.00	5.82
Residential	23.45	1.00	23.44	0.64	14.97
Non-Residential	144.14	1.02	147.07	0.68	100.34
Portfolio Total¹	173.33	1.02	176.33	0.69	121.13

¹ Totals may not equal the sum of columns or rows due to rounding.² RTD excludes unverified savings

Figure 13 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. The Non-Residential Program accounted for a smaller share of MWh and MW savings in PY16 compared to its P4TD contributions.

Figure 13: Summary of PY16 and P4TD Program Contributions – PPL

3.2.2 Cost-Effectiveness

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

Table 36 shows the TRC ratios by program component and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which is 1.29 in PY16. The benefits were calculated using gross verified impacts. The PY16 TRC benefits and ratio are slightly understated as unverified savings are not considered in this analysis. Costs and benefits are expressed in 2024 dollars.

Table 36: PY16 Gross TRC Ratios by Program (\$1,000) – PPL¹

Program Components	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Low-Income	\$14,200	\$10,225	1.39	\$3,975
Appliance Recycling	\$3,796	\$2,525	1.50	\$1,271
Efficient Lighting	\$0	\$1	-	-\$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 Total	\$48,916	\$32,973	1.48	\$15,943
Custom	\$118,574	\$108,009	1.10	\$10,565
Efficient Equipment	\$69,959	\$35,329	1.98	\$34,629
Non-Residential Total	\$188,533	\$143,338	1.34	\$45,195
Cross-cutting		\$8,152		
Portfolio Total	\$237,449	\$184,462	1.29	\$52,987

¹ Totals may not equal the sum of columns or rows due to rounding.

3.2.3 Process Evaluation

Cadmus reported on PY16 process evaluations for the following PPL programs and program components (Table 37).

Table 37: PPL PY16 Process Evaluations Conducted for Program Components

Programs and Program Components	
Residential Program ³⁶	Non-Residential Program ³⁷
Energy Efficient Homes – Audit and Weatherization	Efficient Equipment (downstream direct discount, and direct install)
Energy Efficient Homes - Equipment (downstream)	Custom
Student Energy Efficient Education	
Home Energy Reports	Low-Income (LI) Program
	Remote Energy Assessment (REA)
	In-Home (On-site)
	Welcome Kits

For PY16, Cadmus conducted and reported on full process evaluations for a total of nine components and sub-components within the PPL residential, non-residential, and LI programs. The Residential Program has three major components (Energy Efficient Homes, Student Energy Efficient Education (SEEE), and Home Energy Reports (HER)). Additionally, the Energy Efficient Homes component within the Residential Program has two distinct sub-components (Audit and Weatherization and Downstream Equipment) with separate evaluations.³⁸ The Non-Residential Program has two components (Efficient Equipment and Custom) with separate evaluations. Additionally, the Efficient Equipment component within the Non-Residential Program has two distinct sub-components (Downstream and Midstream) as well as two separate participant pathways within each sub-component (lighting and equipment). The LI Program has three components (REA, On-Site, and Welcome Kits) with separate evaluations.

These evaluations generated a total of four process evaluation conclusions, which resulted in two recommendations that have been implemented and four recommendations that are under consideration. A key cross-program finding was on program satisfaction from participants and participating teachers and students. This evaluation collected participant satisfaction information for four residential program components (Audit and Weatherization, Energy Efficient Homes

³⁶ For the Residential Program, the Appliance Recycling, Efficient Lighting, New Homes (within the Energy Efficient Home component), Online Marketplace (within the Energy Efficient Home component), and Instant Discount (within the Energy Efficient Home component) components were not included because process evaluations were not completed for them in PY16.

³⁷ For the Non-Residential Program, the Efficient Equipment (midstream) component was not included because a process evaluation was not completed for it in PY16.

³⁸ The Energy Efficient Homes component has five additional sub-components, Appliance Recycling, Efficient Lighting, New Homes (within the Energy Efficient Home component), Online Marketplace (within the Energy Efficient Home component), and Instant Discount (within the Energy Efficient Home component), which were not evaluated in PY16.

Downstream Equipment, Student Energy Efficient Education, and Home Energy Reports), two non-residential program components (Custom and Downstream Efficient Equipment), and three residential LI program components (REA, On-Site, and Welcome Kits). On average, across all participant surveys, 68% of residential and LI participants,³⁹ and 94% of non-residential participants were satisfied with the programs overall.⁴⁰

For the *PPL Residential Program*, the PY16 process evaluation provided several key findings. A key cross-program finding was on program satisfaction from participant and participating student and teacher surveys. The evaluation conducted a participant survey for the Audit and Weatherization sub-component of the Efficient Home component, a participant survey for the Downstream Equipment sub-component of the Efficient Homes component, in-depth interviews with distributors and contractor for the Midstream Equipment component, participating teacher and student surveys for the Student Energy Efficient Education component, and a participant (treatment group) survey and a non-participant (control group) survey for the Home Energy Report component. On average 67% of the participants (including participating customers and students and teachers) were satisfied with the program overall.⁴¹ Findings for this program addressed other topics beyond satisfaction, including the following:⁴²

- Ease of participation
- Drivers of program component satisfaction
- Opinions about PPL
- Program influence on sales and stocking practices
- Customer and trade ally feedback
- Program improvement suggestions
- Treatment group experience with the home energy reports
- Control group baseline comparison of information seeking behavior
- Home energy report recommendations
- Awareness of programs and rebate offers
- Engagement with the PPL website
- Engagement in energy saving behaviors and home improvement
- Barriers to engaging in energy saving behaviors and overcoming challenges

For the *PPL Non-Residential Program*, the PY16 process evaluation did not provide any process conclusions or recommendations in the PPL PY16 Annual Report. A key cross-program finding was on program satisfaction from participant surveys. The evaluation conducted participant surveys for the Downstream sub-component of the Efficient Equipment component and the Custom component. On average, 94% of the participants were satisfied

³⁹ When HER participants responses are excluded, 85% of residential and LI participants (combined) were satisfied with the programs overall.

⁴⁰ Weighted by the number of PY16 participants in each component or sub-component.

⁴¹ When HER participants responses are excluded, 87% of residential participants were satisfied with the programs overall.

⁴² The PPL annual report provides further detail regarding these topics.

with the program overall. Findings for this program addressed other topics beyond satisfaction, including the following:⁴³

- Drivers of program component satisfaction
- Customer expectations

For the *PPL Residential LI Program*, the PY16 process evaluation generated one conclusion and recommendation for the program as a whole. The recommendation has been implemented. A key cross-program finding was program satisfaction from participant surveys. The evaluation conducted participant surveys for the REA, the On-Site, and the Welcome Kits components. On average, 82% of the participants were satisfied with the program overall. Findings for this program addressed other topics beyond satisfaction, including the following:⁴⁴

- Ease of participation
- Likelihood to recommend the program
- Drivers of program component satisfaction
- Opinions about PPL
- Energy-saving behaviors
- Information from energy advisors

3.2.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the PPL PY16 Annual Report and the supporting detail provided by PPL's evaluation contractor. The detailed audit findings can be found in [Appendix C](#).

- The SWE's review of PY16 verified savings for non-residential program components found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and that the TRM protocols were applied correctly and are generally accurate
- Cadmus provided nearly all of their residential and low-income verified savings analyses prior to drafting their PPL PY16 Annual Report. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the PPL PY16 Annual Report.
- The SWE's review of verified savings for residential solutions, which includes LI programs, found that, overall, the verified savings followed proper TRM protocols, and most verified savings are accurate. The SWE found errors with the verification of a few measures in the Energy Efficient Homes - Downstream HVAC component that resulted in an increase in verified energy savings by 0.06% of total portfolio savings and 0.39% of total verified savings for the Residential program.
- PPL's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.29. PPL's PY16 gross TRC ratio was above its PY15 gross TRC ratio of 1.19. The gross TRC ratio of 1.29

⁴³ The PPL annual report provides further detail regarding these topics.

⁴⁴ The PPL annual report provides further detail regarding these topics.

reflects a units correction to the increased fossil fuel consumption associated with PPL's largest CHP project.

- The SWE thoroughly audited the TRC model and found all other elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The impact evaluation of the Midstream Lighting portion of PPL's Efficient Equipment offering included one sample point where the program-supported LED fixtures had been ineligible since the beginning of PY15 due to a Codes and Standards update to the 2021 TRM. While the contribution of ineligible product to PY16 spending and reported savings was small, the SWE encourages PPL to review carefully that all equipment it subsidizes with ratepayer funds is eligible to claim Act 129 energy and demand savings.
- The Downstream Lighting portion of PPL's Efficient Equipment offering accounted for over 40,000 MWh and 6 MW of verified savings in PY16. Despite this significant contribution to the portfolio, the impact evaluation included just one phone interview and no site visits with program participants. This absence of primary data collection is concerning, so the SWE is working with PPL and its evaluator to update the PY17 EM&V plan to include more independent verification of key project details and reduce reliance on ICSP documentation.
- HVAC tune-ups were a new offering within the Efficient Equipment program component in PY16 and accounted for approximately 50% of all non-lighting savings. The ICSP collected detailed documentation on each serviced HVAC unit that allowed evaluators to implement the algorithms and assumptions of the HVAC tune-up IMP. For a limited number of units, evaluation uncovered a disconnect between the activities performed and the energy savings factor applied. The SWE audit also identified quantity and cooling-efficiency transcription issues between the contractor's documentation and PPL's tracking system. These issues had opposing effects on savings, so the overall impact to MWh and MW savings was modest.
- PPL launched a behavioral Home Energy Report program in PY16 to approximately 360,000 residential households. The average savings per home in PY16 was 21 kWh. Home Energy Report savings can take several years to reach maturity, and the PPL program did not launch until December for the first accounts, with some accounts not receiving their first HER messaging until early 2025. The SWE expects the savings contribution of the HER program component to expand in PY17, and produce peak-demand savings since the treatment was active during summer 2025. PPL's evaluation contractor followed the regression model specification listed in its approved EM&V Plan and adjusted the savings for dual participation despite the HER control participating in other EE&C programs at a higher rate than the treatment group.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in PPL's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participant counts. The SWE was unable to replicate incentives exactly using the tracking data. Note that PPL expressed to the SWE that the rebate amounts in the tracking data will generally never

exactly equal the incentive dollars in their reports, because the PPL PY16 Annual Report values are pulled from a financial system as opposed to program tracking data.

- Project documentation for the non-residential program components submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of PPL's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted; the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data. Across several programs, the SWE observed a few instances where measure names and their corresponding TRM measure number did not align with the TRM; however, reported savings did not appear to be impacted.
- Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and the approved EM&V plan.
- For the process evaluations, Cadmus completed all the PY16 activities detailed in the approved evaluation plan and sampling memos, and the reporting followed the SWE guidelines. The process evaluation discussion was succinct and highlighted findings that should be of value to PPL and its CSPs.

3.3 DUQUESNE LIGHT

3.3.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 38](#). The non-residential programs accounted for 65% of the verified savings in PY16. The Residential Downstream Incentives program accounted for the largest share of residential savings (19% of PY16 portfolio savings).

Table 38: PY16 Incremental Annual Energy Savings by Program (MWh/Year)¹ – Duquesne Light

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Residential Downstream Incentives	13,096	103%	13,437	0.81	10,856
Residential Midstream Incentives	-	-	-	-	-
Residential Upstream Incentives	-	-	-	-	-
Residential Appliance Recycling	1,408	101%	1,422	0.72	1,019
Low-Income Energy Efficiency (LIEEP)	2,431	99%	2,417	1.00	2,417
Residential Behavioral Savings	6,956	99%	6,891	1.00	6,891
LI Residential Behavioral	549	127%	696	1.00	696
Small Business Direct Install (SBDI)	473	99%	469	0.93	436
Small Business Solutions	5,936	94%	5,558	0.66	3,668
Small Business Midstream Solutions	-	-	-	-	-
Small Business Virtual Commissioning	101	99%	100	0.94	94
Commercial Large Business Solutions	22,139	96%	21,206	0.90	19,054
Industrial Large Business Solutions	2,469	105%	2,585	0.90	2,322
Large Business Midstream Solutions – Commercial	8,797	175%	15,431	0.88	13,579
Large Business Midstream Solutions – Industrial	1,426	111%	1,583	0.88	1,393
Large Business Virtual Commissioning	244	97%	238	0.94	223
Portfolio Total	66,024	109%	72,031	0.87	62,649

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of phase-to-date energy impacts by program is presented in [Table 39](#). Compared to PY16, Duquesne Light's non-residential programs account for an even larger share of P4TD savings (76%).

Table 39: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year)¹ – Duquesne Light

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Residential Downstream Incentives	22,163	100%	22,187	0.80	17,856
Residential Midstream Incentives	7	100%	7	1.00	7
Residential Upstream Incentives	6,756	110%	7,456	0.69	5,108
Residential Appliance Recycling	5,031	106%	5,344	0.59	3,167
Low-Income Energy Efficiency (LIEEP)	9,922	95%	9,424	1.00	9,424
Residential Behavioral Savings	28,148	98%	27,635	1.00	27,635
LI Residential Behavioral	2,539	112%	2,853	1.00	2,853
Small Business Direct Install (SBDI)	11,212	93%	10,428	0.94	9,789
Small Business Solutions	28,167	105%	29,645	0.69	20,564
Small Business Midstream Solutions	52,861	109%	57,431	0.69	39,383
Small Business Virtual Commissioning	2,860	98%	2,804	0.95	2,657
Commercial Large Business Solutions	50,495	100%	50,643	0.70	35,446
Industrial Large Business Solutions	29,338	101%	29,755	0.48	14,349
Large Business Midstream Solutions – Commercial	22,563	140%	31,495	0.81	25,435
Large Business Midstream Solutions – Industrial	16,649	124%	20,580	0.70	14,478
Large Business Virtual Commissioning	4,165	97%	4,051	0.97	3,949
Portfolio Total	292,875	106%	311,736	0.74	232,101

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 are presented in [Table 40](#).

Table 40: PY16 Peak-Demand Savings by Program (MW/Year) – Duquesne Light¹

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Residential Downstream Incentives	1.71	84%	1.43	0.81	1.16
Residential Midstream Incentives	-	-	-	-	-
Residential Upstream Incentives	-	-	-	-	-
Residential Appliance Recycling	0.37	107%	0.4	0.72	0.29
Low-Income Energy Efficiency	0.19	101%	0.2	1.00	0.2
Residential Behavioral Savings	1.95	71%	1.38	1.00	1.38
LI Residential Behavioral	0.07	193%	0.14	1.00	0.14
Small Business Direct Install	0.06	166%	0.11	0.93	0.1
Small Business Solutions	1.15	90%	1.04	0.66	0.68
Small Business Midstream Solutions	-	-	-	-	-
Small Business Virtual Commissioning	0	90%	0	0.94	0
Commercial Large Business Solutions	4.44	106%	4.71	0.90	4.23
Industrial Large Business Solutions	0.3	94%	0.29	0.90	0.26
Large Business Midstream Solutions – Commercial	1.75	195%	3.42	0.88	3.01
Large Business Midstream Solutions – Industrial	0.38	114%	0.43	0.88	0.38
Large Business Virtual Commissioning	-	N/A	-	N/A	-
Portfolio Total	12.40	109%	13.54	0.87	11.82

¹ Totals may not equal the sum of columns or rows due to rounding.

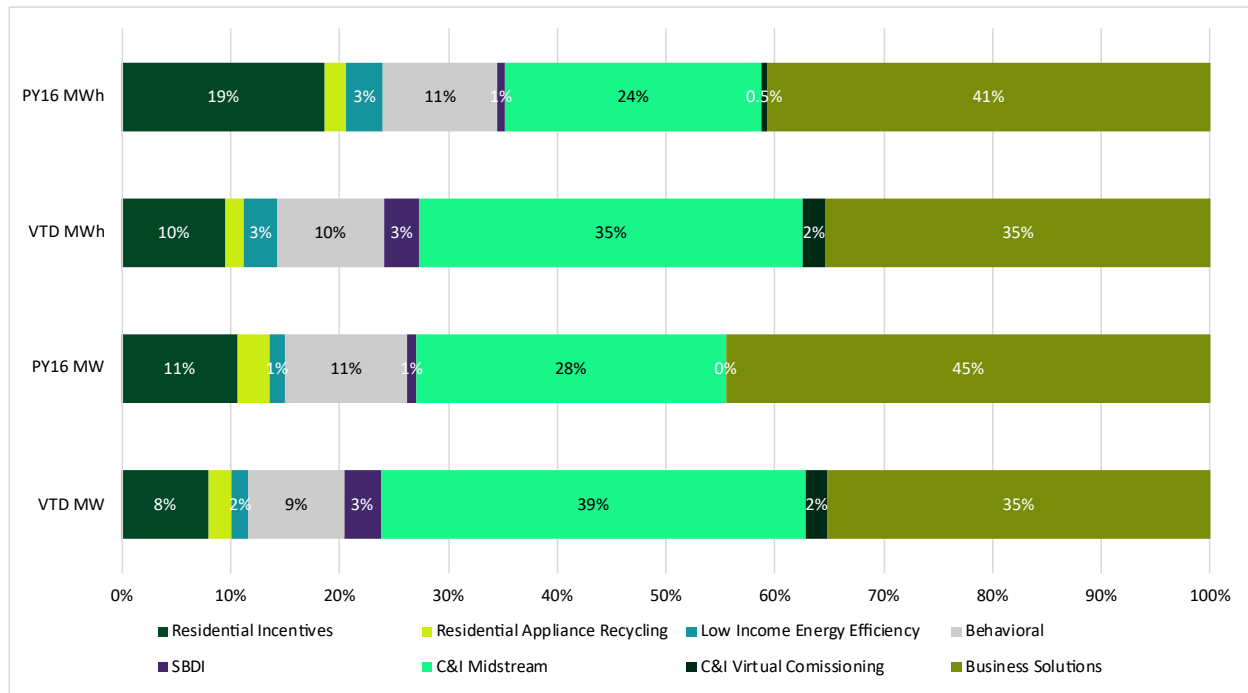
A summary of phase-to-date peak-demand impacts for each energy-efficiency program is presented in [Table 41](#).

Table 41: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – Duquesne Light¹

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Residential Downstream Incentives	3.7	88%	3.26	0.79	2.59
Residential Midstream Incentives	0	NA	0	NA	0
Residential Upstream Incentives	0.97	144%	1.4	0.73	1.02
Residential Appliance Recycling	1.2	108%	1.29	0.60	0.77
Low-Income Energy Efficiency	0.95	98%	0.93	1.00	0.93
Residential Behavioral Savings	5.48	86%	4.72	1.00	4.72
LI Residential Behavioral	0.26	162%	0.42	1.00	0.42
Small Business Direct Install	1.89	105%	1.98	0.93	1.85
Small Business Solutions	6.05	118%	7.11	0.70	4.99
Small Business Midstream Solutions	11.39	112%	12.78	0.69	8.78
Small Business Virtual Commissioning	0.49	110%	0.54	0.94	0.51
Commercial Large Business Solutions	10.3	102%	10.53	0.71	7.51
Industrial Large Business Solutions	3.1	101%	3.13	0.49	1.54
Large Business Midstream Solutions – Commercial	4.38	144%	6.29	0.82	5.14
Large Business Midstream Solutions – Industrial	3.95	101%	3.99	0.72	2.86
Large Business Virtual Commissioning	0.43	137%	0.59	0.98	0.58
Portfolio Total	54.57	108%	58.95	0.75	44.2

¹ Totals may not equal the sum of columns or rows due to rounding.

Figure 14 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. To increase the legibility of the figure, the SWE collapsed several programs across sectors. For example, the Small Business Virtual Commissioning and Large Business Virtual Commissioning programs are combined into a single Virtual Commissioning entry.

Figure 14: Summary of PY16 and P4TD Program Contributions – Duquesne Light

3.3.2 Cost-Effectiveness

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

Table 42 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which is 2.04 in PY16, up from 1.86 in PY15. The benefits were calculated using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table 42: PY16 Gross TRC Ratios by Program (\$1,000) – Duquesne Light¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Res Downstream Incentives	\$7,299	\$4,252	1.72	\$3,047
Res Midstream Incentives	\$0	\$0	0.00	\$0
Res Upstream Lighting	\$0	\$73	0.00	(\$73)
Appliance Recycling	\$353	\$262	1.35	\$91
Low-Income Energy Efficiency	\$877	\$521	1.68	\$356
Res Behavioral EE	\$683	\$955	0.72	(\$272)
Low-Income Behavioral EE	\$69	\$224	0.31	(\$155)
Residential Subtotal	\$9,281	\$6,287	1.48	\$2,994
Small Business Direct Install	\$314	\$286	1.10	\$28
Small Business Downstream	\$3,691	\$2,145	1.72	\$1,547
Small Business Midstream	\$0	\$176	0.00	(\$176)
Small Business VCx	\$27	\$47	0.57	(\$20)
Large Commercial Downstream	\$14,766	\$8,357	1.77	\$6,409
Large Commercial Midstream	\$10,963	\$2,135	5.14	\$8,829
Large Commercial VCx	\$62	\$63	0.99	(\$1)
Large Industrial Downstream	\$1,487	\$659	2.26	\$828
Large Industrial Midstream	\$1,189	\$323	3.68	\$865
Large Industrial VCx	\$0	\$19	0.00	(\$19)
Nonresidential Subtotal	\$32,500	\$14,210	2.29	\$18,290
Portfolio Total	\$41,782	\$20,497	2.04	\$21,284

3.3.3 Process Evaluation

No process evaluation was conducted in PY16.

3.3.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Duquesne Light PY16 Annual Report and the supporting detail provided by Duquesne Light's evaluation contractor. The detailed audit findings can be found in [Appendix D](#).

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework; followed proper custom site-specific M&V activities; applied TRM protocols correctly; and

are generally accurate. The SWE made minor recommendations to Guidehouse regarding the evaluation of large PV systems with limited on-site data, resulting in less than 1% difference in final savings values. The SWE's feedback was provided to the evaluator with sufficient time for Duquesne Light to include all suggested changes in their PY16 Annual Report.

- The SWE's review of verified savings for residential components, which include income-eligible programs, found that, overall, the verification process followed proper TRM protocols and Guidehouse's EM&V plans.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The Duquesne Light portfolio was cost-effective in PY16, with a gross TRC ratio of 2.04. Duquesne Light consistently shows the highest benefit cost ratio statewide due to the lowest assumed incremental measure cost per lifetime MWh. The PY16 TRC audit flagged asymmetry in the handling of fossil fuel impacts. While Duquesne quantifies and monetizes as negative benefits, the increased fossil fuel consumption associated with LED lighting installations, the fossil fuel savings from weatherization, smart thermostat, and low-flow devices were ignored.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Duquesne Light's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE was able to replicate the reported MWh savings and reported MW savings exactly. The SWE was unable to replicate participant counts and incentives exactly using the tracking data, but the SWE did not expect to be able to do so and the differences were generally small.
- Duquesne Light had eleven active behavioral HER cohorts in PY16 with approximately 270,000 treated households. Three of the cohorts consisted of low-income households, but the low-income cohorts only accounted for approximately 9.2% of the PY16 verified HER savings. On average, HER recipients saved approximately 29 kWh, or 0.4% of their annual consumption in PY16. While participation increased for PY16, the average savings per participant is slightly lower than PY15. Six cohorts were mature enough to require persistence calculations to separate incremental savings from persisting savings from prior exposure. The SWE was able to replicate the verified energy and demand savings values and found that HER impact evaluation was entirely consistent with their proposed and approved EM&V plans and the Phase IV HER account framework.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of Duquesne Light's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data with some exceptions.
- Overall, Guidehouse estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.

- No process evaluations were conducted in PY16.

3.4 FIRSTENERGY: METROPOLITAN EDISON COMPANY (MET-ED)

3.4.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 43](#). The two non-residential programs (C&I Energy Solutions for Business, Small and Large), accounted for 74% of verified savings in PY16 while approximately 22% of savings are attributable to the two market-rate residential programs.

Table 43: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – Met-Ed¹

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Energy Efficient Homes	30,072	96%	28,795	0.89	25,728
Energy Efficient Products	6,256	120%	7,506	0.58	4,365
Low-Income Energy Efficiency	5,750	104%	5,952	1.00	5,952
C&I Energy Solutions for Business - Small	35,901	91%	32,555	0.65	21,082
C&I Energy Solutions for Business - Large	91,086	97%	88,255	0.58	51,570
Portfolio Total	169,065	96%	163,063	0.67	108,697

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of phase-to-date energy impacts by program is presented in [Table 44](#). Consistent with PY16, the bulk of savings (66%) in the phase is attributable to the two non-residential programs.

Table 44: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – Met-Ed¹

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Energy Efficient Homes	82,126	86%	70,870	0.87	61,378
Energy Efficient Products	34,144	112%	38,154	0.49	18,567
Low-Income Energy Efficiency	19,421	105%	20,449	1.00	20,449
C&I Energy Solutions for Business - Small	88,101	100%	87,983	0.71	62,598
C&I Energy Solutions for Business - Large	160,975	101%	162,455	0.60	97,061
Portfolio Total	384,767	99%	379,912	0.68	260,053

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 and P4TD are presented in [Table 45](#) and [Table 46](#), respectively.

Table 45: PY16 Peak-Demand Savings by Program (MW/Year) – Met-Ed¹

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Energy Efficient Homes	7.97	45%	3.62	0.89	3.23
Energy Efficient Products	1.44	116%	1.67	0.59	0.99
Low-Income Energy Efficiency	0.88	80%	0.71	1.00	0.71
C&I Energy Solutions for Business - Small	7.88	93%	7.33	0.63	4.64
C&I Energy Solutions for Business - Large	13.80	102%	14.02	0.59	8.22
Portfolio Total	31.97	86%	27.35	0.65	17.78

¹ Totals may not equal the sum of columns or rows due to rounding.

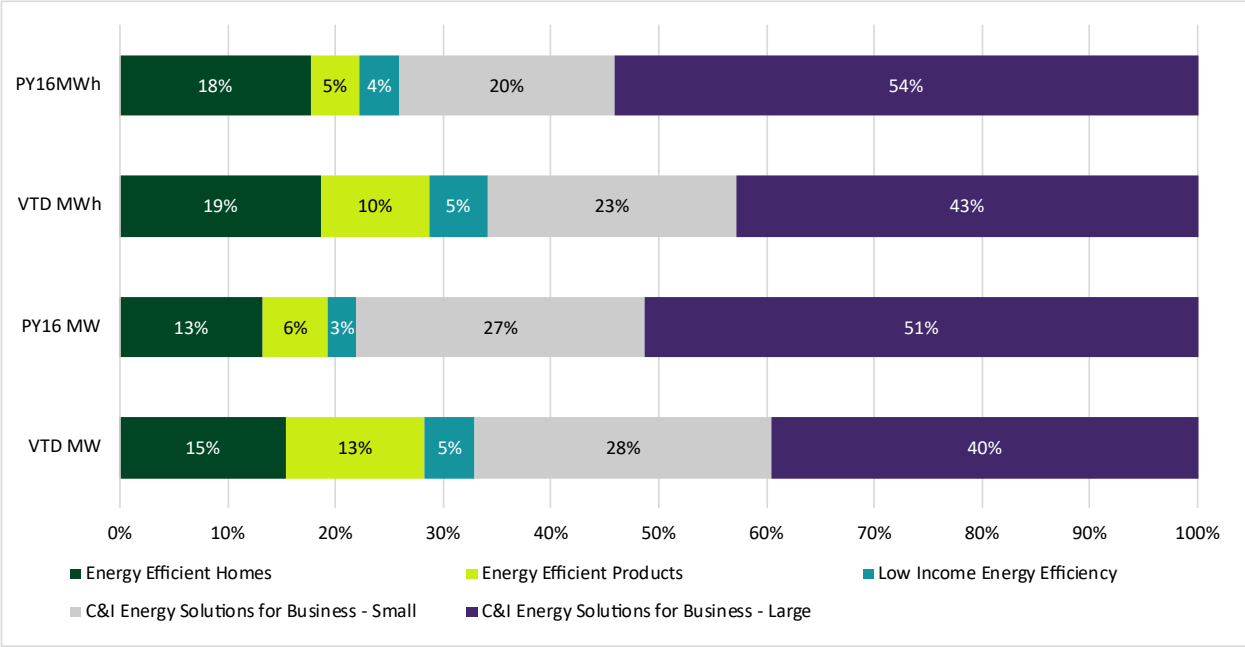
Table 46: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – Met-Ed¹

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Energy Efficient Homes	15.52	60%	9.29	0.85	7.93
Energy Efficient Products	7.48	104%	7.80	0.48	3.76
Low-Income Energy Efficiency	2.96	95%	2.82	1.00	2.82
C&I Energy Solutions for Business - Small	17.60	94%	16.63	0.69	11.43
C&I Energy Solutions for Business - Large	23.88	100%	23.85	0.60	14.36
Portfolio Total	67.44	90%	60.39	0.67	40.31

¹ Totals may not equal the sum of columns or rows due to rounding.

[Figure 15](#) shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. The non-residential programs account for a larger share of Met-Ed's energy savings and peak-demand savings for PY16 compared to P4TD.

Figure 15: Summary of PY16 and P4TD Program Contributions – Met-Ed



3.4.2 Cost-Effectiveness

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

Table 47 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which was 1.34 in PY16. The benefits were calculated using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table 47: PY16 Gross TRC Ratios by Program (\$1,000) – Met-Ed¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$15,740	\$5,447	2.89	\$10,294
Energy Efficient Products	\$4,479	\$6,488	0.69	(\$2,009)
Low Income Energy Efficiency	\$2,886	\$3,299	0.87	(\$413)
Residential Subtotal	\$23,106	\$15,234	1.52	\$7,872
C&I Energy Solutions for Business - Small	\$29,260	\$13,158	2.22	\$16,102
C&I Energy Solutions for Business - Large	\$42,884	\$42,932	1.00	(\$48)
Non-Residential Subtotal	\$72,143	\$56,090	1.29	\$16,053
Portfolio Total	\$95,249	\$71,324	1.34	\$23,925

3.4.3 Process Evaluation

Four EDCs – Met-Ed, Penelec, Penn Power, and West Penn Power – operate an identical set of energy-efficiency programs.⁴⁵ Since the evaluation contractor, ADM, together with its process evaluation subcontractor, Tetra Tech, took unified process evaluation approaches to these programs across the four EDCs, the annual reports of the four EDCs report identical information about the process evaluation. ADM/Tetra Tech reported on PY16 process evaluations for the following FirstEnergy Utilities programs and program components (Table 48).

Table 48: FirstEnergy PY16 Process Evaluations Conducted for Program Components

Programs and Program Components	
Residential Program	Residential Income – Eligible Program
Appliance Recycling Energy Efficient Products Sub-Initiative	Appliance Recycling Residential Income-Eligible Sub-Initiative
C&I Energy Efficiency Solutions for Business Program – Small	C&I Energy Efficiency Solutions for Business Program – Large
Custom – SCI	Custom – LCI
Energy Management – SCI	Energy Management – LCI
Appliance Recycling – Small C&I Energy Efficiency Solutions for Business Programs Sub-Initiative	

For PY16, ADM/Tetra Tech conducted and reported on full process evaluations for a total of seven components within the FirstEnergy residential, income-eligible, and non-residential programs.

⁴⁵ The exception is that West Penn Power discontinued its Appliance Recycling Program as of May 2025.

There are two market-rate residential programs, the Energy Efficient Products Program and the Energy Efficient Homes Program. The Energy Efficient Products Program has several sub-programs: Appliance Recycling, Appliance Rebate, Consumer Electronics, and HVAC. The Appliance Recycling Program has three sub-initiatives (Appliance Recycling, Low-Income Appliance Recycling, and Nonresidential Appliance Recycling) that are implemented in parallel. In PY16, Appliance Recycling received a process evaluation. The Energy Efficient Homes Program has seven distinct sub-programs: Comprehensive Audit, Behavioral Home Energy Reports, Online Audit, Multifamily Residential, School Education, EE Kits, and New Homes. In PY16, no programs received process evaluations. The Residential Income-Eligible Program has seven distinct sub-programs: Weatherization (Direct Install), Appliance Rebates, School Education, EE Kits, Behavioral Home Energy Report, Multifamily Residential, and New Homes. In PY16, School Education and EE Kits received process evaluations. The evaluation of the Appliance Recycling subprogram combined the Energy Efficient Products Program, Residential Income Eligible, and Energy Efficiency Solutions for Business Program – Small participants.

The non-residential program has two distinct components (Energy Efficiency Solutions for Business Program - Small and Energy Efficiency Solutions for Business Program – Large). Both components have five distinct sub-components (Multifamily, Prescriptive, Prescriptive – Other, Custom, and Energy Management). In PY16, the Custom and Energy Management sub-components received process evaluations.

For the *Appliance Recycling Subprogram*, this evaluation generated a total of 6 process evaluation findings, which resulted in four recommendations, all of which were accepted. The evaluation conducted a participant survey for the residential and residential income-eligible participants and in-depth interviews with non-residential participants. On average, 83% of residential participants (customers only) and 93.3% of non-residential participants were satisfied with the program. Findings for this program addressed other topics beyond satisfaction, including the following:⁴⁶

- Relaunching the program
- Awareness of the program
- Program offerings by appliance type
- Drivers of program component satisfaction
- Adherence to program eligibility requirements
- Rebate processing times
- Suggestions for improving the program

For the *C&I programs*, this evaluation generated a total of six process evaluation findings, which resulted in three recommendations, all of which were accepted. A key finding was on program satisfaction from participants and vendors. For the C&I programs, 88% of participants (customers

⁴⁶ The FirstEnergy annual report provides further detail regarding these topics.

only) and 56% of vendors were satisfied with the program. Findings for this program addressed other topics beyond satisfaction, including the following:⁴⁷

- Awareness of the program
- Experience with the program
- Impacts of the program
- Suggestions for improving the program

3.4.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Met-Ed PY16 Annual Report and the supporting detail provided by Met-Ed's evaluation contractor. The detailed audit findings can be found in [Appendix E](#).

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Met-Ed provided their residential and low-income verified savings analyses prior to drafting the Met-Ed PY16 Annual Report. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Met-Ed PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Met-Ed had seven active HER cohorts in PY16. Four of the cohorts consisted of market-rate residential households and the other three cohorts consisted of low-income households. Behavioral HER programming accounted for 9% of Met-Ed's total verified MWh savings in PY16 and 27% of the verified low-income MWh savings. ADM's HER impact evaluation was entirely consistent with their approved EM&V plans.
 - FirstEnergy total PY16 incremental HER savings statewide were 29,691 MWh, with 50% of the savings coming from Met-Ed. Met-Ed's success was driven by the incremental savings of the 2012 Residential cohort, which had a larger incremental savings value than the total incremental savings in the other EDCs individually.
 - Met-Ed reintroduced two historical cohorts after a three-year pause, one low-income and one residential. ADM found that the treatment and control groups in these cohorts were not equivalent in PY15, suggesting savings are persistent and "rebaselining" is not advisable. As a result, Met-Ed's reintroduced cohorts retained their original treatment date and baseline period.
 - One of Met-Ed's cohorts failed its pre-treatment equivalence test and required rebalancing using weights that were calculated using a propensity score

⁴⁷ The FirstEnergy annual report provides further detail regarding these topics.

matching approach. These weights were applied to the cohort throughout the analysis.

- The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Met-Ed's Online Audit offering showed higher average percent savings (1.3%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 8% of market rate households), so the margin of error around the billing analysis estimate was large.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Met-Ed's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- Met-Ed's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.34. Met-Ed's PY16 gross TRC ratio was lower than its PY15 gross TRC ratio of 1.54.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs. Notably, O&M benefits were negative for Met-Ed's Large Commercial and Industrial component due to a high volume of large solar projects. The assumed yearly maintenance costs for these projects led to negative O&M benefits.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Met-Ed's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data, but the SWE did not expect to be able to do so, and the SWE calculated directionally similar values for each program.
- The SWE conducted a project file review for a sample of Met-Ed's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process

evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.

- The SWE found that the Appliance Recycling NTG reported in the PY16 Annual Report for Met-Ed and West Penn Power is 0.01 higher than those shown in the Process and NTG Memo.

3.5 FIRSTENERGY: PENNSYLVANIA ELECTRIC COMPANY (PENELEC)

3.5.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 49](#). The two non-residential programs (C&I Energy Solutions for Business, Small and Large) accounted for 76% of verified savings in PY16 while approximately 19% of savings are attributable to the two market-rate residential programs.

Table 49: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – Penelec¹

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Energy Efficient Homes	21,685	76%	16,463	1.04	17,086
Energy Efficient Products	4,694	104%	4,897	0.56	2,740
Low-Income Energy Efficiency	4,481	116%	5,216	1.00	5,216
C&I Energy Solutions for Business - Small	55,680	94%	52,293	0.68	35,326
C&I Energy Solutions for Business - Large	33,516	95%	31,801	0.65	20,780
Portfolio Total	120,057	92%	110,670	0.73	81,147

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of phase-to-date energy impacts by program is presented in [Table 50](#). While nearly two-thirds of P4TD energy savings (65%) are attributable to the two non-residential programs, it is a smaller share compared to PY16.

Table 50: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – Penelec¹

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Energy Efficient Homes	68,179	83%	56,415	0.96	54,001
Energy Efficient Products	23,118	104%	24,101	0.57	13,846
Low-Income Energy Efficiency	20,535	108%	22,258	1.00	22,258
C&I Energy Solutions for Business - Small	118,904	95%	113,374	0.72	81,283
C&I Energy Solutions for Business - Large	76,133	97%	74,062	0.66	48,927
Portfolio Total	306,870	95%	290,211	0.76	220,316

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 and P4TD are presented in [Table 51](#) and [Table 52](#), respectively.

Table 51: PY16 Peak-Demand Savings by Program (MW/Year) – Penelec¹

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Energy Efficient Homes	5.05	50%	2.53	1.02	2.59
Energy Efficient Products	1.11	103%	1.15	0.56	0.64
Low-Income Energy Efficiency	0.49	67%	0.33	1.00	0.33
C&I Energy Solutions for Business - Small	13.20	86%	11.37	0.66	7.51
C&I Energy Solutions for Business - Large	6.56	84%	5.52	0.65	3.59
Portfolio Total	26.41	79%	20.90	0.70	14.65

¹ Totals may not equal the sum of columns or rows due to rounding.

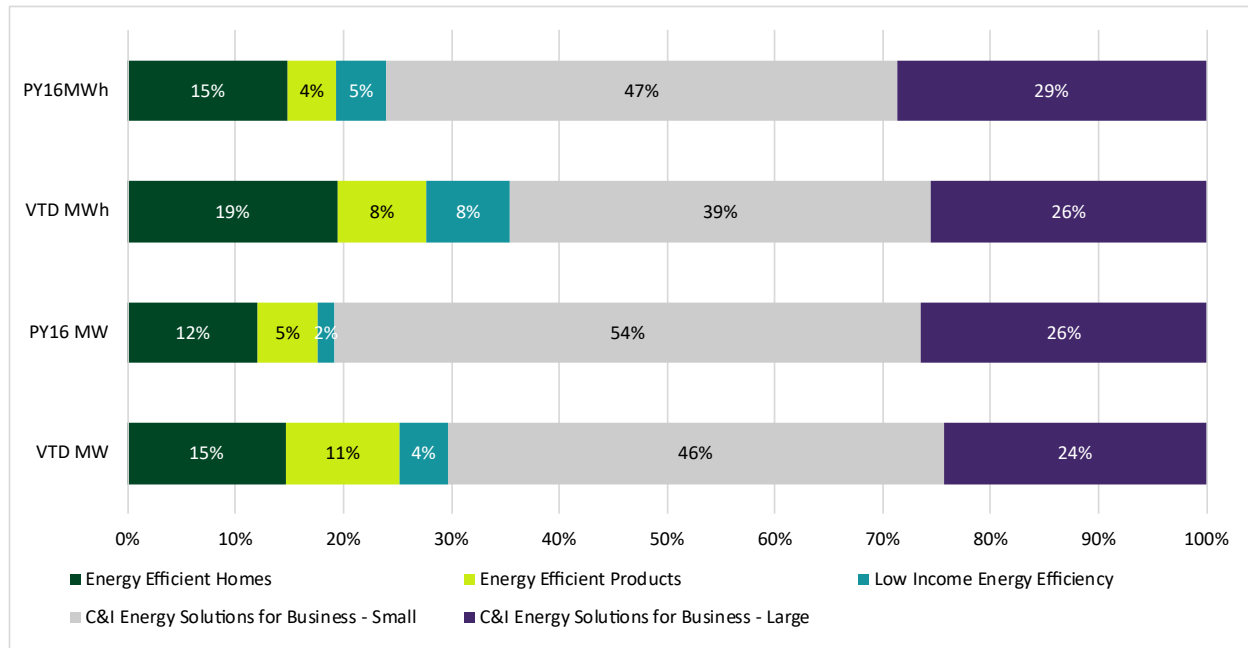
Table 52: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – Penelec¹

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Energy Efficient Homes	10.37	73%	7.61	0.96	7.32
Energy Efficient Products	5.46	101%	5.51	0.58	3.17
Low-Income Energy Efficiency	2.51	92%	2.30	1.00	2.30
C&I Energy Solutions for Business - Small	26.78	89%	23.92	0.71	16.96
C&I Energy Solutions for Business - Large	14.39	88%	12.67	0.65	8.29
Portfolio Total	59.51	87%	52.01	0.73	38.03

¹ Totals may not equal the sum of columns or rows due to rounding.

Figure 16 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. The Energy Efficient Homes program accounts for a slightly larger share of Penelec's energy savings than peak-demand savings for PY16 compared to P4TD.

Figure 16: Summary of PY16 and P4TD Program Contributions – Penelec



3.5.2 Cost-Effectiveness

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

Table 53 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which was 1.66 in PY16. The benefits were calculated using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table 53: PY16 Gross TRC Ratios by Program (\$1,000) – Penelec¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$11,278	\$3,973	2.84	\$7,306
Energy Efficient Products	\$3,082	\$3,597	0.86	(\$515)
Low Income Energy Efficiency	\$1,869	\$4,287	0.44	(\$2,417)
Residential Subtotal	\$16,230	\$11,856	1.37	\$4,374
C&I Energy Solutions for Business – Small	\$43,161	\$25,305	1.71	\$17,856
C&I Energy Solutions for Business – Large	\$19,740	\$10,503	1.88	\$9,237
Non-Residential Subtotal	\$62,901	\$35,808	1.76	\$27,093
Portfolio Total	\$79,131	\$47,664	1.66	\$31,467

¹ Totals may not equal the sum of columns or rows due to rounding.

3.5.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including Penelec, so the annual evaluation report of the four FirstEnergy EDCs reports identical information about the process evaluation. ADM/Tetra Tech reported on PY16 process evaluation activities for the FirstEnergy Utilities programs ([Table 48](#)).

3.5.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Penelec PY16 Annual Report and the supporting detail provided by Penelec's evaluation contractor. The detailed audit findings can be found in [Appendix F](#).

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Penelec provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Penelec PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Penelec had ten active HER cohorts in PY16. Five of the cohorts consist of market-rate residential households and the other five cohorts consist of low-income households. Behavioral HER programming accounted for 4% of Penelec's total verified MWh savings in PY16 and 19% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with its approved EM&V plans.
 - Despite having a comparable number of treated homes, Penelec had one-third the incremental HER MWh savings of Met-Ed.

- Penelec reintroduced three historical cohorts after a three-year pause, two low-income and one residential. ADM found that the treatment and control groups in one of these cohorts were equivalent in PY15, suggesting savings from prior HER exposure are not persistent and rebaselining is possible. As a result, one reintroduced cohort had their treatment date and baseline period updated. The other two cohorts retained their original treatment date and baseline period.
- Penelec's rebaselined cohort had negative savings. The other reintroduced cohorts that were not rebaselined had positive savings.
- One of Penelec's cohorts failed its equivalence test and required rebalancing using weights that were calculated using a propensity score matching approach. These weights are applied to the cohort throughout the analysis.
- The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Penelec's Online Audit offering showed a higher average percent savings (2.3%) compared to market-rate participants (0.5%). However, participation in the program was much lower for low-income households (approximately 18% of market-rate households), so the margin of error around the billing analysis estimate was large.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Penelec's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Penelec's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data, but the SWE did not expect to be able to do so, and the SWE calculated directionally similar values for each program.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of Penelec's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Penelec's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.66. Penelec's PY16 gross TRC ratio was lower than its PY15 gross TRC ratio of 1.57.

- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.

3.6 FIRSTENERGY: PENNSYLVANIA POWER COMPANY (PENN POWER)

3.6.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 54](#). The two non-residential programs (C&I Energy Solutions for Business, Small and Large) accounted for 62% of verified savings in PY16 while approximately 35% of savings are attributable to the two market-rate residential programs.

Table 54: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – Penn Power¹

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Energy Efficient Homes	9,876	96%	9,489	0.89	8,468
Energy Efficient Products	1,859	104%	1,929	0.55	1,056
Low-Income Energy Efficiency	1,228	83%	1,020	1.00	1,020
C&I Energy Solutions for Business - Small	12,249	94%	11,490	0.75	8,576
C&I Energy Solutions for Business - Large	8,881	98%	8,688	0.64	5,597
Portfolio Total	34,093	96%	32,615	0.76	24,717

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of phase-to-date energy impacts by program is presented in [Table 55](#). The non-residential programs account for 58% of the savings in the phase while the two market-rate residential programs account for 37% of the P4TD energy savings.

Table 55: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – Penn Power¹

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Energy Efficient Homes	25,659	94%	24,220	0.86	20,885
Energy Efficient Products	9,054	104%	9,453	0.46	4,370
Low-Income Energy Efficiency	6,055	90%	5,427	1.00	5,427
C&I Energy Solutions for Business - Small	27,085	92%	24,833	0.82	20,414
C&I Energy Solutions for Business - Large	29,208	96%	28,089	0.75	21,073
Portfolio Total	97,060	95%	92,022	0.78	72,169

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 and P4TD are presented in [Table 56](#) and [Table 57](#), respectively.

Table 56: PY16 Peak-Demand Savings by Program (MW/Year) – Penn Power¹

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Energy Efficient Homes	2.46	38%	0.93	0.85	0.79
Energy Efficient Products	0.38	105%	0.397	0.555	0.220
Low-Income Energy Efficiency	0.49	35%	0.17	1.00	0.17
C&I Energy Solutions for Business - Small	2.84	93%	2.64	0.73	1.94
C&I Energy Solutions for Business - Large	1.43	102%	1.46	0.65	0.96
Portfolio Total	7.60	74%	5.60	0.73	4.08

¹ Totals may not equal the sum of columns or rows due to rounding.

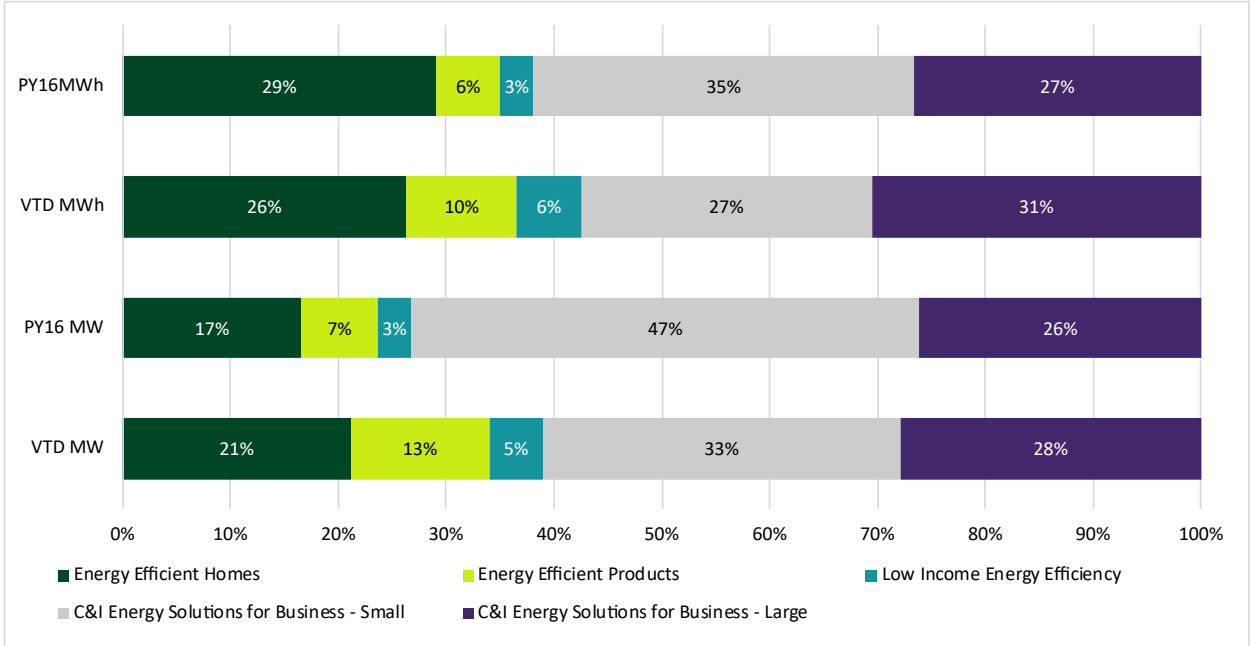
Table 57: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – Penn Power¹

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Energy Efficient Homes	5.29	63%	3.31	0.84	2.78
Energy Efficient Products	1.98	101%	2.00	0.46	0.92
Low-Income Energy Efficiency	1.07	73%	0.78	1.00	0.78
C&I Energy Solutions for Business - Small	5.68	91%	5.17	0.80	4.16
C&I Energy Solutions for Business - Large	4.47	97%	4.35	0.76	3.30
Portfolio Total	18.49	84%	15.61	0.76	11.94

¹ Totals may not equal the sum of columns or rows due to rounding.

Figure 17 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. The two non-residential programs accounted for larger shares of PY16 energy and peak-demand savings than P4TD energy and peak-demand savings.

Figure 17: Summary of PY16 and P4TD Program Contributions – Penn Power



3.6.2 Cost-Effectiveness

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

Table 58 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which was 1.41 in PY16. Costs and benefits are expressed in 2024 dollars.

Table 58: PY16 Gross TRC Ratios by Program (\$1,000) – Penn Power¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$4,492	\$2,406	1.87	\$2,086
Energy Efficient Products	\$1,380	\$1,301	1.06	\$79
Low Income Energy Efficiency	\$274	\$1,308	0.21	(\$1,034)
Residential Subtotal	\$6,145	\$5,015	1.23	\$1,131
C&I Energy Solutions for Business - Small	\$8,420	\$4,117	2.05	\$4,304
C&I Energy Solutions for Business - Large	\$5,762	\$5,326	1.08	\$436
Non-Residential Subtotal	\$14,182	\$9,443	1.50	\$4,739
Portfolio Total	\$20,328	\$14,458	1.41	\$5,870

¹ Totals may not equal the sum of columns or rows due to rounding.

3.6.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including Penn Power, so the annual evaluation report of the four FirstEnergy EDCs reports identical information about the process evaluation. ADM/Tetra Tech reported on PY16 process evaluation activities for the FirstEnergy Utilities programs ([Table 48](#)).

3.6.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Penn Power PY16 Annual Report and the supporting detail provided by Penn Power's evaluation contractor. The detailed audit findings can be found in [Appendix G](#).

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Penn Power provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Penn Power PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Penn Power had five active HER cohorts in PY16. Four of the cohorts consist of market-rate residential households and the other cohort consists of low-income households. Behavioral HER programming accounted for 14% of Penn Power's total verified MWh savings in PY16 and 25% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with their approved EM&V plan.
 - Penn Power reintroduced two historical cohorts after a three-year pause, one low-income and one residential. ADM found that the treatment and control

groups in these cohorts were not equivalent in PY15, suggesting savings are persistent and rebaselining is not possible. As a result, Penn Power's reintroduced cohorts retained their original treatment date and baseline period.

- One of Penn Power's cohorts failed its pre-treatment equivalence test and required rebalancing using weights that were calculated using a propensity score matching approach. These weights are applied to the cohort throughout the analysis.
- The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Penn Power's Online Audit offering showed higher average percent savings (2.1%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 8% of market-rate households), so the margin of error around the billing analysis estimate was large.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Penn Power's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- Penn Power's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.41. Penn Power's PY16 gross TRC ratio was slightly lower than its PY15 gross TRC ratio of 1.43. The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Penn Power's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data, but the SWE did not expect to be able to do so, and the SWE calculated directionally similar values for each program.
- The SWE conducted a project file review for a sample of Penn Power's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.

- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.

3.7 FIRSTENERGY: WEST PENN POWER

3.7.1 Impact Evaluation

A summary of energy impacts by program for PY16 is presented in [Table 59](#). The two non-residential programs (C&I Energy Solutions for Business, Small and Large) accounted for 79% of verified savings in PY16 while approximately 17% of savings are attributable to the two market-rate residential programs.

Table 59: PY16 Incremental Annual Energy Savings by Program (MWh/Year) – West Penn Power¹

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Energy Efficient Homes	36,825	60%	21,992	0.94	20,571
Energy Efficient Products	5,609	107%	5,988	0.58	3,473
Low-Income Energy Efficiency	5,708	89%	5,083	1.00	5,083
C&I Energy Solutions for Business - Small	43,683	101%	44,174	0.68	30,081
C&I Energy Solutions for Business - Large	81,848	102%	83,433	0.61	50,929
Portfolio Total	173,673	93%	160,670	0.69	110,136

¹ Totals may not equal the sum of columns or rows due to rounding.

A summary of phase-to-date energy impacts by program is presented in [Table 60](#). While over two-thirds of P4TD energy savings (68%) are attributable to the two non-residential programs, it is a smaller share compared to PY16.

Table 60: Phase-to-Date Incremental Annual Energy Savings by Program (MWh/Year) – West Penn Power¹

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Energy Efficient Homes	88,231	73%	64,107	0.98	62,547
Energy Efficient Products	27,997	107%	30,091	0.59	17,728
Low-Income Energy Efficiency	24,168	103%	24,890	1.00	24,890
C&I Energy Solutions for Business - Small	108,104	102%	110,175	0.76	83,205
C&I Energy Solutions for Business - Large	135,131	103%	138,743	0.65	89,926
Portfolio Total	383,631	96%	368,007	0.76	278,295

¹ Totals may not equal the sum of columns or row due to rounding.

A summary of the peak-demand impacts for each energy-efficiency program for PY16 and P4TD are presented in [Table 61](#) and [Table 62](#), respectively.

Table 61: PY16 Peak-Demand Savings by Program (MW/Year) – West Penn Power¹

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Energy Efficient Homes	9.47	45%	4.23	0.95	4.01
Energy Efficient Products	1.27	106%	1.34	0.59	0.80
Low-Income Energy Efficiency	0.71	107%	0.76	1.00	0.76
C&I Energy Solutions for Business - Small	9.58	90%	8.64	0.67	5.80
C&I Energy Solutions for Business - Large	12.71	96%	12.15	0.62	7.54
Portfolio Total	33.74	80%	27.13	0.70	18.91

¹ Totals may not equal the sum of columns or rows due to rounding.

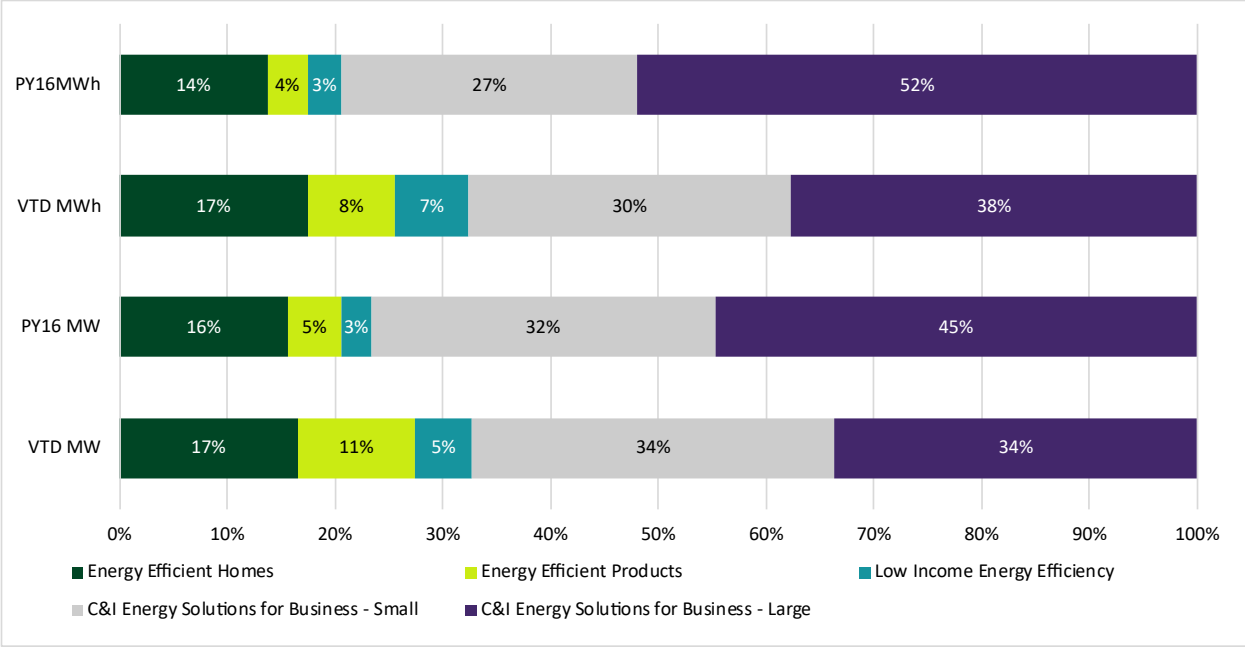
Table 62: Phase-to-Date Peak-Demand Savings by Program (MW/Year) – West Penn Power¹

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Energy Efficient Homes	17.76	55%	9.79	0.96	9.35
Energy Efficient Products	6.37	101%	6.46	0.60	3.87
Low-Income Energy Efficiency	3.26	96%	3.14	1.00	3.14
C&I Energy Solutions for Business - Small	21.97	91%	19.94	0.73	14.56
C&I Energy Solutions for Business - Large	21.23	94%	19.95	0.66	13.21
Portfolio Total	70.60	84%	59.28	0.74	44.12

¹ Totals may not equal the sum of columns or rows due to rounding.

Figure 18 shows the PY16 and VTD energy and peak-demand savings by program on a normalized basis. The C&I programs accounted for a larger share of PY16 energy and peak-demand savings than P4TD energy and peak-demand savings.

Figure 18: Summary of PY16 and P4TD Program Contributions – West Penn Power



3.7.2 Cost-Effectiveness

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

Table 63 shows the TRC ratios by program and for the portfolio. The ratio of TRC benefits to TRC costs is the TRC ratio, which was 1.59 in PY16. The benefits were calculated using gross verified impacts. Costs and benefits are expressed in 2024 dollars.

Table 63: PY16 Gross TRC Ratios by Program (\$1,000) – West Penn Power¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$13,868	\$6,340	2.19	\$7,528
Energy Efficient Products	\$3,167	\$4,635	0.68	(\$1,468)
Low Income Energy Efficiency	\$2,638	\$3,874	0.68	(\$1,236)
Residential Subtotal	\$19,673	\$14,849	1.32	\$4,824
C&I Energy Solutions for Business - Small	\$30,431	\$16,334	1.86	\$14,097
C&I Energy Solutions for Business - Large	\$34,337	\$21,871	1.57	\$12,467
Non-Residential Subtotal	\$64,769	\$38,205	1.70	\$26,564
Portfolio Total	\$84,441	\$53,054	1.59	\$31,388

¹ Totals may not equal the sum of columns or rows due to rounding.

3.7.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including West Penn Power, so the annual evaluation report of the four FirstEnergy EDCs reports identical information about the process evaluation. ADM/Tetra Tech reported on PY16 process evaluation activities for the FirstEnergy Utilities programs ([Table 48](#)).

3.7.4 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the West Penn Power PY16 Annual Report and the supporting detail provided by West Penn Power's evaluation contractor. The detailed audit findings can be found in [Appendix H](#).

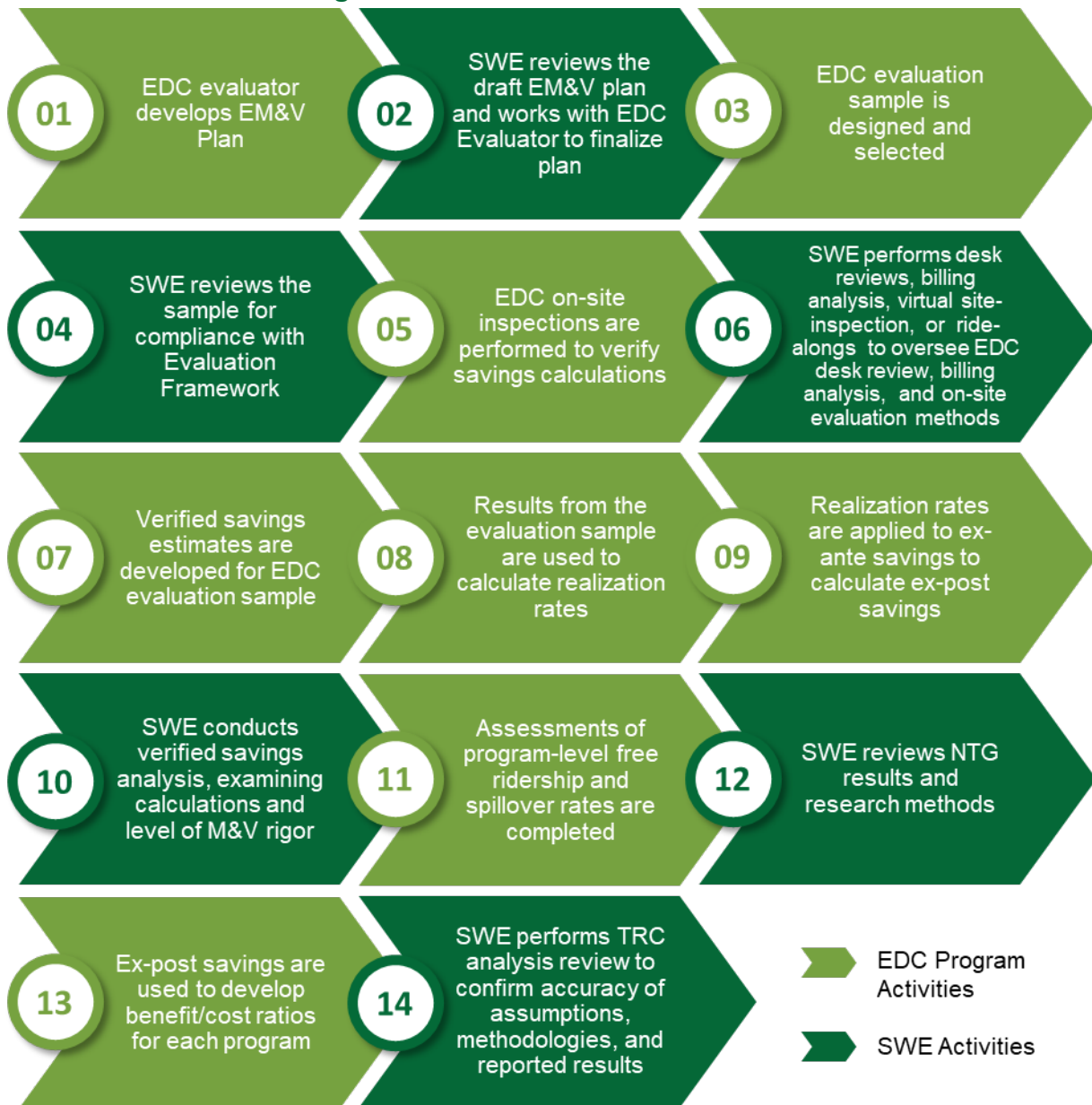
- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- West Penn Power provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the West Penn Power PY16 Annual Report. In addition, the verified savings analyses were well organized and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- West Penn Power had seven active HER cohorts in PY16. Four of the cohorts consisted of market-rate residential households, and the other three cohorts consisted of low-income households. Behavioral HER programming accounted for 3% of West Penn Power's total verified MWh savings in PY16 and 3% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with their approved EM&V plans.

- West Penn Power reintroduced three historical cohorts, two low-income and one residential. ADM found that the treatment and control groups in two of these cohorts were equivalent in PY15, suggesting savings were not persistent and rebaselining was possible. As a result, two reintroduced cohorts had its treatment date and baseline period updated. The other cohort retained their original treatment date and baseline period.
- Both West Penn Power's rebaselined cohorts had negative savings. The other reintroduced cohort that was not rebaselined had positive savings.
- West Penn Power's 2014 Residential cohort was the only market-rate cohort to have negative savings across the FirstEnergy EDCs.
- The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in West Penn Power's Online Audit offering showed a higher average percent savings (1.6%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 9% of market-rate households), so the margin of error around the billing analysis estimate was large.
- West Penn Power's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.59. West Penn Power's PY16 gross TRC ratio was higher than its PY15 gross TRC ratio of 1.34.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs. O&M benefits were negative for West Penn Power's Large Commercial and Industrial component due to a high volume of large solar projects. The assumed early maintenance costs for solar projects led to negative O&M benefits at the portfolio level.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in West Penn Power's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data; however, the SWE did not expect to be able to do so, and calculated directionally similar values for each program.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of West Penn Power's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.

- The SWE conducted a project file review for a sample of West Penn Power's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.
- The SWE found that the Appliance Recycling NTG reported in the PY16 Annual Report for Met-Ed and West Penn Power is 0.01 higher than those shown in the Process and NTG Memo

Section 4 Cross-Cutting SWE Activities

This section presents a summary of the audit and cross-cutting activities conducted by the SWE during PY16, including a review/audit of EDC program delivery mechanisms and all evaluation processes and results submitted by each EDC's evaluation contractor. The SWE uses the audit activity findings, which parallel the EDC evaluation activities, to assess the quality and validity of the EDC reported gross, verified gross, and verified net savings estimates; process evaluation findings and recommendations; and benefit/cost ratios. For example, [Figure 19](#) shows the C&I sector specific SWE audit activities and their correspondence to the evaluation steps.

Figure 19: The SWE Audit Activities⁴⁸

⁴⁸ The figure shows both gross and net components of the C&I audit process, including the TRC audit approach.

4.1 TECHNICAL REFERENCE MANUAL (TRM)

The Pennsylvania Technical Reference Manual provides algorithms and assumptions for calculation of energy and peak-demand savings from prescriptive measures. CSPs use the TRM to calculate reported gross savings, and EDC evaluation contractors use the TRM to calculate gross verified savings. Having each of the seven EDCs subject to Act 129 utilize a common set of formulas and inputs promotes statewide consistency. Following the TRM gives EDCs a degree of certainty when calculating progress towards compliance targets because the TRM is formally issued by the Commission, following a formal comment and reply comment process.

The SWE completed work on several Interim Measure Protocols (IMPs) with the EDCs and their EM&V contractors to refine and expand the library of measure characterizations used to claim and report EE&C Plan performance. The following section summarizes the key efforts during PY16.

4.1.1 TRM Interim Measure Protocols (IMPs)

As described in the Evaluation Framework, IMPs are used for measures that do not exist in the TRM, or to expand the applicability of an existing TRM protocol. IMPs serve as a holding ground before a protocol is fully integrated into the TRM. The SWE maintains a catalog of IMPs, showing their effective dates on the SWE SharePoint site for EDCs to use to claim reported savings, and for evaluators to follow when determining verified savings. The database of IMPs provides a list of new/revised measure protocols that should be included in subsequent TRM updates.

A total of three IMPs were developed or updated and reviewed during PY16 ([Table 64](#)).

Table 64: IMPs Developed and Reviewed During PY16

TRM Section Number	IMP Name	Adopted into 2026 TRM?	Phase IV Program Year Approval
NA	Demand Control Ventilation (Updated)	Yes	PY16
NA	Lead Acid to Li-Ion Forklift Batteries	No	PY16
NA	Compressed Air Leak Repairs	No	PY16

4.2 POTENTIAL STUDIES

Planning efforts for Phase V of Act 129 culminated in the release of the EE and DR market potential studies. In 2024, the SWE incorporated measure characterizations from the 2026 TRM, economic assumptions from the 2026 TRC Test Order, saturation findings from the baseline studies, and other research efforts into models of achievable potential for Phase V of Act 129. The EE and DR market potential studies (MPS) provided the Commission with valuable data to inform the proposed goals in the Tentative Implementation Order for Phase V.⁴⁹ The EE MPS included a dedicated analysis of solar photovoltaic potential in addition to more traditional EE

⁴⁹ Pennsylvania Public Utility Commission, *Energy Efficiency and Conservation Program Tentative Implementation Order*, at Docket No. M-2025-3052826, (*Phase V Tentative Implementation Order*), entered February 20, 2025. <https://www.puc.pa.gov/pcdocs/1866849.pdf>

offerings. The EE MPS includes estimates of Technical, Economic, Maximum Achievable, and Program Achievable potential. Program design is a key element of DR potential, so the DR MPS considered the program design as a precursor to modeling efforts. To minimize overlap with the dispatchable DR programs offered by PJM and avoid the need for derating, the DR MPS focuses on a “daily load shifting” framework. Key DR program offerings included EV managed charging, battery storage paired with solar, C&I auto-DR, thermostat optimization, and domestic hot water load management.

The SWE presented the methodology and results of the potential studies at a stakeholder meeting held in Harrisburg on January 29, 2025.^{50,51} The potential studies were formally released via Secretarial Letter on February 21, 2025.^{52,53}

4.3 PHASE V IMPLEMENTATION ORDER

In 2025, the SWE team worked closely with TUS Staff, Law Bureau, and the Offices to develop the Phase V Tentative Implementation Order, which was approved at the February 20, 2025, Public Meeting. The Tentative Order proposed EDC-specific targets for reductions in overall consumption, as well as reduction targets for the low-income sector. The Tentative Order also proposed peak-demand reductions for Phase V that could be satisfied with coincident demand reductions from energy efficiency, production by distributed generation, or daily load shifting programs. To combine the results of the EE and DR potential studies into a single set of proposed targets, the Tentative Order assumed a funding split between market-rate EE, low-income EE, daily load shifting, solar photovoltaics, and CHP. This assumed funding split was combined with the EDC-specific budgets and the component-specific acquisition costs from the potential studies to calculate the proposed MWh and MW targets. In a departure from prior phases of Act 129, the Tentative Order proposed that peak-demand targets consider both summer and winter peak-demand savings and that compliance be based on the average performance across the two seasons. The Tentative Order proposed a single set of targets for the FirstEnergy Pennsylvania EDC, reflecting the formal consolidation of the Met-Ed, Penelec, West Penn Power, and Penn Power rate districts. The Tentative Implementation Order addressed many other aspects of the proposed Phase V EE&C Programs, including the plan approval process, plan effectiveness evaluation process, benefit-cost analysis approval process, coordination with other program administrators in the Commonwealth, and EDC cost recovery.

The Commission received comments from 20 stakeholder groups and reply comments from 16 stakeholder groups. The Final Implementation Order established Phase V of the EE&C Program and addressed each of the comments raised by stakeholders. The Phase V Final Implementation

⁵⁰ Act 129 Statewide Evaluator Energy Efficiency and Peak Demand Reduction Market Potential Study Presentation. https://www.puc.pa.gov/media/3317/phasev_act129_eepdr_mps_stakeholder_meeting_presentation_020425.pdf

⁵¹ Act 129 Statewide Evaluator Demand Response Market Potential Study Presentation.

https://www.puc.pa.gov/media/3308/phasev_act129_dr_mps_stakeholder_meeting_presentation_012125.pdf

⁵² Pennsylvania Act 129 Phase V Energy Efficiency and Peak Demand Reduction Market Potential Study. <https://www.puc.pa.gov/pdocs/1867286.pdf>

⁵³ Pennsylvania Act 129 Phase V Demand Response Potential Study. <https://www.puc.pa.gov/pdocs/1867287.pdf>

Order was made public at the June 18, 2025 Public Meeting.⁵⁴ The Tentative Order, Final Order, comments, and reply comments can be found on the EE&C Program page of the PUC website.⁵⁵

4.3.1 Phase V EE&C Plan Template

The SWE worked closely with TUS Staff to develop a template for the EDCs' Phase V EE&C Plans. The template was drafted to request key metrics in a common structure and provide guidelines to the EDCs regarding key plan requirements for the fifth phase of the Act 129 EE&C Program. The Phase V EE&C Plan template included enhancements compared to the Phase IV version such as more automated Excel tables to reduce user error, requests for new narrative about program coordination, comprehensive measures, and health and safety plans. The EE&C Plan template also reflected key changes from the June 2025 Implementation Order such as the inclusion of winter peak-demand savings and the additional of daily load shifting programs. The draft template was released for comment on July 24th, 2025, when the Commission issued a Secretarial Letter.⁵⁶

The Commission received comments from six stakeholder groups and the final template addressed each of the comments raised by stakeholders. Comments from stakeholder groups begat a variety of clarifying edits to the template itself, as well as refinements to the Excel Workbook tables, including the addition of a new Table 15 with Lifetime Costs and Benefits tabulated by portfolio component (market-rate EE, low-income EE, daily load shifting, solar, and CHP). The Commission issued a Secretarial Letter releasing its final template for the EDCs' Act 129 Phase V EE&C Plans on September 8th, 2025.⁵⁷

4.4 EM&V PLAN REVIEW AND APPROVAL

EDC evaluation contractors are required to prepare and submit a detailed evaluation plan to the SWE each program year. The intent of the evaluation plan is to document the research objectives and data collection activities for each program within the EDC portfolio. Evaluation plans are expected to generally align with the guidance provided by the SWE in the Pennsylvania Evaluation Framework to ensure consistency in evaluation practices across EDCs. Evaluation contractors were directed to discuss reported savings, the gross impact evaluation, NTG analysis, process evaluation, sampling statistics and uncertainty, cost-effectiveness evaluation activities, frequency of evaluation, and outcomes separately.

One of the main differences between Phase IV and previous phases, from an EM&V perspective, is the frequency of evaluation. During prior phases, every program was generally evaluated in every program year. Prior to Phase IV EDCs and their evaluators were given the opportunity to

⁵⁴ Pennsylvania Public Utility Commission, *Energy Efficiency and Conservation Program* Final Implementation Order, at Docket No. M-2025-3052826, (*Phase V Implementation Order*), entered June 18, 2025.

⁵⁵ <https://www.puc.pa.gov/pcdocs/1883669.pdf>

⁵⁶ <https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/energy-efficiency-and-conservation-ee-c-program/>

⁵⁷ <https://www.puc.pa.gov/pcdocs/1888093.pdf>

⁵⁷ <https://www.puc.pa.gov/pcdocs/1894167.pdf>

set an evaluation schedule that would allow for deeper investigations and meet the shortened, more streamlined, reporting timelines. Process evaluations should still be conducted at least once per phase as well as gross impacts. In years when verification activities do not occur, savings will either be deemed unverified or a previous year's verification rate can be applied in order to yield the verified savings number. Six main criteria were used to determine evaluation cadence:

- **Amount of energy and demand savings** - Programs with larger expected savings warrant more frequent evaluation.
- **Expected EM&V costs** – Programs that require less intensive data gathering techniques can be evaluated more often at a lower cost than those that require more intensive methods.
- **Program continuity/discontinuity** – New initiatives or those that undergo significant changes from year-to-year warrant more frequent evaluation than those that remain unchanged with constant realization rates.
- **Market or technology continuity/discontinuity** – Changes in market or energy efficiency standards warrant more frequent evaluation.
- **Uniformity of measures** – If the efficiency measures offered by a program change from year to year more frequent evaluation may be warranted.
- **Underperforming expectations** – Realization rates below expected levels that may indicate program issues warrant more frequent evaluations.

The SWE reviewed the revised PY16 draft evaluation plans and provided suggestions and requests for clarification. EDC evaluation contractors addressed the feedback and prepared revised plans for review and approval. The EDC-specific appendices of this report each include an “EM&V Plan Review” section that documents the evaluation plan review and approval process for PY16.

4.5 SAMPLE DESIGN REVIEW

Verified savings estimates for most programs, or program components, are based on a sample of projects selected from the full population. Because every project is not evaluated, there is a possibility that the sample is not representative of the full population. The level of uncertainty depends on how large the sample is, and the degree to which the reported savings and verified savings align. The amount of sampling error (margin of error) is represented by the relative precision of the verified savings. For example, if a program has verified savings of 1,000 MWh/year with a relative precision of $\pm 5\%$ at the 85% confidence level, then there is an 85% chance that the true value of savings for the program population is between 950 MWh/year and 1,050 MWh/year. All programs that rely on sampling to calculate verified savings must include the relative precision to quantify the sampling uncertainty.

The Phase IV Evaluation Framework allows a maximum level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. In its annual data request to the EDCs and their EM&V contractors, the SWE requests a table for each initiative that lists the stratum assignment, reported savings, and verified savings for each evaluated project along with a unique identifier that allows the sampled units to be merged with the initiative

population. The SWE then uses this information to independently replicate the energy and peak-demand realization rates and associated relative precision.

This exercise serves to validate the expansion of evaluation findings from the sample to the initiative, program, and population level. It also informs future sample design reviews because the sample size required to achieve $\pm 15\%$ relative precision at the 85% confidence level is a function of the variability between reported and verified savings. Initiatives with high variance may require larger sample sizes in the following program year. Initiatives that exhibit low variance may require smaller sample sizes during future impact evaluations.

4.6 TRACKING DATA REVIEW

After each quarter, EDCs provide responses to a standing request for program implementation data. This request includes a full extract from the program tracking system of records listing the reported gross kWh, kW, measure type, rebate amount, participant information, and relevant dates for all transactions in the quarter. Data for behavioral Home Energy Reports is typically not included in the quarterly tracking data. For Phase IV, the SWE designed a standard file specification for this response to allow for consolidation of data across EDCs.

The tracking data review task is a straightforward task, where the SWE aggregates the very granular tracking records to the program and portfolio level and compares these calculated totals with the reported gross kWh, kW, participation, and incentive totals reported by EDCs in their semi-annual and final annual reports to the PUC. The intent of this exercise is to confirm that the high-level program totals are supported by detailed records for each of the thousands of EE&C measure transactions. This independent validation of reported gross program impacts also ensures that the tracking records archived by the SWE, a foundation of other audit activities, are consistent with the EDC's records.

4.7 PROJECT FILE REVIEWS

In addition to the tracking data review, the SWE conducts a review of a sample of EDC project and program files, cross-checking actual program files, receipts, invoices, and work orders against their corresponding database entries to verify that the EDCs have reported program data correctly and consistently. This "project file review" is designed to audit the accuracy of the savings values stored in the EDC tracking system and to confirm that the EDCs' calculations were performed in accordance with the current TRM. The uploaded project files include project savings calculation workbooks, specification sheets for equipment installed, invoices, customer incentive agreements, and post-inspection forms. Through these reviews, the SWE verifies that the equipment quantities, efficiency levels, and savings values recorded in project files and the program tracking database are consistent.

The SWE also conducts a database review through which the SWE attempts to verify that EDCs are using the correct values and algorithms from the Pennsylvania TRM in their savings calculations. For deemed measures, the SWE reviews whether the EDC used the correct deemed savings value. For partially deemed measures, the SWE used the values from the EDC database to independently calculate savings and verify them against the savings reported by the EDC.

4.8 VERIFIED SAVINGS AUDIT

The SWE conducts a detailed review of data collection, estimation methods, and calculations used by the EDC evaluation contractors to calculate verified gross and verified net savings. Following the submission of their annual reports, EDC evaluation contractors are required to submit the supporting work products for audit. EDC evaluation contractors are also encouraged to submit their supporting work products for early review, before the EDC Annual Report is submitted to the PUC. These datasets and calculation workbooks, along with the EDC annual reports, are the basis for the SWE verified savings audit. Based on the results of the verified savings audit, the SWE makes one of the three recommendations to the PUC for a given initiative:

- The SWE agrees with the verified savings calculations and results and suggests the PUC count the reported total toward EDC compliance targets.
- The SWE discovered an error in the calculation or disagrees with the assumptions used to estimate savings, and the SWE quantifies different verified savings. If the magnitude of the error is greater than 5% of savings at the portfolio level, EDCs refile their annual report to correct the error. If the magnitude of the error is less than 5% of savings, EDCs are expected to update their phase-to-date verified savings going forward.
- The SWE discovered an error or disagrees with an assumption with negligible impact at the portfolio level. This report provides guidance on correcting the issue on a going-forward basis.

4.9 AD HOC TASKS

The SWE's contract provides for ad hoc support for Commission staff on various technical matters as needed. The following sections describe two tasks requested by stakeholders in comments to the 2021 TRC Test Order and completed by the SWE during PY16.

4.9.1 Summary of Alternative Energy Portfolio Standards Costs

Per the 2021 TRC Test Order,⁵⁸ the Phase IV SWE was directed to include a summary of the Alternative Energy Portfolio Standards (AEPS) costs to produce a comparison of how these costs have changed over time. What follows is a brief introduction to the AEPS values, how they are used, and their historic fluctuations.

AEPS costs are electric cost adders included to reflect the cost of purchasing AECs as required by the AEPS Act.⁵⁹ The AECs are categorized into three tiers: Non-Solar Tier I, Tier II and Solar, with their eligible credit sources listed in [Table 65](#).

⁵⁸ From the Public meeting of December 19, 2019, at Docket No. M-2019-3006868. Entered December 19, 2019. <https://www.puc.pa.gov/pdocs/1648126.docx>

⁵⁹ See 73 P.S. §§ 1648.1–1648.8 and 66 Pa. C.S. § 2814. See also 52 Pa. Code §§ 75.1–75.72.

Table 65: Energy Sources Eligible for Alternative Energy Credits

Tier I	Tier II	Solar
Out-of-Commonwealth Solar PV	Distributed Generation Systems	In-Commonwealth Solar PV
Biologically Derived Methane Gas	Demand Side Management	
Biomass Energy	Generation using Pulping Process By-Products	
Coal Mine Methane	Large-Scale Hydropower	
Fuel Cells	Municipal Solid Waste	
Geothermal Energy	Waste Coal	
Low-Impact Hydropower		
Solar Thermal		
Wind Power		

The AEPS Act requires that AECs be purchased at a fixed percentage of EDC retail sales each year. EDCs must procure 10% of their retail MWh sales as Tier II credits, 8% of retail MWh sales as Non-Solar Tier I credits and 0.5% as Solar credits.

In the Phase IV ACC,⁶⁰ AEPS avoided costs are a benefit as any reduction in retail sales associated with energy efficiency will decrease the total number of credits required to be procured. To simplify modeling, a single, weighted, AEPS cost was constructed. The procedure for producing the weighted average price is shown in Table 66, which shows the AEPS costs currently used in the Phase IV ACC, which was developed in 2019 in preparation for Phase IV.

⁶⁰ <https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/total-resource-cost-test/>

Table 66: AEPS Cost Weighted Average Example

Metric	Unit	2021 TRC Credit Type		
		Solar	Tier I	Tier II
Average Bid Price	\$/Credit	\$50.00	\$6.10	\$0.45
Average Offer Price	\$/Credit	\$60.00	\$6.50	\$0.65
Average Price	\$/Credit	\$55.00	\$6.30	\$0.55
Required Credits as % of Retail Sales	%	0.50%	8%	10%
Required Credits by Tier	Credits/1,000MWh	5	80	100
Total Cost per Credit Type	\$/1,000MWh	\$275.00	\$504.00	\$55.00
Total Cost	\$/1,000MWh	\$275 + \$504 + \$55 = \$834		
Total Credits	Credits/1,000MWh	5 + 80 + 100 = 185		
Weighted Average Price	\$/Credit	\$834/185 = \$4.51		
Weighted Average Price	\$/MWh	\$834/1,000 = \$0.83		

The average price per credit is constructed using Marex Spectron⁶¹ data on AEPS bid and offer prices in 2021. For every 1,000MWh of retail energy sales, five Solar credits, 80 Tier I credits, and 100 Tier II credits must be purchased. This amounts to a total cost per credit type of \$275, \$504, and \$55, respectively. The total cost to purchase these 185 credits is \$834 in nominal dollars, which amounts to \$4.51/credit and \$0.83/MWh.

The SWE was instructed to investigate AEPS cost changes and provide a recommendation on whether these values should be updated. To assess the degree to which AEPS costs fluctuate over time, the SWE collected historic⁶² and current AEPS bid and offer prices and constructed the cost per MWh and per credit from 2008 onwards using the same methodology as described in Table 66. Table 67 shows the results.

⁶¹ Marex Spectron is a United Kingdom-based broker of financial instruments and provider of market data services across the metals, agricultural and energy markets. See <https://www.marexspectron.com/about-us>.

⁶² See AEPS Act Historical Pricing reports at <https://www.pennaeps.com/reports/>.

Table 67: Historic AEPS Costs

Year	Solar	Tier I	Tier II	Cost per MWh	Cost per Credit
2008	\$230.00	\$4.48	\$0.66	\$1.57	\$8.51
2009	\$260.19	\$3.65	\$0.36	\$1.63	\$8.81
2010	\$325.00	\$4.77	\$0.32	\$2.04	\$11.02
2011	\$247.82	\$3.94	\$0.22	\$1.58	\$8.52
2012	\$180.39	\$5.23	\$0.17	\$1.34	\$7.23
2013	\$109.23	\$8.31	\$0.22	\$1.23	\$6.66
2014	\$94.39	\$9.78	\$0.13	\$1.27	\$6.85
2015	\$78.62	\$12.51	\$0.12	\$1.41	\$7.60
2016	\$62.06	\$14.56	\$0.10	\$1.49	\$8.03
2017	\$55.20	\$12.16	\$0.16	\$1.26	\$6.84
2018	\$31.31	\$10.15	\$0.22	\$0.99	\$5.35
2019	\$31.58	\$6.41	\$0.31	\$0.70	\$3.79
2020	\$37.00	\$7.87	\$1.92	\$1.01	\$5.44
2021	\$38.24	\$10.62	\$5.76	\$1.62	\$8.74
2022	\$41.45	\$17.68	\$10.86	\$2.71	\$14.64
2023	\$44.00	\$24.30	\$12.00	\$3.36	\$18.18
2024	\$37.00	\$33.50	\$37.13	\$6.58	\$35.55
2025	\$37.00	\$35.70	\$37.38	\$6.78	\$36.64
2025 (Current)	\$26.25	\$25.13	\$33.25	\$5.47	\$29.55
2021 TRC Test Order	\$55.00	\$6.30	\$0.55	\$0.83	\$4.51

Using current Marex Spectron prices, the weighted average cost of the AECs is \$29.55 per credit, or \$5.47 per MWh. Compared to the values originally included in the ACC, the current value of credits is up by almost a factor of seven. AEPS credit values originally made up about 3% of the avoided cost of energy and now it would be approximately 20%.

When looking at the historical trend, three things are clear. First, the AEPS cost incorporated in 2019 represented a time when prices were at a historic low. Second, there has always been fluctuation in AEPS prices, and third, the current prices show a slowing of the trend toward increased AEPS costs over the last five years. The overall increase in costs over Phase IV has roots in policy changes that originated in the amending of the AEPS Act by Act 40⁶³ of 2017 and

⁶³ See PA Act 40 of 2017, Section 2804

Act 114⁶⁴ of 2020. Act 40 requires that Solar AECs come from solar facilities within the Commonwealth while Act 114 implements the same location requirement for Tier II credits.

In line with these findings, the 2026 TRC Order incorporates the higher values of AEPS credits in recent years into the Avoided Cost Calculator that will be used by the EDCs to plan for Act 129 programming in Phase V. In the 2026 TRC Order, the Commission also states that it plans to direct the SWE to continue including a summary of the AEPS costs over time in Phase V. The SWE agrees that continued monitoring of the cost of AEPS credits over time is a valuable exercise for understanding trends in the marketplace.

4.9.2 Annual Avoided Costs Review

Section B.1 of the 2021 TRC Test Final Order called for a single forecast of avoided costs to be used in Phase IV EE&C Plans and EDC Annual Reports. The Industrials⁶⁵ commented that EDCs should use actual experienced market prices rather than forecasted prices in annual and phase reporting. PA-EEFA⁶⁶ comments recommended an annual review of market conditions by the SWE to assess whether an update to the avoided cost forecast was warranted. *The Commission agreed and directed the SWE “to include in its Final Annual Reports a comparison of forecasted avoided costs of electricity to load weighted real time locational marginal prices (LMPs) for each EDC service area.”* According to the 2021 TRC Test Order, the Commission may reconsider the appropriateness of a static forecast of avoided costs or make changes in the methodology currently used to develop the avoided costs forecast based on the results of this exercise.

The Phase III SWE developed a new ACC⁶⁷ to standardize the process by which EDCs develop avoided costs for Phase IV. A 20-year period dissected into three segments is used for the 2021 TRC Test Order, with six distinct periods per year (winter, summer, and shoulder seasons with on and off-peaks). The ACC draws upon different projections in each of the three segments to estimate avoided costs. Figure 20 shows the 20-year avoided costs forecast for Phase IV, by EDC and costing period.

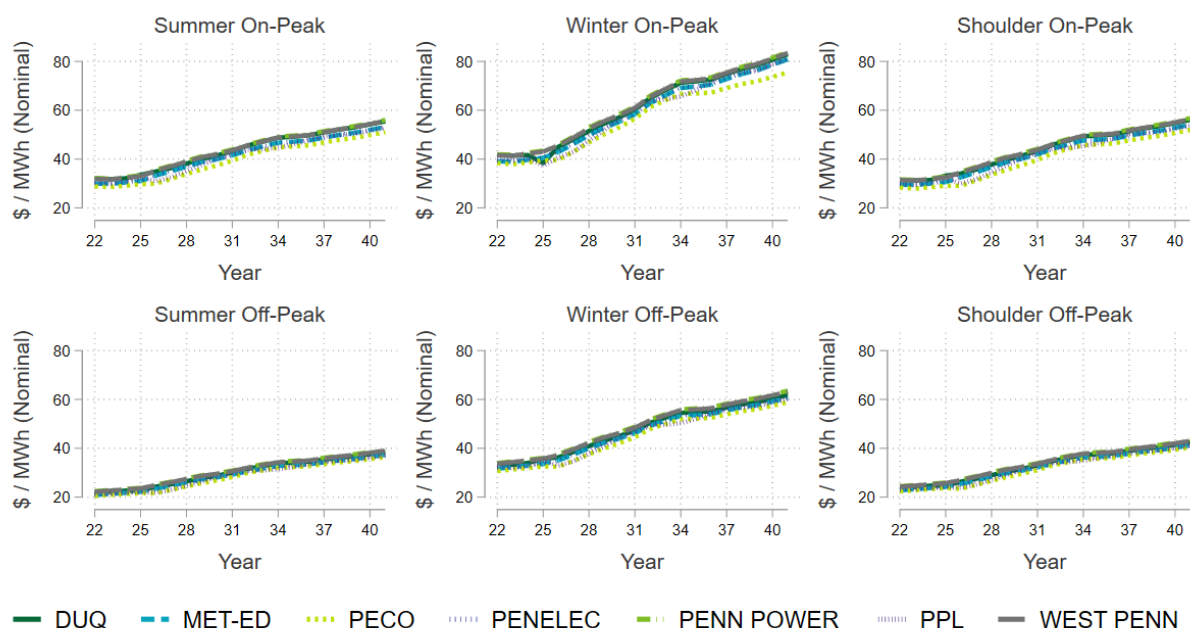
⁶⁴ See PA Act 114 of 2020, Section 1799.10-E

⁶⁵ The Met-Ed Industrial Users Group, the Penelec Industrial Customer Alliance, the Philadelphia Area Industrial Energy Users Group, the PP&L Industrial Customer Alliance, the West Penn Power Industrial Intervenors, and the Pennsylvania Energy Consumer Alliance

⁶⁶ Green and Healthy Homes Initiative, Housing Alliance of Pennsylvania, Keystone Energy Efficiency Alliance, Natural Resources Defense Council, National Housing Trust, Pennsylvania Utility Law Project, and Regional Housing Legal Services (collectively, the Pennsylvania Energy Efficiency for All Coalition (PA-EEFA))

⁶⁷ Avoided Cost Calculator. From the Public meeting of December 19, 2019, at Docket No. M-2019-3006868. Entered December 19, 2019. <https://www.puc.pa.gov/pcdocs/1648144.xlsx>

Figure 20: Phase IV Forecasted Avoided Costs



The avoided cost of energy is particularly important for Pennsylvania because of the relatively limited set of TRC benefits called for in the 2021 TRC Test Order. In many states, the value of CO₂ emissions embedded in energy production is a larger benefits stream than the cost of the energy itself. For Phase IV of Act 129, Pennsylvania does not monetize avoided emissions, recognize Demand Reduction Induced Pricing Effects (DRIPE), or claim non-energy benefits like neighboring states so TRC ratios are lean to begin with and particularly susceptible to assumptions regarding the marginal cost of energy being saved.

Draft Phase IV EE&C plans were due in November 2020. Therefore, EDCs developed avoided cost forecasts in summer 2020, not long after the beginning of the COVID-19 pandemic. To compare the forecast to actual marginal energy costs for each EDC, the SWE gathered hourly load and total real-time LMP for all bus locations for PY16 (6/1/2024 – 5/31/2025) from PJM's DataMiner2 tool.⁶⁸ To find a load-weighted average LMP by season and period, the following method for each EDC, season and period was used: the load for a given hour (MW_i) was multiplied by the mean LMP price for that hour. Mean LMP price for an hour is found by averaging the LMP price from n pricing nodes for each hour and EDC, then divided by the total number of hours in that period of the season. The products are then summed together and divided by the number of hours in the period.

$$\frac{1}{h} \cdot \sum_{i=1}^h MW_i \cdot \left(\frac{1}{n} \cdot \sum_{j=1}^n LMP_j \right)$$

⁶⁸ PJM's DataMiner2. Accessed September 5, 2025. <https://dataminer2.pjm.com/>

In PY16, the actual costs of energy were higher than the forecasted values, unlike in PY15 when they were closely aligned. When similar results were found in the PY13 and PY14 Annual Avoided Costs Review, the SWE recommended the forecast avoided costs not be changed despite actual marginal prices increasing dramatically from prior levels in 2021 and 2022. Industry experts expected energy prices to fall back in line with the original SWE forecasts for Phase IV, and the SWE saw actual marginal prices return to expected levels near the end of PY14 and PY15. The SWE recommendation to avoid changing avoided cost values in response to short term market volatility was prudent.

In the PJM region and in most other locations in the United States, wholesale electricity prices are highly correlated with the price of natural gas since marginal generating units are typically natural gas power plants. Fuel costs are volatile and affected by a variety of factors, political and natural, making the exercise of predicting such costs difficult and inexact. The first segment of the avoided cost forecast relies on electricity futures from summer 2020, as the prompt month for NYMEX futures was established three months prior to the filing date (November 2020). Summer 2020 was the height of the COVID-19 pandemic and forward energy prices – already low pre-pandemic - reflect the reduced demand at the time.

After that time, fuel prices rebounded beyond pre-pandemic levels. PY13 began in June 2021 as the costs began to rise. Some factors that affected prices throughout PY13 and PY14 were unforeseen, such as the war in Ukraine beginning in February 2022 sharply affecting supply and demand for energy, irregularly high inflation, and foreign demand for liquefied natural gas. After the December 2022 spike in locational marginal prices due to winter storm conditions, prices trended downward and began to reach levels in line with the forecasted avoided costs of energy. In PY16, despite brief upward swings in the winter, LMPs have not come close to returning to Summer 2022 levels. [Figure 21](#) displays average monthly LMP across seasons.

Figure 21: Average LMP by Month

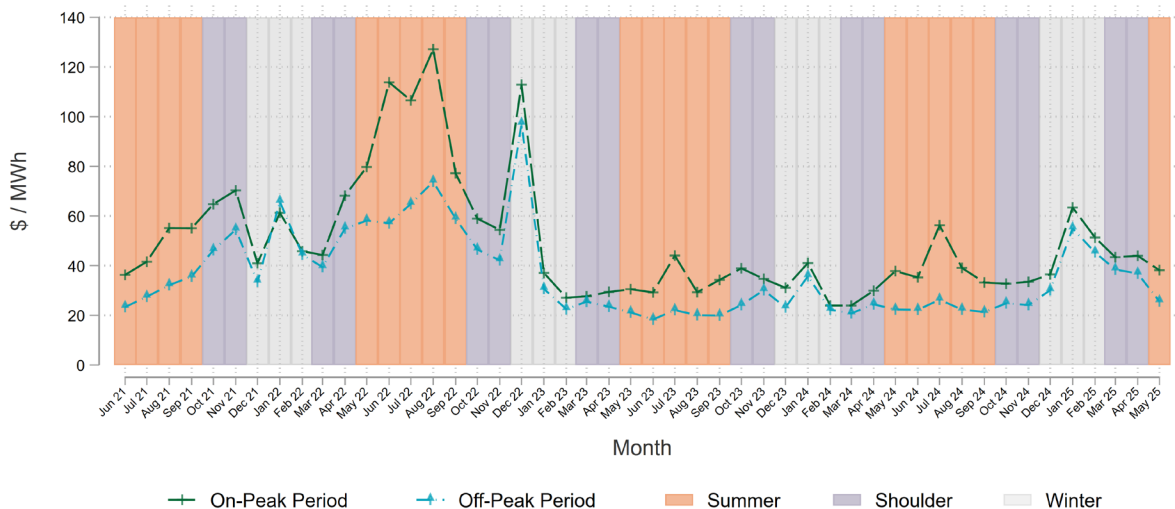


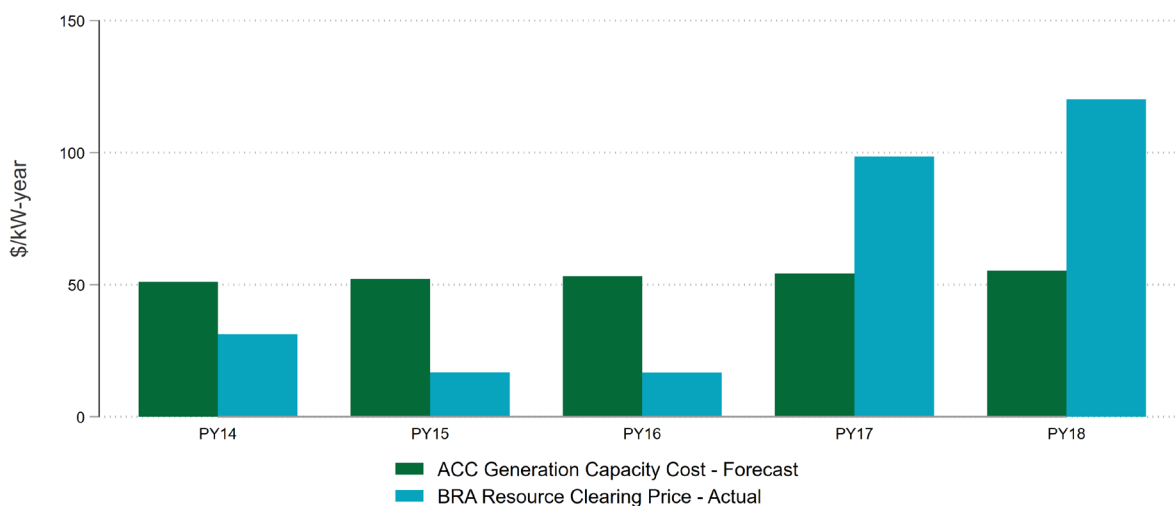
Table 68 presents the PY16 results by season and period, including the percent difference from the forecasted avoided costs of PY16 to the real-time LMP weighted average. The results represent a sales-weighted average of the EDCs subject to Act 129.

Table 68: Load-Weighted Average LMPs by Season and Period for PY16

Season	Period	Forecasted Avoided Cost of Energy	Load-Weighted Average LMP	Percent Difference
Shoulder	Off-Peak	\$24.40	\$30.55	25%
	On-Peak	\$31.22	\$36.83	18%
Summer	Off-Peak	\$22.39	\$25.45	14%
	On-Peak	\$31.67	\$41.60	31%
Winter	Off-Peak	\$34.27	\$42.28	23%
	On-Peak	\$39.67	\$51.86	31%

Over the full year of PY16, average LMPs were higher than the forecasted avoided cost of energy for the same costing period. This is mostly due to short-term increases in natural gas prices over the winter that have since returned to lower levels. While this short-term increase in prices was enough to push regional LMPs above the levels of the Phase IV forecasted avoided costs, the quick return to lower prices means that the SWE does not expect that trend to continue.

PJM has conducted the Base Residual Auction (BRA) for the 2022/2023 (PY14), 2023/2024 (PY15), 2024/2025 (PY16), 2025/2026 (PY17), and 2026/2027 (PY18) delivery years since the SWE developed their avoided cost forecast for Phase IV of Act 129. The BRA sets the price of generation capacity, by zone, in the PJM footprint. Actual capacity clearing prices in PY17 and PY18 were much higher than the Phase IV forecasts. This is a departure from previous years, where capacity clearing prices have been much lower than the forecasted cost of generation capacity. One possible reason for the spike in capacity clearing prices is the planned retirement of several thermal generators in the PJM region, decreasing supply since the last auction. Regional loads are also expected to increase substantially for the first time in many years, contributing to the increased clearing prices. Capacity clearing prices for the 2021/2022 (PY13) delivery year were known and used in the Phase IV forecast, but the remainder of the Phase IV forecast relies on the average of the three most recent auction results at the time of the forecast. Figure 22 compares the average forecasted and actual clearing price for generation capacity in Pennsylvania, weighted by EDC sales.

Figure 22: Forecast versus Actual Generation Capacity (\$/kW-year)

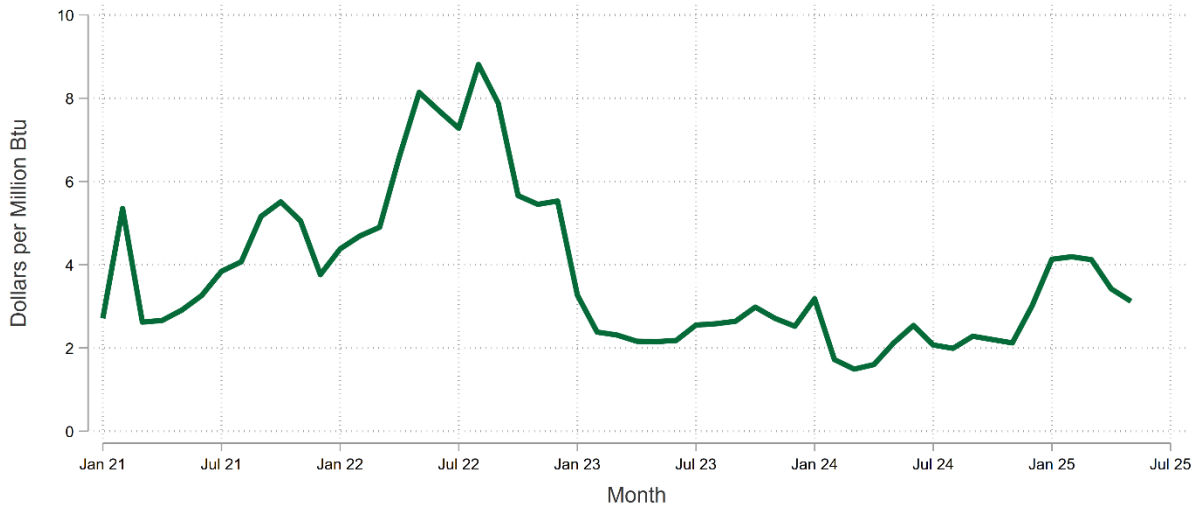
Phase IV avoided cost forecasts were developed at the height of a global pandemic when wholesale prices were at historic lows. In the five years since, wholesale prices swung widely in the opposite direction at times, creating a gap between forecast and actual marginal energy costs during PY13 and much of PY14. Towards the end of PY14, however, actual avoided costs experienced by the EDCs returned around projected levels and remained there for much of PY15. Overall, the Phase IV avoided cost of energy forecast for PY16 was lower than actual market conditions. This discrepancy between projected and actual avoided costs is not a cause for concern as a degree of uncertainty is expected in any long-term forecast. The practical implication of this outcome is that PY16 TRC ratios based on EE&C Plan avoided costs will slightly underestimate the avoided energy benefits of short-lived measures like Home Energy Reports. In contrast, the Phase IV avoided cost of capacity forecast for PY17 and PY18 underestimated the value of reduced peak demand relative to market conditions. However, looking at PY14 through PY18, the years without completed auctions when the avoided cost forecasts were developed, the forecasted avoided cost of capacity seems to correctly estimate capacity costs on average given that in PY14 through PY16 the forecast overestimated actual capacity costs and was underestimated in PY17 and PY18. In addition, the economic signal created by high-capacity prices should trigger generation capacity growth, bringing capacity prices down in future years.

There will always be some difference between forecasted and actual market conditions because no forecast model is perfect. When combining forecasts for multiple resources, however, the differences should be expected to even out unless there is a systematic bias in the forecast. This is indeed the observation of the energy and capacity market forecasts versus actual values that nearly balanced each other out over several years of the annual market conditions review.

Despite the magnitude of differences in short-term forecasted and actual avoided energy costs, it is important to remember that the avoided cost forecast is grounded in historic data. [Figure 23](#) shows Henry Hub Natural Gas Spot Prices stabilizing to a steady \$2.50 per MMBtu during PY15. Economic uncertainty in PY16 led to a rise in natural gas prices. While Phase IV avoided cost projections were created during the pandemic when gas prices were very low, there has been a

gradual return to the low prices experienced in 2020, stabilizing around \$3.50 per MMBtu at the end of PY16.

Figure 23: Henry Hub Natural Gas Spot Price



Over Phase IV, the forecasted avoided costs have at times over predicted and at other times under predicted the actual costs of energy and capacity in the marketplace. While this is generally the expected outcome when comparing actual values to forecasted values, the SWE believes that the exercise of comparing the forecasted avoided costs to actual market conditions is still valuable as a way to keep up to date with actual market values. The SWE recommends that forecasted avoided costs should still be reviewed annually in Phase V for deviations from actual market conditions.

This does not, however, change the SWE's position that a single avoided cost forecast should be used across Phase V to align benefits from program implementation with planning values. Even though the EDCs will have newly developed forecasts of avoided costs as part of their Phase V EE&C plans, the SWE recommends that PY17 benefit-cost modeling should rely on the forecast that was used to plan Phase IV and report the cost-effectiveness of Act 129 programming in prior years of the phase.

Section 5 PY16 Findings, Conclusions, and Recommendations

5.1 FINDINGS & RECOMMENDATIONS

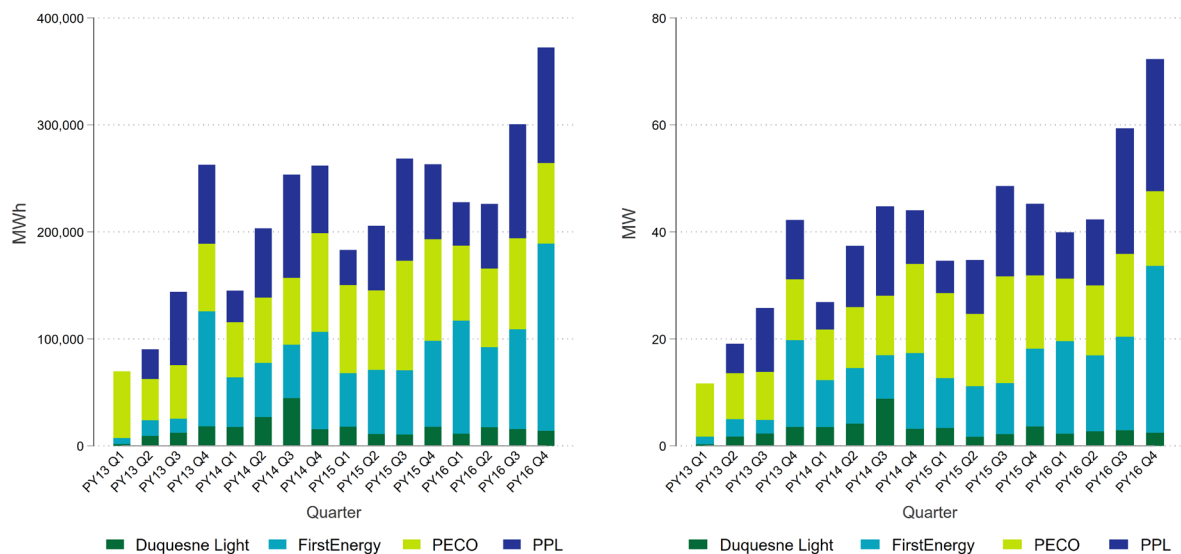
The SWE conducted a review/audit of EDC program delivery mechanisms, tracking data, project and program files and provides the following key findings and recommendations:

5.1.1 Program Delivery

- All seven EDCs have spent less money than projected in their EE&C Plan through the first four years of Phase IV. Actual spending as a percentage of EE&C Plan projected spending ranges from 82% (Met-Ed) to 95% (Duquesne Light). In each case, the EE&C budget is lower than the statutory budget limit established by the Act. EDCs who are behind schedule in attainment of their low-income consumption or peak-demand reduction targets have the available funds to ramp up implementation in PY17. The SWE recommends the EDCs explore increased marketing and elevated incentive levels framed as “limited time offers” to stimulate the market and increase participation in PY17.
- The SWE notes that in PY16, six of the seven EDCs began making up for underspending in previous years of Phase IV by spending more than was approved for PY16 in their EE&C Plans.
- Progress toward the individual EDC Phase IV compliance targets to date in verified gross energy savings ranged from 66% (Penelec) to 90% (Duquesne Light). Including carryover savings from Phase III, total progress toward Phase IV targets ranged from 96% (Penelec) to 123% (Penn Power).
- Progress toward the LI target ranged from 71% (PPL) to 111% (PECO) in P4TD verified gross savings and 76% (Duquesne Light) to 139% (Penelec) when Phase III carryover savings are included.
- Through the first four years of Phase IV, the EDCs collectively achieved 81% of the statewide peak-demand reduction target of 809 MW. This is a notable increase from the 52% statewide progress toward goal at the end of PY15 thanks to strong production in PY16. Penelec (65%) and West Penn Power (69%) are the furthest from goal after four years and will each need to accelerate program implementation in the final year of Phase IV to meet their peak-demand reduction targets. Since Phase III of Act 129 did not include coincident demand reduction targets from EE, the EDCs do not have carryover savings for peak demand like they do for portfolio and low-income energy savings.
- The EDC program tracking data provided to the SWE on a quarterly basis was quite robust for PY16. Most of the changes to measure characterizations resulting from Codes and Standards changes effective at the beginning of PY15 were reflected consistently in reported gross savings claims. EDC evaluation contractors did not have to fix many systematic issues in their PY16 evaluations.

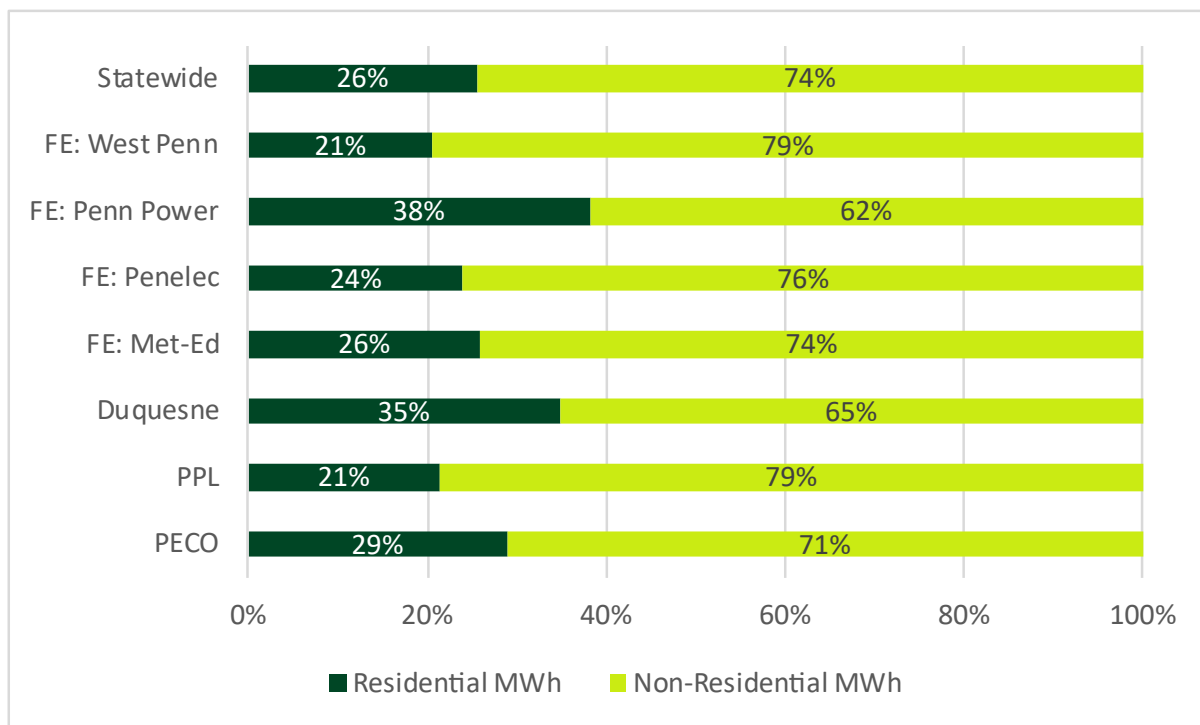
- The Phase IV Implementation Order directed the EDCs to nominate a portion of the expected peak-demand savings in their Phase IV EE&C Plans into PJM's FCM and to use the proceeds from those nominations to lower Act 129 cost recovery requirements. EDCs nominated 15% of the peak-demand savings acquired in PY16 to the FCM. While the limited nominations are a disappointing outcome from a policy standpoint, the low level of FCM involvement lessens EDC exposure to recent changes to the eligibility of EE at PJM. In September 2024, PJM proposed a tariff change eliminating EE nominations from the FCM. This change was approved in November 2024 and prevents the EDCs from nominating any Act 129 MW beginning with the 2026/2027 delivery year. As of PY16, capacity auctions have been completed for all years in which EE remains eligible in the FCM. Over the course of Phase IV to date, proceeds from FCM nominations have reduced cost recovery requirements by 0.27%. Since the EDCs will be unable to realize any FCM proceeds in future years beyond the 2025/2026 delivery year, Act 129 cost recovery will need to be adjusted to make up for the shortfall. Most EDCs only nominated or planned to nominate a small subset of their Phase IV peak-demand savings, meaning the impacts to cost recovery will be small but still should be considered moving forward. EDCs will also need to adjust their CSP contracts to remove any fees associated with FCM support services in any future program years.
- Phase IV implementation was slow to ramp up in PY13 but finished with a strong PY13Q4. PY14 and PY16 saw a similar trajectory with more savings acquired in the second half of the program year. [Figure 24](#) shows the breakdown of reported gross energy and peak-demand savings by quarter. Savings attributable to HER programs are not included. PY16Q3 and PY16Q4 were the largest quarters to date in Phase IV statewide. The strong finish to PY16 helped the EDCs close the gap between EE&C Plan projections and actual P4TD performance.

Figure 24: Reported Gross MWh and MW by Quarter



- Statewide energy savings continued to shift away from the residential sectors and into the non-residential sectors in PY16 (Figure 25). Non-residential savings accounted for 74% of statewide MWh savings in PY16, compared to 71% in PY15, 70% in PY14, 66% in PY13 and 49% of savings in Phase III. Non-residential lighting accounted for the bulk of the PY16 savings (44% statewide). Penn Power had the highest share of residential MWh savings in PY16 at 38% and PPL and West Penn Power had the lowest residential shares at 21%.

Figure 25: Share of Residential and Non-Residential PY16 Verified Gross MWh Savings by EDC and Statewide



- In PY16 savings from the Solar PV measure shifted from a limited portion of verified savings to the second biggest measure in the programs after non-residential lighting, accounting for over 9% of energy savings statewide. Solar PV projects' contributions ranged from 2% (Penn Power) to 23% (PPL) of portfolio energy savings for the EDCs.
- Residential Lighting continued to account for a smaller share of portfolio savings compared to Phase III. In PY16, Residential Lighting accounted for 4% of statewide MWh savings while it accounted for 5% in PY15, 9% in PY14 and 30% of statewide MWh during Phase III. Residential Lighting will likely decline further in PY17 as point-of-sale and downstream lighting measures that meet the U.S. Department of Energy's (DOE) definitions of General Service Lamps (GSLs) are no longer eligible. While direct-install and kit-delivered lighting measures are still eligible, direct install savings opportunities may be diminishing with declining numbers of existing inefficient bulbs.
- Actual acquisition costs in PY16 were nearly identical to EE&C plan projections statewide for energy (\$/kWh), 0.4% higher, and only 1% higher than EE&C plan projections for

capacity (\$/kW) statewide (whereas acquisitions costs were materially higher than planned in PY15). EE&C plans generally assume that targets will be exceeded without using 100% of the spending cap so the EDCs have built in some buffer on this key metric.

- The accounting methodology for behavioral HERs changed significantly in Phase IV. Instead of assuming all measured savings are incremental first-year savings, the 2021 TRM adopted a multi-year measure life perspective that reduces compliance savings beginning in the third year of program delivery. The EDCs operationalized this new framework in different ways. PECO, FirstEnergy, and Duquesne Light moved to a rotating model where legacy waves are paused and then restarted once the assumed persistence has declined. PPL waited until PY16 to launch its HER program so they will not face persistence adjustments in Phase IV. FirstEnergy reintroduced ten HER cohorts in PY16 after a three-year pause, which allowed for most of its measured savings to be treated as incremental and claimed towards compliance targets. HER programs contributed more MWh in PY16 than any prior year of Phase IV, largely because of the addition of nearly 350,000 households at PPL and the reintroduction of ten cohorts by FirstEnergy. HERs accounted for approximately 6% of portfolio MWh savings and 9% of progress towards low-income targets statewide.
- EDC cost categorization is clearly an area of emphasis for the Commission as the Phase IV Implementation Order required that EDCs “*submit an EE&C Plan which shows at least 50% of all spending allocated to incentives and less than 50% of all spending allocated to non-incentive cost categories.*”⁶⁹ While this was an EE&C Plan requirement and not an actual program delivery target, the SWE sees value in reviewing the actual breakdown of expenditures. The statewide share of spending on incentives as a percentage of total EDC expenditure was 60% in PY16.

5.1.2 Evaluation

The Pennsylvania EDCs and their evaluation contractors conducted a significant volume of verification and program design research in PY16. Some of the key findings and recommendations from their research – and the SWE audit activities – included the following:

- Energy realization rates were close at the portfolio level in PY16 – ranging from 92% at Penelec to 109% at Duquesne Light. Peak-demand realization rates ranged from 74% at Penn Power to 109% at Duquesne Light. Overall, this suggests that the EDCs and their CSPs are calculating reported savings in a reliable manner and that any major variations between reported and verified savings were limited to smaller program components. This finding also speaks to the reliance of the EDC evaluation contractors on the TRM for verified savings assumptions. The lower demand realization rates for the FirstEnergy companies were largely driven by low realization rates for HERs, which were primarily due to methodological differences in calculations of reported and verified demand reductions, as well as cross-participation corrections

⁶⁹ Phase IV Implementation Order. Pages 119-127.

- The SWE issued a series of “Codes and Standards” memos in 2022 to reflect changes to federal standards, state building codes, and ENERGY STAR specifications since the release of the 2021 TRM. In most cases, the EDCs and their evaluation contractors reflected these changes in the verified savings calculations for PY16. One update that was missed by all seven EDCs was recessed downlight fixtures in commercial midstream lighting programs. Due to the U.S. Department of Energy’s changes to general service lighting requirements, screw-based lamps and recessed downlights were no longer eligible for Act 129 savings beginning June 1, 2023. In PY16, the EDCs continued to incentivize midstream delivery of recessed downlights. The SWE identified this issue and worked with the EDC evaluation contractors to zero out savings from ineligible products in the PY16 verified savings analyses. This led to a small reduction (1-2%) in verified energy and demand savings from commercial midstream lighting programs.
- Each year, the SWE conducts a comparison of market conditions to the Phase IV avoided cost forecast. Wholesale market prices for energy were higher than the avoided energy cost forecast for PY16. Auction clearing prices for generation capacity have fluctuated significantly over the course of Phase IV. The avoided cost of generation capacity forecast overstated the value of peak savings for the initial years of Phase IV but will understate the value of peak savings beginning in PY17 based on the much higher clearing price results of PJM’s Base Residual Auction for the 2025/2026 and 2026/2027 delivery year.⁷⁰ Despite this volatility, the *average* Base Residual Auction results over the phase are well-aligned with the forecasted generation capacity costs.
- Avoided Alternative Energy Portfolio Standards (AEPS) compliance costs are a component of the value of avoided energy in the TRC Test. Since the Commission issued its 2021 TRC Test Order in 2019, the value of AEPS credits has increased by almost a factor of seven. While the increased value of AEPS credits is large on a relative basis, they are a small component of the overall avoided cost of electric energy. In line with these findings, the 2026 TRC Order incorporates the higher values of AEPS credits in recent years into the Avoided Cost Calculator that will be used by the EDCs to plan for Act 129 programming in Phase V.
- In the 2026 TRC Test Order, the Commission directs the Pennsylvania EDCs to include the value of Demand Reduction Induced Price Effects (DRIPE) in cost effectiveness testing for a potential Phase V. The SWE conducted a study to quantify the value of DRIPE for each EDC in the future years of a potential Phase V and beyond for both energy and capacity. In preparation for this annual report, the Commission requested that the SWE conduct a sensitivity analysis on the value of including DRIPE in cost effectiveness testing. To do so, the SWE calculated what the value of DRIPE benefits would have been for both energy and capacity in PY16 had they been included. If the benefits from DRIPE were included in cost effectiveness testing in PY16 the statewide TRC ratio of 1.38 would increase to 1.64. While price suppression effects will make up only a piece of both avoided energy and avoided capacity when they are officially included in cost effectiveness testing

⁷⁰ <https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2025-2026/2025-2026-base-residual-auction-report.ashx>

in Phase V, the value added to benefits will increase overall cost effectiveness substantially.

- The EDC evaluation contractors' benefit-cost analysis was generally well-organized and consistent with the directives of the 2021 TRC Order. One area of weakness was fossil fuel impacts. Both PPL and PECO had units' issues (therms versus MMBtu) that caused fossil fuel benefits to be misstated by a factor of ten for certain measure categories. Duquesne Light included the fossil fuel penalty from LED lighting measures in its TRC model but ignored the fuel savings from weatherization and low-flow devices installed in buildings with fossil fuel space heating or domestic water heating. The handling of fossil fuel savings from smart thermostats was also inconsistent across EDCs, with the FirstEnergy EDCs and PPL quantifying the fossil fuel heating savings from wi-fi connected smart thermostats and PECO and Duquesne Light ignoring the fossil fuel heating benefits.
- The SWE's review of verified savings for residential and non-residential programs for all EDC's found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and were generally accurate.
- The SWE conducted comprehensive reviews of Solar PV projects in PY16. Each project was reviewed to ensure adherence to the Solar PV IMP and associated M&V requirements. Energy generation values were also checked against historical consumption to ensure the systems will offset existing facility loads. The SWE concluded that evaluators performed their due diligence, and verified savings are reliable, consistent, and in accordance with Act 129 requirements
- Overall, the EDC evaluators estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework.
- Overall, the EDC evaluators conducted process evaluations consistent with the Phase IV Evaluation Plan and with the approved EM&V plans. Participant satisfaction was generally high across all EDCs for residential, low-income, and C&I customers (the lower residential satisfaction was driven by HER satisfaction). [Table 69](#) provides an overview of the PY16 process evaluations conducted by each EDC.

Table 69: PY16 Process Evaluations by EDC: Percent of Participating Customers Satisfied

EDC	# of PY16 Programs & Components Evaluated	% of Satisfied Residential & LI Customers*	% of Satisfied C&I Customers*
PECO	3	84%	100%
PPL	9	68%***	94%
Duquesne Light	0	N/A	N/A
FirstEnergy EDCs**	6	83%	91%

* Average across all programs for which participant surveys were conducted. The average is weighted by the number of PY16 participants in each program. Percent satisfied is defined as ratings of seven to ten on a scale from zero to ten for PECO and ratings of satisfied or very satisfied for PPL and the FirstEnergy EDCs.

** The four FirstEnergy EDCs (Met-Ed, Penelec, Penn Power, and West Penn Power) operate an identical set of programs. The evaluation contractor took unified process evaluation approaches to these programs and reported process evaluation results across all four EDCs.

*** When HER participants responses are excluded, 85% of residential and LI participants (combined) were satisfied with the programs overall.

Appendix A Summary of EDC Performance Against Portfolio Targets & Cross-Cutting Findings

The following tables provide a summary of progress toward the individual EDC Phase IV compliance targets in PY16, as well as a comparison of EDC- and SWE-verified savings.

A.1 EDC PERFORMANCE AGAINST PORTFOLIO TARGETS

The SWE-verified savings for PECO and PPL were slightly larger than the respective EDC-verified savings (Table 71 and Table 74). The SWE discovered minor errors in PECO's verification of some residential education measures (see Appendix B.5.1) and minor errors in PPL's verification of a few measures in the Energy Efficient Homes - Downstream HVAC component (see Appendix C.5.1). Overall, statewide savings increased by 423 MWh and 0.19 MW.

Table 70: Summary of PY16 Verified Energy Savings and Phase IV Portfolio Targets¹

EDC	Phase IV Compliance Target (MWh/yr)		PY16 Verified Gross Savings (MWh/yr)	
	Overall	LI	Overall	LI
PECO	1,380,837	80,089	321,861	19,535
PPL	1,250,157	72,509	299,784	15,530
Duquesne Light	348,126	18,566	72,031	3,308
FE: Met-Ed	463,215	26,866	163,063	6,694
FE: Penelec	437,676	25,385	110,670	5,990
FE: Penn Power	128,909	7,477	32,615	1,059
FE: West Penn Power	504,951	29,287	160,670	5,124
Statewide	4,513,871	260,179	1,160,694	57,240

¹Totals may not equal the sum of columns or rows due to rounding.

Table 71: Comparison of EDC and SWE PY16 Verified Energy Savings¹

EDC	PY16 EDC Verified Gross Savings (MWh/yr)		PY16 SWE Verified Gross Savings (MWh/yr)	
	Overall	LI	Overall	LI
PECO	321,631	19,518	321,861	19,535
PPL	299,591	15,530	299,784	15,530
Duquesne Light	72,031	3,308	72,031	3,308
FE: Met-Ed	163,063	6,694	163,063	6,694
FE: Penelec	110,670	5,990	110,670	5,990
FE: Penn Power	32,615	1,059	32,615	1,059
FE: West Penn Power	160,670	5,124	160,670	5,124
Statewide	1,160,271	57,222	1,160,694	57,240

¹Totals may not equal the sum of columns or rows due to rounding.

Table 72: Summary of Phase-to-Date Verified Energy Savings and Phase IV Portfolio Targets¹

EDC	Phase IV Compliance Target (MWh/yr)		Phase IV Verified Gross Savings (MWh/yr)	
	Overall	LI	Overall	LI
PECO	1,380,837	80,089	1,233,910	89,028
PPL	1,250,157	72,509	975,545	51,614
Duquesne Light	348,126	18,566	311,736	14,115
FE: Met-Ed	463,215	26,866	379,912	22,370
FE: Penelec	437,676	25,385	290,211	24,821
FE: Penn Power	128,909	7,477	92,022	5,625
FE: West Penn Power	504,951	29,287	368,007	26,972
Statewide	4,513,871	260,179	3,651,343	234,545

¹Totals may not equal the sum of columns or rows due to rounding.**Table 73: Summary of PY16 Verified Peak-Demand Savings and Phase IV Portfolio Targets¹**

EDC	Phase IV Compliance Target (MW/yr)	PY16 SWE Verified (MW/yr)
PECO	256	62.10
PPL	229	63.00
Duquesne Light	62	13.54
FE: Met-Ed	76	27.35
FE: Penelec	80	20.90
FE: Penn Power	20	5.60
FE: West Penn Power	86	27.13
Statewide	809	219.63

¹Totals may not equal the sum of columns or rows due to rounding.**Table 74: Comparison of EDC and SWE PY16 Verified Peak-Demand Savings¹**

EDC	PY16 EDC Verified (MW/yr)	PY16 SWE Verified (MW/yr)
PECO	62.09	62.10
PPL	62.83	63.00
Duquesne Light	13.54	13.54
FE: Met-Ed	27.35	27.35
FE: Penelec	20.90	20.90
FE: Penn Power	5.60	5.60
FE: West Penn Power	27.13	27.13
Statewide	219.44	219.63

¹Totals may not equal the sum of columns or rows due to rounding.

Table 75: Summary of Phase-to-Date Verified Peak-Demand Savings and Phase IV Portfolio Targets¹

EDC	Phase IV Compliance Target (MW/yr)	Phase IV SWE Verified (MW/yr)
PECO	256	229.99
PPL	229	176.33
Duquesne Light	62	58.95
FE: Met-Ed	76	60.39
FE: Penelec	80	52.01
FE: Penn Power	20	15.61
FE: West Penn Power	86	59.28
Statewide	809	652.57

¹Totals may not equal the sum of columns or rows due to rounding.

A.2 LOW-INCOME MEASURE PROPORTIONALITY ANALYSIS

As noted in the [Low-Income Measure Proportionality Analysis](#) section of the Executive Summary, the Phase IV Implementation Order directed the EDCs to offer conservation measures to the LI customer segment based on the proportion of electric sales attributable to LI households.⁷¹ This “Low-Income Measure Proportionality” requirement directs each EDC to include in its programs a minimum number of energy-efficiency measures for households at or below 150% of the federal poverty income guidelines. The minimum number of measures must be proportionate to each EDC’s total LI consumption relative to the total energy usage in its service territory. An LI measure is defined as one that is targeted to LI customers and is available at no cost to LI customers.

The SWE found that each EDC complied with the LI proportionality requirement.

[Table 76](#) reports the required minimum proportions and the results of the SWE’s verification analysis.

⁷¹ 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.
<https://www.puc.pa.gov/pcdocs/1666981.docx>

Table 76: LI Measure Proportionality Targets and SWE Verification Results

EDC	Proportionate Number of Measures, Target	PY16 Proportionate Number of Measures, Reported	PY16 Proportionate Number of Measures, SWE Verified
PECO	8.80%	30.6%	31.0%
PPL	9.95%	23.4%	23.4%
Duquesne Light	8.40%	37.8%	37.8%
FE: Met-Ed	8.79%	21.3%	21.3%
FE: Penelec	10.23%	21.3%	21.3%
FE: Penn Power	10.64%	21.3%	21.3%
FE: West Penn Power	8.79%	21.3%	21.3%

A.2.1 Matching Measures to TRM Algorithms Subheading

EDCs reported compliance with the proportionate number of measures targeted in their individual PY16 Annual Reports and provided supporting lists of measures from their Phase IV EE&C Plans, along with classifications of measures, to the SWE. Upon analysis of the EDC's measure classifications, the SWE found a minor error with PECO's analysis. Overall, the EDCs accurately followed the guidance from the Phase IV Evaluation Framework, in which the SWE advised them to differentiate measures at the same granularity as algorithms in the TRM. Technologies that are addressed by a single algorithm section in the TRM should not be further subdivided. Measure divisions should be based on equipment types, not differences in equipment efficiency or sizing of the same type of equipment. For example, EDCs should not separate LED bulbs into multiple measures based on wattage. A grouping approach that distinguishes between equipment types, but not sizes or efficiency levels, should be employed for measures that are not addressed in the PA TRM.⁷² When multiple EDC-reported measures were combined to match a single algorithm section in the TRM, the final measure was considered LI if it included any EDC-reported LI-qualified measures.

A.2.2 Results

Every EDC complied with the LI proportionality requirement. The SWE found a minor error with PECO's analyses but no errors with the remaining EDCs.

A.2.2.1 PECO

PECO reported that 30.6% of its 85 conservation measures qualified as LI measures, surpassing its 8.8% requirement. The SWE found that a residential lighting measure had been counted twice, which reduced the number of conservation measures to 84 and slightly increased the proportionality to 31%.

⁷² Evaluation Framework for Pennsylvania Act 129 Phase IV Energy Efficiency and Conservation Programs. https://www.puc.pa.gov/media/1584/swe-phaseiv_evaluation_framework071621.pdf

A.2.2.2 PPL

PPL reported that 23.4% of its 77 conservation measures qualified as LI measures, surpassing its 9.95% requirement. The SWE concurs with PPL's assessment.

A.2.2.3 Duquesne Light

Duquesne Light reported that 37.8% of its 90 conservation measures qualified as LI measures, surpassing its 8.4% requirement. The SWE concurs with Duquesne Light's assessment.

A.2.2.4 FirstEnergy Companies

The FirstEnergy EDCs were assessed as a group since their measure counts are identical, and the SWE concurs with FirstEnergy's assessment that 21.3% of their conservation measures qualified as LI measures.

A.3 NTG

Overall, the EDCs estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework. The EDCs made the NTG input data, calculators, and estimation syntax available to the SWE, allowing for a complete audit of the reported values.

Appendix B PECO PY16 Audit Detail

B.1 KEY AUDIT FINDINGS

- The SWE's review of verified savings for residential components, which include income-eligible programs, found that, overall, the verification process followed proper TRM protocols and Guidehouse's EM&V plans. The SWE found minor errors with a few individual measures that had a cumulative positive impact of 0.25% of total residential and low-income verified savings.
- PECO's Phase IV EM&V Plan calls for an intermediate savings quantity between reported and verified gross savings referred to as "adjusted database savings." The ratio of verified savings to "adjusted database savings" is called the "verification ratio." The adjusted database savings are computed for every program component annually, even in program years when no impact evaluation was conducted. The documentation improved further for PY16, allowing the SWE to more easily replicate the expansion process and verified savings calculations for all program components.
- Adjusted database savings are the result from Guidehouse's review of every measure to identify systematic patterns or errors in applying TRM algorithms, constants, or deemed values. The adjusted database savings differed only slightly from the reported savings in PY16, with adjusted database MWh and MW approximately 0.4% lower than reported MWh and MW at the portfolio level. While the SWE has questioned the usefulness of this intermediate quantity, it provided a natural place to zero out savings from ineligible products incentivized through the commercial midstream channel. This systematic issue should not persist; therefore, separating it from the broader realization rates is reasonable.
- The dataset used in the sample expansion and realization rate calculations differs from PECO's annual report values for the Downstream component of the Non-Residential program because the sample frame includes 3,192 MWh of unverified PY15 savings that were verified in PY16 and excludes 746 MWh of unverified PY16 savings that will be evaluated in PY17. This difference is a natural consequence of unverified savings and does not create any sampling or expansion issues, given the limited contribution of unverified savings to overall program totals.
- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific Measurement and Verification (M&V) activities, and applied TRM protocols correctly. Minor revisions included updating the operational schedule for the demand calculation of one air compressor project to align with data collected.
- PECO has a portfolio TRC ratio of 1.24 in PY16, lower than PY15's TRC ratio of 1.59. The SWE's TRC audit led to an adjustment of the fossil fuel benefits from low-flow water savings devices, such as faucet aerators and showerheads. Guidehouse's TRC model monetized per-unit therm savings estimates on a \$/MMBtu basis, meaning the fossil fuel benefits of these measures were overstated by a factor of 10 in PECO's PY16 annual report. Guidehouse also updated the assumed domestic hot water fossil fuel share for

these devices to align with TRM defaults for the PECO service territory. The corrections lowered the portfolio TRC benefits by approximately \$20 million. All TRC values in this report reflect corrected fossil fuel impacts for low-flow devices. The SWE thoroughly audited the TRC model and found all other elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.

- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in PECO's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and incentives. The SWE was unable to replicate participant counts exactly using the tracking data, but the SWE did not expect to be able to do so.
- PECO had eleven active behavioral HER cohorts in PY16, with approximately 540,000 treated households. Ten of eleven cohorts were mature enough to require persistence calculations to separate incremental savings from persisting savings from prior exposure. Over half of the MWh savings measured at the meter were attributed to prior HER exposure and therefore not eligible to count towards Phase IV compliance targets. Approximately 8% of all gross verified MWh savings came from HER programs in PY16, and 4.3% of PECO's progress towards its low-income compliance target came from the Income-Eligible HER program. The SWE was able to replicate the verified energy and demand savings values.
- The Income-Eligible HER program delivered 807 MWh of verified gross savings in PY16, thanks to improved performance from Wave 8. In PY15, the Income-Eligible HER program contributed -237 MWh of verified gross savings, causing a setback for PECO in terms of progress toward its Phase IV low-income compliance target. It is unclear what led to the lack of performance of Wave 8 in PY15, but the positive savings in PY16 are an encouraging trend.
- Non-residential project document reviews were conducted for 30 projects across five non-program components. Overall, project documentation was thorough and provided the data needed to inform savings analyses. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of PECO's residential and income-eligible components in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data. The SWE notes that while PECO's Residential Appliance Recycling program component was active in PY16 there were no project files submitted for review in PY16. Project files should be submitted for the Appliance Recycling program component in the PY17 quarterly data request responses.
- Overall, Guidehouse estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and applied historic NTG according to the approved EM&V plan.
- For the process evaluations, Guidehouse completed all the PY16 activities detailed in the approved evaluation plan and sampling memos, and the reporting followed the SWE

guidelines. The process evaluation discussion was succinct and highlighted findings that should be of value to PECO and its CSPs.

B.2 EM&V PLAN REVIEWS

PECO's evaluation contractor, Guidehouse, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, Guidehouse submitted several memos detailing their sampling approach for program components selected for impact, process, and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 77](#) shows which PECO programs produced verified impacts in PY16, and which used historic realizations rates from previous program years.

Table 77: PY16 PECO Program Impact Evaluation Summary

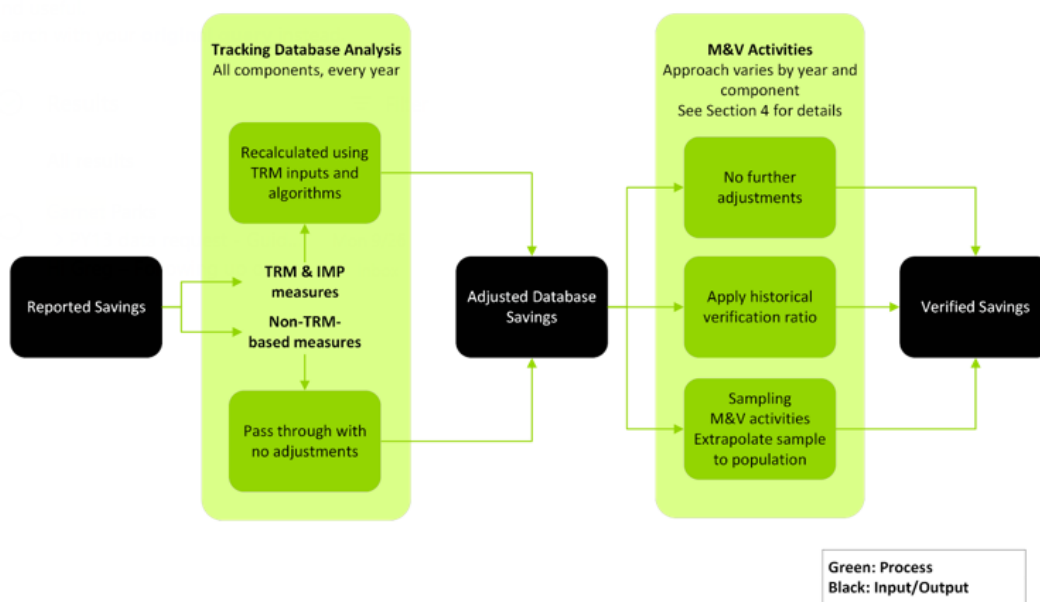
Program	Component	Delivery Channel	PY16 Impacts
Residential	Rebates and Marketplace	Downstream	Verified ductless heat pumps and solar PV; historic verification ratios for all other measures
		Trade ally and Distributor Network	Historical verification ratios
		Point of Purchase	Verified for spray foam, Historical verification ratios
		Marketplace	Historical verification ratios
	Appliance Recycling	N/A	Historical verification ratios
	In-Home Assessments	N/A	Verified
	New Construction	N/A	Historical verification ratios
	Multifamily	N/A	Historical verification ratios
	HER	N/A	Verified
	Single-Family	All	Verified
Income-Eligible	Appliance Recycling	N/A	Historical verification ratios
	Long-Term Savings	All	Verified
Income-Eligible HER	HER	N/A	Verified
Non-Residential	Downstream Rebates	N/A	Verified
	Midstream Rebates	N/A	Verified
	New Construction	N/A	Historical verification ratios
	Small Business Direct Install	N/A	Verified

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft surveys and interview guides for the applicable components.

B.3 SAMPLE DESIGN REVIEW

Of the seven EDCs subject to Act 129, PECO had the most complex sample design and expansion process in PY16. PECO's evaluation contractor, Guidehouse, implemented an intermediary step of tracking database adjustments to correct for any systematic issues in the reported savings. The output of this intermediate step serves as the denominator of a "verification ratio" when sampling is done and is what the results of prior sample findings are applied to in years where the EM&V Plan calls for a historic realization rate.

Figure 26 documents the two-step process by which Guidehouse verified PY16 impacts taken from the PECO Phase IV EM&V plan.

Figure 26: Phase IV Savings Verification Process

In PY16, at the portfolio level, the adjusted database savings values were very close to the reported savings, with the adjusted database savings 0.4% lower than the reported savings for energy and demand values. For most program components, the database adjustments were very minor, and the components with more substantive adjustments tended to have a small contribution to portfolio savings. This alignment speaks to the quality of the reported savings stored in PECO's tracking system. Note the dataset used in the sample design review differs from PECO's annual report values in that the sample frame includes 3,192 MWh of unverified PY15 savings that were verified in PY16 and excludes 746 MWh of unverified PY16 savings that were punted to PY17. This difference does not significantly affect sample design review findings.

The PY16 annual data request response adhered to the guidance provided by the SWE in PY14, and included all three savings values (reported, adjusted database, and verified) in the sample roll-up files. This allowed the SWE to replicate the PY16 verified savings calculations.

The Phase IV Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at an 85% confidence level for each "initiative." This ensures uncertainty introduced by sampling is capped at a certain acceptable level. For Phase IV of Act 129, the SWE established precision requirements at the initiative level instead of by program. This affects EDCs like PECO, who define EE&C programs broadly but have specific offerings grouped more logically for evaluation purposes. PECO denotes the initiative level with the term "component." Within some components, multiple strata are used to ensure robust sampling. The Guidehouse evaluation activities for PECO were broken down by program (residential or non-residential), and component, and reported in the PECO PY16 Annual Report by component. Samples were devised to meet the 85/15 sampling requirement for each program component.

Table 78 shows the relative precision of the energy and peak-demand savings for each component evaluated in PY16. The SWE reproduced the precision values for energy with the project-level sample dispositions furnished in response to the SWE annual data request. Program components that relied on historic realization rates have been omitted. Behavioral programs that have no uncertainty associated with sampling have also been omitted.

With respect to the Residential Rebates and Marketplace Component, the Spray Foam, Ductless Heat Pump, and Solar measures were verified in PY16. For all other Rebates and Marketplace measures, the results of the tracking database analysis were combined with the PY15 verification ratios to determine final verified gross savings.

Table 78: Relative Precision of PY16 Impacts by Component at the 85% Confidence Level

Program	Component	Relative Precision (Energy)	Relative Precision (Demand)
Residential	Rebates and Marketplace	7%	4%
	In-Home Assessment	20%	21%
Income-Eligible	Single-Family	8%	8%
	Long-Term Savings	8%	8%
	Downstream	6%	17%
Non-Residential	Midstream	5%	5%
	Small Business Direct Install	5%	10%

The SWE was able to closely replicate the reported relative precision values for energy and demand in the table above. The relative precision values calculated by the SWE were slightly lower than those reported across all programs for both energy and demand. This is presumably due to the SWE using z-statistics in the calculation instead of the student's t-statistic that Guidehouse uses. The Residential In-Home Assessment component failed to meet the $\pm 15\%$ relative precision requirement for both energy and demand due to an unexpectedly high coefficient of variation.

Not all components rely on sampling to estimate verified savings. For the Residential HER and Income-Eligible HER programs, the impact evaluation relies on a statistical billing analysis of all participants so there is no uncertainty associated with sampling. The precision requirements for the behavioral program are unique, with the Phase IV Evaluation Framework requiring the component-level verification to achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). This requirement for program design is less stringent than the sampling requirement (described above) that programs annually achieve $\pm 15\%$ relative precision at the 85% confidence level. Standard precision requirements are not reasonable expectations for behavioral programs because the size of the average effect is typically much smaller, and all estimation error is captured as opposed to sampling error only. The HER analysis examines the program's entire population, a census evaluation, and the reported precision values reflect the error of the regression analysis estimate rather than sampling uncertainty. PECO reports impacts and the associated uncertainty by cohort and month, with overall program totals comfortably below the threshold.

B.4 REPORTED GROSS SAVINGS AUDITS

B.4.1 Tracking Data Review

This section summarizes the SWE's assessment of the savings, participation counts, and incentives reported in PECO's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts
- Incentive dollars

The SWE leveraged PECO's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset, but rather a subset tailored to our standing quarterly data request. Also, note that HER programs are not audited using the tracking data; thus they are not included in the tables or totals in the following sections. The SWE's findings regarding PECO's Residential HER and Income-Eligible HER programs can be found in [Appendix B.5.1](#).

[Table 79](#) summarizes our findings regarding reported gross energy savings. The "Match" column contains "Yes" if the tracking data supports the values in PECO's PY16 Annual Report and "No" otherwise. The tracking data supports the Annual Report for all programs.

Table 79: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Residential Energy Efficiency	59,476	59,476	Yes
Residential Income-Eligible	13,943	13,943	Yes
Non-Residential Energy Efficiency	230,715	230,715	Yes
Portfolio Total	304,134	304,134	Yes*

*The Residential HER and Income-Eligible HER programs are not included in this table.

[Table 80](#) summarizes the SWE's findings regarding reported gross peak-demand savings by program. The tracking data is provided at the meter level. To facilitate the comparison, the SWE applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. As with reported gross energy savings, the tracking data supports the PECO PY16 Annual Report value exactly for all programs.

Table 80: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Residential Energy Efficiency	7.83	7.83	Yes
Residential Income-Eligible	1.60	1.60	Yes
Non-Residential Energy Efficiency	45.32	45.32	Yes
Portfolio Total	54.75	54.75	Yes*

*The Residential HER and Income-Eligible HER programs are not included in this table.

The SWE also used the tracking data to audit PECO's reported participation counts and customer rebate amounts. As with the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by PECO. No substantive issues were discovered.

B.4.2 Project File Reviews

B.4.2.1 Residential

The SWE conducted a project file review for a sample of PECO's residential and income-eligible components in PY16 as part of the reported savings (i.e., ex ante) review. The project file documentation was provided by PECO, the program implementers, and the evaluation contractor, Guidehouse, in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. [Table 81](#) summarizes SWE's residential project file reviews. Project files were found to match most of the tracking data, with some exceptions. The SWE notes that no project files were submitted for the Appliance Recycling program component in PY16. Assuming the Appliance Recycling component is active in PY17, project files should be included in the PY17 quarterly data request responses.

Table 81: PECO Residential Project File Review Summary

Program	Component	Number of Files Reviewed	Did EDC Provide Project Files?	Are Most of the Requested Files Included?	Are Projects Easily Located in the Tracking Data?	Does the Data in the Files Match the Tracking Data? ¹
Residential EE Program	Energy Assessment	19	✓	✓	✓	✓
Residential EE Program	Rebates and Marketplace	23	✓	✓	✓	✓
Residential EE Program	Appliance Recycling	-	-	-	-	-
Residential EE Program	Residential New Construction	16	✓	✓	✓	✓
Residential EE Program	Multifamily	-	-	-	-	-
Income-Eligible EE Program	Giveaways (SFIE)	16	✓	✓	✓	✓
Income-Eligible EE Program	Appliance Recycling	-	-	-	-	-
Income-Eligible EE Program	Long-Term Savings	-	-	-	-	-

¹ It should be noted that while typically the data matches, minor discrepancies were found and are detailed in the paragraphs below.

As detailed above, the requested number of project files and supporting details were submitted for the residential program. Below is a summary of the SWE's review of the Residential EE Program and Income-Eligible EE Program project file packages and program tracking data.

Residential EE Program: Energy Assessment (EA)

The project file documentation provided for the In-Home Energy Assessment solution included reports containing energy assessments for customers, which specified home addresses, wattage, and information about new equipment installed. The SWE determined that project file documentation matched the tracking data for the sampled Residential Rebates and Marketplace projects.

Residential EE Program: Rebates and Marketplace

The project file documentation provided for the Rebates and Marketplace solution included images of receipts, contractor invoices, ENERGY STAR certificates, and AHRI certificates. The SWE determined that the project files matched the tracking data for the residential rebates and marketplace projects. In Q1, there were four examples where the submitted receipts and invoices were not a clear match for the equipment listed in the tracking data.

Residential and Income-Eligible EE Program: Appliance Recycling Solution

The SWE did not review Appliance Recycling project files, as PECO did not submit any Appliance Recycling files for review in PY16.

Residential EE Program: Residential New Construction (RNC)

The SWE was provided with a sample of project files for individual projects, which were compared to the program tracking data spreadsheet. In all reviewed cases, the project files consisted of a REM/Rate or Ekotrope file, an image of the REM/Rate or Ekotrope PECO savings report, and an image of the REM/Rate or Ekotrope PECO HERs report. The SWE did not observe any discrepancies between the tracking data and the REM/Rate files.

Residential EE Program: Multifamily

The SWE did not review any Multifamily savings projects as part of the sampled project review. The SWE notes that this may have been due to limited participation or because these projects were included within the sampled projects for other programs.

Income-Eligible EE Program: Giveaways (SFIE)

The project file documentation provided for the Income-Eligible EE – SFIE Giveaway Program included invoices detailing incentives and quantities for equipment that matched the corresponding entries in the program tracking data.

Income-Eligible EE Program: Long Term Savings

The SWE did not review any Long-Term Savings project documentation. The SWE notes that this may have been due to these projects being included within the sampled projects for other programs.

B.4.2.2 Non-Residential

The SWE reviewed a sample of PECO's Downstream, Midstream, and Small Business Direct Install (SBDI) projects for PY16 using the project documentation provided by the evaluation contractor in response to the SWE's standing quarterly data request. The project file packages included savings calculation worksheets, rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. The majority of the reviewed project file packages included all documentation requested and were well organized.

Table 82 presents an overview of the results of the SWE's C&I project file reviews. The SWE noted instances where the project tracking documentation did not match the provided calculation workbooks and/or project files. These noted inconsistencies generally reflect minor impacts on reported savings values.

Table 82: PECO PY16 C&I Project File Review

Program	Segment	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Midstream	Midstream	6	✓	✓	✓	✓	✓
Direct Install	SBS	6	✓	✓	✓	✓	✓
Downstream	Muni	5	✓	✓	✓	✓	✓
Downstream	SCI	7	✓	✓	✓	✓	✓
Downstream	LCI	6	✓	✓	✓	✓	✓

Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

B.5 VERIFIED GROSS SAVINGS AUDITS

B.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings for PECO's portfolio of residential programs. PECO's portfolio of residential programs consists of the following components: Appliance Recycling; Rebates and Marketplace; In-Home Assessments; Multifamily (which includes income-eligible multifamily); Residential New Construction; and separate Home Energy Reports (HER) and Income-Eligible HER programs. In addition, the SWE's audit covered the Income-Eligible Program, which includes the following components: Single-family, Appliance Recycling, and Long-Term Savings. Note that the SWE reports residential savings in two sections: residential and behavior.

Table 83 provides a summary of the evaluation and M&V approaches PECO used in its PY16 verified savings calculations.

Table 83: Residential and LI Impact Evaluation Activities - PECO

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Historic Realization Rate
Residential Program					
Appliance Recycling	-	-	✓	-	✓
Rebates and Marketplace ^b	✓	-	✓	-	✓
Residential In-Home Assessments	✓	-	✓	-	-
Multifamily (includes Income-Eligible)	-	-	✓	-	✓
New Construction	-	-	✓	-	✓
Home Energy Report	-	-	-	✓	-
Income-Eligible Program					
Single-family	✓	-	✓	-	-
Appliance Recycling	-	-	✓	-	✓
Long-Term Savings	✓	-	✓	-	-

^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.

^b Historic realization rates were applied to all measures except for spray foam, ductless heat pump, and solar PV.

The SWE's review of verified savings for residential components, which include income-eligible programs, found that, overall, the adjusted database reviews followed proper TRM protocols. For education measures, the SWE found some savings calculation errors as well as the use of an incorrect verification ratio. Correcting these errors increased the total residential and low-income verified savings by 0.25%.

Appliance Recycling (Market-Rate and Income-Eligible)

The Appliance Recycling component of the Residential program recycles refrigerators, freezers, and room air conditioning units. Guidehouse conducted a tracking database analysis of the PY16 tracking data, referred to as the adjusted tracking database savings review, and then applied the historic verification ratio from the PY15 evaluation to calculate the verified savings in PY16.

The SWE reviewed the tracking database analysis and discovered an issue with how single-door configuration estimates were applied to the population. Guidehouse explained the issue and corrected the analysis prior to submitting the PY16 annual report. The PY15 verification ratio was applied to the corrected adjusted database savings results. The SWE confirmed that verified energy and demand savings were consistent between the analysis and the EDC PY16 annual report.

Rebates and Marketplace

The Rebates and Marketplace component includes customer rebates for appliances, HVAC, solar PV, and other energy-saving devices. There are multiple delivery pathways to receive product

rebates, including Downstream, Marketplace, and Point of Purchase. The Guidehouse evaluation team conducted a tracking database analysis for all measures to confirm whether the tracking database was accurate as reported. In addition, the team conducted survey-based verification for canned spray foam and ductless heat pumps. The SWE reviewed the tracking database analysis and confirmed that savings had been calculated in accordance with TRM algorithms. Next, the SWE reviewed the survey analysis for measures that underwent additional M&V activities (including canned spray foam) and confirmed that survey inputs had been applied correctly. The SWE found that total reported savings, database review savings, and survey-verified savings for the survey samples matched the corresponding savings of the sampled records in the roll-up file.

The Residential Solar component of Rebates and Marketplace provides rebates for solar PV panel installation for residential customers to help reduce their annual electricity costs. The Guidehouse evaluation team provided customer array, inverter and panel data and API (Application Programming Interface) script used to calculate savings. The SWE reviewed the tracking data and the API script used to calculate the summer and winter demand savings. The SWE confirmed that the tracking data applied the correct IMP algorithms and deemed values to the PVWatts model. Using zip-codes from the program tracking data the SWE confirmed the reported savings from the projects.

Residential In-home Assessments

The Residential In-Home Assessments component provides in-home or virtual assessments and comprehensive audits to educate customers, install efficient measures, and identify potentially larger opportunities (like insulation and air sealing). Measures include LED lighting, LED nightlights, advanced power strips, low-flow showerheads and aerators, water heater pipe insulation, HVAC maintenance, insulation, and air sealing. Guidehouse conducted a tracking database analysis of the PY16 data to confirm that the measure savings adhered to the TRM protocols and conducted customer survey-based verification of a sample of projects.

The SWE confirmed that the tracking data review applied the correct TRM algorithms and deemed values. The SWE also confirmed that reported and adjusted database savings matched the Guidehouse roll-up file.

The SWE found that Guidehouse initially referenced an outdated verified savings calculation for the education measures. After updating the savings calculation, the SWE noted several errors in the new calculation, including referencing the PY14 survey results instead of the PY16 survey results. Also, the SWE discussed with Guidehouse their choice of data reference source (i.e., survey data, baseline study findings, or national census data) for algorithm input parameters such as the percentage of homes with clothes washers. Guidehouse and the SWE agreed that, when sample sizes were considered to be large enough to be representative of the population, survey data should be used to inform algorithm input parameters; otherwise, the most recent baseline study findings should be used. All of the SWE's education savings calculation feedback and corrections were incorporated into Guidehouse's final verified savings estimates.

Guidehouse inserted verified savings for education measures at the adjusted database savings step, with the intention of applying verification ratios equal to 1.0. However, Guidehouse did not apply verification ratios equal to 1.0 and agreed that this was an error. The SWE brought this

concern to Guidehouse's attention after Guidehouse had finalized their savings, so the SWE calculated a new SWE verified savings total different from Guidehouse's verified savings.

Residential and Income-Eligible (IE) Multifamily

The Residential Multifamily component of the Residential and Income-eligible EE programs provides analysis, direct-install measures, and larger, investment-level upgrades to improve the energy efficiency of multifamily buildings, both in-unit and in common areas. The program covers market-rate and income-eligible customers and has a commercial savings component.

Guidehouse conducted a tracking database analysis of the PY16 data to confirm that the measure savings adhered to the TRM protocols and applied historical verification ratios to calculate verified savings.

The SWE confirmed that the tracking data review applied the correct TRM algorithms and deemed values. The SWE also confirmed that reported and adjusted database savings matched the Guidehouse roll-up file and that the correct historic verification ratios were applied.

Residential New Construction

The Residential New Construction component supports the construction of more energy-efficient homes compared to those that were built to code. Guidehouse conducted a tracking data review to confirm that reported savings values matched energy model outputs and then applied verification ratios from the PY15 evaluation.

After Guidehouse submitted its PY15 annual report, the CSP discovered that the energy modeling software used to estimate savings (Ekotrope) appeared to significantly underestimate cooling systems' design capacities, which in turn greatly underestimated peak-demand savings. The CSP and Guidehouse revised the peak-demand savings calculation approach to rely instead on the energy models' 8760 outputs for electric cooling system kW and the TRM's peak-demand period definition. This change resulted in higher and conceivably more accurate peak-demand savings estimates. The SWE reviewed and approved the new approach after PY15 results were finalized. Therefore, the peak-demand savings verification ratio for PY16 is different from the one used in PY15, despite this program component not being evaluated in PY16.

Single Family (Income-Eligible)

The Single-Family component of the Income-Eligible EE Program enables income-eligible customers to improve the energy efficiency of their homes through home energy check-ups (in-person and virtual), direct install measures, and giveaway measures. Guidehouse conducted a tracking database analysis of the PY16 data to confirm that the measure savings adhered to the TRM protocols and conducted customer survey-based verification of a sample of projects.

The SWE confirmed that the tracking data review applied the correct TRM algorithms and deemed values. The SWE also confirmed that reported and adjusted database savings matched the Guidehouse roll-up file.

In Guidehouse's survey analysis workbook, the SWE identified 14 project-level "clean_unique_ids" that were listed under multiple strata, depending on the measure. Guidehouse cited manual data entry errors as the source of the errors and provided the SWE with an updated and corrected savings workbook.

The SWE found that Guidehouse initially referenced an outdated verified savings calculation for the education measures. After updating the savings calculation, the SWE noted several errors in the new calculation, including referencing the PY16 survey results instead of the PY14 survey results. Also, the SWE discussed with Guidehouse their choice of data reference source (i.e., survey data, baseline study findings, or national census data) for algorithm input parameters such as the percentage of homes with clothes washers. Guidehouse and the SWE agreed that, when sample sizes were considered to be large enough to be representative of the population, survey data should be used to inform algorithm input parameters; otherwise, the most recent baseline study findings should be used. All of the SWE's education savings calculation feedback and corrections were incorporated into Guidehouse's final verified savings estimates.

Guidehouse inserted verified savings for education measures at the adjusted database savings step, with the intention of applying verification ratios equal to 1.0. However, Guidehouse did not apply verification ratios equal to 1.0 and agreed that this was an error.

The SWE brought both of the above concerns (duplicate strata per clean_unique_id and incorrect Education stratum verification ratio) to Guidehouse's attention after Guidehouse had finalized their savings. As a result, the SWE calculated a new SWE verified savings total that differed from Guidehouse's verified savings and incorporated these updates.

Long-Term Savings (Income-Eligible)

The Long-Term Savings (LTS) component is implemented as an overlay service through the Single-Family component to encourage the installation of long-term, comprehensive measures. These may include insulation, air sealing, duct sealing, ducted and ductless air-source heat pumps, air conditioners, thermostats, and heat pump water heaters. Guidehouse included these measures in its tracking database analysis and survey-based verification of the broader Single Family (Income-Eligible) program component. Correspondingly, the SWE's review and findings of the Long-Term Savings component are incorporated into the Single-Family (Income-Eligible) description above.

Behavior

Approximately 8% of the PY16 verified gross energy savings listed in PECO's PY16 Annual Report came from Home Energy Reports issued to approximately 540,700 households by the start of the season. For PY16, the program provided 26,962 MWh of net energy savings, with 807 MWh accruing to low-income households. The program also generated 7.339 MW of meter-level peak-demand savings and 7.925 MW of system-level peak-demand savings toward PECO's Phase IV PDR target.

PECO's Residential Market-Rate and Income-Eligible HER programs consist of seven waves in total, with later waves further subdivided into smaller groups. Only Wave 3 and Wave 5 (Electric) were inactive in PY16. [Table 84](#) shows the initial number of active households by wave and group in PY16, rounded to the nearest hundred.

Table 84: PECO HER Cohort Summary

Cohort	Start Date	Treatment Group Homes	Control Group Homes
1	Aug 1, 2013	18,800	11,900
2	May 1, 2014	25,200	10,400
4	Jun 1, 2016	134,800	12,300
5 - Dual Fuel	Jun 11, 2017	11,200	4,500
6 - Dual Fuel	Jul 28, 2019	3,900	3,200
6 - Electric	Jul 28, 2019	11,100	8,900
7 - Dual Fuel	Jun 27, 2021	81,500	19,300
7 - Has Email	Jun 27, 2021	153,400	11,400
7 – Income-Eligible	Jun 27, 2021	15,000	8,200
7 - No Email	Jun 27, 2021	66,300	14,700
8 - Low-Income	Jul 16, 2023	19,500	11,000
Total	-	540,700	115,800

Wave 1 participants began receiving Home Energy Reports on August 1, 2013, and additional waves were started almost every year following. The latest wave's participants, Wave 8, all of whom are low-income, began receiving Home Energy Reports on July 16, 2023. Additionally, Waves 5, 6, and 7 are divided into groups by customer type (all groups are active this year, except for Wave 5 Electric), as shown in [Table 84](#). Wave 7 - Has Email had the largest treatment group by far, with over 153,000 active customers treated in PY16. Oracle is the implementer for all waves of the program. Guidehouse evaluated program impacts for PY16.

All waves in PECO's HER programs were organized as randomized control trials (RCTs). Oracle first identified eligible customers for each wave, then randomly assigned each to either receive Home Energy Reports (the treatment group) or not (the control group). Sub-groups in waves with multiple groups (5, 6, and 7) were designated by customer characteristics after the initial random assignment.

To validate Oracle's random assignment of customers to receive HERs, pre-treatment energy use patterns are compared across the treatment and control groups. Pre-treatment usage for treatment and control group customers for all waves has been reported previously. For all groups, the SWE confirmed that pre-treatment energy use patterns were similar across treatment and control groups. The SWE confirmed this result using a random-effects model with indicators for treatment and months as explanatory variables. There was essentially no difference in energy use between the treatment and control groups in the pre-treatment period. The treatment indicator's impact was estimated to be zero, with a very high p-value.

These equivalence checks were run in prior evaluation years, and all evaluated waves passed the equivalency checks. The SWE was able to confirm all energy savings estimates. Using data prepared by Guidehouse, estimates were replicated exactly, and estimates using data prepared by the SWE were very similar.

Guidehouse estimated the average daily impact of HERs on energy use with a lagged-dependent-variable (LDV) regression model. The model estimates usage in PY16 while controlling for a customer's usage during the same calendar month before treatment began. Average daily HER impacts were estimated separately for each month and wave, then multiplied by the number of participants and days to produce monthly savings estimates. These are further aggregated to annual estimates for PY16 in [Table 85](#) below.

[Figure 27](#) through [Figure 30](#) compare the results between the average daily kWh impacts reported by Guidehouse, and the results from the data prepared by the SWE, by wave and month. For each wave, the figures show that the SWE estimates were very similar to the energy impacts reported by Guidehouse. Note that each figure uses a distinct vertical and horizontal axis scale.

Figure 27: PECO and SWE Regression Coefficient Comparison, Average Daily kWh Impact by Month (Waves 1, 2 and 4)

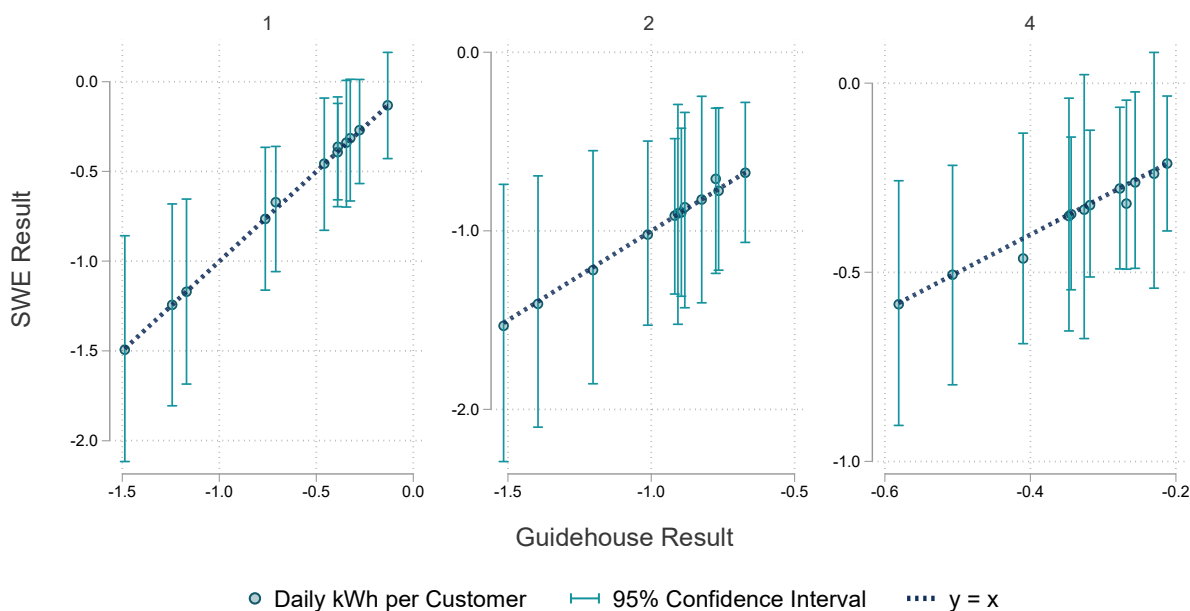


Figure 28: PECO and SWE Regression Coefficient Comparison, Average Daily kWh Impact by Month (Dual Fuel Waves)

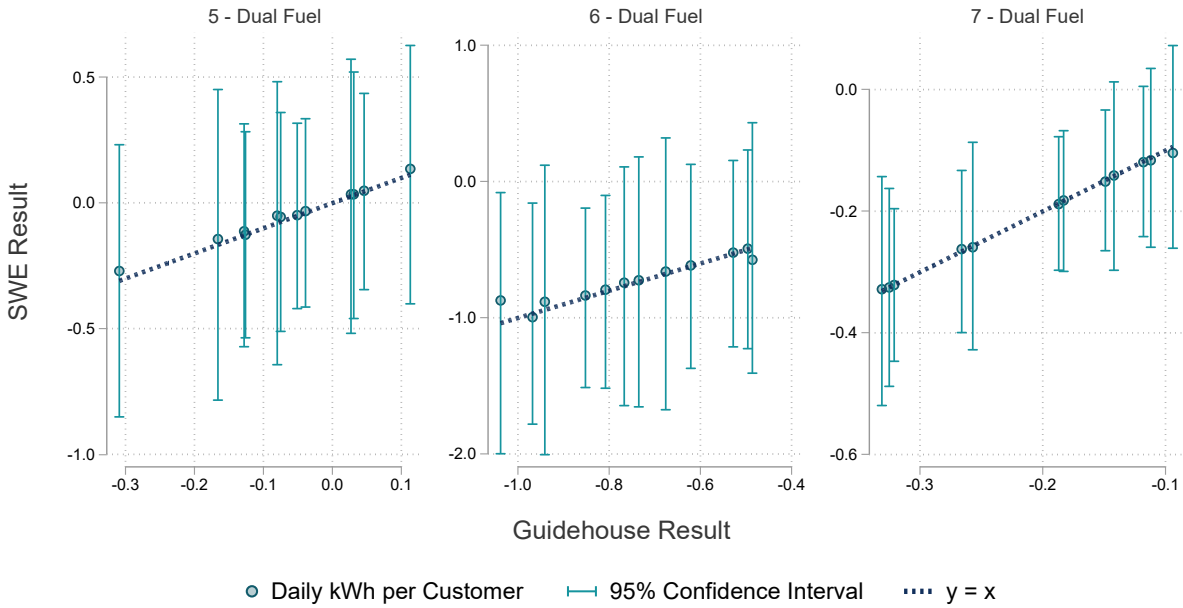


Figure 29: PECO and SWE Regression Coefficient Comparison, Average Daily kWh Impact by Month (Electric Waves)

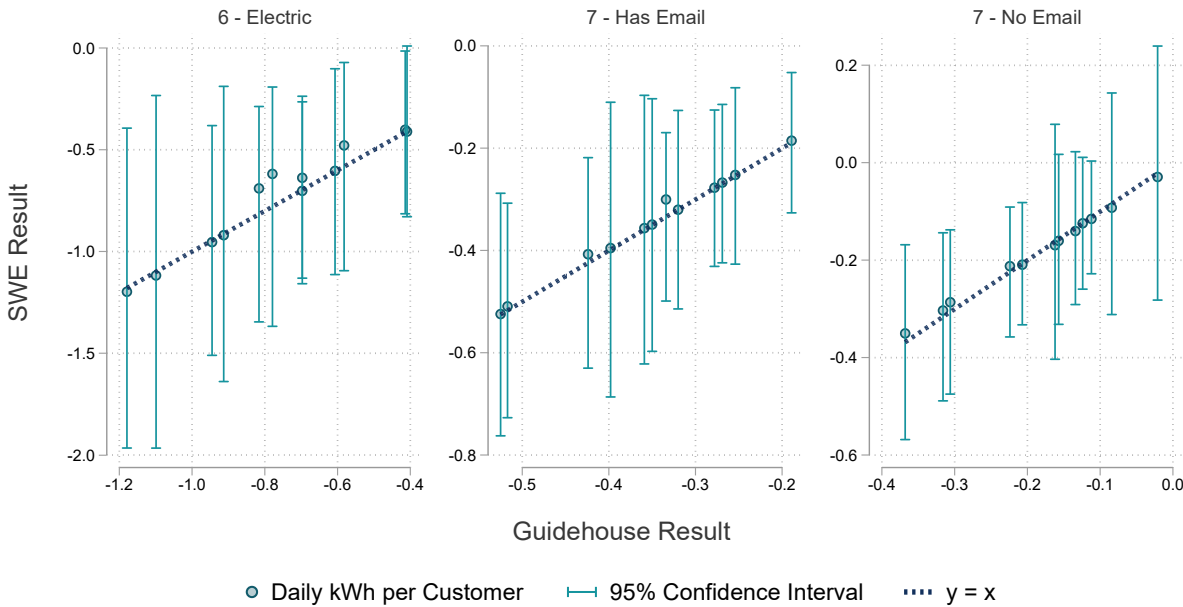
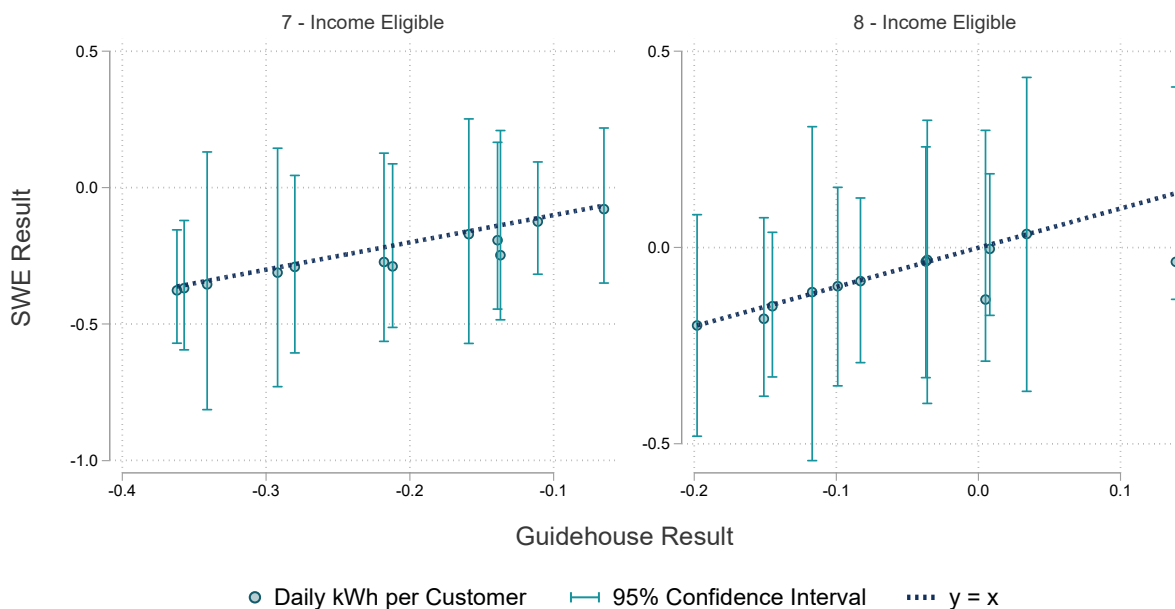


Figure 30: PECO and SWE Regression Coefficient Comparison, Average Daily kWh Impact by Month (Income-Eligible Waves)



Home Energy Reports promote participation in additional PECO EE&C programs, such as ENERGY STAR appliances, weatherization, and high-efficiency HVAC rebates. To the extent that treatment-group households participate in these programs more frequently than the control group, gross savings estimates capture impacts of both the HERs and the other programs. Since these other programs claim savings separately from PECO's HER programs, their impact must be removed to avoid double-counting. As shown in [Table 85](#), HER savings estimates are reduced to account for the difference in program participation observed between the treatment and control groups.

For PY16, estimated gross savings before adjusting for dual participation were roughly 64,600 MWh. Of this, about 6,370 MWh can be attributed to upstream or downstream dual participation.

Table 85: PY16 Energy Savings from Home Energy Reports (MWh)

Wave	Gross Savings	Downstream Dual Participation	Upstream Dual Participation	Persistence	PY16 Incremental Savings
1	4,292	776	105	1,729	1,681
2	8,827	1,575	218	4,514	2,521
4	16,471	397	482	10,397	5,195
5 - Dual Fuel	260	113	4	30	113
6 - Dual Fuel	1,048	92	29	617	310
6 - Electric	2,977	461	75	1,577	863
7 - Dual Fuel	6,011	682	160	3,206	2,042
7 - Has Email	18,903	81	565	6,846	11,694
7 – Income-Eligible	1,147	0	34	708	422
7 - No Email	4,340	396	118	2,148	1,737
8 – Low-Income	385	0	6	-	385
Total	64,660	4,573	1,797	31,772	26,962

Some PECO customers have been receiving Home Energy Reports for multiple years, with impacts persisting, to some degree, from HERs sent in earlier years. Starting in PY13, these impacts from previous years must be subtracted from savings estimates to yield *incremental first-year savings*, the impact attributable to HERs in the current program year only. Act 129 compliance goals are based on incremental first-year savings only.

As shown in Table 85, roughly 60% of the measured PY16 savings in Wave 7 Income-Eligible are attributable to persistent impacts from previous years' HERs. Guidehouse calculated PECO's first-year savings as PY16 savings (net of uplift), minus estimated persistent impacts from the previous three program years. Impacts from previous years are assumed to decay at a rate of 31.3% per year, for up to three years.⁷³

Following the 2021 Pennsylvania TRM, persistence is assumed to be zero for the first two years of HER exposure, and the *first-year savings average treatment effect* (FYSATE) simply equals the average treatment effect (ATE). PECO's Wave 8 cohort, which launched in 2023 and is now completing its second year, therefore has no persistent impacts removed.

⁷³ Addendum to Act 129 Home Energy Report Persistence Study. November 2018. https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

For waves receiving HERs for two years or more, the FYSATE is calculated as the ATE minus the decayed impacts from each of the previous three program years, as shown in Equation 1 below:

Equation 1: First-Year Savings Average Treatment Effect

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

Where:

- $FYSATE_y$ is the average daily savings attributable to HERs in the current year y
- $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in an earlier year $y - x$
- Year i is the first year of HER exposure, up to a maximum of 5 (since waves in years 1 and 2 of treatment are not included in these calculations)
- x indicates one to a maximum of three previous years

Table 86 shows the persistent impacts of prior HER exposure on each wave of PECO participants. Any impacts before PY13 are assumed to have decayed to zero. Daily impacts in Table 86 are multiplied by participants and days to yield the total persistent savings shown in Table 85. Some waves were not active in certain previous years, causing some impacts to be zero for specific years.

Table 86: Persistent Impacts from PY13 – PY15, Average Daily Savings (kWh)

Wave	Persistent Impact from PY15	Persistent Impact from PY14	Persistent Impact from PY13	Total
1	0.21	0.00	0.05	0.26
2	0.40	0.00	0.10	0.50
4	0.22	0.00	0.00	0.22
5 - Dual Fuel	0.01	0.00	0.00	0.01
6 - Dual Fuel	0.37	0.00	0.07	0.44
6 - Electric	0.35	0.00	0.06	0.40
7 - Dual Fuel	0.00	0.11	0.02	0.13
7 - Has Email	0.00	0.13	0.02	0.15
7 – Income-Eligible	0.05	0.09	0.02	0.16
7 - No Email	0.00	0.09	0.01	0.10
8 – Low-Income	0.00			0.00

The SWE team found that Guidehouse accurately estimated persistent savings for each wave following TRM specifications. Guidehouse provided the SWE team with estimated impacts from all previous years. These were used to calculate first-year savings for the earliest program years, with the estimates carried forward to calculate the FYSATE for program years 13-15. FYSATE estimates were then used in the formula above to calculate persistence for each wave.

PECO issues Home Energy Reports to both low-income and market-rate residential customers via two different programs with similar objectives. The “Income-Eligible” cohort of Wave 7 and all of Wave 8 are composed of low-income customers, both in treatment and control groups. These participants’ savings count directly toward PECO’s Phase IV low-income target. About 27,500 Wave 7 participants were income-eligible, with total savings of 422 MWh. Wave 8, despite a larger participant base, contributed an additional 385 MWh in savings. [Table 87](#) shows the PY16 savings for the Income-Eligible Home Energy Reports program.

Table 87: PY16 First-Year Savings for Income-Eligible HER Program

Wave	First-Year Savings (MWh)
Wave 7: Income-Eligible	422
Wave 8: Low-Income	385
Total	807

For PY16, peak-demand savings at the meter level from HERs were estimated with hourly usage data. Peak periods were defined as hours from 2 to 6 p.m. on non-holiday weekdays from June to August. Since hourly data for the pre-treatment period were not available for all customers, peak-demand impacts were measured by comparing treatment and control-group customers in PY16 only. Treatment/control groups were randomly assigned in each wave and had equivalent usage patterns before they began receiving HERs, so these comparisons are valid. Guidehouse estimated the impact of HERs on peak hourly usage in June, July, and August 2024, while controlling for average hourly usage in each month. Estimated savings are shown in [Table 88](#). These values are scaled up by a line loss factor of 1.0799 when reporting progress toward Phase IV compliance targets.

Table 88: PY16 Peak-Demand Savings from Home Energy Reports (MW)

Wave	June 2024	July 2024	August 2024	Monthly Average
1	0.23	0.23	0.18	0.21
2	0.31	0.26	0.21	0.26
4	1.79	1.79	1.57	1.72
5 – Dual-Fuel	0.04	0.08	0.03	0.05
6 – Dual-Fuel	0.05	0.07	0.05	0.06
6 – Electric	0.13	0.09	0.12	0.12
7 – Dual-Fuel	0.50	0.53	0.53	0.52
7 – Has Email	4.10	3.93	3.40	3.80
7 – Income-Eligible	0.12	0.09	0.10	0.10
7 – No Email	0.44	0.47	0.37	0.43
8 – Low-Income	-0.05	0.20	0.09	0.08
Total	7.67	7.73	6.65	7.34

The SWE largely replicated Guidehouse’s estimated peak-demand savings for all waves. SWE estimates were directionally similar to, and not statistically different from, Guidehouse’s estimates. Small differences in the point estimates resulted from differences in the handling of outliers: extremely small and large meter reads.

Guidehouse’s data management and reporting processes are clear and repeatable. The SWE was able to replicate savings estimates using the modeling procedures laid out in PECO’s Phase IV EM&V Plan for both energy and peak-demand savings. First-year incremental savings (net of uplift and persistent impacts) were also verified. Overall, the SWE can verify all PY16 savings reported by Guidehouse for PECO’s Residential Market-Rate and Income-Eligible HER programs.

B.5.2 Non-Residential Audit Activities

The SWE conducted various review and audit activities for PECO’s non-residential program components, including an assessment of the evaluation efforts and an audit of the savings verification performed by PECO’s evaluation contractor, Guidehouse. The following section presents the key findings from these activities.

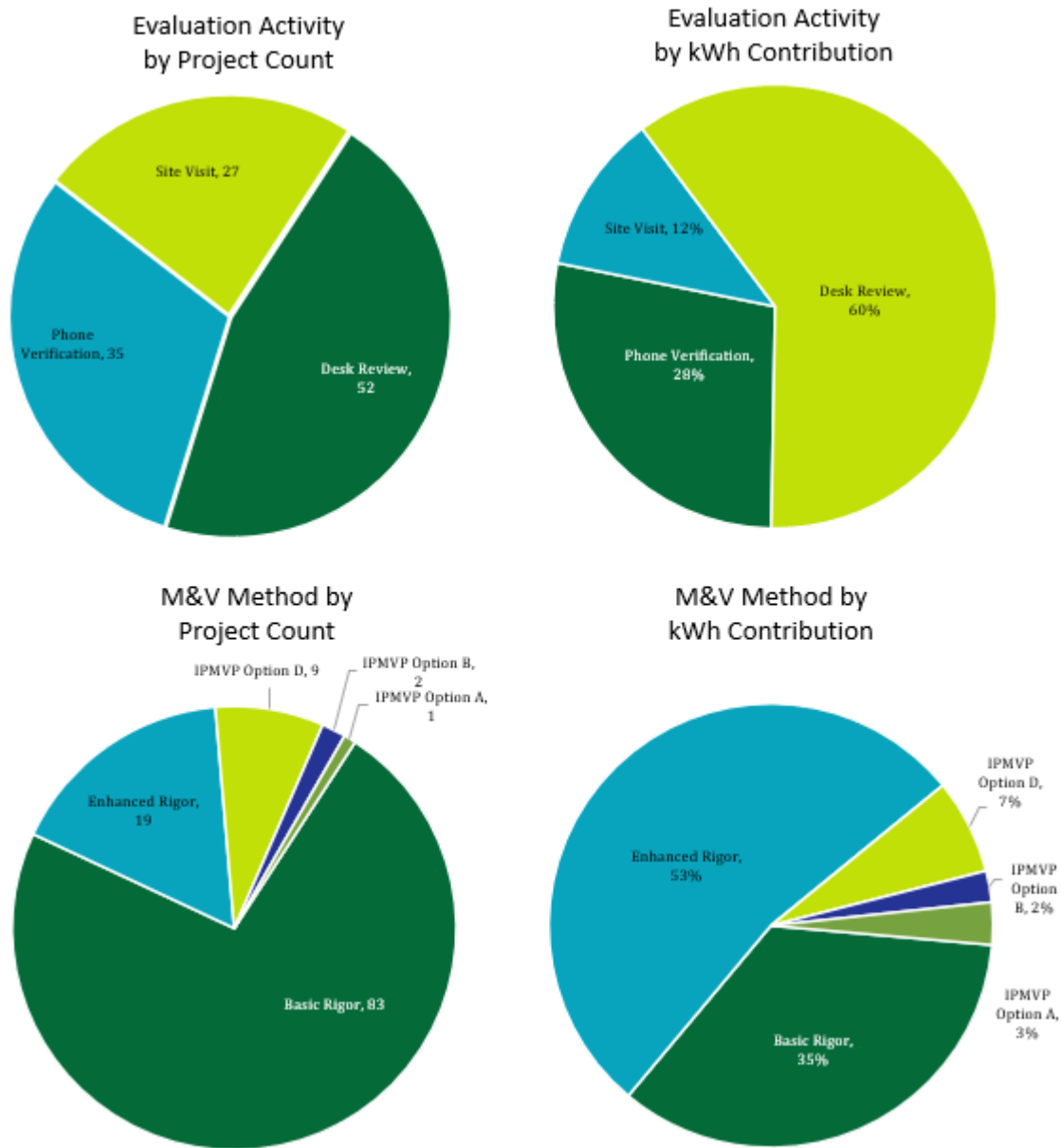
Guidehouse employed multiple approaches to verify the gross impact estimates for each non-residential program component. This section discusses the results of the SWE’s review of Guidehouse’s application of various Measurement and Verification (M&V) methods used to assess and estimate project impacts within the evaluation sample. The review was based on

evaluation sample population extracts provided by Guidehouse, which detailed the evaluation methodologies and M&V approaches used for each sampled project. [Table 89](#) summarizes the evaluation activities by project count for each of PECO's non-residential program components, along with the associated evaluation realization rates.

Table 89: Summary of PECO's PY16 Non-Residential Evaluation Activities by Program Component

Program Component	Sample Quantity	RR-Energy	RR-Demand	Desk Review	Phone Interview	On-Site Verification
Midstream	54	99%	102%	30	19	5
XL	5	102%	109%	3	0	2
Large	16	96%	97%	10	5	1
Medium	18	103%	106%	6	12	0
Small	5	102%	109%	3	0	2
Downstream	45	91%	87%	12	12	21
XL	12	91%	93%	1	1	10
Large	8	86%	84%	2	2	4
Medium	8	92%	88%	3	3	2
Small	8	101%	100%	3	5	0
Solar	9	102%	80%	3	1	5
Direct Install	15	89%	87%	10	4	1
Large	5	84%	84%	3	1	1
Medium	5	98%	90%	3	2	0
Small	5	103%	107%	4	1	0
TOTAL	114	94%	93%	52	35	27

[Figure 31](#) provides a summary of the evaluation activities and M&V methods utilized by PECO's evaluation contractor in their PY16 verified savings calculations.

Figure 31: Summary of PECO's Non-Residential Evaluation Activities

The SWE's review of verified savings for non-residential program components concluded that, overall, the savings estimations were consistent with the Evaluation Framework. The review also confirmed that appropriate custom, site-specific Measurement and Verification (M&V) activities were conducted, that TRM protocols were correctly applied, and that the verified savings were generally accurate.

B.5.2.1 Downstream Rebates

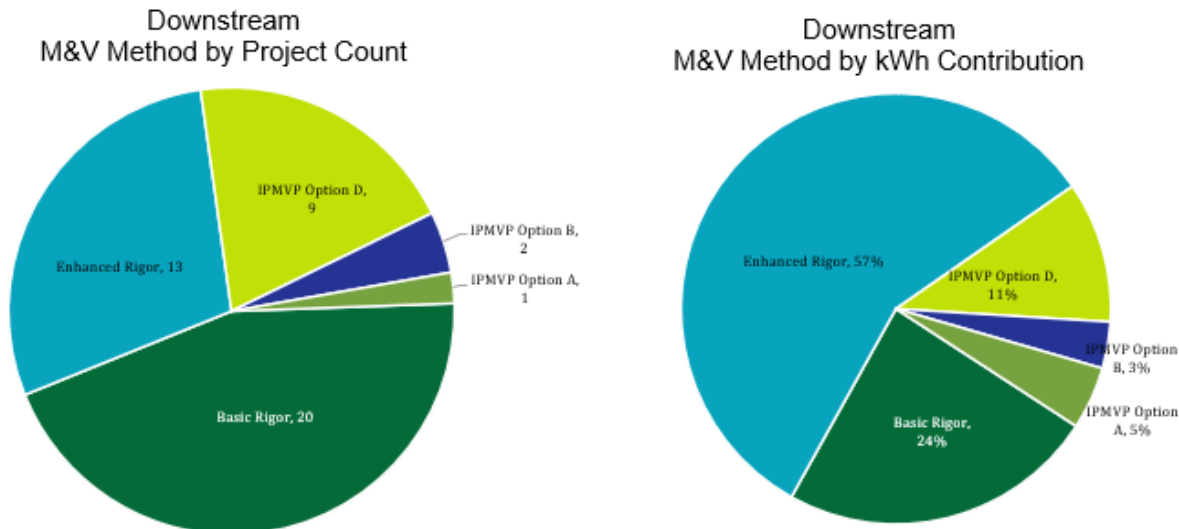
The Downstream Rebates component includes both custom and prescriptive measures and accounted for 41% of the Non-Residential Program's verified energy savings and 33% of its verified demand savings across 940 projects and multiple segments (Large C&I, Small C&I, Municipal Lighting, Large GNI and Small GNI). Guidehouse derived a sample of 44 projects from each segment and allocated them to multiple strata based on project type and size. .

- Large C&I (16): lighting and lighting controls (11), custom HVAC (2), compressed air (1), refrigeration (1), retro-commissioning (1)
- Small C&I (10): solar PV (6), lighting and lighting controls (3), custom (1)
- Municipal lighting (7)
- Large GNI (9): lighting and lighting controls (4), motors and pumps (3), solar PV (1), retro-commissioning (1)
- Small GNI (2): lighting and lighting controls (2)

The SWE attended Guidehouse's site visits for one of the six site verification sampled projects.

Guidehouse conducted desk reviews for all projects in the evaluation sample. The desk reviews used project applications, project-specific analysis files and associated calculation sheets, measure invoices, measure specification sheets, construction plans, and other construction documents provided by PECO. Guidehouse supplemented desk reviews with phone verification, on-site verification, and metering. Most sampled projects from the Downstream component achieved realization rates for both demand and energy within 20% of the expected values. Six of the projects had verified savings values above 120% of the reported values, while nine of the projects fell below 80% of reported values. Guidehouse observed the following conditions that resulted in adjustments to reported savings:

- Control types, HVAC system types, and HOU were revised for lighting projects based on site-specific data and customer reviews.
- Energy and peak-demand savings were re-calculated for one extremely large lighting project to account for a typo in an incorrect fixture wattage (the reported baseline was 1,000 watts, instead of 100 watts, which inflated reported savings approximately tenfold).
- Database tracking data analysis revealed minor discrepancies including the following measures: LED Refrigerated Case Lighting, Evaporator Fan Controllers, Floating Head Pressure Controls and High-Efficiency Evaporator Fan Motors for Walk-In or Reach-In Refrigerated Cases. [Figure 32](#) displays the share of M&V methods performed under the Downstream component. Thirteen sites were completed through an on-site visit and these facilities were 57% of Downstream energy savings. International Performance Measurement and Verification Protocol (IPMVP) methods accounted for 19% of the evaluated savings and represented twelve of the projects.

Figure 32: Summary of PECO's PY16 Downstream M&V Methods

The SWE conducted a detailed review of the prescriptive measures rebated during PY16. The projects evaluated in the Downstream program included:

- Lighting improvements and control retrofits, new construction lighting, and LED refrigeration display case lighting.
- Refrigeration measures including:
 - Adding doors to existing refrigerated display cases
 - Air-cooled refrigeration condenser
 - Anti-sweat heater controls
 - Evaporator fan controllers
 - Floating head pressure controls
 - High-efficiency evaporator fan motors for walk-in or reach-in refrigeration cases
 - Special doors with low or no anti-sweat heat for reach-in freezers and coolers
 - Suction pipe insulation for walk-in coolers and freezers
- HVAC Systems including:
 - Air-source systems
 - Packaged terminal heat pump and air conditioning
 - Electric chillers
 - Ductless mini-split heat pumps
 - Guest room occupancy sensors
- Variable frequency drive (VFD) improvements

The SWE also reviewed Guidehouse's adjusted database review calculations associated with the TRM-based measures included in this component and found no discrepancies or errors. The audit involved a comprehensive examination of quantities, capacities, efficiencies, and other variables embedded in the TRM equations. Independent recalculations confirmed that the original results were accurate and consistent. Additionally, the estimated kWh and kW savings adhered to the

TRM algorithm and incorporated appropriate default values, confirming the reliability of the reported savings for these measures.

The SWE conducted comprehensive reviews of solar PV projects completed by PECO in PY16. Each project was reviewed to make sure it met M&V requirements and followed the Photovoltaic Solar Generation IMP. For Solar PV the SWE reviewed projects that included both on-site verification and PVWatts modeling, confirming that evaluators followed IMP guidance, verified system design parameters, and properly transitioned from ETDF-based to hourly modeling methods. Verified savings closely matched the SWE's independent results, confirming the evaluator's reported values. Based on these analyses, the SWE concludes that the evaluators performed their due diligence, and verified solar PV savings are reliable and in accordance with Act 129 requirements.

B.5.2.2 Midstream Rebates

The Midstream component works with distributors to incentivize efficient equipment by reducing the sale price at the point of sale (POS) for customers. The Midstream Rebates component accounted for 50% of the Non-Residential EE Program's verified energy savings and 58% of its verified demand savings in PY16. Guidehouse sampled 54 participants from this program, including 19 phone interviews and 30 desk reviews. The projects reviewed in the Midstream program included HVAC and LED lighting equipment.

The SWE conducted a detailed review of the prescriptive measure calculations and found no discrepancies or errors. The audit involved a comprehensive examination of quantities, capacities, efficiencies, and other variables used in the TRM equations. Independent recalculations confirmed that the results matched the original calculations, validating their accuracy and consistency. The kWh and kW calculations correctly followed the TRM algorithm and used the appropriate default values. Additionally, the adjusted savings appropriately excluded ineligible LED fixtures in accordance with the Codes and Standards update to TRM Measure 3.1.7: Lighting Improvements for Midstream Delivery Programs.

B.5.2.3 Small Business Direct Install

The Small Business Direct Install component provides rebates to small businesses to support the direct installation of energy-efficiency measures with the goal of improving overall energy performance. Common measures offered through this program include energy-efficient lighting and lighting controls, door gaskets, anti-sweat heater controls, and suction pipe insulation for walk-in coolers and freezers. This component accounted for 4% of the Non-Residential EE Program's verified energy savings and 6% of the program's verified demand savings in PY16.

The SWE's review of Guidehouse's adjusted database review calculations associated with these measures found no discrepancies or errors. The audit involved a thorough examination of quantities, capacities, efficiencies, and other variables embedded in the TRM equations. Independent recalculations confirmed that the results were accurate and consistent, validating the original calculations. Additionally, the estimated kWh and kW savings adhered to the TRM algorithm and incorporated the correct default values, confirming the reliability of the savings estimates.

B.5.2.4 New Construction

The New Construction component aims to promote the adoption of energy-efficient design and construction practices in both new and retrofit facilities. The program encompasses new buildings as well as projects undergoing major renovations—defined as construction efforts involving the complete removal, redesign, and replacement of two or more major building systems. Through this program, facility designers and builders receive training, design assistance, and financial incentives to integrate energy-efficient systems into their building plans.

Many projects under the Non-Residential New Construction component focus on implementing efficient lighting, heating and cooling systems, advanced controls, and other energy-saving measures. This component accounted for 4% of the Non-Residential EE Program's verified energy savings and 3% of the program's verified demand savings in PY16.

The SWE reviewed the calculations associated with the measures included in this program and found no discrepancies or errors. The audit involved a comprehensive examination of quantities, capacities, efficiencies, and other variables embedded in the TRM equations. Independent recalculations confirmed that the original results were accurate and consistent. Additionally, the estimated kWh and kW savings adhered to the TRM algorithm and incorporated appropriate default values, confirming the reliability of the reported savings for these measures.

B.5.2.5 Verified Savings Audits

The SWE audited the activities above through a detailed review of Guidehouse's evaluation work for a sample of their evaluated projects and a detailed review of calculations of TRM-based measures incentivized through the program.

The SWE audit of Guidehouse in PY16 included a review of twenty projects, encompassing the following activities:

- Three field and analysis engineers observed
- Nine solar PV, six lighting, two custom, two retro-commissioning, and one refrigeration project was audited
- 5% of verified non-residential energy savings reviewed
- 5% of verified non-residential demand savings reviewed

Table 90 provides the overall results of the SWE Verified Savings Audit for audited C&I projects:

Table 90: PECO C&I Verified Savings Audit Results

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
20	12,584,479	100%	2,401.7	100%

Overall, the SWE agreed with the calculation methods utilized by PECO's evaluation contractors. The savings calculations and accompanying reports were easy to follow and showed evidence that the TRM was utilized by the contractor for the appropriate measures. The SWE agreed with all the engineering decisions made by the evaluators for custom calculations. Therefore, the attainment percentage for the sample of projects was 100% for both energy and demand.

B.6 NTG

Table 91 lists PECO's PY16 NTG results across all programs. Details concerning the methods and data used to estimate NTG values are provided in Appendices B.6.1 and B.6.2.

Table 91: Summary of PECO's PY16 NTG Results

Program Name	Component	NTG
Residential	Rebates and Marketplace	0.37
Residential	Appliance Recycling	0.51
Residential	In-Home Assessment	0.82
Residential	New Construction	0.55
Residential	Multifamily	0.82
Residential	Multifamily Income-Eligible	1.0
Residential	HER	1.0
Low-Income	HER	1.0
Low-Income	Single-Family	1.0
Low-Income	Appliance Recycling	1.0
Non-Residential	Downstream	0.72
Non-Residential	Midstream	0.67
Non-Residential	Small Business Direct Install	0.93
Non-Residential	New Construction	0.30
Portfolio Total		0.70

B.6.1 Residential Programs

Guidehouse planned and conducted NTG research for the Residential Energy-Efficiency Program's Downstream and Point of Purchase (PoP) pathways for the Rebates and Marketplace component (Table 92). The NTG for the Rebates and Marketplace program was estimated by weighting three program pathways - Downstream, PoP, and Marketplace.

New data were collected for Downstream (solar) NTG (0.29) and PoP (spray foam) NTG (0.27), shown in Table 92. Overall NTG values for program components are Downstream at 0.43, Marketplace at 0.76, and PoP at 0.30. PoP accounted for 53% of Residential Rebates and Marketplace savings. The SWE verified that the weighting of the three program components matched the overall Rebates and Marketplace NTG (0.37).

Guidehouse utilized participant surveys to estimate free-ridership, spillover, and NTG for both components. Guidehouse utilized question batteries that were consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation.

Table 92: Summary of PECO's PY16 Residential NTG Results

Program Name	Approach	Sample Size	Free-ridership	Spillover	NTG
Residential Rebates and Marketplace (Downstream - Solar)	Participant survey	43	0.72	0.002	0.29
Residential Rebates and Marketplace (PoP – Spray Foam)	Participant survey	17	0.73	0.0	0.27
Residential Rebates and Marketplace Component Total			0.65	0.01	0.37

B.6.2 Non-Residential Program

Guidehouse planned and enacted NTG research for the Downstream Rebates, Midstream Rebates, and Small Business Direct Install components of the Non-Residential Energy-Efficiency Program. New data were collected for Downstream Rebates NTG (0.72), Midstream Rebates (0.67), and Small Business Direct Install NTG (0.93). The New Construction NTG (0.30) was estimated in PY15.

Guidehouse utilized participant surveys to estimate free-ridership, spillover, and NTG for each component. Guidehouse utilized question batteries consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation. NTG results for Midstream Rebates should be interpreted with caution due to the small sample size of four respondents who participated in the program (Guidehouse's sample target was a census attempt from a population of 34; see [Table 93](#)).

Table 93: Summary of PECO's PY16 Non-Residential NTG Results

Program Name	Approach	Sample Size	Free-ridership	Spillover	NTG
Downstream Rebates	Participant survey	21	0.29	0.009	0.72
Midstream Rebates	Participant survey	4	0.33	--	0.67
Small Business Direct Install	Participant survey	19	0.08	0.003	0.93
New Construction	Participant survey	9	0.74	0.04	0.30
Non-Residential Component Total			0.31	0.00	0.69

B.7 TRC

[Table 94](#) presents the TRC NPV benefits, TRC NPV costs, and the TRC Ratios for PECO's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results presented in the PECO PY16 Annual

Report. The values in Table 94 reflect a unit correction to account for the fossil fuel impacts of low-flow water devices.

Table 94: Summary of PECO's PY16 TRC Results

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Residential EE	\$42,337	\$41,473	1.02	\$863
Income-Eligible EE	\$18,259	\$5,317	3.43	\$12,943
Residential HER	\$9,119	\$2,217	4.11	\$6,902
Income-Eligible HER	\$249	\$97	2.57	\$152
Residential Subtotal	\$69,964	\$49,104	1.42	\$20,860
Non-Residential Subtotal	\$119,468	\$92,755	1.29	\$26,713
Common Portfolio Costs	--	\$10,406	--	(\$10,406)
Portfolio Total	\$189,432	\$152,265	1.24	\$37,166

All of PECO's programs were found to be cost-effective using gross savings in PY16, led by the Residential HER Program, with a gross TRC ratio of 4.11. All programs were also found to be cost-effective on a net basis, except Residential Energy Efficiency, which has a net TRC ratio of 0.87.

B.7.1 Notes from the TRC Model Review

The PY16 TRC model was developed by Guidehouse using its proprietary ProCESS tool. The SWE received the input and output files and built a replica model that implements the calculations according to the 2021 TRC Test Order for audit purposes. Below is a summary of the TRC audit findings for PY16.

- The PY16 TRC model used a nominal discount rate of 5.0%, which matches PECO's Phase IV EE&C plan. In the 2021 TRC Test Order, the Commission directed all EDCs to use a common discount rate rather than their own weighted average cost of capital.
- The PY16 TRC model uses the avoided costs of energy approved in PECO's Phase IV EE&C Plan and the avoided capacity costs outlined in the 2021 TRC Test Order. The SWE was able to independently replicate the calculation of all TRC Benefits.
- The PY16 TRC model was based on verified savings, so Guidehouse adjusted program impacts by an applicable realization rate prior to importing them into the model. The SWE confirmed that energy and demand realization rates reflected in the TRC model inputs are consistent with the impact evaluation results reported in PECO's PY16 Annual Report.
- The application of the NTG results in the calculation of net TRC Benefits and costs was handled consistently with the 2021 TRC Test Order directive for Phase IV. All NTG ratios in the TRC model inputs were consistent with PECO's PY16 Annual Report.
- In PY16, Guidehouse and PECO broke out Non-Electric Benefits into O&M Benefits and Fossil Fuel/Water Benefits in accordance with the Phase IV Annual Report template. Consistent with the 2021 TRC Test Order, the model treats all fossil fuel impacts as TRC Benefits whether they are positive or negative.

- The SWE's TRC audit led to an adjustment of the fossil fuel benefits from low-flow water savings devices, such as faucet aerators and showerheads. Guidehouse TRC model monetized per-unit therm savings estimates on a \$/MMBtu basis, meaning the fossil fuel benefits of these measures were overstated by a factor of 10 in PECO's PY16 annual report. Guidehouse also updated the assumed domestic hot water fossil fuel share for these devices to align with TRM defaults for the PECO service territory. The corrections lowered the portfolio TRC benefits by approximately \$20 million. All TRC values in this report reflect corrected fossil fuel impacts for low-flow devices.
- In Phase IV, HER cohorts, after their initial year, have a "decay" of 31.3% applied to future years of savings, up the EUL of those savings. The SWE found that this method was correctly applied to savings in the Residential Home Energy Report program.
- In PY16, the Residential HER Program had the highest TRC ratio at 4.11. Two-thirds (66% or nearly \$6 million) of monetary benefits came from summer peak-demand savings, with the other third derived from energy savings.
- For commercial lighting measures, PECO consistently calculated savings and assigned incremental costs using a Retrofit (Early Replacement) measure characterization. This approach results in more conservative TRC results because the full cost of materials plus labor are assumed in the cost ledger.
- A line loss factor (LLF) of 1.0799 was used for energy and demand savings in the residential and non-residential sectors, which is consistent with the 2021 TRM.
- Measure lives were reported at the measure-level. The SWE spot-checked the measure life assumptions in the PY16 TRC model and found them to be consistent with the 2021 TRM.

B.8 PROCESS

B.8.1 Residential EE Program

For PY16, Guidehouse reported on a process evaluation of the Residential EE Program. The Residential Program is made up of five components shown below:

- Rebates and Marketplace⁷⁴ (Downstream and Point of Purchase evaluations only in PY16)
- In-Home Assessments (no process evaluation in PY16)
- Multifamily (no process evaluation in PY16)
- Appliance Recycling (no process evaluation in PY16)
- New Construction (no process evaluation in PY16)

Table 95 summarizes satisfaction levels by program component or sub-component for the Residential EE Program.

⁷⁴ For the Rebates and Marketplace component, there are multiple delivery channels to receive product rebates: Downstream, Trade Ally and Distributor Network, Marketplace, and Point of Purchase.

Table 95: PECO PY16 Program Satisfaction Summary - Residential EE Program

Program Component / Sub-component	Population	% Satisfied
Rebates and Marketplace – Downstream	Participants	93%
Rebates and Marketplace – Point of Purchase	Participants	84%
Rebates and Marketplace – Point of Purchase	Retailers	0%
Residential EE Program – Overall	Participants	84%

B.8.1.1 Rebates and Marketplace Component

Summary of the Process Evaluation Findings

For the process evaluation of this program, Guidehouse reviewed program documents and data, and interviewed retail store managers, PECO program managers, and CSP staff. The research issues addressed by the primary data collection activities (surveys and interviews) included program goals, significant implementation changes, customer satisfaction, likelihood to recommend the program to others, and program awareness. Based on these data, the mean satisfaction for the component overall was 84%.⁷⁵

There were two key findings that emerged from the process evaluation:

- Respondents indicated a high mean overall satisfaction with the solar offering provided through the program. Of 46 respondents, the average satisfaction was 9.0 out of 10. Respondents provided the lowest satisfaction ratings for the solar offering for the assistance provided by PECO customer service (6.9 out of 10, n=25), the documentation required to apply for a rebate (6.8 out of 10, n=12), and the ease of applying for a rebate (6.5 out of 10, n=12).
- Forty-four percent of respondents first heard about the PECO solar offering after the installation of the solar energy system was complete. Over one-third (36%) learned about the program while working with a contractor to install the system. Only 14% were familiar with the solar offering prior to working with the contractor to install the solar energy system (n=36). Through staff interviews, Guidehouse learned that PECO's outreach strategy is evolving, given that this offering is new. PECO expects to generate awareness earlier in the decision-making process moving forward.

Summary of the Process Evaluation Audit

Guidehouse completed all PY16 activities listed in the Phase IV Evaluation Plan. For the data-collection tasks requiring sampling, the SWE determined that the sampling approach followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

Guidehouse fielded two surveys: one for the Downstream pathway and one for the Point of Purchase pathway of the Rebates and Marketplace program. The team contacted 121

⁷⁵ Satisfaction for the Downstream sub-component was 93% (based on 929 solar participants) and satisfaction for the Point of Purchase sub-component was 84% (based on an estimated 136,000 spray foam participants).

Downstream customers and achieved 46 completes, and contacted 110 Point of Purchase customers to achieve 17 completes, for a total of 63 survey completes. With an original target of 94 completes for the Point of Purchase pathway survey, Guidehouse did not reach the target overall. However, Guidehouse exceeded the target of 20 completes for the Downstream stratum.

Guidehouse also interviewed retail store managers for the Point of Purchase pathway of the Rebates and Marketplace program. The team contacted 39 retail store managers and corporate contacts with a target of 39 (census) completes and achieved two completes with retailer store managers. Thirty-four of these 39 contacts were retail store managers. None of the corporate contacts were responsive, so the process results focused only on the retail store managers.

The SWE also determined that the reporting followed the SWE guidelines. The PECO PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PECO was implementing or considering those recommendations. Two process-related recommendations resulted from the evaluation of the Residential EE program: one is in progress, and one is under consideration. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to both the administrator and implementer.

B.8.1.2 In-Home Assessments (Single-Family) Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.1.3 Multifamily Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.1.4 Appliance Recycling Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.1.5 New Construction Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.2 Residential Home Energy Reports Program

No process evaluation was conducted in PY16 beyond interviews with program and CSP staff.

B.8.3 Income-Eligible Home Energy Reports Program

No process evaluation was conducted in PY16 beyond interviews with program and CSP staff.

B.8.4 Non-Residential Program

The Non-Residential Program is made up of four components, shown below:

- Downstream Rebates
- Midstream Rebates (no process evaluation in PY16)
- New Construction (no process evaluation in PY16)
- Small Business Direct Install (no process evaluation in PY16)

Table 96 summarizes program component and sub-component satisfaction for the Non-Residential Program.

Table 96: PECO PY16 Program Satisfaction Summary – Non-Residential Program

Program Component / Sub-component	Population	% Satisfied
Downstream	Participants	100%
Non-Residential Program – Overall	Participants	100%

B.8.4.1 Downstream Rebate Component

Summary of the Process Evaluation Findings

For the process evaluation of this program, Guidehouse reviewed program documents and data, interviewed PECO program managers and CSP staff, and surveyed PY16 customers who participated in the Non-Residential Program's Downstream Rebates solar

component. The research issues addressed by the primary data-collection activities (in-depth interviews [IDIs] and surveys) included program goals, significant implementation changes, customer satisfaction, likelihood to recommend the program to others, and program awareness. Guidehouse also attempted to survey non-lighting distributors for the Midstream Rebates component of the Non-Residential Program; however, due to not receiving any responses, Guidehouse plans to continue this research and share results in PY17. Based on these data, the mean satisfaction for the component overall was 100%, with all five Downstream respondents reporting a satisfaction level of at least seven on a scale of zero to ten.

There were three key findings that followed from the process evaluation:

- Staff interviews indicated that PECO's outreach strategy is evolving, given that the Downstream Rebates solar component is a new offering, and, in the future, PECO plans to generate awareness of the offering earlier in the decision-making process.
- Respondents indicated a high mean overall satisfaction for the offering provided through the program. Of five respondents, the average satisfaction was 8.8 out of 10. Respondents provided the lowest satisfaction ratings for the ease of finding the PECO Ways to Save solar incentive webpage (7.5 out of 10, n=2), the documentation required to apply for the solar project incentive (7.5 out of 10, n=4), and the process of connecting the solar system to PECO's distribution grid (6.4 out of 10, n=5).

- All five respondents reported that they were very likely (8 out of 10) to recommend the solar component to others. Two respondents reported that they had already recommended the component to another business.

Summary of the Process Evaluation Audit

Guidehouse completed all the PY16 activities listed in the Phase IV Evaluation Plan. For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

Guidehouse contacted 31 non-residential customers who participated in the Downstream component and achieved a total of five completed responses for a 16% response rate. Due to challenges reaching these participants, Guidehouse only reached 83% of the targeted six survey completes.

The SWE also determined that the reporting followed SWE guidelines. The PECO PY16 Annual Report included descriptions of the methods, a summary of conclusions, and a table of recommendations with descriptions of whether PECO was implementing or considering those recommendations. Three process recommendations were made in PY16; two recommendations are in progress, and one recommendation is under consideration. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

B.8.4.2 Midstream Rebate Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.4.3 New Construction Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

B.8.4.4 Small Business Direct Install Component

No process evaluation was conducted in PY16 beyond interviews with program and implementation staff.

Appendix C PPL PY16 Audit Detail

C.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential program components found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and that the TRM protocols were applied correctly and are generally accurate
- Cadmus provided nearly all of their residential and low-income verified savings analyses prior to drafting their PPL PY16 Annual Report. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the PPL PY16 Annual Report.
- The SWE's review of verified savings for residential solutions, which includes LI programs, found that, overall, the verified savings followed proper TRM protocols, and most verified savings are accurate. The SWE found errors with the verification of a few measures in the Energy Efficient Homes - Downstream HVAC component that resulted in an increase in verified energy savings by 0.06% of portfolio savings and 0.39% of total verified savings for the Residential program.
- PPL's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.29. PPL's PY16 gross TRC ratio was above its PY15 gross TRC ratio of 1.19. The gross TRC ratio of 1.29 reflects a units correction to the increased fossil fuel consumption associated with PPL's largest CHP project.
- The SWE thoroughly audited the TRC model and found all other elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The impact evaluation of the Midstream Lighting portion of PPL's Efficient Equipment offering included one sample point where the program-supported LED fixtures had been ineligible since the beginning of PY15 due to a Codes and Standards update to the 2021 TRM. While the contribution of ineligible product to PY16 spending and reported savings was small, the SWE encourages PPL to review carefully that all equipment it subsidizes with ratepayer funds is eligible to claim Act 129 energy and demand savings.
- The Downstream Lighting portion of PPL's Efficient Equipment offering accounted for over 40,000 MWh and 6 MW of verified savings in PY16. Despite this significant contribution to the portfolio, the impact evaluation included just one phone interview and no site visits with program participants. This absence of primary data collection is concerning, so the SWE is working with PPL and its evaluator to update the PY17 EM&V plan to include more independent verification of key project details and reduce reliance on ICSP documentation.
- HVAC tune-ups were a new offering within the Efficient Equipment program component in PY16 and accounted for approximately 50% of all non-lighting savings. The ICSP collected detailed documentation on each serviced HVAC unit that allowed evaluators to

implement the algorithms and assumptions of the HVAC tune-up IMP. For a limited number of units, evaluation uncovered a disconnect between the activities performed and the energy savings factor applied. The SWE audit also identified quantity and cooling-efficiency transcription issues between the contractor's documentation and PPL's tracking system. These issues had opposing effects on savings, so the overall impact to MWh and MW savings was modest.

- PPL launched a behavioral Home Energy Report program in PY16 to approximately 360,000 residential households. The average savings per home in PY16 was 21 kWh. Home Energy Report savings can take several years to reach maturity, and the PPL program did not launch until December for the first accounts, with some accounts not receiving their first HER messaging until early 2025. The SWE expects the savings contribution of the HER program component to expand in PY17, and produce peak-demand savings since the treatment was active during summer 2025. PPL's evaluation contractor followed the regression model specification listed in its approved EM&V Plan and adjusted the savings for dual participation despite the HER control participating in other EE&C programs at a higher rate than the treatment group.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in PPL's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participant counts. The SWE was unable to replicate the incentive amounts exactly using the tracking data. Note that PPL expressed to the SWE that the rebate amounts in the tracking data will generally never exactly equal the incentive dollars in their reports, because the PPL PY16 Annual Report values are pulled from a financial system as opposed to program tracking data.
- Project documentation for the non-residential program components submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of PPL's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted; the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data. Across several programs, the SWE observed a few instances where measure names and their corresponding TRM measure number did not align with the TRM; however, reported savings did not appear to be impacted.
- Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and the approved EM&V plan.
- For the process evaluations, Cadmus completed all the PY16 activities detailed in the approved evaluation plan and sampling memos, and the reporting followed the SWE guidelines. The process evaluation discussion was succinct and highlighted findings that should be of value to PPL and its CSPs.

C.2 EM&V PLAN REVIEWS

Cadmus, PPL's evaluation contractor, submitted a summary memo of the PY16 and Phase IV EM&V plans for each program and program component, as well as redline versions of the individual EM&V plans for each program in PPL's Phase IV EE&C plan. The SWE reviewed and approved the plans, generally with minor revisions.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 97](#) shows which PPL programs produced verified impacts in PY16 and which used historic realization rates in PY16. In addition, [Table 97](#) shows which PPL programs used a two-year sample (PY15 and PY16) and verified results in PY16.

Table 97: PY16 PPL Program Impact Evaluation Summary

Program	Component	Delivery Channel	PY16 Impacts
Non-Residential Program	Custom	Large	Verified
		Small	Verified (2-year sample)
		CHP	Verified
	Equipment	Downstream	Verified
		Midstream	Verified
	Lighting	Downstream	Verified
		Midstream	Verified
Low-Income Program	Remote Energy Assessment		Verified
	In-home Assessment		Verified
Residential Program	Welcome kits		Verified
	Appliance Recycling	Refrigerators	Historic realization rate
		Freezers	Historic realization rate
		Room AC's and dehumidifiers	Verified
	Energy Efficient Home	Audit and Weatherization	Verified
		Midstream Equipment	Verified (2-year sample)
		Downstream Equipment	Verified
		Online Marketplace	Historic realization rate
		New Homes	Unverified
		Instant Discount	Verified for spray foam; Historic realization rate for all other measures
	Efficient Lighting	Lighting	NA
	Student Energy Efficiency Education	All strata	Historic realization rate

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft surveys, interview guides, and stakeholder guides for the applicable components. These documents covered components and delivery channels in the Non-Residential, Low-Income, and Residential programs.

C.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework established a maximum level of sampling uncertainty (or precision) of $\pm 15\%$ at an 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. PPL’s energy-efficiency portfolio consists of three programs (Non-Residential, Residential, and Low-Income), organized by sector. Each program consists of several “components,” each broken down into strata made up of projects that are made up of similar measures and sizes of savings. PPL designed its strata sample sizes to meet the minimum 85/15 requirement as outlined in its SWE-approved EM&V plan. PPL provided the SWE with their energy and demand gross impact realization rates, along with the relative precision of their savings estimates for each stratum. The SWE conducted a review of the realization rate and relative precision calculations provided by PPL’s evaluation contractor and confirmed that all components met the 85/15 requirement outlined in the Phase IV Evaluation Framework.

Table 98 shows the relative precision of energy and demand savings estimates by PPL program component. Note that the Residential Efficient Lighting component is omitted, as it relied on historical realization rates. Not all programs rely on sampling to estimate verified savings. For the Residential Home Energy Report (HER) program component, the impact evaluation relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. This approach, following IPMVP Option C protocol, means all population participants in the HER component are sampled and thus sampling precision is irrelevant.

Table 98: Relative Precision of PY16 Impacts by Component at the 85% Confidence Level

Program	Component	Relative Precision (Energy)	Relative Precision (Demand)
Non-Residential Program	Efficient Equipment (Lighting)	2%	6%
	Efficient Equipment (Equipment)	4%	10%
	Custom	4%	8%
Residential Program	Appliance Recycling	7%	4%
	Student Energy Efficient Education	1%	1%
	Energy Efficient Homes	8%	7%
Low-Income	--	7%	7%

In the process of replicating relative precision calculations, the SWE noted that Cadmus used precision equations from the Uniform Methods Project (UMP), rather than those detailed in the

California Evaluation Framework.⁷⁶ The two sets of equations are indistinguishable when sample sizes are large but diverge as sample sizes narrow. The SWE finds the UMP approach valid in this setting, as sample sizes were relatively small. Also, Cadmus's assessment of precision was done more conservatively using data collapsed to the participant level, which can widen error (precision) estimates.

Based on the evaluation plan, Cadmus did not sample REA-Full Cost jobs in the Low-Income component and instead applied the In-Home Full Cost job realization rate. Next, 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.

All program components comfortably satisfied the 85/15 requirement in PY16 for both energy and demand.

C.4 REPORTED GROSS SAVINGS AUDITS

C.4.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in PPL's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts
- Incentive dollars

The SWE leveraged Appendix A of PPL's Q1-Q4 tracking data to audit these values. Note that PPL's Appendix A to the quarterly tracking data responses is a subset of the full tracking dataset (which PPL provides in Appendix Z of their quarterly data submissions). This subset is used in creating the statewide tracking database, as it is tailored to the SWE's PY16 quarterly data request. Any references to "tracking data" herein refer to tracking data in PPL's Appendix A, not the tracking data in PPL's Appendix Z.

⁷⁶ Weblink to UMP: <https://www.energy.gov/sites/default/files/2013/05/f0/53827-11.pdf>; weblink to CA Evaluation Framework: https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy/energy_programs/demand_side_management/ee_and_energy_savings_assist/caevaluationframework.pdf.

Table 99 summarizes our findings regarding reported gross energy savings. The “Match” column contains “Yes” if the tracking data supports the values in the PPL PY16 Annual Report and “No” otherwise. The tracking data supports PPL’s PY16 Annual Report for all programs.

Table 99: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Non-Residential	248,286	248,286	Yes
Low-Income	18,402	18,402	Yes
Residential	48,493	48,493	Yes*
Portfolio Total	315,181	315,181	Yes*

*The Residential Program has an HER component that is not represented in this table.

Table 100 summarizes the SWE’s findings regarding reported gross peak-demand savings by program. The tracking data is provided at the meter-level. Like with reported gross energy savings, the tracking data supports PPL’s PY16 Annual Report value exactly for all programs. Note that these values are not adjusted for line losses.

Table 100: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Non-Residential	55.65	55.65	Yes
Low-Income	1.87	1.87	Yes
Residential	7.10	7.10	Yes*
Portfolio Total	64.62	64.62	Yes*

*The Residential Program has an HER component that is not represented in this table.

The SWE also used the tracking data to audit PPL’s reported participation counts and customer rebate amounts. Like the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by PPL. For financials, PPL expressed to the SWE that the rebate amounts in the tracking data will generally never exactly equal the incentive dollars in their reports, because the PPL PY16 Annual Report values are pulled from a financial system as opposed to program tracking data. Still, the SWE was able to calculate directionally similar values.

C.4.2 Project File Reviews

C.4.2.1 Residential

The SWE conducted a project file review for a sample of PPL’s residential and low-income solutions in PY16 as part of the reported savings (i.e., ex ante) review. The project file documentation was provided by PPL, the program implementers, and the evaluation contractor, Cadmus, in response to the SWE’s standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. The sampled project file packages included most of the documentation

requested. For the sample files that were provided, a sample key and sample memo were included that allowed for consistent matching between files and the tracking data.

Table 101 presents a summary of the SWE's residential project file reviews.

Table 101: PPL Residential Project File Review Summary

Program	Solution	Number of Files Reviewed	Did EDC Provide Project Files?	Are Most of the Requested Files Included?	Are Projects Easily Located in the Tracking Data?	Does the Data in the Files Match the Tracking Data? ¹
Appliance Recycling	N/A	40	✓	✓	✓	✓
Energy Efficient Homes	New Homes	40	✓	✓	✓	✓
Energy Efficient Homes	Downstream Equipment	30	✓	✓	✓	✓
Energy Efficient Homes	Online Marketplace	3	✓	✓	✓	✓
Energy Efficient Homes	Efficient Lighting	-	-	-	-	-
Energy Efficient Homes	Audit and Weatherization	15	✓	✓ ²	✓	✓
Low-Income Program	REA, In-Home, and Multifamily	20	✓	✓	✓	✓

¹ It should be noted that while typically the data matches, minor discrepancies were found and are detailed in the paragraphs below.

² Files for Q3 and Q4 were missing due to an error during file upload. Cadmus was made aware of the issue and has provided the missing files.

As outlined above, the requested number of project files and supporting details were submitted for the residential program. All the program measures used default or EDC-collected data as outlined in the EM&V plan. Across several programs, the SWE observed a few instances where measure names and their corresponding TRM measure numbers did not align with the TRM; however, reported savings did not appear to be impacted.

Appliance Recycling Program

The SWE located all Appliance Recycling project files within the tracking database. The SWE observed five instances where a photo and signature were not provided. The SWE observed six instances where the appliance photos were of such poor quality that the appliance could not be identified. All other entries accurately reflected the tracking data.

Energy-Efficient Homes: New Homes

Each project file contained a HERS Energy Report, PPL New Home Report, and either a building analysis file or a screenshot of information about the building modeling software used. The SWE found that the savings provided in the REM/Rate file matched the reported savings in the tracking data.

Energy-Efficient Homes: Downstream Equipment

Invoices or receipts were provided with quarterly samples of project documentation for downstream equipment. The SWE found that the project file documentation matched the tracking data.

Energy-Efficient Homes: Online Marketplace

Three invoices were provided in total, one from Q1 and two from Q2, and the SWE was able to match the invoices with the tracking data. Each monthly invoice was paired with an invoice summary spreadsheet that contained detailed information on the count of each measure purchased and the rebate cost of each unit. The SWE did not observe any discrepancies between the project files and the tracking data regarding quantities, reported energy and demand savings, and rebate amounts.

Energy-Efficient Homes: Efficient Lighting

The Efficient Lighting program was not in operation in PY16 and therefore not part of the project file review.

Energy-Efficient Homes: In-Home Audit and Virtual Assessment

In-Home Audit information was provided for two homes. For one home in Q1, only an invoice and a signed rebate form were provided as proof that the audit was completed. For one home in Q2, a more thorough inspection report was provided.

The Virtual Assessment program was in operation during Q1 and Q2 of PY16. The SWE did not observe any discrepancies in the files submitted for this program.

Energy-Efficient Homes: Weatherization

In-Home Audit project files were comprised of either a rebate application or a payment authorization form and an invoice. The projects contained all the necessary files for savings verification and were easy to find in the tracking data.

Weatherization project files were comprised of invoices from weatherization service providers with itemized receipts. All the reviewed files were easy to find in the tracking data and accurate. Five sites were listed in the tracking data in Q2, but no files were provided for those sites.

Low-Income Program: Remote Energy Assessment, In-Home Audits, Multifamily

Each project submitted for the Low-Income program was linked to a Wrap Audit Record, which provided detailed information on the installed measures and identified potential measures that could improve efficiency outcomes. Four of the 20 projects submitted for this program also included recordings of phone-guided audits, which supplemented the details provided in the Wrap

Audit Records. Projects were submitted only for Q1 and Q2. No discrepancies in rebate or savings amounts were found between the projects and tracking data.

C.4.2.2 Non-Residential

The SWE reviewed a sample of PPL's Efficient Equipment projects for PY16 using the project documentation provided by the evaluation contractor in response to the SWE's standing quarterly data request. The project file packages included savings calculation worksheets, rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the reviewed project file packages included all documentation requested and were well organized, allowing for a comprehensive review of the 32 projects sampled.

Table 102 presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 102: PPL PY16 C&I Project File Review Summary

Program	Segment	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Custom	Custom	3	✓	✓	✓	✓	✓
Efficient Equipment	Prescriptive Lighting	4	✓	✓	✓	✓	✓
Efficient Equipment	Midstream Lighting	4	✓	✓	✓	✓	✓
Efficient Equipment	Prescriptive Non-Lighting	4	✓	✓	✓	✓	✓
Efficient Equipment	Midstream Non-Lighting	3	✓	✓	✓	✓	✓

C.5 VERIFIED GROSS SAVINGS AUDITS

C.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of PPL's portfolio of residential and Low-Income (LI) programs. PPL's portfolio of residential and LI programs includes the following: Appliance Recycling, Energy Efficient Homes, and Student Energy Efficient Education program components. The Low-Income Program consists of the following components: Remote Energy Assessments, In-Home / Direct Install, Master-Metered Multifamily, and Welcome Kits. Note that the SWE reports the residential savings in two sections: residential and behavioral.

Table 103 provides a summary of the EM&V approaches used by Cadmus in their PY16 verified savings calculations.

Table 103: Residential and LI Impact Evaluation Activities - PPL

Program/ Subprogram	Surveys	Site Visits	Desk Review ¹	Billing Analysis	Historic Realization Rate
Residential Program					
EE Homes, Downstream Equipment	✓	-	✓	-	-
EE Homes, Online Marketplace	-	-	-	-	✓
EE Homes, Instant Discount	-	-	✓	-	✓
EE Homes, New Homes ²	-	-	-	-	-
EE Homes, Audit and Weatherization	✓	-	✓	-	✓
EE Homes, Midstream HVAC	-	-	✓	-	-
Appliance Recycling	-	-	✓	-	✓
Student Energy Efficient Education (SEEE)	-	-	-	-	✓
Home Energy Reports	-	-	-	✓	-
Low-Income Program					
Remote Energy Assessment	✓	-	✓	-	-
In-Home Assessments	✓	-	✓	-	-
Welcome Kits	-	-	✓	-	-

¹ The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.

² The New Homes sub-component was not evaluated in PY16.

The SWE's review of verified savings for residential solutions, which include LI programs, found that, overall, the verified savings followed proper TRM protocols, and the verified savings were accurate. The SWE found errors with the verification of a few measures in the Downstream Equipment components that resulted in an increase in verified energy savings by 0.76% of total residential and low-income verified savings.

Residential Program: Energy Efficient (EE) Homes, Downstream Equipment

The Energy Efficient Homes component of PPL's Residential Program provides downstream incentives for high-efficiency equipment such as HVAC equipment, water heaters, and

appliances. In PY16, Cadmus conducted desk reviews for a sample of measures and a survey to gather in-service rates and other savings inputs. The SWE confirmed that savings were calculated in accordance with the TRM and found that the correct inputs were utilized in all but a few instances. The SWE verified that savings had been rolled up correctly and aligned with those in the EDC PY16 annual report.

Residential Program: Energy Efficient (EE) Homes, Online Marketplace

The Energy Efficient Homes component also provides discounts on energy-efficient products via an Online Marketplace sub-component. The Online Marketplace sub-component includes dehumidifiers, air purifiers, smart power strips, smart thermostats, room air conditioners, weatherstripping, and welcome kits of assorted items. The SWE confirmed that the correct historical realization rates were applied to the Online Marketplace strata and that verified savings aligned between the analysis files and the EDC PY16 Annual Report.

Residential Program: Energy Efficient (EE) Homes, Instant Discount

The Instant Discount sub-component includes air purifiers, smart power strips, spray foam, pipe insulation, dehumidifiers, room air conditioning, and air filters. Cadmus applied a historical realization rate from PY15 to reported PY16 energy and demand savings, except for spray foam measures.

Cadmus conducted surveys to verify the installation of the spray foam measure. Cadmus included spray foam verification questions in four different surveys (general population, customer satisfaction, Downstream Equipment, Audits and Weatherization) to determine if respondents had purchased spray foam within the last 12 months and, if so, asked them to verify that they had used the spray foam to seal windows, doors, or gaps/cracks in conditioned spaces. Cadmus estimated that, on average, respondents applied approximately 10 linear feet of insulation per can. The SWE evaluated the survey results, input data, algorithms, and associated calculations and confirmed that the verified savings for spray foam were calculated correctly. The SWE confirmed that the reported savings, verified savings, and realization rates were in alignment between the analysis files and the EDC PY16 annual report.

Residential Program: Student Energy Efficient Education (SEEE)

This component provides three types of energy savings kits to classrooms in the service territory. While the contents of each kit vary, the measures include showerheads, faucet aerators, LED bulbs, LED nightlights, advanced power strips, water heater temperature setback, and furnace whistles.

Cadmus planned to apply historical realization rates from the PY15 Annual Report to derive verified savings for PY16. However, the SWE review found, and Cadmus confirmed that PPL's reported savings incorporated verified measure-level installation rates (ISRs) from the PY15 evaluation report. Because ISRs are the primary drivers of realization rates, applying historical realization rates after reported savings had already been adjusted to account for updated ISRs would double-count the measure-level adjustments. The SWE agreed with Cadmus on passing through the reported savings for PY16 as verified savings, effectively resulting in realization rates of 100% for PY16.

Residential Program: Appliance Recycling

The Appliance Recycling component provides incentives for recycling inefficient appliances. For room air conditioners and dehumidifiers, Cadmus conducted a tracking database review and confirmed that savings estimates aligned with the TRM. For refrigerators and freezers, Cadmus used historic realization rates from PY15. For dehumidifiers and room air conditioners, Cadmus used ZIP code data to assign default savings values from the TRM. The SWE confirmed that participation counts, realization rates, and verified savings were calculated and reported accurately.

Residential Program: EE Homes, New Homes

The New Homes sub-component was not evaluated in PY16. The PY16 participants will be evaluated in PY17 as part of a two-year sample. PY16 savings were left unverified.

Residential Program: EE Homes, Audits and Weatherization

Cadmus conducted desk reviews and incorporated survey data of the Audits and Weatherization component of the EE Homes Program in PY16. For the weatherization measures, Cadmus used survey data to determine the existing cooling and heating system type to determine verified savings. The SWE reviewed and confirmed that the verified savings were calculated in accordance with the TRM protocols. For the virtual and in-home audit measures, Cadmus conducted a database review and used the participant survey data to calculate an in-service rate (ISR) for individual measures. For measures with limited survey data, Cadmus used TRM ISRs or historic ISRs from previous evaluations. The SWE reviewed and recommended several updates to the calculations for several measures, including LED lighting, nightlights, weather stripping and outlet gaskets. Cadmus incorporated the updates in the PY16 annual report. The SWE also confirmed that verified energy and demand savings were consistent between the analysis and the PY16 PPL Annual Report.

Residential Program: EE Homes, Midstream HVAC

In PY16, Cadmus conducted desk reviews for a sample of PY15 and PY16 HVAC measures (central air conditioners and air source heat pumps). The SWE reviewed the verified savings that were calculated in accordance with the TRM protocols, but for one project, the SWE found a different cooling capacity in the AHRI database. Cadmus updated their analysis of verified savings and incorporated the updates into the PPL PY16 Annual Report.

Low-Income Program

The Low-Income Program provides four job types (baseload, low-cost, full-cost, and welcome kits) to income-qualified customers that offer services such as: HVAC, lighting, water-saving and heating, power strips, and energy education. These services are offered through welcome kits, remote energy assessments, and in-home assessments. For the Remote Energy Assessment, the CSP sends a custom kit to each participant after the assessment, which is determined from opportunities identified during the remote assessment.

The SWE reviewed the Remote Energy Assessment, In-Home Assessment, and Welcome Kit components of the Low-Income Program. In PY16, Cadmus, conducted a survey to gather in-service rates for remote energy assessment and in-home assessment measures. Cadmus

performed a desk review of the impact data for Welcome Kits, calculating savings using TRM defaults for each item type as appropriate. The SWE evaluated the input data, algorithms, and associated calculations, and confirmed that the verified savings were calculated correctly. The SWE confirmed that the reported savings, verified savings, and realization rates were in alignment between the analysis files and the EDC PY16 annual report.

Behavior

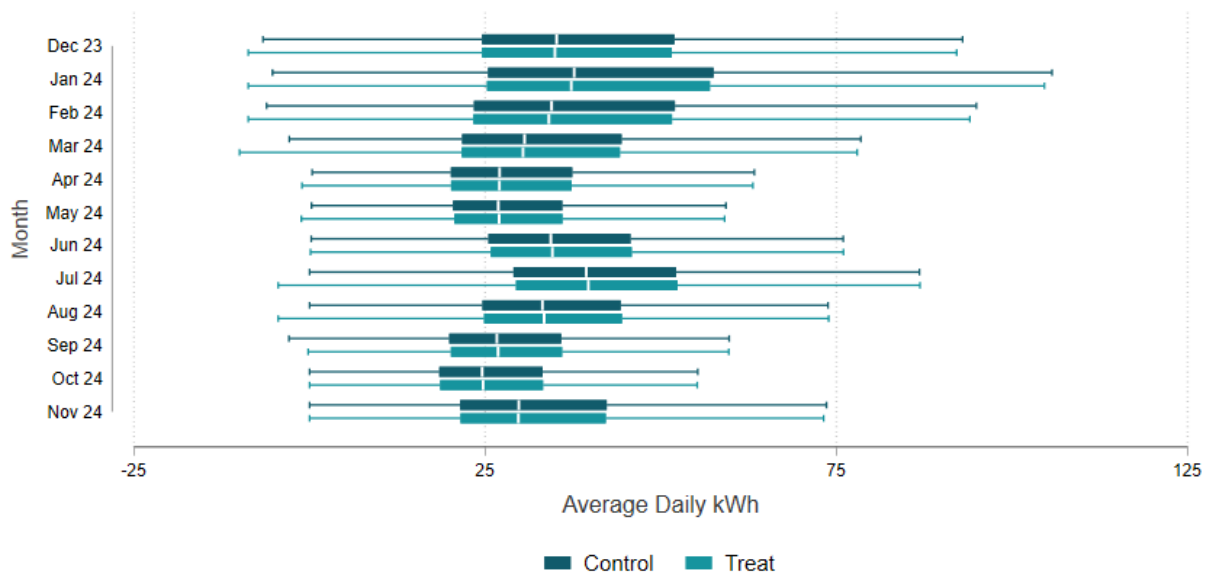
Home Energy Reports were issued to around 360,000 residential households in PY16. PPL's behavioral program component consists of a single wave, which was launched partway through PY16. PY16 was the first year of Phase IV that the Home Energy Report component was active. [Table 104](#) summarizes the number of active treatment and control households during PY16.

Table 104: PPL HER Summary

Start Date	Treatment Group Homes	Control Group Homes
12/01/2024	361,810	94,542

The ICSP's subcontractor Bidgely implemented the program as a randomized control trial (RCT), where the eligible households were identified and then randomly assigned to either a treatment or a control group. Following randomization, Cadmus conducted statistical tests on the pre-treatment energy usage patterns to confirm equivalence between the treatment and control groups.

The SWE conducted an audit of randomization soundness and pre-treatment equivalence for the program. The SWE ran a simple fixed-effects regression model using the pre-treatment data with indicator variables for each month and for the treatment. During the pre-treatment period, the SWE expected the "treatment" indicator variable to be statistically insignificant, as the treatment effect is only expected after HER delivery begins. Indeed, the SWE found the treatment indicator variable to be statistically insignificant. The SWE also ran a t-test of pre-period usage by treatment status and found all differences in usage to be statistically insignificant. [Figure 33](#) compares the monthly distribution of daily kWh usage for the treatment and control groups. These visuals reinforce the finding that pre-treatment usage patterns are extremely similar between the treatment and control groups.

Figure 33: Pre-Treatment Equivalence

Cadmus provided the SWE with monthly consumption data for all homes in the treatment and control groups. The monthly data are the primary input in the estimation of HER impacts. To determine daily impacts, Cadmus calendarized the data. The SWE independently checked the calendarization of the monthly data, and found the calculations to be sound. The SWE also found the distribution of monthly kWh to be reasonable. Cadmus ran two models: a Lagged Dependent Variable (LDV) model and a Linear Fixed-Effects Regression (LFER) model. The LDV model contains a lagged variable for the average daily energy consumption in the same month during the pre-treatment period. The LDV model is used to estimate energy savings and impact estimates, while the LFER model is used to check sensitivity and robustness.

Cadmus and the SWE worked together to obtain the number of treatment days for each customer. The HER program was not active throughout the entirety of PY16. Treatment days were calculated using 12/01/24 (the program's start date) and the last bill end date in PY16 of each premise. If a customer's last bill date ended in the middle of May 2025 and they had no deactivation date, they were considered active through the end of PY16.

Customers that did not have twelve months of pre-treatment data were not included in the impact estimation (because the lagged seasonal variables for these customers could not be calculated), but they were included in the customer counts.

Table 105 shows the average daily savings estimate per household along with the number of days used to scale from per-household results to program totals. The practical interpretation is that treatment group homes saved 0.11 kWh per day, on average, and the treatment group homes experienced over 65 million days during PY16 after HER messaging began.

Table 105: PPL HER Impact Estimates

Evaluation Output	Value	Units
Impact Coefficient	0.1117	kWh saved per home per day
Standard Error	0.0329	kWh saved per home per day
Treatment Days	65,487,610	Days
Regression-Based Savings	7,312	MWh

The SWE and Cadmus worked together to calculate gross MWh savings from regression coefficients and the number of treatment days. [Table 106](#) shows the aggregate PY16 pre-adjustment gross MWh savings, as well as the adjustment for dual participation.

Table 106: PPL PY16 HER Energy Savings

Program Year	Pre-adjustment Gross Savings (MWh)	Dual Participation Savings (MWh)	Total Gross Savings (MWh)
PY16	7,312	-250	7,562

In the table above, gross savings before adjusting for dual participation were 7,312 MWh. Home Energy Reports advertise other PPL residential EE&C programs and measures such as ENERGY STAR appliances, water heaters, and HVAC, etc. To the extent that treatment group households participate in these programs more frequently than control group homes, the incremental savings are captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings are adjusted to account for the incremental program participation observed in the treatment group compared to the control group. The negative dual participation value indicates that control group households participated in other PPL programs at a higher rate than homes in the treatment group. While this is not the expected direction of the dual participation adjustment, the correction is necessary regardless of the sign to remove the impact of other EE&C programs from the estimated HER impacts.

Because the HER program component launched in December, it was not active during the summer peak-demand period of PY16, and therefore the peak-demand impact is zero.

C.5.2 Non-Residential Audit Activities

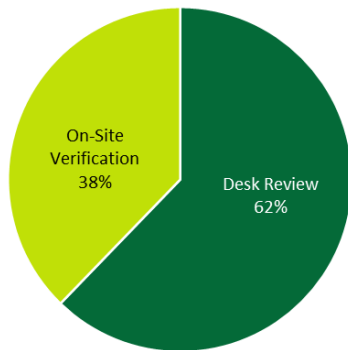
The SWE conducted various reviews and audit activities for PPL's energy-efficiency programs. These activities included a review of the evaluation efforts and an audit of the savings verification completed by PPL's evaluation contractor, Cadmus. The remainder of this section presents the SWE's findings from these activities.

[Figure 34](#) provides a summary of the evaluation activities and M&V approaches utilized by PPL's evaluation contractor in their PY16 verified savings calculations, summarized by total project counts and evaluated savings. For PY16, PPL's evaluation contractor completed site visits for 38% of sampled projects. Some of these site visits were virtual site-visits, for which Cadmus conducted a video conference with the customer, and the customer provided supplemental

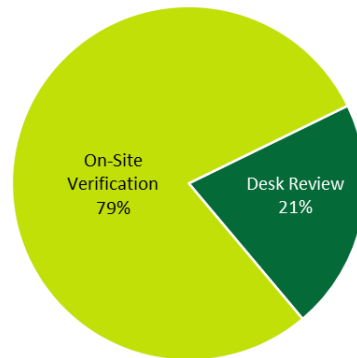
pictures to verify project-specific information. In assessing savings, enhanced M&V techniques (IPMVP Options A, B, and C) were employed for the majority (79%) of total energy savings reviewed. Basic evaluation rigor (desk reviews, and on-site verification) was employed for non-residential Efficient Equipment (lighting and non-lighting) projects and Midstream Lighting projects. Figure 34 provides a summary of the share of projects that underwent Cadmus' evaluation activities by quantity of projects and evaluated savings. Figure 34 also displays the share of projects that were reviewed using basic rigor methods and IPMVP methods.

Figure 34: Summary of PPL's C&I Evaluation Activities

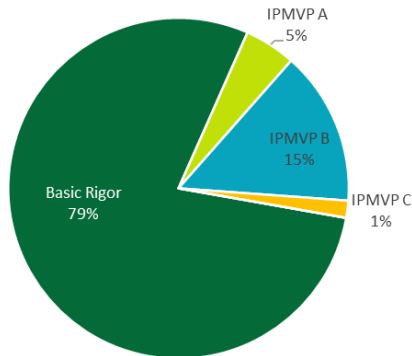
Evaluation Activities by Project Count



Evaluation Activities by kWh Contribution



M&V Method by Project Count



M&V Method by kWh Contribution

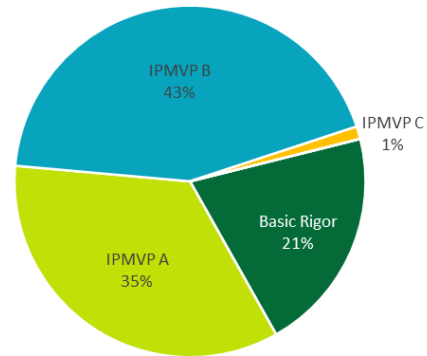


Table 107 provides a summary of the evaluation activities and M&V approaches that PPL's evaluation contractor used across strata for all projects, stratified by program.

Table 107: Summary of PPL's PY16 C&I Evaluation Activities by Program

Program / Strata	Sample Quantity	Realization Rate	Desk Review	On-Site Verification*
Non-Residential Equipment Program	33	100%	31	2
Midstream - agriculture	8	96%	8	0
Midstream - food service equipment	1	79%	1	0
Downstream - HVAC	6	92%	5	1
Downstream - HVAC - certainty	3	100%	3	0
Downstream - motors	5	125%	5	0
Downstream - motors - certainty	1	100%	1	0
Downstream - other equipment	4	86%	3	1
Downstream - refrigeration	4	122%	4	0
Downstream - refrigeration - certainty	1	98%	1	0
Non-Residential Lighting Program	54	97%	54	0
Downstream lighting (<120 kWh/yr)	13	100%	13	0
Downstream lighting (120-750 kWh/yr)	13	98%	13	0
Downstream lighting threshold (>750 kWh/yr)	5	96%	5	0
Non-Residential midstream lighting	23	104%	23	0
Custom Program	33	96%	0	33
Custom - Large	27	95%	0	27
Custom - Small	4	101%	0	4
Custom - CHP	2	100%	0	2
Total	120	96%	85	35

* All virtual site visits are also counted as on-site visits.

The SWE's review of verified savings for non-residential program components found that, overall, the verified savings methods were aligned with the Evaluation Framework. Cadmus followed proper custom site-specific M&V protocols, applied TRM protocols correctly, and the verified savings were generally accurate. The following program sections describe the SWE's audit of the verified savings methodology for non-residential program components in further detail.

C.5.2.1 Non-Residential Efficient Equipment Program Component

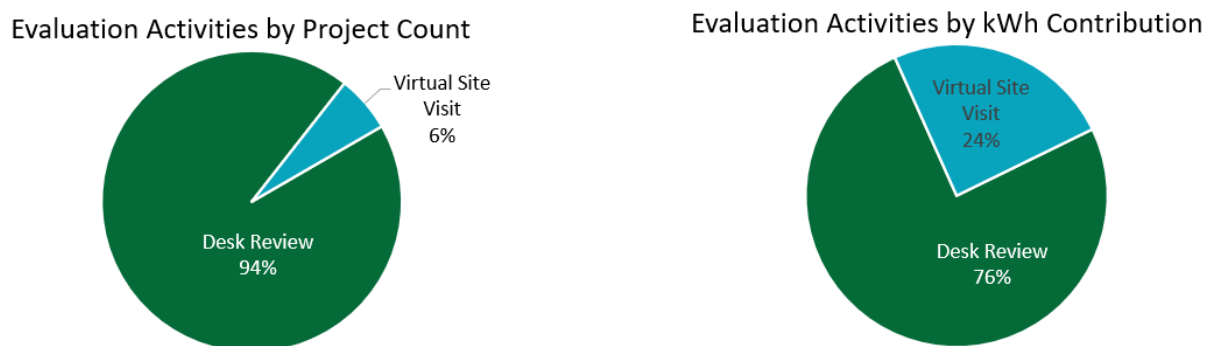
PPL's Efficient Equipment program component includes a wide range of prescriptive incentives for high-efficiency equipment in businesses. This section discusses the non-lighting equipment; and the following section describes the lighting impact evaluation. Cadmus evaluated all 33 sampled non-lighting equipment projects at a basic level of rigor using TRM algorithms and assumptions (31 by desk review and two by desk review plus a virtual site visit). Cadmus grouped the non-lighting equipment measures into the four downstream strata and two midstream strata shown below:

- Downstream – HVAC
- Downstream – Motors
- Downstream – Other Equipment
- Downstream – Refrigeration

- Midstream – Agriculture
- Midstream – Food Service Equipment

Figure 35 shows the distribution of the sampled projects and savings by method. PPL's evaluation contractor verified most sample points via desk reviews with two larger projects receiving a virtual site visit to complement the desk review.

Figure 35: Summary of PPL's PY16 Efficient Equipment Program Evaluation Activities (Non-Lighting)



The SWE audit focused on the Downstream – HVAC stratum in PY16. Specifically, the SWE conducted a detailed review of the HVAC tune-up measure, which was newly added to the program in PY16 and accounted for approximately 50% of all reported non-lighting kWh savings in the Efficient Equipment program component. The HVAC tune-up sample consisted of three participating facilities, with a total of 363 units serviced. Cadmus evaluated the three projects via a detailed desk review that fed unit-specific capacity and efficiency information through the algorithms and savings assumptions of an Interim Measure Protocol (IMP) developed in 2022. Table 108 shows the percentage savings assumptions for different tune-up activities.

Table 108: Energy Savings Factors for HVAC Tune-Up Types

Tune-Up Component	ESF
Condenser Cleaning	6.1%
Evaporator Cleaning	0.22%
Refrigerant Charge Correction (<=20% of refrigerant capacity)	0.68%
Refrigerant Charge Correction (>20% of refrigerant capacity)	8.44%
Combo: Condenser Cleaning, Evaporator Cleaning, Charge Correction (<=20%)	7.0%
Combo: Condenser Cleaning, Evaporator Cleaning, Charge Correction (>20%)	14.76%

Evaluation desk reviews verified quantities, capacities, and efficiencies based on provided documentation. The most common adjustment was to the tune-up component and corresponding Energy Savings Factors (ESFs). Engineers determined that Package Terminal Air Conditioners (PTACs) and Package Terminal Heat Pumps (PTHPs) do not have a way to check and correct refrigerant charge, so the contractor did not implement that tune-up activity. This led to a modest reduction in ESFs for a subset of units. The SWE audit identified two discrepancies between the

quantity values in the supporting documentation and the values stored in the program tracking system. The SWE also identified multiple instances where the ICSP incorrectly transcribed the efficiency values used to calculate reported and draft verified savings from the unit nameplate. These findings were part of an early review process, so Cadmus was able to correct the desk review findings and update the realization rates prior to finalizing the PY16 Annual Report.

C.5.2.2 Non-Residential Efficient Lighting Program Component

In PY16, Cadmus grouped the efficient lighting projects into three downstream strata and a single midstream stratum. The lighting strata are listed below.

- Downstream (>750 MWh/yr)
- Downstream (120-750 MWh/yr)
- Downstream (<120 MWh/yr)
- Midstream

Consistent with the approved EM&V plan for PY16, Cadmus evaluated the midstream lighting stratum via a database review and interviews with a sample of 23 participants. Interviewers confirmed that the program-supported lighting was installed in the location reported in the program tracking data rather than being placed in storage or installed at another location. Evaluators also collected information on the principal business activity in the facility for mapping TRM default hours of use, coincidence factor values, and whether the space(s) were heated and air-conditioned, as these parameters also impact lighting savings. Respondents were also asked how the LED fixtures were controlled, and verified savings were adjusted based on the responses. For one sample point, it was determined that the program-supported recessed downlight fixtures were ineligible for Act 129 savings, so the energy and demand impacts for the case were zeroed out. Given the prescriptive nature of the midstream offering, an interview approach makes sense for verification. The SWE's primary concern for PY16 (aside from PPL incentivizing ineligible products) was the top-heavy nature of the midstream interview sample. Over 50% of the reported kWh savings came from a single project and 95% of the reported savings came from just five sample points. This makes the impact evaluation results sensitive to the responses of a handful of participants. For PY17, the SWE recommends targeting a distribution of savings across the sample that more closely mirrors the distribution of the population.

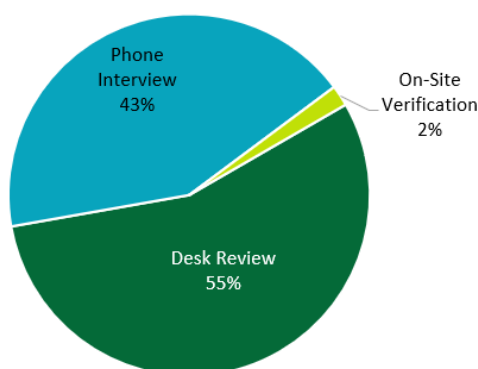
Cadmus evaluated 31 downstream lighting projects and the SWE reviewed each of the verification reports. Of 31 downstream lighting sample points, one received a phone interview, and none received a site visit. Verifications were completed using documents and photos collected by the ICSP. The most frequent evaluation adjustments were for post-install fixture codes and controls. Often, the ICSP used the fixture wattage included in the manufacturer's spec sheets, and Cadmus updated it to reflect the DLC-listed wattage. Most of the adjustments were small and did not materially affect the realization rate. Baseline fixture types and quantities were not usually verified, and Cadmus accepted the ICSP claims with respect to installation quantities, baseline fixture types, operating hours, and other key parameters. In some cases, the HVAC configuration was set to "unknown" instead of using the information listed in project documentation, contacting the participant to ask, or even looking up the building online to see if it had rooftop AC units. The most meaningful evaluation adjustment occurred for new construction lighting, where Cadmus correctly updated the baseline lighting power density values to reflect IECC 2018 allowances. This

adjustment reflects the Commonwealth's adoption of new commercial building codes in 2022, and the subsequent Codes and Standards memo developed by the SWE documenting the impact on the 2021 TRM.

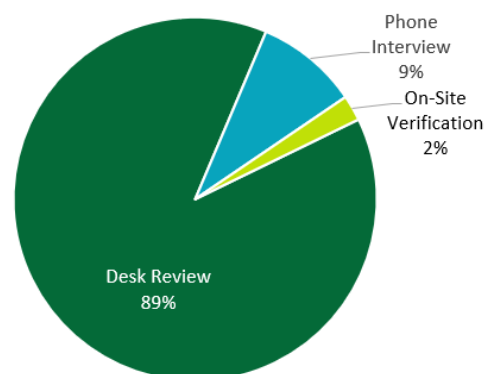
Figure 36 shows the distribution of sampled projects and sampled project energy savings by evaluation method. The kWh contribution shown in the figure is within the sample rather than the expanded population total. Midstream lighting accounted for almost half of the PY16 Efficient Equipment Lighting verified savings so that the phone interview share would be much higher on expanded totals. Downstream lighting projects above the TRM threshold for site-specific data collection relied on logging completed by the ICSP to determine the verified hours of use and coincidence factors so that a subset of the desk review category did include IPMVP Option A – style data collection – albeit not by the evaluator. The absence of primary data collection from the Downstream Lighting strata in PY16 was concerning. The SWE is working with PPL and its evaluator to ensure PY17 includes more phone interviews and site visits to collect key project details.

Figure 36: Summary of PPL's PY16 Efficient Equipment Program Evaluation Activities (Lighting)

Evaluation Activities by Project Count



Evaluation Activities by kWh Contribution



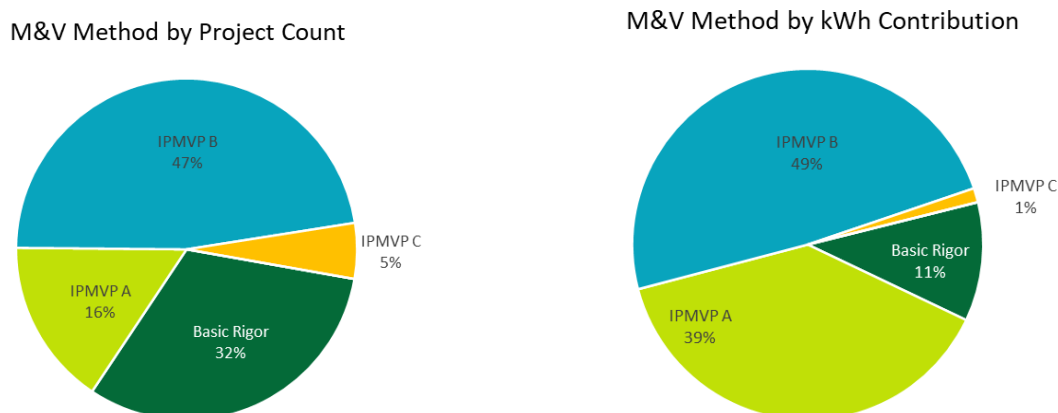
C.5.2.3 Non-Residential Custom Program Component

The evaluation contractor evaluated large (expected energy savings greater than 2,000,000 kWh/yr or high level of uncertainty), small (expected energy savings below 2,000,000 kWh/yr), and CHP projects. Solar PV projects were also included in the large stratum if their expected energy savings exceeded 1 million kWh/yr.

Cadmus evaluated all sampled projects, verifying savings at a high level of rigor, using approaches described in the IPMVP. The CHP project verification strata was a census of the participation population, with Cadmus conducting onsite verification and M&V. Therefore, the projects in these strata achieved realization rates of 100%. Cadmus sampled four small projects and 27 large projects for evaluation in PY16. Cadmus also evaluated four small PY15 projects. Cadmus prepared SSMVPs for each evaluated project and then conducted post-installation inspections and verified savings. IPMVP Option A and B were used to calculate the first-year energy savings for all the sampled projects in large and CHP strata. Similarly, IPMVP Option A and C were used to calculate the first-year energy savings for all the sampled projects in small

strata. Figure 37 provides a summary of the quantity and annual energy savings contribution of the custom projects reviewed by Cadmus for each level of rigor. Nearly half of the projects were evaluated using IPMVP Options B.

Figure 37: Summary of PPL's PY16 Custom Program M&V Methods



C.5.2.4 Verified Savings Audits

The SWE conducted additional audit activities through a detailed review of Cadmus' evaluation work for a sample of their evaluated projects. The SWE audit for Cadmus' activities in PY16 included a review of 12 projects encompassing the following activities:

- Four field and analysis engineers audited
- Two lighting, one refrigeration, two CHP, and seven solar PV measures reviewed
- Thirty-two percent of verified non-residential energy savings reviewed
- Twenty-nine percent of verified non-residential demand savings reviewed

Table 109 provides the overall results of the SWE Verified Savings Audit for C&I projects.

Table 109: PPL C&I Verified Savings Audit Results

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
12	74,857,396	100%	16,069	100%

Overall, the SWE agreed with the calculation methods utilized by PPL's evaluation contractors. The savings calculations and accompanying reports were easy to follow and showed evidence that the TRM was utilized by the contractor for appropriate measures. The SWE agreed with all the engineering decisions made by the evaluators for custom calculations. Therefore, the attainment percentage for the sample of projects was 100% for both energy and demand.

C.6 NTG

Table 110 lists PPL's PY16 NTG results across all programs. Details concerning the methods and data used to estimate NTG values are in sections C.6.1 and C.6.2.

Table 110: Summary of PPL's PY16 NTG Results

Program Name	Component	NTG
Non-Residential	Custom	0.74
Non-Residential	Efficient Equipment	0.64
Low-Income	Low-Income	1.0
Residential	Appliance Recycling	0.50
Residential	Energy Efficient Homes	0.57
Residential	Home Energy Reports	1.0
Residential	Student Energy Efficient Education	1.0
Portfolio Total		0.71

C.6.1 Residential Program

Cadmus planned and conducted PY16 residential program NTG estimation for Energy Efficient Homes. The Energy Efficient Homes NTG was estimated by weighting six program strata NTG values to PY16 gross savings.

New data were collected for the Downstream Equipment stratum, resulting in an NTG of 0.52. For the Midstream Equipment stratum, Cadmus applied measure-level NTG values from the PY16 Downstream Equipment research to comparable measures, yielding an NTG of 0.51. This approach deviated from the original evaluation plan due to a limited number of program participants.

These two strata were combined with NTG values from previously evaluated components:

- Online Marketplace (0.88) and Instant Discount (0.75), estimated in PY15⁷⁷
- Audit and Weatherization (0.62), estimated in PY14⁷⁸
- High Performance Homes, which has a deemed NTG of 1.0

Notably, 79% of PY16 Energy Efficient Homes program savings came from the Downstream Equipment stratum. As a result, the overall Energy Efficient Homes NTG of 0.57 was heavily weighted toward that stratum's NTG value.

For the other programs in the residential portfolio, the Appliance Recycling NTG was estimated previously for PY15. Cadmus continued to assign an NTG of one to Student Energy Efficient

⁷⁷ Cadmus applied the PY15 measure level NTG ratios to PY16 Instant Discount measure-level verified gross savings to derive a NTG ratio of 0.75 for PY16 (compared to a NTG ratio of 0.73 in PY15).

⁷⁸ Cadmus applied the PY14 program sub-component specific "Audit" and "Weatherization" NTG ratios to sub-component verified gross savings to derive a NTG ratio of 0.62 for PY16 (compared to a NTG ratio of 0.61 in PY14).

Education program and Home Energy Report (Table 111). These values contributed to an overall residential program NTG of 0.66.

The SWE reviewed PPL's Phase IV EMV Plan, all surveys, analyses, and data used to estimate NTG and have found that they have correctly employed NTG methodology recommended in the Phase IV Evaluation Framework.

Table 111: Summary of PPL's PY16 Residential NTG Results

Program Name	Approach	Sample Size	Free-ridership	Spillover	NTG
Appliance Recycling (Refrigerators and Freezers)	Historic NTG (PY15)	N/A	0.50	0.00	0.50
Energy Efficient Homes – Audit and Weatherization	N/A	N/A	0.53	0.14	0.62
Energy Efficient Homes – Downstream Equipment	Self-report surveys	266	0.48	0.00	0.52
Energy Efficient Homes – Midstream Equipment	Self-report surveys ¹	147	0.49	0.00	0.51
Energy Efficient Homes – Online Marketplace	Historic NTG (PY15)	N/A	0.20	0.08	0.88
Energy Efficient Homes – Instant Discount	Historic NTG (PY15)	N/A	0.27	0.00	0.75 ²
Energy Efficient Homes – High Performance Homes	N/A	N/A	0%	0.00	1.0
Home Energy Reports	N/A	N/A	N/A	N/A	1.0
Student Energy Efficient Education	N/A	N/A	N/A	N/A	1.0
Residential Total	N/A	N/A	N/A	N/A	0.66

¹ Based on Downstream Equipment self-report survey values

² Updated based on applying PY15 measure level NTG ratios to PY16 Instant Discount measure-level verified gross savings.

C.6.2 Non-Residential Energy-Efficiency Program

For PY16 Non-Residential Program NTG estimation, Cadmus did not collect new data for individual program components. Instead, NTG values were drawn from prior-year studies, as summarized in Table 112. The Midstream Lighting NTG (0.70) was estimated previously for PY15. The Custom NTG (0.74) and Efficient Equipment (0.16 Non-lighting, 0.65 lighting) NTG were estimated previously for PY14. For Midstream Non-Lighting NTG, Cadmus used the previous NTG value from PY15, which applied the recommended NTG from the New Jersey TRM's *NTG Recommendations Guidance Document*.

Table 112: Summary of PPL's PY16 Non-Residential NTG Results

Program Name	Approach	Sample Size	Free-ridership	Spillover	NTG
Custom	Historic NTG (PY14)	N/A	0.26	0.00	0.74
Efficient Equipment Non-Lighting	Historic NTG (PY14)	N/A	0.84	0.00	0.16
Efficient Equipment Lighting	Historic NTG (PY14)	N/A	0.35	0.00	0.65
Midstream Lighting	Historic NTG (PY15)	N/A	0.30	0.00	0.70
Midstream Non-Lighting	Historic NTG (PY15)	N/A	0.06	0.00	0.94
Non-Residential Total	N/A		0.30	0.00	0.70

C.7 TRC

Table 113 shows the high-level TRC Test results for PPL in PY16 at the program component level and for the portfolio overall. The table shows benefits and costs, on a gross basis, for each program component in the PPL portfolio and overall, as well as the resultant TRC Ratios. The components may not add up to the totals due to rounding.

Table 113: Summary of PPL's PY16 TRC Results (\$1,000s)

Program Component	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Low-Income	\$14,200	\$10,225	1.39	\$3,975
Appliance Recycling	\$3,796	\$2,525	1.50	\$1,271
Efficient Lighting	\$0	\$1	0.00	(\$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 Total	\$48,916	\$32,973	1.48	\$15,943
Custom	\$118,574	\$108,009	1.10	\$10,565
Efficient Equipment	\$69,959	\$35,329	1.98	\$34,629
Non-Residential Total	\$188,533	\$143,338	1.32	\$45,195
Cross-cutting	\$0	\$8,152	-	(\$8,152)
Portfolio Total	\$237,449	\$184,463	1.29	\$52,986

¹ Totals may not equal the sum of columns or rows due to rounding.

PY16 TRC test results showed that all program components, except Residential Efficient Lighting and Residential Home Energy Report, were cost-effective on a gross basis. The two non-cost-effective program components had the lowest associated costs and thus did not significantly affect the Portfolio TRC ratio. The Non-Residential sector accounted for roughly 80% of the total TRC Gross Benefits in PY16. The Residential program component with the highest individual Gross TRC benefits was Student Energy Efficient Education at 4.25.

C.7.1 Notes from the TRC Model Review

The PY16 TRC model was developed by Cadmus for PPL. Below is a summary of the assumptions and inputs verified by the SWE.

- For the larger of the two CHP projects claimed in PY16, the increased natural gas consumption required to power the CHP was quantified in MMBtu/year but treated as therms/year in the Cadmus TRC model. This caused the negative fossil fuel benefits to be understated by a factor of 10. The correction lowered the portfolio TRC ratio from 1.31 to 1.29. All TRC Test results in this report reflect the corrected fossil fuel benefits.
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. The SWE was able to recreate the PY16 fossil fuel benefits through a similar process as described for the electric benefits. The derivation of these non-electric impacts was well-documented in PY16 with supporting workbooks for each program.
- Review of the TRC model found that PPL correctly applied the 2021 TRC Test Order nominal discount rate of 5.0%. In Phase IV the Commission directed all EDCs to use a common discount rate rather than their own weighted average costs of capital as had been done in previous phases.
- The correct line-loss multipliers of 1.042 for Large C&I and 1.0875 for Small C&I and Residential were used for all measures. Consistent with the 2021 TRC Test Order, avoided distribution capacity benefits were omitted for Large C&I measures with a LLF of 1.042. The rationale being that these customers take primary service from PPL and their peak-demand reductions have little to no impact on the secondary distribution network.
- Approximately 63% of the TRC benefits for the Low-Income program come from water benefits rather than avoided energy. The TRC model assumes that low-flow measures installed in PY16 will save 114 million gallons of water annually for a weighted average EUL of nearly ten years. Many of these water-saving devices were delivered via kits so the installation rate of the devices has important implications for both water and energy conservation. Similarly, 45% of the TRC benefits for the Residential program were attributable to avoided water and fossil fuel consumption – largely due to the prevalence of low-flow devices like showerheads and aerators.
- For many measures, the Cadmus TRC model relied on incremental cost assumptions from Version 5.1 of the Incremental Measure Cost Database released November 7, 2024, as an exhibit to the 2026 TRC Test Final Order. Use of these current incremental measure cost assumptions should improve the accuracy of the TRC Test results, given the rapid change in equipment costs for key measure categories in recent years.
- The SWE found that PPL utilized a replacement on burnout measure vintage for incremental measure costs for prescriptive non-residential LED lighting measures. The savings and associated benefits were calculated using the early replacement vintage per the 2021 TRM. This inconsistent perspective on measure vintage creates an upward bias in the TRC test results.
- The SWE found, through spot checking, that EULs were correctly applied from the 2021 TRM.

C.8 PROCESS

C.8.1 Residential Program

The Residential Program is made up of the following components and sub-components, shown below:

- Appliance Recycling component (no process evaluation in PY16)
- Efficient Lighting component (no process evaluation in PY16)
- Energy Efficient Homes component
 - Audit and Weatherization sub-component
 - New Homes sub-component (no process evaluation in PY16)
 - Online Marketplace sub-component (no process evaluation in PY16)
 - Downstream Equipment sub-component
 - Midstream Equipment sub-component
 - Instant Discount (no process evaluation in PY16)
- Student Energy Efficient Education component
- Home Energy Efficiency Report component (new in PY16)

Table 114 summarizes program component or sub-component satisfaction for the Residential Program.

Table 114: PPL PY16 Program Satisfaction Summary- Residential Program

Program Component / Sub-component	Population	% Satisfied
Energy Efficient Home – Audit and Weatherization	Participants	81%
Energy Efficient Homes – Equipment (downstream)	Participants	92%
Energy Efficient Homes – Overall	Participants	91%
Student Energy Efficient Education	Students	85%
Student Energy Efficient Education	Teachers	100%
Student Energy Efficient Education – Overall	Students and Teachers	86%
Home Energy Reports	Participants	65%
Residential Program – Overall	Participants, Teachers, Students	67%

C.8.1.1 Appliance Recycling

A limited process evaluation was conducted in PY16, consisting of two stakeholder interviews with PPL and CSP program managers to discuss program changes. There were no participant surveys in PY16, though the Cadmus team calculated satisfaction by averaging the percentages from PY13 through PY15 (n=742), yielding a satisfaction score of 96%. This score is not included in the overall residential program satisfaction estimate included in Table 114 since the table is intended to report on research conducted in PY16.

C.8.1.2 Efficient Lighting

No process evaluation was conducted in PY16.

C.8.1.3 Energy Efficient Homes

Summary of Process Evaluation Results

For the process evaluation of this program component, Cadmus reviewed program documents and data, interviewed PPL and CSP program managers, interviewed the CSP's subcontractors, and surveyed customers and interviewed one of two participating distributors and one of three purchasers or contractors. The research issues addressed by the primary data-collection activities (IDIs and surveys) included the effectiveness of program administration, implementation, and delivery; ease of participation; customer program component satisfaction; drivers of program component satisfaction; opinions about PPL; program influence on sales and stocking practices; customer and trade ally feedback; and recommendations. Based on these data, the following key process findings emerged:

- Downstream Equipment and Audit and Weatherization participants were satisfied with their experience; 91% of respondents were very satisfied or somewhat satisfied (n=304). Overall satisfaction for these components increased from PY15 by 4%.
- Downstream Equipment respondents' satisfaction was particularly driven by the rebate amount, the amount of time it took to receive the rebate, and increased energy savings. Similarly, Audit and Weatherization respondents' satisfaction was driven by the rebate they received, increased energy savings, and reduced energy bills.
- Downstream Equipment overall satisfaction in PY16 (92%, n=260) increased by 6% from PY15 (86%, n=325). However, Audit and Weatherization overall satisfaction in PY16 (81%, n=44) decreased by 10% from PY15 (91%, n=49).
- The decrease in the Audit and Weatherization overall satisfaction is due to four survey respondents who were not satisfied with the program citing the quality of the equipment or services they received, the time it took for them to receive a rebate in the mail, a lack of clarity on why part of their weatherization project did not receive a rebate, not being informed about the rebate by the contractor who filed it for them, and wanting the audit to be in-person rather than over the phone.
- Both the contractor and distributor reported that the process of joining the program and submitting rebate applications went quite smoothly. Both interviewees rated themselves as somewhat satisfied with their program experience.
- The distributor noted that participation helped increase their sales and open new markets for them while the contractor said that the rebate and utility program participation were good points in their advertising to customers.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

The evaluation targeted all eligible Audit and Weatherization participant survey responses and all eligible Downstream Equipment participant survey responses. It achieved a total of 44 Audit and Weatherization participant survey responses and 260 Downstream Equipment participant survey responses. Cadmus also completed interviews with distributors and contractors participating in the Midstream Equipment component. It targeted all eligible distributors and contractors and achieved a total of one distributor responses and one contractor interview responses.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations. There were three process recommendations made for program improvement; PPL Electric Utilities acknowledged these recommendations, implemented one and has taken the two others under consideration. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.1.4 Student Energy Efficient Education

Summary of Process Evaluation Results

For the process evaluation of this program component, Cadmus reviewed program documents and data, interviewed PPL and CSP program managers, and surveyed participants (e.g., teachers and students). The research issues addressed by the primary data-collection activities (IDIs and surveys) included the effectiveness of program administration, implementation, and delivery; student and teacher program component satisfaction; teacher feedback; and recommendations. Based on these data, the following key process findings emerged:

- Student satisfaction (percentage somewhat or very satisfied) declined slightly in PY16 from PY15 for kits (84% from 86%) and presentations (82% from 83%). However, teacher satisfaction with presentations grew from 87% to 93%.
- Overall program component satisfaction remained high with 85% of students and 100% of teachers responding that they are somewhat or very satisfied. Student satisfaction ranged from 78% for Innovation students to 93% for Bright Kids students. Innovation student satisfaction decreased from PY15 to PY16, changing from 79% to 77% for kits and 80% to 76% for presentations.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

The evaluation targeted all eligible student and teacher survey responses. It achieved a total of 15,083 student survey responses and 166 teacher survey responses.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations, though there were no process recommendations made for program improvement in PY16 for this sub-component.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.1.5 Home Energy Report

Summary of Process Evaluation Results

Since the Home Energy Report component of the Residential Program was started in PY16, there is no comparison to previous years. For the process evaluation of this program component, Cadmus reviewed program documents and data, including the program logic model, interviewed PPL and CSP program managers, and surveyed participants (treatment group) as well as a control group who had not received Home Energy Reports. The research issues addressed by the primary data-collection activities (IDIs and surveys) included the effectiveness of program administration, implementation, and delivery; treatment group satisfaction; drivers of treatment group satisfaction; treatment group experience with the home energy reports, control group baseline comparison of information seeking behavior; home energy report recommendations; awareness of programs and rebate offers; engagement with the PPL website; engagement in energy saving behaviors and home improvement; barriers to engaging in energy saving behaviors and overcoming challenges; and customer perceptions of PPL. Based on these data, the following key process findings emerged:

- Participants were moderately satisfied with Home Energy Reports overall with 65% of respondents being very satisfied or somewhat satisfied (n=492). The most common drivers of high satisfaction were tips for optimizing energy efficiency (63%) and comparison with similar homes (62%). The most common driver of lower satisfaction was that the respondents did not believe the comparisons to similar homes were accurate (33%).
- Respondents who received Home Energy Reports had a higher satisfaction rate for PPL Electric Utilities as a whole (79%) than those in the control group who had not received Home Energy Reports (71%)

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. The evaluation targeted 55,000 customers in the treatment group and 35,000 customers in the control group. It had set a goal of 240 responses for each group. The study exceeded this goal with 475 treatment group responses and 522 control group responses

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations. There was one process recommendation made for program improvement; PPL Electric Utilities acknowledged the recommendation and has taken it under consideration.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.2 Non-Residential Program

The Non-Residential Program is made up of the following components and sub-components, shown below:

- Efficient Equipment component
 - Downstream including lighting and equipment participant pathways (process evaluation in PY16)
 - Midstream sub-component, including lighting and equipment participant pathways (no process evaluation in PY16)
- Custom component (process evaluation in PY16)

Table 115 summarizes program component or sub-component satisfaction for the Non-Residential Program.

Table 115: PPL PY16 Program Satisfaction Summary- Non-Residential Program

Program Component / Sub-component	Population	% Satisfied
Efficient Equipment and Lighting (downstream)	Participants	96%
Custom	Participants	86%
Non-Residential Program – Overall	Participants	94%

C.8.2.1 Efficient Equipment (Downstream, Direct Discount, and Direct Install)

Summary of Process Evaluation Results

For the process evaluation of this program sub-component, Cadmus interviewed PPL and CSP program managers, and surveyed participants. The participant surveys were not part of the evaluation plan but added at the request of PPL Electric Utilities. The research issues addressed by the primary data-collection activities (IDIs and surveys) included the effectiveness of program administration, implementation and delivery; customer program satisfaction, drivers of program sub-component satisfaction; and customer expectations. Based on these data, the following key process findings emerged:

- Most respondents were very or somewhat satisfied with the component overall (96%; n=23), the outcome from the most recent Energy Efficiency initiative (88%; n=25), and PPL Electric Utilities as an electric provider (96%; n=27).
- 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.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan, with one exception. At the request of PPL Electric Utilities, Cadmus conducted an online survey to measure customer satisfaction among participants, reaching out to all eligible participants. This survey generated 27 responses, covering downstream and direct discount participants.

The SWE determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations, though there were no process recommendations made for program improvement in PY16 for this sub-component. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.2.2 Efficient Equipment (Midstream)

No process evaluation was conducted in PY16.

C.8.2.3 Lighting (Midstream)

No process evaluation was conducted in PY16.

C.8.2.4 Custom

Summary of Process Evaluation Results

For the process evaluation of this program component, Cadmus reviewed program documents and data, interviewed PPL and CSP program managers, and surveyed participants. The research issues addressed by the primary data-collection activities (IDIs and surveys) included the effectiveness of program administration, implementation, and delivery; customer program satisfaction; and drivers of program sub-component satisfaction. Based on this data, the following key process findings emerged:

- 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). The top reasons for respondent satisfaction were the rebate amount (four respondents), the application process (four respondents), and the timeliness of the rebate payment (three 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%).

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan with one exception. The approved Phase IV Evaluation Plan did not include a participant survey, but PPL added one to the PY16 evaluation.

The evaluation targeted a census of custom participant survey responses and achieved a total of seven participant survey responses.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations though there were no process recommendations made for program improvement in PY16 for this sub-component. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.3 Low-Income Program

The Low-Income Program is made up of the following components shown below:

- Remote Energy Assessments (REA)
- On-site Assessments
- Welcome Kits

Table 116 summarizes program component satisfaction for the LI Program.

Table 116: PPL PY16 Program Satisfaction Summary- LI Program

Program Component	Population	% Satisfied
Remote Energy Assessments (REA)	Participants	78%
On-site Assessments	Participants	78%
On-site Assessments	Master-Metered Multifamily (MMMF) Building Managers	100%
Welcome Kits	Participants	84%
LI Program – Overall	Participants	82%

C.8.3.1 Remote Energy Assessment (REA)

Summary of Process Evaluation Results

For the process evaluation of this program component, Cadmus reviewed program documents and data, conducted bi-monthly check-in meetings with PPL and CSP program managers, and surveyed participants. The research issues addressed by the primary data-collection activities (bi-monthly check-in meetings and surveys) included the effectiveness of program administration, implementation, and delivery; ease of participation; customer program satisfaction, likelihood to

recommend the program; drivers of program component satisfaction; opinions about PPL; energy-saving behaviors; and information from energy advisors. Based on these data, the following key process findings emerged:

- The program component had an overall customer satisfaction rate of 78%, down from 88% in PY15. Respondents who gave low satisfaction scores most frequently cited “other” as the reason they gave the rating; the open-ended responses indicated that expectations, such as for new appliances or equipment, were not met. The most common driver of program satisfaction was reduced energy bills.⁷⁹
- Over half (52%) of respondents noted their opinion of PPL Electric Utilities had improved after participating in the program, 37% said their opinion had not changed, and 11% said their opinion decreased.⁸⁰

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

The evaluation targeted all eligible participant survey responses and achieved a total of 64 participant survey responses for the Remote Energy Assessment sub-component.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations for the Low-Income Program as a whole. There were two process recommendations made for improvement of the Low-Income Program as a whole; PPL Electric Utilities implemented the recommendation. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

C.8.3.2 On-Site Assessments

Summary of Process Evaluation Results

For the process evaluation of this program sub-component, Cadmus reviewed program documents and data, conducted bi-monthly check-in meetings with PPL and CSP program managers, and surveyed participants. The research issues addressed by the primary data-collection activities (bi-monthly check-in meetings and surveys) included the effectiveness of program administration, implementation, and delivery; ease of participation; customer program satisfaction, likelihood to recommend the program; drivers of program component satisfaction;

⁷⁹ The reasons for both low and high satisfaction scores apply to both REA and the on-site assessments.

⁸⁰ This applies to both REA and on-site assessments.

opinions about PPL; energy-saving behaviors; and information from energy advisors. Based on these data, the following key process findings emerged:

- The program had an overall customer satisfaction rate of 78%, down from 88% in PY15. Respondents who gave low satisfaction scores most frequently cited “other” as the reason they gave the rating; the open-ended responses indicated that expectations, such as for new appliances or equipment, were not met. The most common driver of program satisfaction was reduced energy bills.⁸¹
- Over half (52%) of respondents noted their opinion of PPL Electric Utilities had improved after participating in the program, 37% said their opinion had not changed, and 11% said their opinion decreased.⁸²
- Cadmus completed one interview with a master-metered multifamily (MMMF) building managers. 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 by energy savings, bill reductions, and property improvements resulting in better lighting.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

The evaluation targeted all eligible participant survey responses and achieved a total of 154 participant survey responses for the On-site Assessment sub-component. The evaluation also targeted all 11 unique MMMF building owners and had a completion target of five in the evaluation plan. Both Cadmus and the ICSP made multiple attempts via email and telephone to reach all participants; however, despite these attempts, only one response was achieved.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations for the Low-Income Program as a whole. There was one process recommendation made for improvement of the Low-Income Program as a whole; PPL Electric Utilities implemented the recommendation. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

⁸¹ The reasons for both low and high satisfaction scores apply to both REA and the on-site assessments

⁸² This applies to both REA and on-site assessments

C.8.3.3 Welcome Kits

Summary of Process Evaluation Results

For the process evaluation of this program sub-component, Cadmus reviewed program documents and data, conducted bi-monthly check-in meetings with PPL and CSP program managers, and surveyed participants. The research issues addressed by the primary data-collection activities (bi-monthly check-in meetings and surveys) included the effectiveness of program administration, implementation, and delivery; customer program satisfaction, drivers of program sub-component satisfaction; and opinions about PPL. Based on these data, the following key process findings emerged:

- Most respondents were satisfied with the welcome kit with 84% overall satisfaction. These results are similar to PY13 and PY14. Cadmus did not survey welcome kit respondents in PY15.
- The key driver of satisfaction with welcome kits was the equipment quality (39%).
- Over half (62%) said their opinion of PPL Electric Utilities had improved after receiving the kits, 30% said their opinion had not changed, and 7% said their opinion had decreased.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase IV Evaluation Plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy.

The evaluation targeted all eligible participant survey responses, contacted about a third of kit recipients, and achieved a total of 38 participant survey responses for the Welcome Kits sub-component.

The SWE also determined that the reporting followed the SWE guidelines. The PPL PY16 Annual Report included descriptions of the methods, summary of conclusions, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations for the Low-Income Program as a whole. There was one process recommendation made for improvement of the Low-Income Program as a whole; PPL Electric Utilities implemented the recommendation. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

Appendix D Duquesne Light PY16 Audit Detail

D.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework; followed proper custom site-specific M&V activities; applied TRM protocols correctly; and are generally accurate. The SWE made minor recommendations to Guidehouse regarding the evaluation of large PV systems with limited on-site data, resulting in less than 1% difference in final savings values. The SWE's feedback was provided to the evaluator with sufficient time for Duquesne Light to include all suggested changes in their PY16 Annual Report.
- The SWE's review of verified savings for residential components, which include income-eligible programs, found that, overall, the verification process followed proper TRM protocols and Guidehouse's EM&V plans.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The Duquesne Light portfolio was cost-effective in PY16, with a gross TRC ratio of 2.04. Duquesne Light consistently shows the highest benefit cost ratio statewide due to the lowest assumed incremental measure cost per lifetime MWh. The PY16 TRC audit flagged asymmetry in the handling of fossil fuel impacts. While Duquesne quantifies and monetizes as negative benefits, the increased fossil fuel consumption associated with LED lighting installations, the fossil fuel savings from weatherization, smart thermostat, and low-flow devices were ignored.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Duquesne Light's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE was able to replicate the reported MWh savings and reported MW savings exactly. The SWE was unable to replicate participant counts and incentives exactly using the tracking data, but the SWE did not expect to be able to do so and the differences were generally small.
- Duquesne Light had eleven active behavioral HER cohorts in PY16 with approximately 270,000 treated households. Three of the cohorts consisted of low-income households, but the low-income cohorts only accounted for approximately 9.2% of the PY16 verified HER savings. On average, HER recipients saved approximately 29 kWh, or 0.4% of their annual consumption in PY16. While participation increased for PY16, the average savings per participant is slightly lower than PY15. Six cohorts were mature enough to require persistence calculations to separate incremental savings from persisting savings from prior exposure. The SWE was able to replicate the verified energy and demand savings values and found that HER impact evaluation was entirely consistent with their proposed and approved EM&V plans and the Phase IV HER account framework.

- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of Duquesne Light's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data with some exceptions.
- Overall, Guidehouse estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- No process evaluations were conducted in PY16.

D.2 EM&V PLAN REVIEWS

Duquesne Light's evaluation contractor, Guidehouse, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, Guidehouse submitted several memos detailing their sampling approach for program components selected for impact, process and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 117](#) shows which Duquesne Light programs produced verified impacts in PY16 and which used historic realization rates in PY16.

Table 117: PY16 Duquesne Light Program Impact Evaluation Summary

Sector	Program	PY16 Impacts
Residential	Upstream Incentives	NA ¹
	Midstream Incentives	NA ¹
	Downstream Incentives	Verified (New Customer Kits)
	Appliance Recycling	Historic Realization Rate
	Residential Behavioral	Verified
Low-Income	Low-Income Behavioral	Verified
	Low-Income Energy Efficiency	Verified
Small C&I	Small Business Direct-Install	Historic Realization Rate
	Small Business Solutions	2-year sample
	Small Business Midstream	NA
	Small Virtual Commissioning	Historic Realization Rate
	Large Business Solutions	2-year sample
Large C&I	Large Business Midstream	NA
	Large Virtual Commissioning	Historic Realization Rate

¹ The following programs were not active in PY16 and therefore not verified: Residential Upstream Incentives, Residential Midstream Incentives, Small and Large Business Midstream.

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft surveys and interview guides for the applicable delivery channels.

D.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework allows a maximum level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. Duquesne Light’s energy-efficiency portfolio consists of multiple programs that serve multiple sectors. [Table 118](#) shows the reported relative precision of savings estimates by sector and program. The Appliance Recycling initiatives, as well as Small Business Direct Install and Small and Large Business Virtual Commissioning were verified using historic realization rates and are therefore omitted from the table below. Behavioral programs that do not have uncertainty associated with sampling are also omitted from the table. Residential Midstream and Upstream Incentives, and Small Business Midstream Solutions had limited activity in PY16 and are likewise omitted from the table, despite being included in this year’s evaluation plan.

Regarding the Low-Income Energy Efficiency program, the sample for the direct-install participant survey did not result in any responses for appliance measures installed through the audit. Therefore, Guidehouse applied a historic realization rate from the PY14 analysis to that stratum.

Though the original evaluation plan did not schedule an evaluation of Residential Downstream Incentives in PY16, Guidehouse evaluated the new RDIP customer kit, given the significant amount of savings associated with the component.

For Small and Large Business Solutions, Guidehouse combined both the PY15 and PY16 populations when determining the PY16 evaluation sample and included the realization rates of the sites sampled in PY15 in determining the rolling 2-year realization rate.

Table 118: Relative Precision of PY16 Impacts by Component at the 85% Confidence Level

Sector	Program/Initiative	Relative Precision (Energy)	Relative Precision (Demand)
Residential Program	Downstream Incentives (RDIP only)	4%	2%
	Low-Income Energy Efficiency	2%	5%
Small C&I	Small Business Solutions	10%	14%
Large C&I	Large Business Solutions	3%	7%
	Large Business Midstream Solutions	13%	9%

In addition to reporting relative precision by program, Guidehouse also reported relative precision at an aggregated initiative level. All initiatives evaluated during PY16 met the 85/15 precision requirement for energy and demand impacts. The SWE was able to replicate the realization rates and relative precision figures provided by Guidehouse for most of the initiatives using standard roll-up procedures.

Not all programs rely on sampling to estimate verified savings. For the Residential and Low-Income Behavioral programs, the impact evaluation relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. The precision requirements for the behavioral program are unique, with the Phase IV Evaluation Framework requiring the solution-level verification to achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). This requirement for program design is less stringent than the sampling requirement, described above, that programs annually achieve $\pm 15\%$ relative precision at the 85% confidence level. Standard precision requirements are not reasonable expectations for behavioral programs because the size of the average effect is typically much smaller, and all estimation error is captured as opposed to sampling error only. The SWE reviewed the design of Duquesne Light's behavioral offerings and found the treatment and control group sizes were adequate to achieve ± 0.5 absolute precision at the 95% confidence level in aggregate.

D.4 REPORTED GROSS SAVINGS AUDITS

D.4.1 Tracking Data Review

This report section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Duquesne Light's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts
- Incentive dollars

The SWE leveraged Duquesne Light's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset, rather a subset of the full tracking dataset tailored to our quarterly data request. Note that HER programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding Duquesne Light's Residential and Low-Income Behavioral Savings programs can be found in [Appendix D.5.1](#).

[Table 119](#) summarizes our findings regarding reported gross energy savings. The "Match" column contains "Yes" if the tracking data supports the values in Duquesne Light's PY16 Annual Report and "No" otherwise. The SWE was able to replicate all values reported by Duquesne Light.

Table 119: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Residential Downstream Incentives	13,096	13,096	Yes
Residential Midstream Incentives	-	-	Yes
Residential Upstream Incentives	-	-	Yes
Residential Appliance Recycling	1,408	1,408	Yes
Low Income Energy Efficiency	2,431	2,431	Yes
Small Business Direct Install	473	473	Yes
Small Business Solutions	5,936	5,936	Yes
Small Business Midstream Solutions	-	-	Yes
Small Business Virtual Commissioning	101	101	Yes
Commercial Large Business Solutions	22,139	22,139	Yes
Industrial Large Business Solutions	2,469	2,469	Yes
Large Business Midstream Solutions – Commercial	8,797	8,797	Yes
Large Business Midstream Solutions – Industrial	1,426	1,426	Yes
Large Business Virtual Commissioning	244	244	Yes
Portfolio Total	58,993	58,993	Yes*

*The Residential Behavioral and Low-Income Behavioral programs are not included in this table.

[Table 120](#) summarizes the SWE's findings regarding reported gross peak-demand savings, by program. The tracking data is provided at the meter-level. To facilitate the comparison, the SWE

applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. The SWE was able to replicate all values reported by Duquesne Light.

Table 120: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Residential Downstream Incentives	1.71	1.71	Yes
Residential Midstream Incentives	-	-	Yes
Residential Upstream Incentives	-	-	Yes
Residential Appliance Recycling	0.37	0.37	Yes
Low Income Energy Efficiency	0.19	0.19	Yes
Small Business Direct Install	0.06	0.06	Yes
Small Business Solutions	1.15	1.15	Yes
Small Business Midstream Solutions	-	-	Yes
Small Business Virtual Commissioning	0	0	Yes
Commercial Large Business Solutions	4.44	4.44	Yes
Industrial Large Business Solutions	0.30	0.30	Yes
Large Business Midstream Solutions – Commercial	1.75	1.75	Yes
Large Business Midstream Solutions – Industrial	0.38	0.38	Yes
Large Business Virtual Commissioning	-	0	Yes
Portfolio Total	10.41	10.41	Yes*

*The Residential Behavioral and Low-Income Behavioral programs are not included in this table.

The SWE also used the tracking data to audit Duquesne Light's reported participation counts and customer rebate amounts. Like with the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by Duquesne Light. No substantive issues were discovered.

D.4.2 Project File Reviews

D.4.2.1 Residential

The SWE conducted a project file review for a sample of projects within Duquesne Light's residential programs in PY16 as part of the reported savings (i.e., ex ante) review. The project file documentation was provided by Duquesne Light, the program implementers, and the evaluation contractor, Guidehouse, in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, and post-inspection forms. The sampled project file packages included most of the documentation requested.

Table 121 presents a summary of the SWE's residential project file reviews. Project files were found to match most of the tracking data, though there were some exceptions.

Table 121: Duquesne Light PY16 Residential Project File Review

Program	Sub Program	Number of Files Reviewed	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data? ¹
Residential Downstream Incentives	Rebates, Audits, EE Education	21	✓	✓	✓	✓
Residential Appliance Recycling		39	✓	✓	✓	✓
Residential Midstream Incentive		-	-	-	-	-
Residential Upstream Incentive	Lighting, Appliances	-	-	-	-	-
Low-Income Energy Efficiency		30	✓	✓	✓	✓

¹ It should be noted that while the data typically matches, minor discrepancies were found and are detailed in the paragraphs below.

As detailed above, the requested number of project files and supporting details were submitted for the residential program. Below is a summary of the SWE's review of the project file packages and quarterly tracking data.

In general, the SWE found that tracking data matched the measures and quantities in project documentation. Overall, the SWE felt that the documentation provided for Duquesne Light residential and low-income programs fulfilled the requirements.

Residential Downstream Incentives

The Residential Downstream Incentives program had project files containing invoices on purchased refrigerators, dehumidifiers, thermostats, heat pumps, and other energy efficient equipment. The SWE verified that all the reviewed project files matched the measures and quantities in the tracking data.

Residential Appliance Recycling

The Residential Appliance Recycling program had project files containing photos of the recycled appliances. The SWE verified that most of the reviewed project files matched the measures and quantities in the tracking data. The SWE noted seven instances where the program provided photographic documentation but not proof of the appliance's model number.

Residential Midstream Incentive

There had limited participation in PY16 and therefore this program was not part of the project file review.

Residential Upstream Incentive

This program was not in operation in PY16 and therefore not part of the project file review.

Low-Income Energy Efficiency

The Low-Income Energy Efficiency program had project files containing invoices on purchased LED lighting, faucet aerators, showerheads, smart strips, and other energy efficient equipment. The SWE verified that the reviewed project files matched the measures and quantities in the tracking data. However, the SWE does note that there were multiple cases where the tracking data did not align with the documentation.

Nine sites in Q3 and Q4 documented more LED lights, night lights, power strips, and showerheads than were listed in the tracking data. It is unclear if this was an error, or if these entries were deemed inappropriate for the program. Conversely, for one site in Q4, the tracking data describes an air-source heat pump that is not documented in the site documentation. The site documentation describes an existing central air system.

D.4.2.2 Non-Residential

The SWE reviewed a sample of Duquesne Light's Small C&I, Large C&I, and Industrial C&I projects for PY16 using the project documentation provided by the evaluation contractor in response to the SWE's standing quarterly data request. The project file packages included savings calculation worksheets, rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the reviewed project file packages included all documentation requested and were well organized, allowing for a comprehensive review of the forty-three projects sampled.

[Table 122](#) presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 122: Duquesne Light PY16 C&I Project File Review Summary

Program	Sub-Program	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
SBS	Small Commercial Business Solutions	4	✓	✓	✓	✓	✓
SBDI	Small Business Direct Install	4	✓	✓	✓	✓	✓
LBS	Large Commercial Business Solutions	4	✓	✓	✓	✓	✓
LBS	Large Industrial Business Solutions	3	✓	✓	✓	✓	✓
Midstream	Large Commercial	4	✓	✓	✓	✓	✓
Midstream	Large Industrial	4	✓	✓	✓	✓	✓

D.5 VERIFIED GROSS SAVINGS AUDITS

D.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of Duquesne Light's portfolio of residential programs. Duquesne Light's portfolio of residential programs consists of the following programs: Residential Downstream Incentives Program (RDIP), Residential Appliance Recycling Program (RARP), Residential Behavioral Savings Program, Residential Midstream Incentive Program (RMIP), Residential Upstream Incentive Program (RIUP) and the Residential LI Energy-Efficiency Program (LIEEP). Note that the SWE reports the residential savings in two sections: residential and behavior.

Table 123 provides a summary of the evaluation and M&V approaches used by Duquesne Light in their PY16 verified savings calculations.

Table 123: Residential Program Evaluation Activities – Duquesne Light

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied Historic RR
RDIP (Rebates)	-	-	-	-	✓
RDIP (Audits)	-	-	-	-	✓
RDIP (Kits)	✓	-	-	-	-
RARP	-	-	-	-	✓
RMIP ^b	-	-	-	-	-
RIUP ^b	-	-	-	-	-
LIEEP – Audits	✓	-	-	-	-
Residential Behavior Savings	-	-	-	✓	-

^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.

^b The Residential Midstream and Upstream Incentive programs were not evaluated due to limited activity.

The SWE's review of verified savings for residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE review includes descriptions of the measures within each program and reviewed evaluation activities. No discrepancies were observed.

Residential Downstream Incentive Program (RDIP)

The Residential Downstream Incentive Program provides rebates for HVAC, connected thermostats, heat pump water heaters, appliances, and a mix of other energy efficient measures. RDIP also provides energy efficiency audits to residential customers, which sometimes result in the direct installation of measures such as LEDs, advanced power strips, and nightlights.

Additionally, RDIP provides a variety of kits to K-12 students, which include energy saving measures to be installed in the home.

The final report combines the savings from rebates, audits, and kits together. The SWE confirmed the rebate and audit samples correctly applied survey results and calculated measure-level savings in accordance with the TRM. The realization rates for these samples were correctly applied from each sampled stratum to the population and the SWE verified the savings were aligned in the EDC report. The evaluation contractor, Guidehouse, conducted a tracking data review to verify that kit savings calculations and the inputs were in accordance with the TRM for all distributed kits. The SWE confirmed that the verified savings values for kits were in accordance with the TRM and aligned with the PY16 EDC annual report.

Residential Appliance Recycling Program

The Residential Appliance Recycling Program (RARP) allows customers to recycle refrigerators, freezers, room air conditioners, and dehumidifiers. The program claims savings based on the energy participants save from the retirement of this old equipment. The SWE confirmed savings calculations correctly applied survey results, savings were calculated in accordance with the TRM, and the verified savings results aligned with the EDC report for energy and demand savings for each appliance type.

Residential Midstream Incentive Program

There was no evaluation conducted for the Residential Midstream Incentives Program in PY16 due to limited activity.

Residential Upstream Incentive Program

There was no evaluation conducted for the Residential Upstream Incentives Program in PY16 due to limited activity.

Low-Income Energy-Efficiency Program

Duquesne Light offers low-income customers no-cost energy audits and a range of directly installed energy saving measures. In PY16 Guidehouse conducted a participant survey for the direct-install component of the program and an engineering desk review of the giveaway component. The SWE confirmed savings calculations correctly applied survey results, savings were calculated in accordance with the TRM, realization rates for samples were correctly applied from each sampled stratum to the population, and the verified energy and demand savings aligned with those in the EDC report.

Behavior

Approximately 10% of Duquesne Light's verified gross energy savings for PY16 came from Home Energy Reports (HERs) issued to around 277,000 residential market-rate and residential low-income households. Twenty-one percent of Duquesne Light's progress toward its low-income target in PY16 came from HERs. Duquesne Light's behavioral portfolio consists of twelve different waves in total. In PY16, eleven waves were active and received HERs. The 2018 Low-Income wave was the only inactive wave in PY16. [Table 124](#) shows the average number of treatment and control group homes for the eleven active waves during PY16. Duquesne Light has eight market-rate waves, which began receiving HERs in 2012, 2015, 2021, 2023, and 2024. It also has three

waves targeting low-income households, which began receiving HERs in 2015, 2021, and 2023. The 2021 and 2023 cohorts include separate waves for homes receiving Digital HER delivery and traditional Non-Digital HER delivery.

Details regarding our review of Guidehouse's evaluation of Duquesne Light's HER offerings are provided below. In summary, the SWE team did not find any issues with Guidehouse's evaluation and does not propose any revisions to the reported PY16 methods or results.

Table 124: Duquesne Light HER Waves Summary

Wave	First HER Mailing	Treatment Group Homes	Control Group Homes
2012 Market-Rate	July 2012	11,246	29,463
2015 Low-Income	March 2015	6,371	2,940
2015 Market-Rate	March 2015	29,147	10,177
2021 Digital	October 2021	53,151	13,936
2021 Low-Income	October 2021	7,773	5,609
2021 Non-Digital	October 2021	54,419	15,449
2023 Digital	July 2023	40,273	11,628
2023 Low-Income	July 2023	14,792	5,822
2023 Non-Digital	July 2023	13,583	8,123
2024 Digital 1	June 2024	29,708	10,545
2024 Digital 2	June 2024	16,833	9,123
Total		277,296	122,815

RCT Validation

Assuming treatment and control groups consume the same amount of energy prior to HER delivery, differences between the groups after HER delivery begins can be attributed to the HER messaging. Thus, one important step in our analysis is to compare pre-treatment consumption in the treatment and control groups for each wave. Ideally, average daily consumption is approximately the same between the two experimental groups.

The SWE team verified that pre-treatment daily usage was similar between treatment and control groups by (1) performing a simple fixed-effects regression, and (2) performing a t-test of daily usage between treatment and control. By wave, results for these tests are shown in [Table 125](#). The test results indicate that any pre-treatment differences between experimental cells are not statistically significant. Note: these tests were run exclusively on accounts that were still active in PY16.

Table 125: Pre-Treatment Equivalence Tests on Daily Usage

Wave	Average Daily Pre-Treatment Usage (kWh)		FE Regression		T-Test P-value ¹
	Treatment	Control	Treatment Effect	P-value ¹	
2012 Market-Rate	38.0	37.9	0.089	0.542	0.525
2015 Low-Income	24.8	24.5	0.287	0.342	0.300
2015 Market-Rate	26.1	26.2	-0.037	0.786	0.816
2021 Digital	22.9	23.0	-0.127	0.349	0.393
2021 Low-Income	24.8	24.8	0.014	0.948	0.757
2021 Non-Digital	20.0	20.2	-0.144	0.228	0.247
2023 Digital	18.1	18.1	0.028	0.830	0.740
2023 Low-Income	19.3	19.4	-0.085	0.676	0.700
2023 Non-Digital	13.4	13.5	-0.065	0.622	0.557
2024 Digital 1	21.5	21.5	-0.004	0.973	0.763
2024 Digital 2	21.5	21.5	0.040	0.776	0.907

¹ A p-value less than 0.05 indicates the difference between groups is non-trivial (i.e., statistically significant).

By month and wave, [Figure 38](#) through [Figure 42](#) compare pre-treatment daily usage between treatment and control. The figures support the findings noted above; pre-treatment usage differences between treatment and control are negligible among the active households.

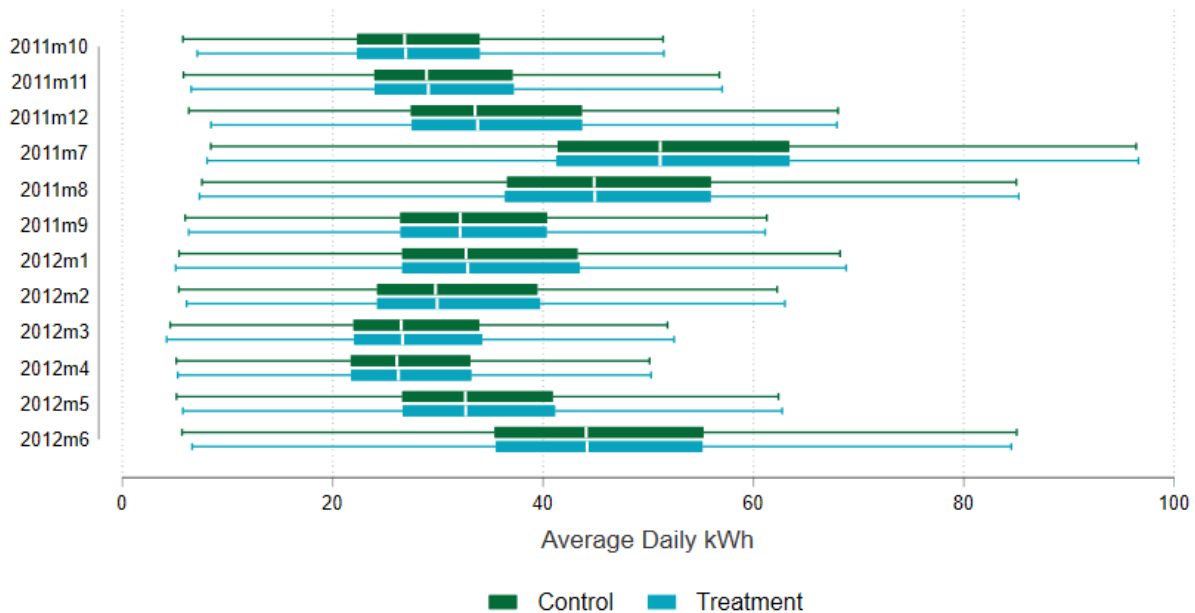
Figure 38: Pre-Treatment Equivalence (2012 Market-Rate Wave)

Figure 39: Pre-Treatment Equivalence (2015 Waves)

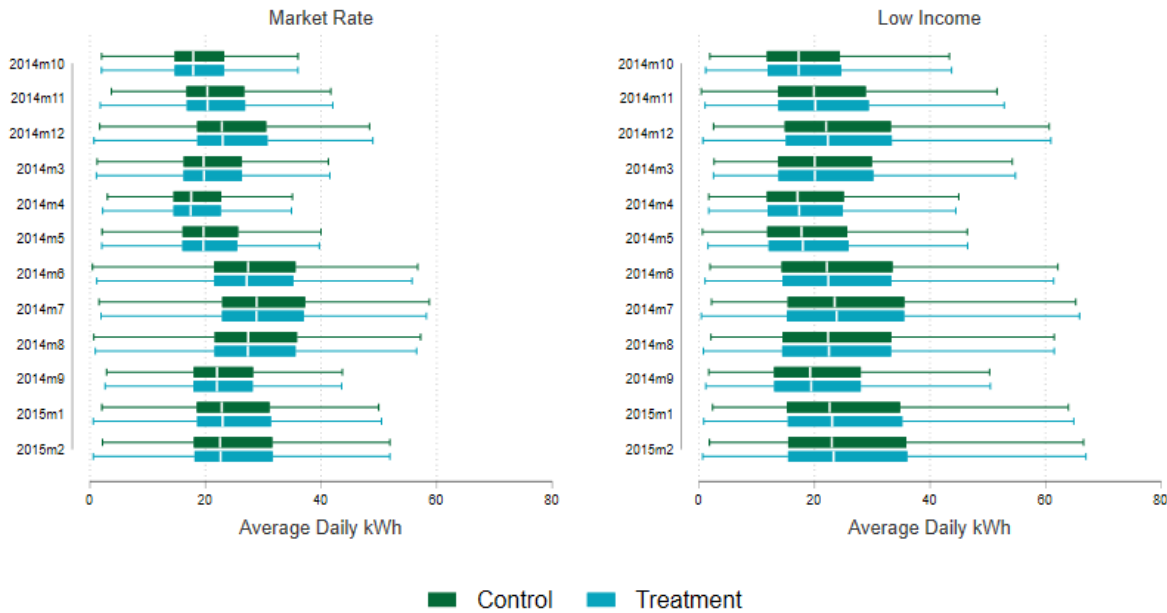


Figure 40: Pre-Treatment Equivalence (2021 Waves)

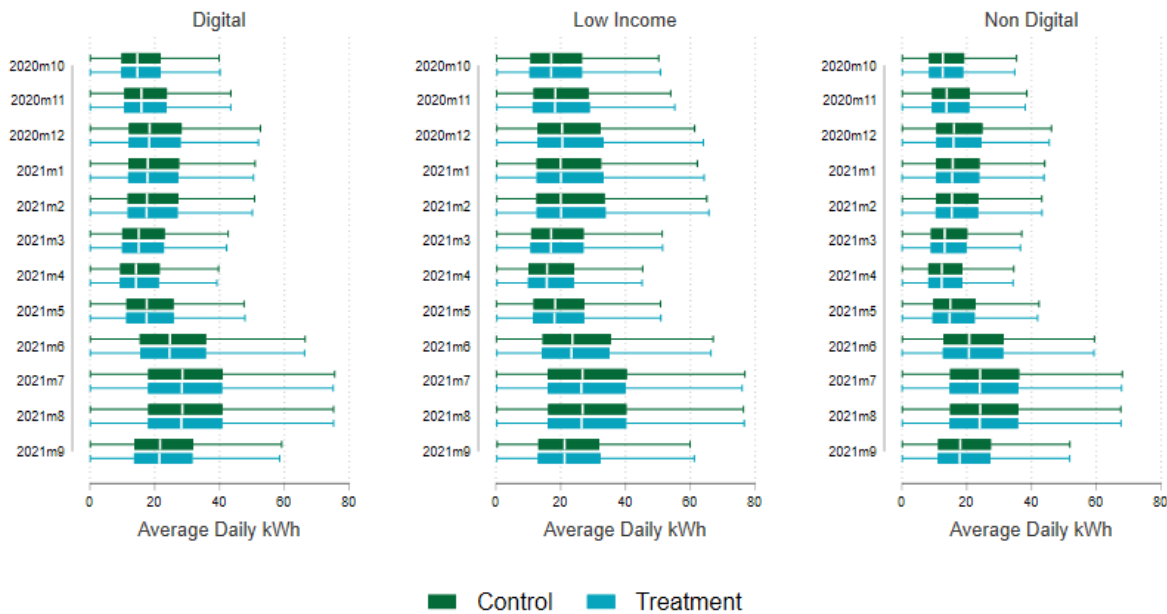


Figure 41: Pre-Treatment Equivalence (2023 Waves)

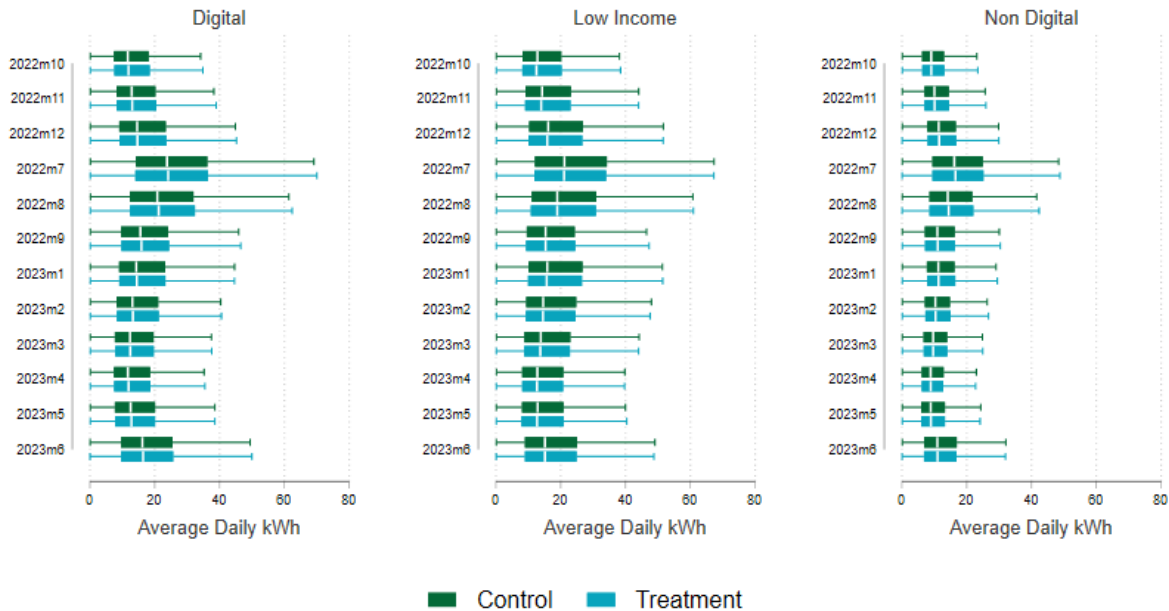
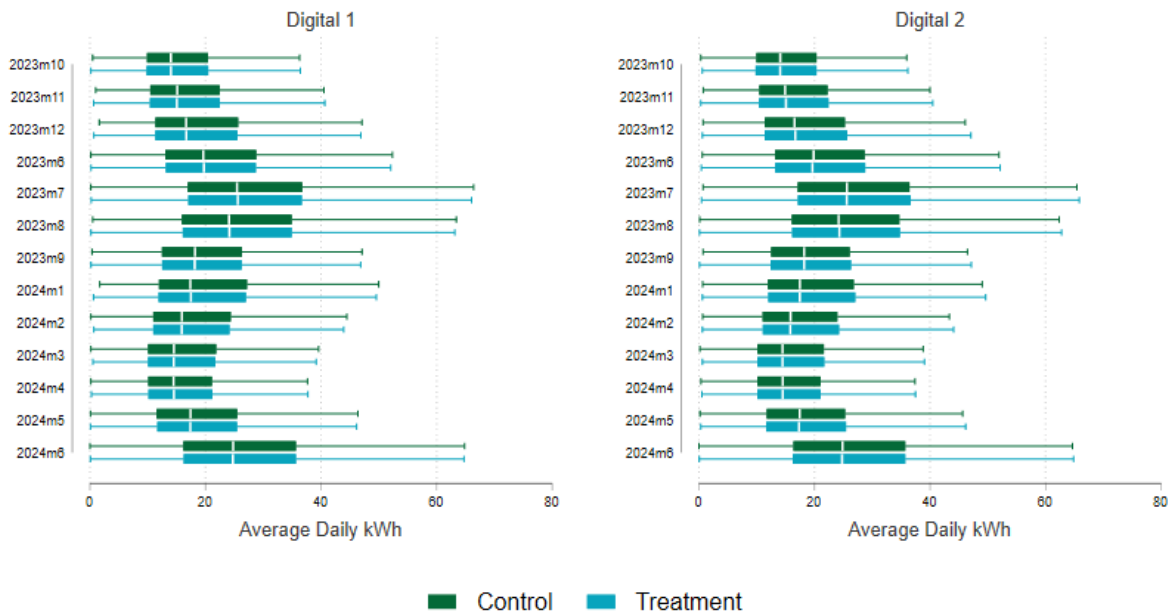


Figure 42: Pre-Treatment Equivalence (2024 Waves)



Data Preparation and Regression Coefficients

The SWE team received both raw and calendarized billing data in response to the annual data request. To ensure the validity of the data preparation methods used by Guidehouse, the SWE team conducted their own preparation of the raw data. Guidehouse used a Lagged Dependent

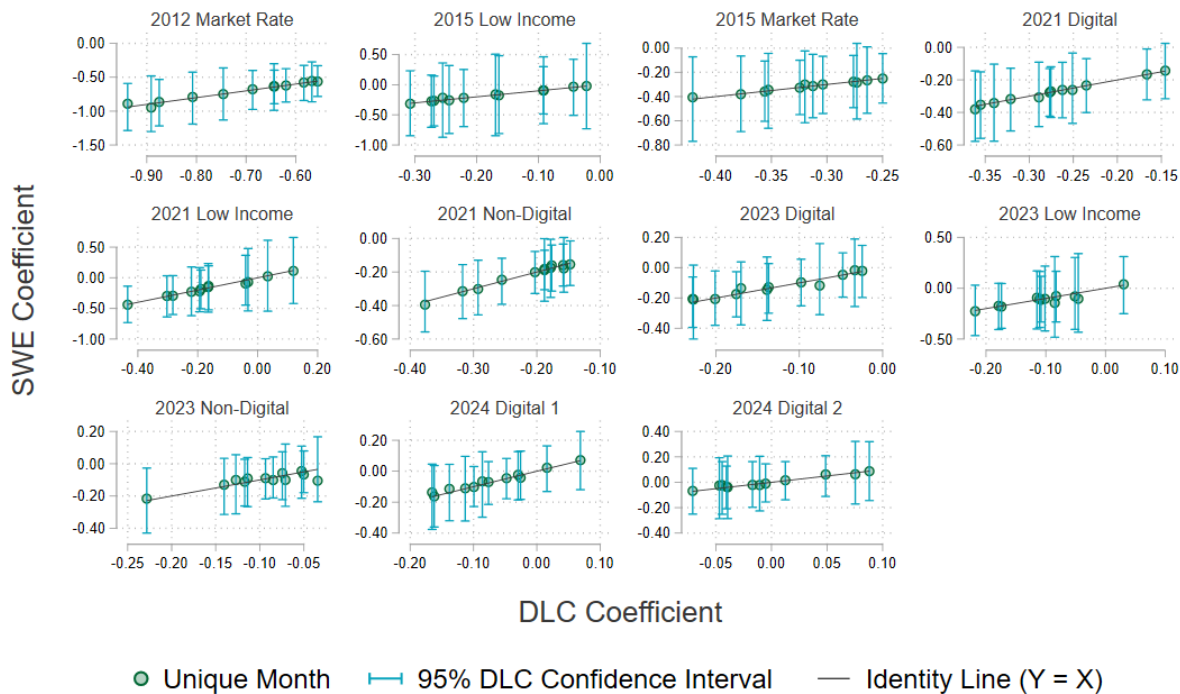
variable (LDV) regression model for the PY16 impact analysis, as called for in the Duquesne Light PY16 EM&V plan, and the model specification matches that of the EM&V plan exactly.

The SWE team first used Guidehouse-prepared data and regression specification and replicated exactly the regression coefficients reported by Guidehouse in their PY16 results. The SWE team then used SWE-prepared data to produce regression coefficients and found any differences between SWE coefficients and DLC coefficients to be insignificant. Figure 43 compares the SWE and DLC regression coefficients for each active wave and illustrates that any differences between the two sets of coefficients are tiny and well within the margin of error of the estimates. Reported coefficients are in daily kWh per customer units.

The SWE offers the following observations regarding the performance of the active cohorts in PY16.

- Daily kWh impacts tend to be larger for older waves compared to newer waves. The 2012 Market-Rate and 2015 Market-Rate waves produced the largest daily kWh impacts.
- Daily kWh impacts tend to be larger for market-rate waves compared to low-income waves.
- The 2021 and 2023 Digital waves showed greater daily savings than their Non-Digital counterparts.
- Savings estimates were statistically significant during each month in PY16 for the following waves: 2012 Market Rate, 2012 Non-Digital, 2021 Digital, and 2021 Non-Digital.
- The 2024 Digital 2 wave showed minimal savings in PY16.

Figure 43: Monthly Coefficient Comparison



Participant Counts

Guidehouse obtains active customer counts by first taking the original customer data and removing accounts that are flagged as inactive prior to the start of the program year. If an account has multiple inactive dates, then the most recent date is used. If one of the inactive dates is marked as “NA”, then that customer is considered active.

The SWE team validated Guidehouse’s enrollment counts by performing a similar counting method on the raw, non-calendarized billing data. Customers are considered active through the end of the month that they received their last bill. For example, if a customer received their last bill in the middle of August 2024, then they would be counted in June, July, and August 2024, but not in September or any month following. The SWE team’s final customer counts matched Guidehouse’s counts within 0.04% for each month and each wave.

Impacts

The SWE team independently calculated gross MWh savings using regression coefficients and active participant counts, and SWE’s estimates closely match Guidehouse’s estimates. [Table 126](#) shows the aggregate PY16 pre-adjustment gross savings (MWh) for each wave. Gross savings are largest for the 2021 Digital wave, while first-year incremental savings are largest for the 2023 Digital wave.

Table 126: PY16 HER Energy Savings (MWh)

Wave	Gross Savings	Downstream Dual Participation	Upstream Dual Participation	Savings Net of Dual Participation	Persistence	First-Year Incremental Savings
2012 Market-Rate	2,880	475	72	2,332	1,381	951
2015 Low-Income	398	152	7	239	188	50
2015 Market-Rate	3,326	1,365	59	1,902	1,207	695
2021 Digital	5,106	478	69	4,559	3,008	1,551
2021 Low-Income	412	58	5	349	171	178
2021 Non-Digital	4,246	236	60	3,950	3,179	771
2023 Digital	1,771	18	7	1,746	0	1,747
2023 Low-Income	510	40	2	468	0	468
2023 Non-Digital	474	8	2	464	0	464
2024 Digital 1	706	5	0	701	0	701
2024 Digital 2	15	4	0	11	0	11
Total	19,843	2,839	283	16,721	9,134	7,587

Dual Participation

Home Energy Reports advertise other Duquesne Light residential EE&C programs and measures such as ENERGY STAR appliances, weatherization, HVAC rebates, etc. To the extent that treatment group households participate in these programs more frequently than control group homes, the incremental savings is captured in the regression estimates for the HER analysis. To

avoid double-counting savings, the HER savings are reduced to account for the incremental program participation observed in the treatment group compared to the control group. Table 126 shows that the total gross savings before adjusting for dual participation was 19,843 MWh, and after adjusting for dual participation was 16,721 MWh.

Persistence

The 2021 Pennsylvania TRM assumes an annual decay rate of 31.3%, derived from Pennsylvania-specific research⁸³ on the persistent effects of behavioral energy efficiency treatment in the years after discontinuing treatment. Since Act 129 compliance goals are based on first-year incremental savings, these persistent impacts are subtracted from the measured savings to estimate incremental first-year savings (i.e., those directly due to the current program year of treatment).

For the first two years of HER exposure, persistence is assumed to be zero, and the first-year savings average treatment effect (FYSATE) simply equals the average treatment effect (ATE). For year three and beyond of HER exposure, the FYSATE is calculated with the following formula from the 2021 TRM. For year i of HER exposure:

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

$$\Delta kWh_y = FYSATE_y * Treatment\ Accounts_y * Days_y$$

Where $FYSATE_y$ is the average daily savings attributable to HERs delivered in the current year (Y), and $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in an earlier year Y-X.

The SWE team found that Guidehouse correctly modeled persistence in accordance with TRM specifications. Guidehouse provided the SWE team with detailed manual calculations of persistence for the eleven waves, which the SWE team verified matched TRM accounting rules. Table 127 displays persistence and first-year savings and their respective percentage of PY16 total dual-participation-adjusted savings.

Table 127: PY16 HER Persistence and First-Year Savings

Component	Savings (MWh)	Percent of PY16 Total
Persistence from Prior Years	9,134	55%
PY16 First-Year Savings	7,587	45%
Total	16,721	100%

⁸³ Addendum to Act 129 Home Energy Report Persistence Study. November 2018. https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

Impacts by Sector

Table 128 shows the breakdown of HER first-year savings by sector. Note that the 2024 Digital 1 and Digital 2 cohorts are classified as market rate.

Table 128: PY16 HER First-Year Savings by Sector

Sector	PY16 MWh
Low-Income	696
Market-Rate	6,891
Total	7,587

Peak-Demand Impacts

In the Duquesne Light Phase IV EM&V Plan, Guidehouse chose to estimate peak-demand savings from HERs via a peak-demand multiplier. The selected approach corresponds to option 3 in section 6.1.6 of the Phase IV Evaluation Framework. Guidehouse calculated the Phase IV peak-demand multiplier from five years of reference residential 8760 load shapes supplied by the ICSP. The peak-demand multiplier was calculated as follows:

- Advanced Metering Infrastructure (AMI) interval data for residential customers in Duquesne Light service territory was used to create an average hour-of-year (8760) load shape for the years from 2017 through 2021.
- The ratio of average annual load for all hours and days of the year over average summer peak load (per the TRM-defined peak period) was calculated for each of the years from 2017 through 2021.
- The 5-year average ratio was then used as the peak-demand multiplier for determining Phase IV HER peak-demand impacts.

The Phase IV Duquesne Light peak-demand multiplier is 1.63. Incremental peak-demand savings is calculated as follows for HER in PY16:

$$\text{Incremental Peak Demand Savings (MW)} = \frac{\text{Incremental Savings (MWh)}}{8,760 \text{ hours}} * 1.63 * 1.0741$$

Duquesne Light found the total PY16 incremental first-year savings were 7,587 MWh. The total incremental first savings were converted to MW by dividing by 8760, scaled by the peak-demand multiplier (1.63), and finally, scaled by the line loss factor of 1.0741. For waves launched after June 1 the incremental peak-demand savings was pro-rated based on the number of non-holiday weekdays that the wave was exposed to treatment (scaled down by a 2/3 factor). Table 129 shows the incremental peak-demand savings for waves launched before and after June 2024, the total incremental peak-demand savings is 1.51 MW, which the SWE team agrees with.

Table 129: PY16 HER Incremental Peak-Demand Savings

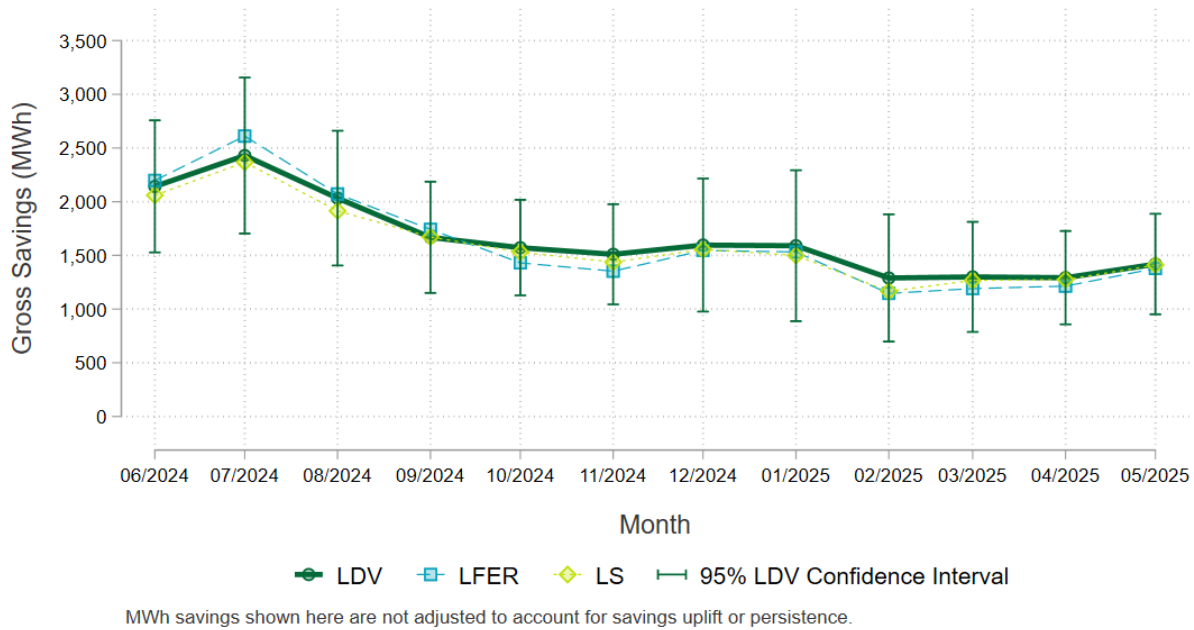
Waves	Incremental Savings (MWh)	Incremental Peak-Demand Savings (MW)
Launched before June 2024	6,875	1.37
Launched after June 2024	712	0.14
Total	7,587	1.51

Conclusion

The SWE team found that Guidehouse's evaluation was entirely consistent with their proposed and approved EM&V plans. The SWE team does not propose any revisions to the PY16 methods or results. The SWE also found that the results were robust to model specification. In addition to the LDV model called for in the Duquesne Light PY16 EM&V plan, the SWE estimated average daily impacts for each wave using two other methods mentioned in section 6.1.5 of Phase IV Evaluation Framework:

- **Linear fixed effects regression (LFER) model.** This is effectively a difference-in-difference regression model that has been widely used in estimating savings associated with behavioral interventions.
- **Lagged seasonal (LS) model.** The lagged seasonal model is a post-only model, like the LDV model, but contains three lag terms (one for average summer usage, one for average winter usage, and one for average usage across all seasons) instead of a single lag term.

Figure 44 shows total MWh savings by month for each model. Note the MWh savings shown in this figure do not account for savings uplift or persistence. The figure shows that the LDV, LFER, and LS models all produce similar savings estimates.

Figure 44: Model Comparison

D.5.2 Non-Residential Audit Activities

The SWE conducted various review and audit activities for Duquesne Light's programs. These activities included a review of the evaluation efforts and an audit of the savings verification completed by Duquesne Light's evaluation contractor, Guidehouse. The remainder of this section presents the SWE's findings from these activities.

Guidehouse used various approaches to verify the gross impact estimates for each non-residential program. This section discusses results from the SWE's review of Guidehouse's evaluation methodology that were applied to estimate project and program impacts from their sample of evaluated projects. The SWE completed this review using evaluation sample and population extracts provided by Guidehouse. These files provided details on each sampled project including the type of evaluation activity completed and the level of rigor applied to achieve evaluated results.

Table 130 outlines the evaluation activities by project count for each of Duquesne Light's non-residential programs, along with the evaluation realization rates.

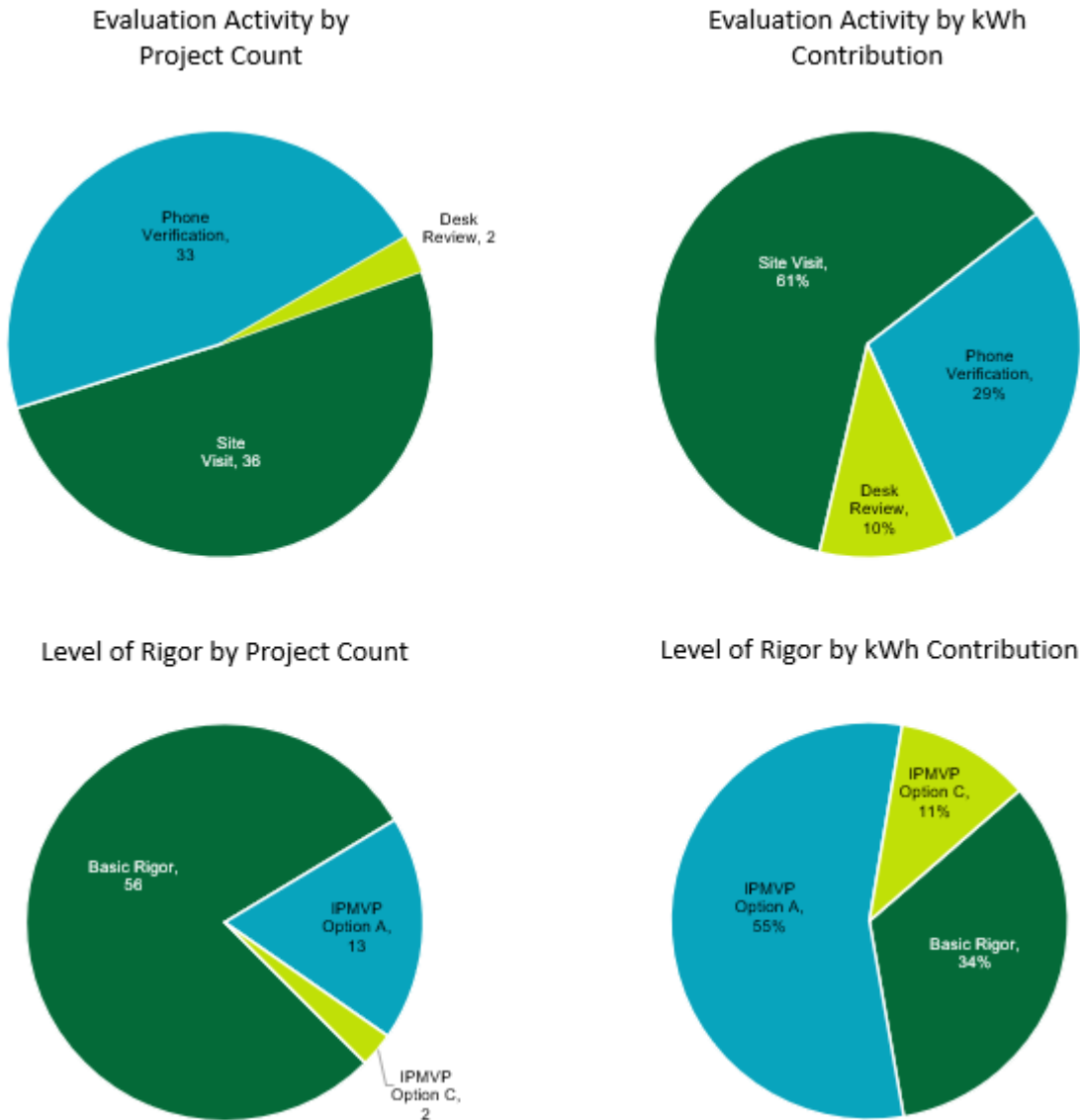
Table 130: Duquesne Light Evaluation Activities by Project Count

Program / Strata	Sample Quantity (PY16)	RR-Energy	RR-Demand	Desk Review	Phone Interview	On-Site Verification
Downstream Business Solutions	47	101%	101%	2	16	29
Small Business Solutions - Small	8	88%	93%	1	7	-
Small Business Solutions - Medium	7	100%	90%	-	1	6
Small Business Solutions - Large	4	92%	76%	-	-	4
Commercial - Small	6	98%	100%	-	6	-
Commercial - Medium	9	95%	104%	-	-	9
Commercial - Large	6	97%	109%	-	-	6
Commercial - Certainty	2	94%	99%	1	-	1
Industrial - Large	3	107%	90%	-	-	3
Industrial - Certainty	2	112%	112%	-	2	-
Midstream Business Solutions	24	126%	148%	-	17	7
Commercial - Small	5	310%	271%	-	5	-
Commercial - Medium	10	159%	147%	-	8	2
Commercial - Large	5	138%	199%	-	2	3
Industrial - Small	1	135%	111%	-	1	-
Industrial - Large	3	72%	86%	-	1	2
Virtual Commissioning	-	-	-	-	-	-
Small Business Direct Install	-	-	-	-	-	-
Total	71			2	33	36

Figure 45 provides a summary of the evaluation activities and M&V approaches utilized by Duquesne Light's evaluation contractor in their PY16 verified savings calculations. Guidehouse conducted site verification for approximately 51% of the PY16 evaluation sample, with IPMVP Options A and C applied to estimate 65% of the evaluation sample energy savings.

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The Downstream Business Solutions program realized 101% energy savings, and Midstream Business Solutions realized 126% energy savings, primarily due to variations in lighting hours of use for midstream projects. The following subsections outline the evaluation activities for each of Duquesne Light's non-residential programs in PY16.

Figure 45: Summary of Duquesne Light's C&I Evaluation Activities Small and Large Business Solutions



These programs offer rebates to offset the higher cost of high efficiency equipment compared to standard efficiency equipment. Program incentives help bridge the cost difference between standard and high efficiency equipment, increasing customer adoption of energy and demand saving equipment. The primary objective of the programs is to provide C&I customers an expedited, quantifiable, and simple-to-understand incentive offering that helps them save energy and money. This program is filed as two programs in Duquesne Light's Phase IV EE&C Plan — the small C&I program and the large C&I program. From the participant perspective the two programs are marketed together as Business Solutions.

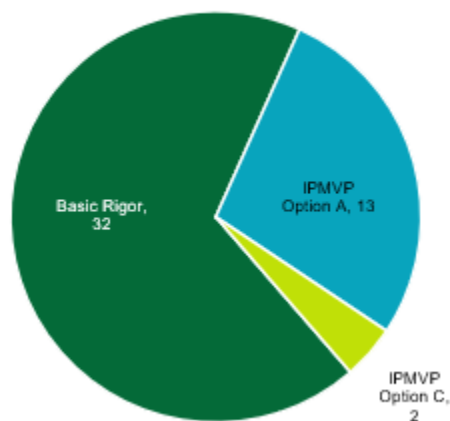
Although they share a common structure, the Large Business Solutions program targets C&I customers with annual demand savings greater than or equal to 300 kW, whereas the Small Business Solutions program targets C&I customers having annual demand less than 300 kW. The

Small and Large Building Solutions programs employ targeted customer engagement channels to assist customers to overcome unique, segment-specific barriers to energy-efficiency program participation. Both programs offer two core participation tracks: prescriptive and custom. The prescriptive track offers a simplified method on pre-defined measures without requiring complex analysis and will generally include deemed and partially deemed measures from the TRM. The custom track makes it possible to include more complex, site-specific measures and projects in the programs. Custom projects must be able to show specific and verifiable energy savings and costs using TRM protocols.

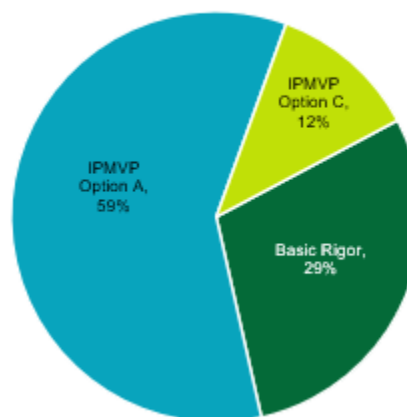
The Downstream Business Solution programs account for approximately 94% of the sampled PY16 non-residential program savings. Figure 46 provides a summary of the M&V approaches utilized by Duquesne Light's evaluation contractor in their PY16 verified savings calculations. Guidehouse employed Enhanced Rigor – IPMVP Options A and C for approximately 68% of the PY16 verified savings in this solution.

Figure 46: Summary of Duquesne Light's PY16 Small and Large Downstream Business Solutions Evaluation Activities

Level of Rigor by Project Count



Level of Rigor by kWh Contribution

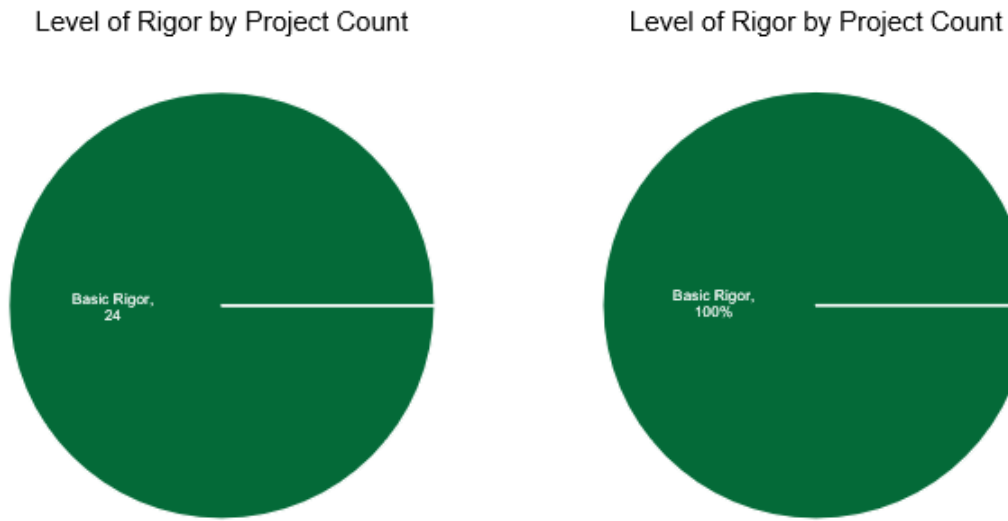


D.5.2.1 Small and Large Business Midstream Solutions

The non-Residential Midstream Lighting program delivers utility incentives to end-use customers via C&I product distributors or manufacturers. End-use customers, property/facility managers, and installation contractors acting on behalf of C&I end-use customers may purchase qualified products from a participating distributor. This program is filed as two programs in Duquesne Light's Phase IV—one as a small C&I program and one as a large C&I program. However, from the perspective of the customers and distributors there is only one program.

Figure 47 provides a summary of evaluation activities performed by Guidehouse in PY16 for evaluating midstream projects. Site visits were performed for 33% of projects in the sample. These verification site visits applied basic rigor and reviewed 75% of the sample verified Midstream savings.

Figure 47: Summary of Duquesne Light's PY16 Midstream Business Solutions Program Evaluation Activities



D.5.2.2 Small Business Direct Install

The Small Business Direct Install (SBDI) program targets Duquesne Light C&I customers and municipalities with monthly demand less than 300 kW. The SBDI program is designed to address sector-specific barriers to small and medium C&I customers and municipalities. During Phase IV, this program focuses on very small businesses (micro-businesses), such as small local bakeries or hardware stores. In addition to the SBDI program, Guidehouse is reporting the common area portion of the Small Multifamily Housing Retrofit Program (SMHR) under SBDI. For Phase IV, participating customers will receive a no-cost energy assessment and incentives that cover up to 80% of the resulting equipment and installation costs. A limited quantity of energy-saving products may be provided at the time of assessment at no cost.

SBDI impact evaluation activities were not conducted for PY16 and the results from PY15 are applied to the PY16 program reported savings to determine the verified savings.

D.5.2.3 Virtual Commissioning

The Virtual Commissioning (VCx) program provides a data-driven approach to energy efficiency engagement for sites that do not fit the traditional model of using trade allies, mass marketing, or standardized prescriptive retrofits. The SWE completed detailed reviews of the VCx verified savings in prior years and agreed with the Guidehouse econometric analysis. Because the program had lower participation in PY16 (0.5% of portfolio savings in PY16), the SWE did not conduct a detailed review in PY16.

D.5.2.4 Verified Savings Audits

The SWE audited the activities above through a detailed audit of Guidehouse's evaluation work for a sample of their evaluated projects. The SWE audit for Guidehouse's evaluation for Duquesne Light in PY16 included review of 14 projects, encompassing the following activities:

- Seven downstream lighting, two custom, one HVAC, and one Retro-commissioning measures observed
- Four in-person ride-a-longs conducted
- 26% of sample verified energy savings reviewed
- 38% of sample verified demand savings reviewed

Table 131 provides an overview of the SWE milestones for the verified savings audit review of evaluated Duquesne Light projects.

Table 131: Duquesne Light Verified Savings Audit Review Milestones

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
14	7,539,562	100%	1,945.4	100%

Overall, the SWE found that Duquesne Light's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures. The overall energy and demand savings attainment percentages of Duquesne Light's reviewed projects 100% for both energy and demand savings.

D.6 NTG

Table 132 lists Duquesne Light's PY16 NTG as listed in the Duquesne Light PY16 Annual Report. Details concerning the methods and data used to estimate NTG values are in sections D.6.1 and D.6.2.

Table 132: Summary of Duquesne Light's PY16 NTG Results

Program Name	Component	NTG
Residential	Downstream Incentives	0.81
Residential	Appliance Recycling	0.72
Residential	HER Total	1.0
Low-Income	Low-Income	1.0
Non-Residential	Small Business Direct-Install	0.93
Non-Residential	Small Business Solutions	0.66
Non-Residential	Small Business Virtual Commissioning	0.94
Non-Residential	Commercial – Large Business Solutions	0.90
Non-Residential	Industrial – Large Business Solutions	0.90
Non-Residential	Commercial – Large Business Midstream Solutions	0.88
Non-Residential	Industrial – Large Business Midstream Solutions	0.88
Non-Residential	Large Business Virtual Commissioning	0.94
Portfolio Total		0.87

D.6.1 Residential Programs

Guidehouse did not plan for or enact residential NTG research in PY16.

D.6.2 C&I Energy-Efficiency Programs

Guidehouse planned and enacted NTG research for the Large Business Solution program (Table 133). The SWE reviewed the survey, data, and analysis file that informed the NTG estimation and found that all methods were consistent with the recommended NTG methodology outlined in the Phase IV Evaluation Framework.

Table 133: Summary of Duquesne Light's PY16 C&I NTG Results

Program Name	Approach	Sample Size	Free-ridership	Spillover	NTG
Large Business Solutions	Participant web survey	5	0.10	0.00	0.90
C&I Programs, Total					0.90

D.7 TRC

Table 134 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Duquesne Light's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the Duquesne Light PY16 Annual Report and the model itself was well-organized and documented.

Table 134: Summary of Duquesne Light's PY16 TRC Results

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Res Downstream Incentives	\$7,299	\$4,252	1.72	\$3,047
Res Midstream Incentives	\$0	\$0	--	\$0
Res Upstream Lighting	\$0	\$73	0.00	(\$73)
Appliance Recycling	\$353	\$262	1.35	\$91
Low-Income Energy Efficiency	\$877	\$521	1.68	\$356
Res Behavioral EE	\$683	\$955	0.72	(\$272)
Low-Income Behavioral EE	\$69	\$224	0.31	(\$155)
Residential Subtotal	\$9,281	\$6,287	1.48	\$2,994
Small Business Direct Install	\$314	\$286	1.10	\$28
Small Business Downstream	\$3,691	\$2,145	1.72	\$1,547
Small Business Midstream	\$0	\$176	0.00	(\$176)
Small Business VCx	\$27	\$47	0.57	(\$20)
Large Commercial Downstream	\$14,766	\$8,357	1.77	\$6,409
Large Commercial Midstream	\$10,963	\$2,135	5.14	\$8,829
Large Commercial VCx	\$62	\$63	0.99	(\$1)
Large Industrial Downstream	\$1,487	\$659	2.26	\$828
Large Industrial Midstream	\$1,189	\$323	3.68	\$865
Large Industrial VCx	\$0	\$19	0.00	(\$19)
Non-Residential Subtotal	\$32,500	\$14,210	2.29	\$18,290
Portfolio Total	\$41,782	\$20,497	2.04	\$21,284

Nine of Duquesne Light's 17 EE&C programs were found to be cost-effective when estimating the TRC using gross verified savings. The same nine programs were found to be cost-effective using net verified savings. The non-residential sector accounted for 78% of the total TRC gross benefits in PY16. The residential program with the highest gross TRC ratio was the Downstream Incentives Program at 1.72. The non-residential program with the highest gross TRC ratio was the Large Commercial Midstream Program at 5.14.

D.7.1 Notes from the TRC Model Review

The PY16 TRC model organized program costs, measured impacts, and avoided costs in a comprehensive calculation workbook. Below is a summary of the assumptions and inputs verified by the SWE.

- The correct line-loss multiplier of 1.0741 was used for all Residential and Small C&I measures. A line-loss multiplier of 1.0081 was applied to savings from participants that take high-voltage service (69 kV).
- The SWE verified the reported energy and demand savings in the TRC model with the evaluation rollup and quarterly tracking data reported by Duquesne Light.
- The PY16 TRC model used a nominal discount rate of 5.0%, which matches Duquesne Light's Phase IV EE&C plan. In the 2021 TRC Test Order, the Commission directed all

EDCs to use a common discount rate rather than their own weighted average cost of capital.

- Realization rates for energy and demand impacts were applied to the program impacts in the TRC model, which were based on reported gross savings values, to calculate verified gross savings.
- In the PY15 TRC audit, the SWE expressed concern over the 15-year assumed measure life of Virtual Commissioning measures. The PY16 TRC model uses a more appropriate 8-year EUL to estimate lifetime savings from Virtual Commissioning. The Virtual Commissioning program was not cost effective in PY16 with the reduced measure life.
- Duquesne Light relies on the SWE Incremental Cost Database for assumptions regarding commercial lighting equipment costs. However, the SWE found that Duquesne Light utilized a replacement on burnout measure vintage for incremental measure costs for prescriptive non-residential lighting measures. The savings and associated benefits were calculated using the early replacement vintage per the 2021 TRM. This inconsistent handling of measure vintage creates an upward bias in the TRC test results.
- Duquesne Light has the lowest Incremental Measure Cost per Lifetime MWh of any of the four EDCs at \$14.61 per Lifetime MWh. Excluding Duquesne Light, the average of other EDCs in PY16 was roughly double at approximately \$32 per Lifetime MWh.
- The calculation of NTG using free-ridership and spillover, as well as the application of the NTG in the calculation of TRC benefits and costs, were consistent with the 2021 TRC Test Order directive for Phase IV. The TRC model followed the protocol pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The SWE found that Duquesne Light's TRC model handles fossil fuel impacts asymmetrically, assigning a fossil fuel penalty to the interactive effects of LED lighting measures but no fossil fuel benefits for measures that reduce natural gas consumption. While Duquesne quantifies and monetizes as negative benefits, the increased fossil fuel consumption associated with LED lighting installations, the fossil fuel savings from weatherization measures, smart thermostats installed in homes with gas heat, and low-flow devices in homes with gas water heating were ignored.

D.8 PROCESS

No process evaluation was conducted in PY16.

Appendix E FirstEnergy: Metropolitan Edison Company PY16 Audit Detail

E.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Met-Ed provided their residential and low-income verified savings analyses prior to drafting the Met-Ed PY16 Annual Report. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Met-Ed PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Met-Ed had seven active HER cohorts in PY16. Four of the cohorts consisted of market-rate residential households and the other three cohorts consisted of low-income households. Behavioral HER programming accounted for 9% of Met-Ed's total verified MWh savings in PY16 and 27% of the verified low-income MWh savings. ADM's HER impact evaluation was entirely consistent with their approved EM&V plans.
 - FirstEnergy total PY16 incremental HER savings statewide were 29,691 MWh, with 50% of the savings coming from Met-Ed. Met-Ed's success was driven by the incremental savings of the 2012 Residential cohort, which had a larger incremental savings value than the total incremental savings in the other EDCs individually.
 - Met-Ed reintroduced two historical cohorts after a three-year pause, one low-income and one residential. ADM found that the treatment and control groups in these cohorts were not equivalent in PY15, suggesting savings are persistent and "rebaselining" is not advisable. As a result, Met-Ed's reintroduced cohorts retained their original treatment date and baseline period.
 - One of Met-Ed's cohorts failed its pre-treatment equivalence test and required rebalancing using weights that were calculated using a propensity score matching approach. These weights were applied to the cohort throughout the analysis.
 - The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Met-Ed's Online Audit offering showed higher average percent savings (1.3%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 8% of market rate households), so the margin of error around the billing analysis estimate was large.

- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Met-Ed's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- Met-Ed's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.34. Met-Ed's PY16 gross TRC ratio was lower than its PY15 gross TRC ratio of 1.54.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs. Notably, O&M benefits were negative for Met-Ed's Large Commercial and Industrial component due to a high volume of large solar projects. The assumed yearly maintenance costs for these projects led to negative O&M benefits.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Met-Ed's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data, but the SWE did not expect to be able to do so, and the SWE calculated directionally similar values for each program.
- The SWE conducted a project file review for a sample of Met-Ed's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.
- The SWE found that the Appliance Recycling NTG reported in the PY16 Annual Report for Met-Ed and West Penn Power is 0.01 higher than those shown in the Process and NTG Memo.

E.2 EM&V PLAN REVIEWS

ADM, FirstEnergy's evaluation contractor, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, the ADM team submitted

several memos detailing their sampling approach for program components selected for impact, process and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 135](#) shows which Met-Ed programs produced verified impacts in PY16, and which used historic realization rates in PY16.

Table 135: PY16 Met-Ed Impact Evaluation Summary

Sector	Components	PY16 Impacts
Residential	EE Kits	Verified
	Home Energy Reports	Verified
	Midstream Appliances	Verified
	Midstream Electronics	NA
	New Homes	Verified
	Downstream HVAC	Verified
	LI Direct Install	Verified
	LI On-Line Audit	Verified
	Downstream Appliances	Verified
	LI - Home Energy Reports	Verified
	Audit and DI	Verified
	Online Audit	Verified
Cross-Cutting	Appliance Recycling	Verified
	Multifamily	Verified
C&I	Custom	Verified
	Prescriptive – Downstream Lighting, Midstream Lighting, Downstream Non-lighting	Verified
	Energy Management and New Construction – Building Improvements, Building Operations Training, Building Tune-ups and Commissioning. New Construction, MODIFY	Verified

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft survey instruments for multiple programs.

E.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework establishes a maximum level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change was

implemented specifically for EDCs like Met-Ed, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes due to program delivery channel or supported technology.

Met-Ed's EE&C portfolio consists of five programs: Energy Efficient Homes, Energy Efficient Products, Low-Income Energy Efficiency, C&I Energy Solutions for Business – Large, and C&I Energy Solutions for Business – Small. The SWE performed its annual sample design review at the initiative level, which sometimes spans multiple programs or sectors. In response to the annual data request, FirstEnergy's EM&V contractor provided the SWE with a sample disposition for each initiative detailing the project-level ex ante and ex post savings for each unit in the samples.

Table 136 shows the relative precision of PY16 energy and demand impacts by component at the 85% confidence level. In PY16, all programs were evaluated, none relied on historic realization rates. The Residential Online Audit and Behavioral Modifications programs, which were evaluated via regression analysis, have no uncertainty associated with sampling and thus is omitted from the below table. Residential Upstream Electronics Initiative is also omitted as it was not offered in PY16. All evaluated components met the 15% threshold for relative precision in both energy and demand.

Table 136: Relative Precision of PY16 Impacts by Program Component at the 85% Confidence Level

Sector	Components	Relative Precision (Energy)	Relative Precision (Demand)
Residential	EE Kits	5.8%	5.5%
	LI - EE Kits	7.7%	7.5%
	Direct Install	11.3%	10.9%
	LI Direct Install	10.5%	10.6%
	Multifamily Direct Install	10.2%	10.2%
	HVAC	13.1%	13.7%
	Appliance Recycling	4.0%	4.1%
	LI Appliance Recycling	0.0%	0.0%
	Appliances	10.4%	8.6%
	Midstream Appliances	0.0%	0.0%
	New Construction	10.9%	14.9%
C&I	Custom	1.4%	3.1%
	Prescriptive	8.8%	8.7%
	Energy Management and New Construction	10.2%	9.2%
	Multifamily Direct Install	10.7%	11.5%
	Appliance Recycling	0.0%	0.0%

ADM established in their Phase IV evaluation plan submitted to the SWE that they would use an assumed coefficient of variation (CV) derived from past program years for the initial sample design. However, ADM also used these planning CVs to calculate and report initiative-level relative precision. In PY16, ADM did calculate CV manually for the New Construction component but otherwise relied on assumed, rather than actual, CVs. The SWE recommends that ADM use

manual variance calculations in place of planning coefficients of variation in their PY17 report to yield more accurate estimates of relative precision. Although the SWE still recommends leaving a hedge to guarantee that the $\pm 15\%$ relative precision threshold is met, ADM might be able to use fewer sample points than they did in PY16 for certain initiatives with low coefficients of variation.

The Behavioral Modification subprogram provides HERs to residential customers in the Met-Ed service territory. The subprogram is divided between market-rate residential customers and LI customers, and each is administered as an RCT. Participants are enrolled in experimental cohorts, and a monthly billing analysis regression is used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model cannot fully capture the variation present in the data. Precision requirements for behavioral programs are unique, with the Phase IV Evaluation Framework requiring the solution-level verification to achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). [Table 137](#) shows the absolute precision of PY16 Behavioral Modification impacts at the 95% confidence level.

Table 137: Absolute Precision of PY16 Impacts for Behavioral Modification Programs at the 95% Confidence Level

Program	Absolute Precision (Energy)
Behavioral Modification (Market Rate)	0.17%
Behavioral Modification (LI)	0.35%

The Online Audit component also relies on regression analysis of all participants and a matched control group of non-participants. While there is no sampling error, there is uncertainty associated with the regression model. The reported relative precision of the market-rate Online Audit energy savings was $\pm 74.8\%$ at the 85% confidence level and the relative precision of the Low-Income Online Audit energy savings was $\pm 39.6\%$ at the 85% confidence level. The relative precision of the low-income group was better than the market-rate group, despite a much smaller number of homes, because the savings estimate for low-income recipients was significantly higher. However, when the cluster robust standard errors are calculated based on the number of homes, instead of the number of observations, the relative precision exceeds $\pm 100\%$ at the 85% confidence level for both the market rate and the low-income results. To remedy the larger uncertainty, PY17 will use a rolling multi-year regression model to increase the number of homes included in the analysis.

E.4 REPORTED GROSS SAVINGS AUDITS

E.4.1 Tracking Data Review

This section summarizes the SWE team's assessment of the reported gross savings, participation counts, and incentives reported in Met-Ed's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)

- Participation counts
- Incentive dollars

The SWE leveraged Met-Ed's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset, but a subset of the full tracking dataset tailored to our PY16 quarterly data request. Also note that HER programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding the HER components of the Energy Efficient Homes and LIEEP can be found in [Appendix E.5.1](#).

[Table 138](#) summarizes our findings regarding reported gross energy savings. The "Match" column contains "Yes" if the tracking data supports the values in Met-Ed's PY16 Annual Report and "No" otherwise. For each program, the SWE was able to replicate the values reported by Met-Ed.

Table 138: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Energy Efficient Homes	17,021	17,021	Yes*
Energy Efficient Products	6,256	6,256	Yes
Low Income Energy Efficiency	3,924	3,924	Yes*
C&I Energy Solutions for Business - Small	35,901	35,901	Yes
C&I Energy Solutions for Business - Large	91,086	91,086	Yes
Portfolio Total	154,188	154,188	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

[Table 139](#) summarizes the SWE's findings regarding reported gross peak-demand savings, by program. The tracking data is provided at the meter-level. To facilitate the comparison, the SWE applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. Like with reported gross energy savings, the tracking data supports the Annual Report value exactly for all programs.

Table 139: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Energy Efficient Homes	2.14	2.14	Yes*
Energy Efficient Products	1.44	1.44	Yes
Low Income Energy Efficiency	0.47	0.47	Yes*
C&I Energy Solutions for Business - Small	7.88	7.88	Yes
C&I Energy Solutions for Business - Large	13.80	13.80	Yes
Portfolio Total	25.73	25.73	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

The SWE also used the tracking data to audit Met-Ed's reported participation counts and customer rebate amounts. Like with the energy and peak-demand audits, the SWE found strong

alignment between the tracking data sums and the values reported by Met-Ed. No substantive issues were discovered.

E.4.2 Project File Reviews

E.4.2.1 Residential

As part of the reported savings (i.e., ex ante) review, the SWE conducted a project file review of a sample of Met-Ed's residential project files for PY16 using the project file documentation provided by Met-Ed, the program implementers, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included most of the documentation requested.

[Table 140](#) presents a summary of the SWE's residential project file reviews.

Table 140: Met-Ed PY16 Project File Review Summary

Program	Sub Program	Number of files reviewed ¹	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data? ²
EE Homes Program and LIEEP	Direct Install	-	-	-	-	-
EE Homes Program and LIEEP	EE Kits	40	✓	✓	✓	✓
EE Homes Program	Comprehensive Audits	40	✓	✓	✓	✓
EE Homes Program and LIEEP	New Homes	40	✓	✓	✓	✓
EE Products Programs and LIEEP	Appliance Rebates	20	✓	✓	✓	✓
EE Products Programs	Appliance Recycling	40	✓	✓	✓	✓
EE Products Programs	HVAC	20	✓	✓	✓	✓
EE Products Programs	Midstream Appliances	20	✓	✓	✓	✓
LIEEP	Appliance Recycling	10	✓	✓	✓	✓
LIEEP	LI WARM	40	✓	✓	✓	✓

¹ The number of files reviewed reflects the total number for all FirstEnergy EDCs.

² It should be noted that the Comprehensive Audits count includes audits performed at single-family and multifamily dwellings.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews.

Energy Efficient Homes Program and LIEEP: Direct Install

While the FirstEnergy companies offered the Direct Install component of the EE products program in PY16, the SWE did not receive any project files for this program. The SWE acknowledges that this program was not evaluated in PY16 and will evaluate project files in PY16.

Energy Efficient Homes Program: Energy Efficiency Kits

The Energy Efficiency Kits program contains two sub-components: energy efficient kits and school education. The documentation for the Energy Efficiency Kits program consisted of

shipment data, specification sheets, and kit contents. The specification sheets include information on the wattage and wattage equivalency of LED bulbs (e.g., a 9-watt LED bulb replaces a 60-watt standard bulb), the wattage of LED nightlights, and the GPM rating of faucet aerators and low-flow showerheads. The shipment data was similar to the quarterly tracking data but was broken out by month and income status. The SWE did not find any discrepancies with quantities or measure descriptions between the project documentation and the tracking data. Project files do not contain data on some of the variables used in savings calculations, such as the number of people in the home, water heater setpoint temperature and fuel type, and HVAC system specifications.

Energy Efficient Homes Program: Comprehensive Audits (Single Family)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: Comprehensive Audits (Multifamily)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: New Homes

All project files contained builder certificates and REM/Rate or Ekotrope analysis reports, and most project files contained REM/Rate or Ekotrope modeling files. Project files, which included a REM/Rate or Ekotrope report contained the heating and cooling capacity and efficiency metrics for the HVAC equipment as well as the volume of the hot water heater at the newly constructed home.

Energy Efficient Products Program and LIEEP: Appliance Rebates

The Appliance Rebate program had project files containing either receipts for rebated appliances, appliance rebate application forms, or both. These project files were accompanied by tracking data that recorded the date the rebate amount, the appliance purchased, the appliance type, and the appliance's quantity.

Energy Efficient Products Program and LIEEP: Appliance Recycling

The Appliance Recycling program had project files containing photos of the participant's signatures, photos of the nameplates of the recycled appliances, and photos of the recycled appliances themselves. These project files were accompanied by tracking data that recorded the type of recycled appliances, the date it was recycled, the town it was from, and the quantity of

recycled appliances. Although some of the photos of the appliances did not include nameplates, the SWE notes the thoroughness of the documentation.

Energy Efficient Products Program: HVAC

The HVAC program was only in operation during Q1 and Q2 of PY16. The HVAC project files included AHRI certifications, invoices equipment registration and rebate application forms. There were no discrepancies found in the project files as compared to the tracking database. However, there were some instances where the SWE was unable to confirm the tracking data matched the project file due to missing documentation such as the AHRI certificate.

Energy Efficient Products Program: Midstream Appliances

The Midstream Appliances program was only in operation during Q1 and Q2 of PY16. The project files for Midstream Appliances were comprised of invoice-styled excel sheets with tracking data that could be easily matched to the sample data given for each quarter. The invoice data recorded the type of appliance rebated, quantity, the appliance price, and the rebate amount. The SWE review of the sampled files did not reveal any discrepancies between the project files and the tracking database.

Low-Income Energy-Efficiency Program: New Homes

The SWE review of LI New Homes files is summarized in the New Homes subsection above.

Low-Income Energy Efficiency Program: LI WARM

Invoices, audit forms, preassessment, and post assessment forms were provided for sampled projects. The SWE notes that some projects had varying levels of documentation described above, but generally the necessary documentation existed for each sampled project reviewed by the SWE. A review of the sampled files did not reveal any discrepancies and the information provided within each project matched the tracking database. The SWE acknowledges that EDC collected data may be stored in solution specific datasets that were not requested as part of the quarterly data submission.

Low-Income Energy-Efficiency Program: Kits

The SWE review of LI kit files is summarized in the energy efficient kits subsection above.

E.4.2.2 Non-Residential

As part of its audit process, the SWE conducts a review of ex ante savings values and methodologies. This review involves assessing specific project files for a sample of Met-Ed's non-residential programs in PY16. Throughout the program year, Met-Ed, program implementers, and the evaluation contractor provide project documentation on a quarterly basis to the SWE for review. The project documentation typically includes program rebate applications and approvals, invoices for installed equipment, equipment specification or "cut" sheets, post-inspection forms, and calculation workbooks. The SWE reviews these documents for completeness and consistency. The SWE also compares the data points in the documentation against the program tracking database to ensure values such as savings, rebate amounts, installation, approval, and invoice dates align.

Overall, the SWE found that the project files were organized, complete, and accurate. [Table 141](#) presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 141: Met-Ed PY16 C&I Project File Review Summary

Program	Sub-Program	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Downstream	Custom - LCI	1	✓	✓	✓	✓	✓
Downstream	Custom - SCI	1	✓	✓	✓	✓	✓
Downstream	Energy Management - LCI	2	✓	✓	✓	✓	✓
Downstream	Energy Management - SCI	1	✓	✓	✓	✓	✓
Downstream	Prescriptive - LCI	1	✓	✓	✓	✓	✓
Downstream	Prescriptive - SCI	2	✓	✓	✓	✓	✓
Midstream	Prescriptive - LCI	2	✓	✓	N/A	N/A	N/A
Midstream	Prescriptive - SCI	2	✓	✓	N/A	N/A	N/A
Downstream	Multifamily	2	✓	✓	✓	✓	✓

E.5 VERIFIED GROSS SAVINGS AUDITS

E.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the Met-Ed portfolio of residential programs. Met-Ed's portfolio of residential programs includes the following: the Energy-Efficient Homes Program, the Energy-Efficient Products Program, and the LI Energy-Efficiency Program. Each program contains various subprograms, which are addressed separately below. Note that the SWE reports the residential savings in two sections: residential and behavior.

The SWE identified the evaluation activities used to verify savings for the residential programs. [Table 142](#) provides a summary of the evaluation and M&V approaches used by Met-Ed in their PY16 verified savings calculations.

Table 142: Residential Program Evaluation Activities – Met-Ed

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied Historic RR
Energy Efficient Homes					
Energy Efficiency Kits	✓	-	✓	-	-
HERs	-	-	-	✓	-
Residential Direct Install	-	-	✓	-	-
Residential Direct Install – Multifamily	-	-	✓	-	-
Residential New Construction	-	✓	✓	-	-
Energy Efficient Products					
Upstream Electronics	-	-	-	-	-
HVAC	✓	-	✓	-	-
Appliances	✓	-	✓	-	-
Appliance Turn-in	✓	-	✓	-	-
Midstream Appliances	-	-	✓	-	-
Low-Income Energy-Efficiency Program					
LI Direct Install	-	-	✓	-	-
LI Appliance Turn-in	✓	-	✓	-	-
LI Appliances	✓	-	✓	-	-
LI New Homes	-	✓	✓	-	-
LI Kits	✓	-	✓	-	-
^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.					

The SWE's review of verified savings for residential programs found that the verified savings followed proper TRM protocols and were accurate.

Energy Efficiency Kits Initiative: EE Kits and Low-Income Kits

The Energy Efficiency Kits (EE Kits) initiative has two sub-initiatives – EE Kits and Low-Income EE Kits. Each sub-initiative has two sub-components: EE Kits and School Education. The SWE reviewed school education kits for both the EE Kits and Low-Income EE Kits sub-initiatives. The kits provided through the School Education sub-component contained LED lamps, LED night lights, a furnace whistle, and electrical outlet gaskets. The Low-Income kits included advanced power strips in place of electrical outlet gaskets. The SWE confirmed the verified savings for each sub-initiative were in accordance with the TRM protocols for the relevant measures and worked with ADM to resolve any discrepancies prior to the filing of the FirstEnergy annual report. The

SWE also confirmed that participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Homes Program and LIEEP: New Homes

The SWE worked with evaluation contractor, ADM, to resolve some discrepancies in the evaluated savings prior to annual reporting. ADM reviewed and corrected the *ex post* energy models for a sample of PY16 projects to develop a realization rate for program-wide savings. ADM also revised the calculation method used for cooling demand savings to use hourly load results from the sampled models, which aligns with the approach used by other EDCs.

The Residential and Residential Low-Income Direct Install Initiatives

The Residential and Low-Income Direct Install Initiatives primarily used an SSRS Tracking and Reporting database for this evaluation as well as documentation from on-site QA/QC inspections. ADM used a stratified sampling approach to perform a desk review of a sample of participants in this program and rolled up the realization rates to the total program participant population. ADM provided the SWE with data from home inspections and with the subsequent savings calculations and roll up. The SWE confirmed the verified savings for each measure were in accordance with TRM protocol. The SWE also confirmed that the participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Products Program: HVAC

The HVAC component includes measures such as: air-source heat pumps, central air conditioning, furnace fans, ground source heat pumps, HVAC tune-ups, mini-split heat pumps, packaged terminal heat pumps and air conditioning, connected thermostats, bathroom fans, and circulating pumps. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. The SWE confirmed that participation, verified savings, and realization rates were in alignment with those in the annual report.

Energy Efficient Products Program and LIEEP: Appliances

The appliance component includes measures such as: refrigerators, freezers, clothes washers and dryers, dehumidifiers, dishwashers, window ACs, HPWHs, and connected thermostats. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. For the final report, Low-Income and Non-Low-Income Energy Efficient Products Programs were combined. The SWE confirmed that participation, energy savings, and energy realization rates were in alignment with those in the annual report.

The SWE notes that the appendix for this component includes a list of the variables for each appliance, and where the data source came from. This was helpful to the SWE audit.

Appliance Recycling and Low-Income Appliance Turn-In Initiative

The SWE conducted an early review of the Appliance Recycling and Low-Income Appliance Recycling Initiatives. Each initiative includes five measures: refrigerator recycling, freezer recycling, room air conditioner (RAC) recycling, dehumidifier recycling, and mini refrigerator recycling. ADM's evaluation included calculating measure level savings using program tracking data and survey data from PY16, including TRM inputs when necessary. The SWE did not observe any discrepancies with the application of TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Homes Program: Multifamily

Gross impact evaluation for the Res MF Initiative utilized a stratified sampling plan. Most projects are placed into one sampling stratum, with an additional stratum reserved for high-impact projects.

The program tracking and reporting system is at the measure level, and also identifies the rebate application and participant address associated with each measure. ADM aggregated all measures by unique address and then placed each household in one of the two strata: high-impact projects with reported energy savings above 2,000 kWh, and all other projects.

Due to the low participation and impacts in this initiative in Phase IV, desk reviews were the most appropriate evaluation activity. ADM evaluators compared audit reports and invoices to program tracking and reporting data to reconcile quantities of installed measures. The evaluators also independently calculated impacts for all measures according to their respective protocols in the 2021 PA TRM.

Energy Efficient Products Program: Midstream Appliances

The SWE conducted an early review of the Midstream Appliances component. ADM's evaluation included a full review of the program tracking data and aligning savings estimates with the TRM and product-specific data. The SWE did not observe any discrepancies with the application of the TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Products Program: Upstream Electronics

The FirstEnergy companies did not offer the Upstream Electronics component of the EE products program in PY16.

Energy Efficient Products Program and LIEEP: Online Audit

In PY13, FirstEnergy launched an Online Audit component to the Behavioral subprogram included in both the Energy Efficient Homes (EEH) and Low-Income Energy Efficiency (LI) programs. The Online Audit component operates on an opt-in basis and offers residential customers a web-based platform featuring energy usage visualizations, energy-saving tips, and promotion of other FirstEnergy residential energy-efficiency programs. Participation is defined as logging into the online portal and completing the registration to receive an audit. A total of 3,997 market-rate residential and 315 low-income households participated in the Online Audit in PY16, which is down from PY15 for both programs. Market-rate participants decreased by 34% and low-income participants decreased by 45% between PY15 and PY16.

The Phase IV Online Audit subprogram is an opt-in program, and the SWE team reviewed the propensity score matching ADM performed to create a matched control group using five pre-treatment consumption variables, latitude, longitude, and a categorical variable that identifies to which HERs cohort a customer belongs. The comparison group matching was performed using a 1:1 treatment-to-comparison group ratio. Due to the non-RCT design of the Online Audit component, ADM included weather terms to improve model fit and control for potential differences in weather-sensitivity between the treatment group and matched control group. In PY16, ADM adhered to the guidance provided by the SWE in PY14 to run a pooled regression model across all four EDCs. Given the relatively small sample sizes at the individual EDC x Program level, ADM chose to consolidate analysis at the Program level across the four FirstEnergy EDCs. A single regression model was estimated for EE Homes across all four EDCs, and another model for LI programs. Estimated regression coefficients were allowed to vary with temperature, and the resulting impacts were then adjusted for each EDC using EDC-specific weather variables. The SWE team independently calculated per-household kWh savings from regression coefficients, active participant counts, and aggregate MWh and MW impacts.

Our savings estimates and standard errors matched ADM's estimates once a cluster robust standard error correction was included in both model specifications. This statistical technique deals with autocorrelation and computes uncertainty based on the number of homes in the analysis rather than the number of observations. Use of the cluster robust standard error corrections causes the relative precision to exceed $\pm 100\%$ at the 85% confidence level, which means neither the market-rate nor low-income results are statistically significant. The Pennsylvania Evaluation Framework discusses this potential outcome for impact evaluations that rely on billing analysis and asks evaluation contractors to explore remedial actions. The planned remedial action for PY17 is to rely on a rolling multi-year regression model to increase the overall number of homes included in the analysis.

The SWE also reviewed the dual participation analysis. Online Audit participants tend to participate in other Met-Ed EE&C programs at a higher rate than the matched control groups, so this adjustment is necessary to avoid double-counting. To calculate gross verified demand savings, ADM generated an Energy to Demand Factor (ETDF) using residential load profiles corresponding to the treatment group and then applied ETDF to energy savings to estimate. The SWE was able to replicate the verified demand savings for both the residential and residential low-income group.

Table 143 shows the aggregate PY16 verified gross MWh savings and MW reductions by program. The table also shows the number of participants and average percent savings per household by program group. Using the first impact estimate as an example, the practical interpretation is as follows: all treatment group homes in the EEH Program saved 153 MWh and each household lowered their annual electric consumption by 0.27% during PY16. It is unclear why the low-income households saved more energy per household than their market-rate counterparts in PY16. Higher per household savings in the LI program could simply be a result of noise due to a small number of participants.

Table 143: PY16 Met-Ed Online Audit Energy and Demand Savings

Program	Participants	Gross Energy Savings (MWh)	Gross Demand Savings (MW)	Average Percent Savings per Home
EEH Program	3997	153	0.03	0.27%
LI Program	315	70	0.01	1.28%
Total	4,312	223	0.04	-

Behavior

Home Energy Reports were issued to around 164,000 residential and residential-LI households in PY16. Met-Ed's behavioral portfolio consists of both active waves and inactive legacy waves, which may be reactivated later in Phase IV. Seven waves, or cohorts, were active during PY16 and three of them targeted low-income households. [Table 144](#) summarizes the number of active households during PY16 by cohort and summarizes key features of the PY16 evaluation method.

Table 144: Met-Ed HER Cohort Summary

Cohort	Start Date	Treatment Group Homes	Control Group Homes	Reintroduced Cohort	Rebaselined Cohort	Weighted Regression
2012 Low-Income	7/1/2012	6,786	1,935	Yes	No	No
2012 Residential	7/1/2012	57,873	21,060	Yes	No	No
2014 Residential	1/1/2014	36,063	10,661	No	N/A	Yes
2021 Low-Income	9/26/2021	7,703	6,958	No	N/A	No
2021 Residential	9/26/2021	26,657	9,046	No	N/A	No
2023 Low-Income	6/4/2023	8,919	7,378	No	N/A	No
2024 Residential	5/12/2024	19,866	19,867	No	N/A	No
Total		163,867	76,905			

The program implementer, ICSP Oracle, administered all cohorts as randomized control trials (RCTs). Eligible households were identified and then randomly assigned to either a treatment or control group. Following randomization, ADM conducted statistical tests on the pre-treatment energy usage patterns to confirm equivalence between the treatment and control groups.

The SWE team conducted an audit of the pre-treatment equivalence test for all cohorts. To check the pre-treatment equivalence, the SWE team ran a Welch Two Sample T-Test on pre-period usage by treatment status for each cohort. The pre-period usage variables include the average annual, summer, and winter energy usage per household in the year prior to treatment. With these defined baselines and pre-treatment lag variables, the SWE team was able to replicate the same p-values for the t-test results as ADM.

As part of the PY16 implementation of the Home Energy Reports (HER) measure, two previously suspended historical Met-Ed cohorts were reintroduced into the program. ADM also assessed the equivalence of the treatment and control groups in these cohorts, 2012 Low-Income and 2012 Residential, during PY15 to determine if the HER impact had decayed sufficiently to allow PY15 data to be used as the pre-treatment period. ADM found that the treatment and control groups in these two cohorts showed statistically significant differences, suggesting savings are persistent, rendering them unsuitable for rebaselining. Both reintroduced Met-Ed cohorts retained their original baseline periods and treatment dates.

Both ADM and the SWE team found that one Met-Ed cohort failed the annual consumption equivalence check at the 90% confidence level. To accommodate this, ADM proposed using propensity score matching (PSM) on the three pre-treatment variables for this cohort, using with-replacement matching. Following ADM's approach, propensity score matching was used to rebalance the 2014 Residential cohort by providing a series of weights for the control customers in that cohort. With those weights, the 2014 Residential cohort passed the equivalence test. The SWE team was able to replicate the equivalence t-test results for this cohort using ADM's weights. Those weights are used in the linear regression to calculate consumption savings and used in the simple difference calculation to determine peak-demand reduction.

ADM provided the SWE team with both daily and monthly consumption data for all homes in the treatment and control groups. The monthly data served as the primary input in the estimation of HER impacts. The SWE team found the calculations and distribution of monthly kWh to be reasonable. Models used throughout the analysis rely on three pre-treatment lag variables: average usage, average summer usage, and average winter usage. The pre-treatment period is 12 months prior to original treatment for all Met-Ed's cohorts. Using the daily consumption data, the SWE team was able to replicate the three lagged variables calculated by ADM for each customer. These lag terms were calculated for customers with 12 months of pre-treatment data, who also had no data issues as flagged by ADM (i.e. invalid hourly observations or outlier consumption amounts).

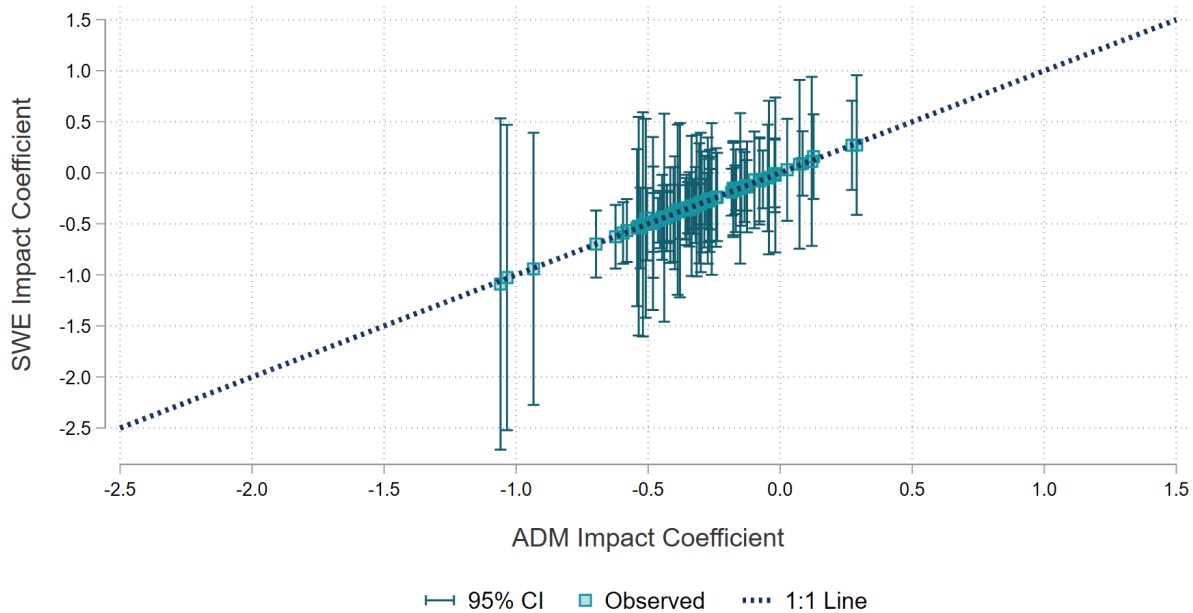
ADM obtained active customer counts for each month by tallying up the number of accounts that have daily interval data for the month. Only active treatment group accounts where HER delivery has begun are included in these calculations. Both ADM and the SWE team found an inconsequential number of accounts that were not counted because they either were placed in both the control group and treatment group or had multiple treatment starting dates. A few accounts were not included in the counts because Oracle never began HER delivery to these homes or due to pre-start date attrition.

The SWE team validated ADM's enrollment counts by performing a similar counting method on the daily consumption data. Customers are considered active through the end of the month that they last have interval data. For example, if a customer's final AMI record is from February 15th, the customer would be included in the count for February but not in March or any month following. The SWE team's final customer counts matched ADM's for each month and cohort.

Customers that do not have twelve months of pre-treatment data or were flagged as having a data issue were not included in the impact estimation (because the lagged seasonal variables for these customers were not calculated), but they were included in the customer counts.

ADM used a lagged seasonal (LS) regression model for the PY16 impact analysis. Using the monthly billing data, the LS model estimates the relationship between daily usage and pre-treatment variables. Unlike previous years, the regression included weights for the 2014 Residential cohort that failed the equivalence test without weighting. The SWE team was able to replicate ADM's coefficients with no notable differences in coefficients, as shown in [Figure 48](#). The SWE estimates all fell within the confidence interval for ADM's coefficients.

Figure 48: Med-Ed PY16 HER LS Coefficient Comparison



The SWE team independently calculated gross MWh savings using regression coefficients and active participant counts, and our estimates match those provided by ADM. [Table 145](#) shows the aggregate PY16 pre-adjustment gross MWh savings by cohort. The table also shows three adjustments, which are discussed in greater detail later, and the PY16 incremental verified gross savings estimate.

Table 145: Met-Ed PY16 Energy Savings*

Cohort	Gross Savings (MWh)	Downstream Dual Participation (MWh)	Upstream Dual Participation (MWh)	Persistence (MWh)	Incremental Savings (MWh)
2012 Low-Income	1,305	-25	40	0	1,290
2012 Residential	8,964	745	247	0	7,972
2014 Residential	3,847	747	93	2,238	769
2021 Low-Income	-76	27	0	44	-147
2021 Residential	3,765	-27	0	1,054	2,738
2023 Low-Income	683	1	0	0	682
2024 Residential	1,581	29	0	0	1,552
Total	20,069	1,498	379	3,336	14,856

* Totals may not equal the sum of columns or rows due to rounding.

Home Energy Reports advertise other Met-Ed residential EE&C programs and measures such as ENERGY STAR appliances, water heaters, and high-efficiency HVAC rebates. To the extent that treatment group households participate in these programs more frequently than the control group homes, the incremental savings are captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings are adjusted to account for the incremental program participation observed in the treatment group compared to the control group. An upstream dual participation adjustment is only applied to the gross savings estimates of 2012 and 2014 cohorts.

The 2021 Pennsylvania TRM assumes an annual decay rate of 31.3% derived from Pennsylvania-specific research⁸⁴ on the persistent effects of behavioral energy efficiency treatment in the years after discontinuing treatment. Since Act 129 compliance goals are based on first-year incremental savings, these persistent impacts are subtracted from the measured savings to estimate incremental first-year savings (those directly due to the current program year of treatment).

For the first two years of HER exposure, persistence is assumed to be zero and the first-year savings average treatment effect (FYSATE) simply equals the average treatment effect (ATE). For year three and beyond of HER exposure, the FYSATE is calculated using Equation 2, which comes from the 2021 TRM. For year i of HER exposure:

Equation 2: First Year Savings Average Treatment Effect (FYSATE)

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

$$\Delta kWh_y = FYSATE_y * Treatment\ Accounts_y * Days_y$$

⁸⁴ Addendum to Act 129 Home Energy Report Persistence Study. November 2018.

https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

Where $FYSATE_y$ is the average daily savings attributable to HERs delivered in the current year (Y) and $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in year Y-X.

Because the 2023 and 2024 waves were launched during PY15 and PY16, their savings are considered incremental. Separating persistent savings from incremental savings was not necessary for these waves, but the 2014 and 2021 waves did require such an adjustment. The reintroduced historical cohorts did not have any persistence adjustment, as they were not treated for three years, so there is no persistence still in effect. The SWE team found that ADM correctly modeled persistence in accordance with TRM specifications for these waves.

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 SWE team was able to replicate ADM's peak-demand impact estimate and peak-demand reduction for each cohort, with no noticeable differences between the SWE team and ADM impacts.

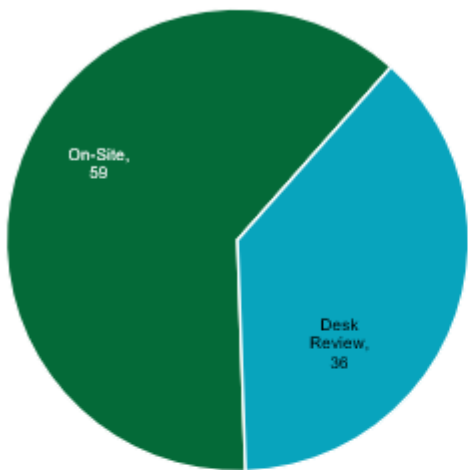
In conclusion, the SWE team successfully replicated ADM's findings for Met-Ed. Their methodology was transparent and reproducible, and any adjustments to the analysis were well-justified and reviewed collaboratively to ensure their validity.

E.5.2 Non-Residential Audit Activities

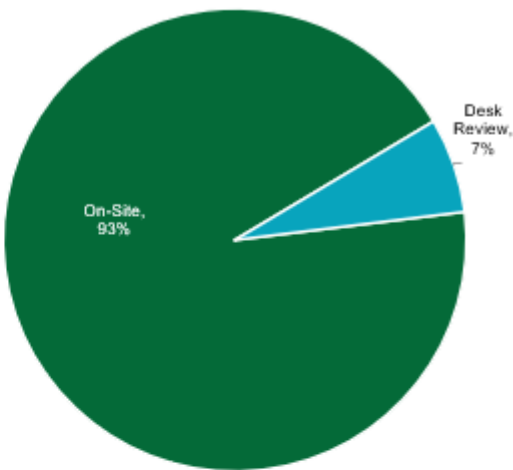
Figure 49 provides a summary of the evaluation activities and M&V approaches utilized by ADM in their PY16 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY16, Met-Ed's evaluation contractor completed site visits to 59 of 95 evaluated projects, and these on-site projects represented 93% of total evaluated energy savings. IPMVP Options A, B, C, and D were employed for 90% of the total evaluated energy savings.

Figure 49: Summary of Met-Ed’s C&I Evaluation Activities

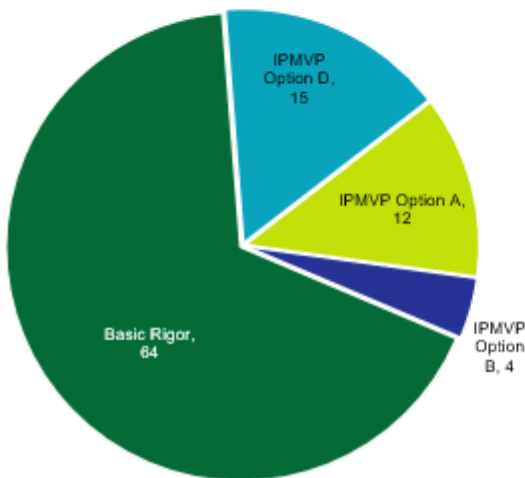
M&V Activity by Project Count



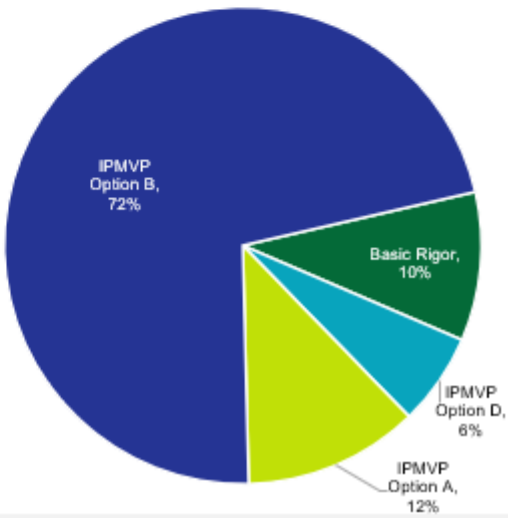
M&V Activity by kWh Contribution



M&V Method by Project Count



M&V Method by kWh Contribution



Met-Ed's evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Met-Ed's C&I programs are assigned to one of five evaluation initiatives, as Met-Ed's programs target specific sectors of C&I customers, but offerings are often identical across the programs. Table 146 provides a summary of the evaluation activities Met-Ed's evaluation contractor used across strata for all projects by initiative.

Table 146: Summary of Met-Ed's PY16 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR - Energy	RR - Demand	Desk Review	On-Site Verification
Appliance Recycling		109%	114%		
Custom	18	100%	105%	7	11
Custom-C	6	100%	102%	3	3
Custom-2	8	103%	153%	3	5
Custom-1	4	117%	105%	1	3
Prescriptive	42	95%	91%	32	10
Downstream Lighting-C	5	100%	100%	5	-
Downstream Lighting-2	6	90%	98%	6	-
Downstream Lighting-1	4	96%	89%	2	2
Downstream Non-lighting	3	56%	83%	3	-
Midstream Lighting-1	14	95%	113%	9	5
Midstream Lighting-2	10	93%	75%	7	3
EMNC	26	96%	93%	16	10
Building Tune-Ups-2	7	94%	104%	5	2
Building Tune-Ups-1	6	82%	87%	2	4
Building Tune-Ups-3	2	117%	94%	2	-
BOC-1	1	100%	100%	-	1
CBI-RCX-1	4	98%	68%	2	2
CNC-1	1	71%	62%	-	1
EMNC-C	5	94%	95%	5	-
Multifamily-1	9	104%	112%	4	5
TOTAL	95			59	36

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

E.5.2.1 Appliance Recycling Initiative

In PY16, projects in Met-Ed's Appliance Recycling Sub-Initiative were evaluated through a review of tracking and reporting data. The gross energy and demand realization rates for each evaluation stratum were taken to be the realization rates from the broader initiative-level evaluation, which included the residential and low-income residential components.

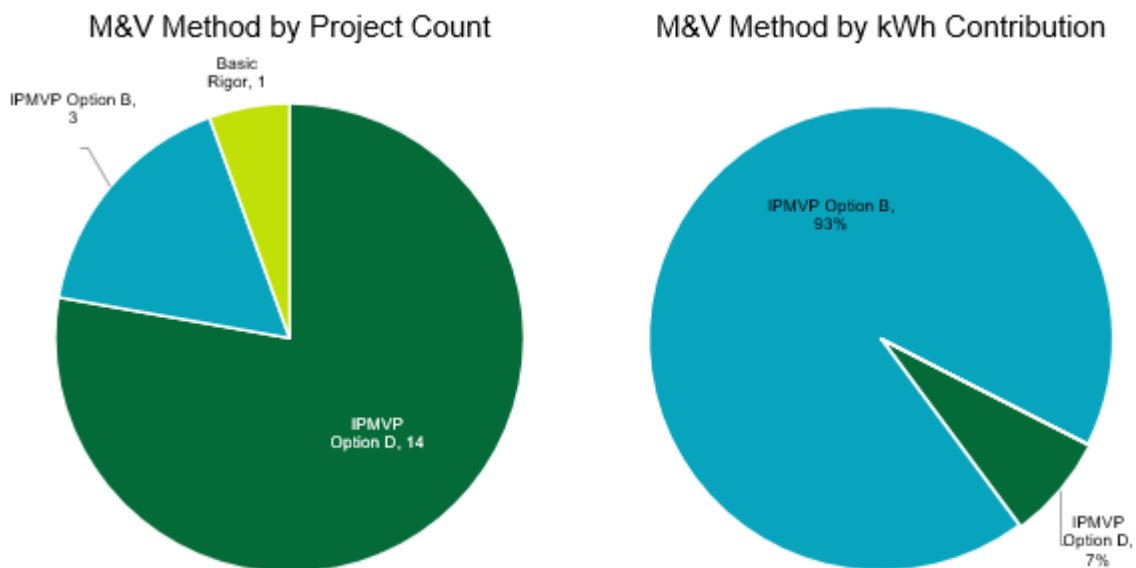
E.5.2.2 Custom Initiative

Evaluation activities for this initiative include desk reviews and/or IPMVP evaluation methods for all sampled projects. Seven site visits were conducted for PY16 Custom sampled projects. The eleven remaining project evaluations were satisfactorily conducted through desk reviews using data provided by the customer. Met Ed Solar PV projects were evaluated through the Custom Initiative using NREL's SAM and PVWatts models. The SWE independently replicated savings calculations, applied caps based on actual utility billing data where appropriate, and verified correct definitions of peak hours.

Met-Ed's evaluation contractor employed two strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a "certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with the Phase IV Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty. Enhanced rigor methods were employed to evaluate all but one project through IPMVP Options B and D selected as the primary enhanced M&V methods, as shown in [Figure 50](#).

Figure 50: Summary of Met-Ed's C&I Custom Program M&V Methods

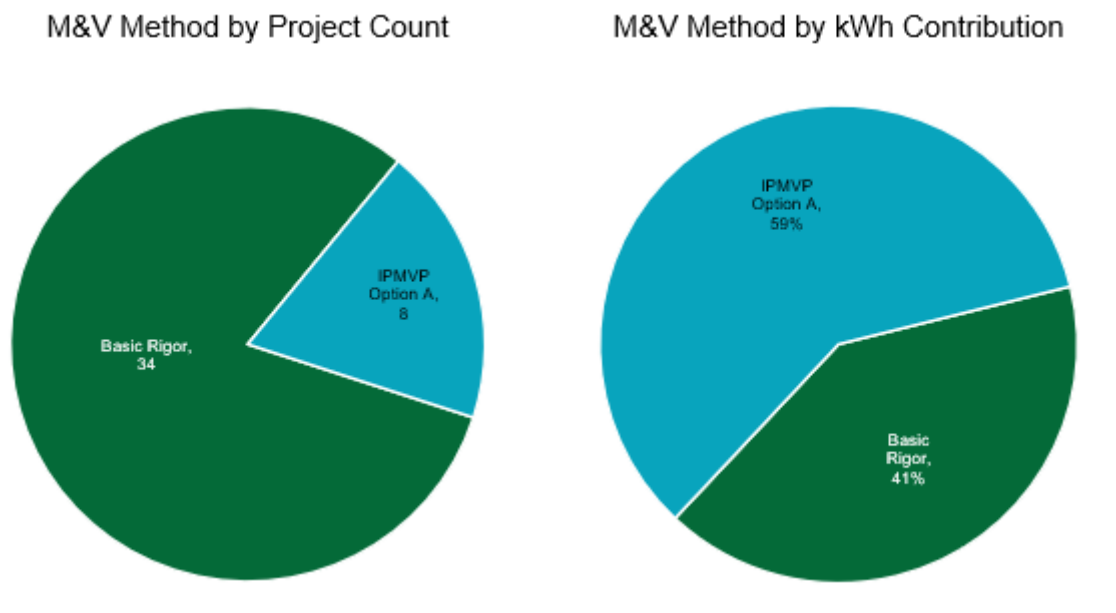


E.5.2.3 Prescriptive Initiative

Met-Ed's evaluation contractor employed six strata for projects in the Prescriptive initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a "Downstream – Certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

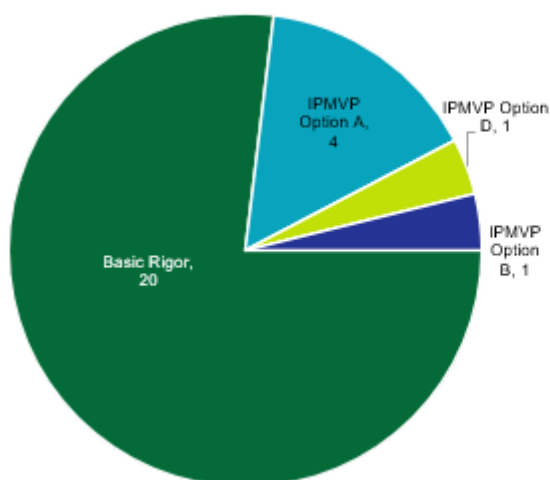
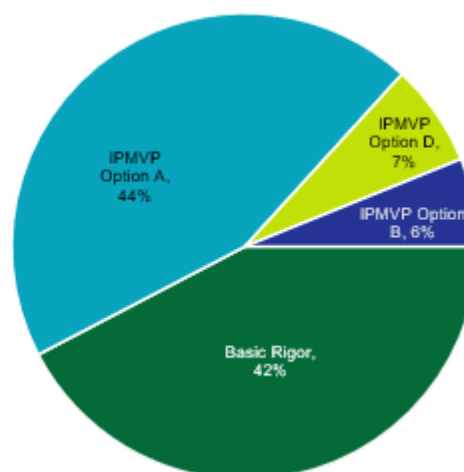
IPMVP Option A was employed for 59% of evaluated project savings in this initiative with the remaining projects using IPMVP Option A and Basic Rigor, as seen in [Figure 51](#) below.

Figure 51: Summary of Met-Ed's C&I Prescriptive Program M&V Methods



E.5.2.4 Commercial and Industrial Energy Management and New Construction Initiative (CI EMNC)

The CI EMNC Initiative has five sub-components, and four were active in PY16: Building Tune-Up, Building Operator Certification, New Construction, and Retro-commissioning. Evaluation activities for this initiative were all completed through desk reviews. Basic rigor M&V methods were most commonly applied to the EMNC projects, incorporating TRM algorithms and reconciliations of invoices with equipment specification sheets, and IPMVP Options A, B, and D were also used. Option A evaluations accounted for 44% of Initiative savings with Basic Rigor employed for 42% of evaluated project savings, as seen in [Figure 52](#) below.

Figure 52: Summary of Met-Ed's CI EMNC Program M&V Methods**M&V Method by Project Count****M&V Method by kWh Contribution**

E.5.2.5 Verified Savings Audits

The SWE audited the activities above through a detailed audit of ADM's evaluation work for a sample of their evaluated projects. The SWE audit for ADM's Met-Ed evaluation in PY16 included review of nine projects, encompassing the following activities:

- Three field and analysis engineers audited
- Sixteen custom, four Prescriptive, four EMNC, and one multifamily measure reviewed
- 8% of verified energy savings checked by SWE
- 80% of verified demand savings checked by SWE

Table 147 provides an overview of the SWE milestones for the verified savings audit review of evaluated Met-Ed projects.

Table 147: Met-Ed Verified Savings Audit Review Milestones

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
25	68,408,097	100%	10,229	100%

Overall, the SWE found that Met-Ed's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods for custom measures.

MODIFY C&I Direct Install

The MODIFY subprogram, offered for Met-Ed and Penelec only, provided direct delivery of 25 or 50 TLEDs to small commercial businesses. The SWE reviewed FirstEnergy's survey, tracking

and reporting data of the MODIFY program. Activities included review of valid survey respondents, verified savings checked by the SWE and demand savings reviewed by the SWE. The SWE found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper TRM protocols correctly, and were accurate.

E.6 NTG

Table 148 lists Met-Ed's PY16 NTG as listed in the First Energy PY16 Annual Report. Details concerning the methods and data used to estimate NTG values are in sections E.6.1 and E.6.2.

Table 148: Summary of Met-Ed's PY16 NTG Results

Program Name	Component	NTG
Energy Efficient Products	Appliance Recycling	0.61*
Energy Efficient Products	HVAC	0.51
Energy Efficient Products	Appliances	0.69
Energy Efficient Products	Midstream Appliances	0.58
Energy Efficient Homes	EE Kits	0.82
Energy Efficient Homes	Home Energy Reports	1.00
Energy Efficient Homes	Direct Install	0.87
Energy Efficient Homes	New Homes	0.72
Energy Efficient Homes	Multifamily Residential	1.00
Energy Efficient Homes	Comprehensive Audits	1.00
C&I Solutions for Business Programs – Small and Large	Multifamily	1.00
C&I Solutions for Business Programs – Small and Large	Prescriptive	0.64
C&I Solutions for Business Programs – Small and Large	Appliance Recycling	0.61*
C&I Solutions for Business Programs – Small	Custom	0.43
C&I Solutions for Business Programs – Small	EMNC	0.66
C&I Solutions for Business Programs – Large	Custom	0.56
C&I Solutions for Business Programs – Large	EMNC	0.73
Portfolio Total		0.73

* NTG is from the Process and NTG Memo.

E.6.1 Residential Programs

ADM planned and enacted NTG research for the Appliance Recycling component of the EE Products Program component of the EE Homes Program. ADM utilized participant surveys to estimate free-ridership and NTG for all components. Spillover is not calculated because the program is not designed to encourage customers to implement additional energy-efficiency projects. ADM utilized question batteries that were consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation (Table 149). The SWE reviewed FirstEnergy's Phase IV EMV Plan, all surveys, analyses code and data used to estimate NTG and have found that the NTG reported in the PY16 Annual Report is 0.01 higher than that shown in the Appliance Recycling NTG analysis and the Process and NTG Memo.

Table 149: Summary of Met-Ed's PY16 Residential NTG Results

Program Component	Approach	Sample Size	Free-Ridership	Spillover	NTG
Appliance Recycling	Participant Surveys	346	0.39	0.00	0.61*

* NTG for Appliance Recycling is from the Process and NTG Memo.

E.6.2 C&I Energy-Efficiency Programs

ADM planned and enacted NTG research for the C&I Custom and Energy Management subprograms of the Energy Solutions for Business (ESB) program for small and large commercial customers in PY16 (Table 150).

Table 150: Summary of Met-Ed's PY16 C&I NTG Results

Program Components	Approach	Sample Size	Free-ridership	Spillover	NTG
EMNC	Participant Surveys	120	0.34	0.02	0.68 ¹
Custom	Participant Surveys	24	0.49	0.05	0.56

¹ Includes the MODIFY program which alone had a FR of 0.20, SO of 0.0, and a NTG of 0.80%.

E.7 TRC

Table 151 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Met-Ed's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY16 annual report, and the model itself was well-organized and documented.

Table 151: Summary of Met-Ed's PY16 TRC Results¹

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$15,740	\$5,447	2.89	\$10,294
Energy Efficient Products	\$4,479	\$6,488	0.69	(\$2,009)
Low Income Energy Efficiency	\$2,886	\$3,299	0.87	(\$413)
Residential Subtotal	\$23,106	\$15,234	1.52	\$7,872
C&I Energy Solutions for Business - Small	\$29,260	\$13,158	2.22	\$16,102
C&I Energy Solutions for Business - Large	\$42,884	\$42,932	1.00	(\$48)
Non-Residential Subtotal	\$72,143	\$56,090	1.29	\$16,053
Cross-cutting	\$0	\$0	--	\$0
Portfolio Total	\$95,249	\$71,324	1.34	\$23,925

¹ Totals may not equal the sum of columns or rows due to rounding.

Three of Met-Ed's five EE&C programs were found to be cost-effective when estimating the TRC using gross verified savings. Two programs (EEH and C&I Small) were found to be cost-effective

using net verified savings. The Energy Efficient Products and Low Income Energy Efficiency programs were not cost-effective on a gross or net verified basis.

E.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- The SWE also verified that the correct avoided costs from Met-Ed's EE&C Plan were used in the TRC model.
- To calculate the avoided cost of natural gas, Met-Ed used a three-segment approach outlined in the 2021 TRC Test Order. The SWE verified the TRC Model correctly applied the EE&C Plan avoided costs to estimate TRC benefits.
- Pursuant to the 2021 TRC Test Order, the SWE verified that Met-Ed used a nominal discount rate of 5% to calculate the net present value of future program benefits. This discount rate is consistent with their EE&C plan and the 2021 TRC Test Order. Line loss adjustment factors varied by sector. Residential (1.0945), Small C&I (1.072), and Large C&I (1.072).
- The incremental costs were derived from the SWE Incremental Cost Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumptions, and actual project costs as gathered from the PY16 evaluation. The SWE spot checked the incremental measure costs used in the TRC model and found them to be generally reasonable and consistent.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to calculate verified gross savings.
- The calculation of NTG using free-ridership and spillover, as well as the application of the NTG in the calculation of TRC benefits and costs, were consistent with the 2021 TRC Test Order directive for Phase IV. The TRC model followed the protocol pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The SWE found that the cost categories were handled correctly in the TRC model. Participant incentives were not considered TRC costs, while administrative costs, incremental costs, and kits were incorporated as costs.
- The SWE verified the reported demand and capacity savings were accurate in the TRC model by comparing them to the Quarterly Tracking Data and Met-Ed's Annual Report.
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Fossil Fuel Impacts and Total NPV Lifetime Water Impacts. The SWE verified that the savings were accounted for in accordance with the 2021 TRC Test Order. O&M benefits were negative in PY16 due to a large fraction of solar projects with yearly per kW maintenance expenses.

E.8 PROCESS

Four EDCs – Met-Ed, Penn Power, Penelec, and West Penn Power – operate an identical set of energy-efficiency programs.⁸⁵ Since ADM, together with its process evaluation subcontractor, Tetra Tech, took unified process evaluation approaches to these programs across the four EDCs, the annual reports of the four EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described in this section pertains to all four FirstEnergy utilities. Sample sizes are noted under each EDC.

E.8.1 Residential Programs

There are two residential programs: Energy Efficient Products and Energy Efficient Homes. Each program has multiple subprograms. In PY16, ADM/Tetra Tech completed process evaluations for the Appliance Recycling subprogram within the Energy Efficient Products program including its residential income-eligible and non-residential sub-initiatives. There was an evolution in the Comprehensive Audits subprogram within the Energy Efficient Homes program, but no process audit.

E.8.1.1 Energy Efficient Products Program – Appliance Recycling

Summary of Process Evaluation Results

For the process evaluation of this subprogram, ADM/Tetra Tech reviewed program documents and data, interviewed program staff and implementation staff, and surveyed participants. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) included the effectiveness of program administration, implementation, and delivery, and customer subprogram awareness and satisfaction.

The evaluators reported on the following key findings:

- *Relaunching the program with a new CPS has been smooth, with no reported issues.*
- *CLEAResult reports that standalone pickups of room air conditioners were successful for the program.*
- *Bill inserts continue to be the most common source of program information.*
- *Satisfaction with the program remains high, with a slight downward shift, due to dissatisfaction with the timing of rebate receipt.*

Summary of Process Evaluation Audit

The process evaluation of the Appliance Recycling subprogram appears to have been generally consistent with the Phase IV evaluation plan. For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans. The SWE notes that the PY16 annual report presented high-level, key findings while the

⁸⁵ The single exception is that West Penn Power discontinued the Appliance Recycling subprogram as of May 2025.

required tables showing the sampling strategy and detailed findings were reported in separate, supplemental memos.

The PY16 evaluation team completed 379 participant surveys with Met-Ed customers.

The SWE also determined that the reporting followed the SWE guidelines. The FirstEnergy PY16 Annual Report included descriptions of the methods, summaries of conclusions, and a list of recommendations with a description of whether FirstEnergy was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, conclusions, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

E.8.1.2 Energy Efficient Products Homes – Comprehensive Audits

There were not any surveys as part of the PY16 evaluation.

E.8.1.3 Energy Efficient Products Homes – Multifamily Residential

There were not any surveys as part of the PY16 evaluation.

E.8.1.4 Energy Efficient Products Homes – School Education

There were not any surveys as part of the PY16 evaluation.

E.8.1.5 Energy Efficient Products Homes – EE Kits

There were not any surveys as part of the PY16 evaluation.

E.8.2 Residential Low-Income Program

There is one low-income residential program, the Low-Income Energy Efficiency Program, which has seven subprograms. In PY16, ADM/Tetra Tech completed process evaluations for the income-eligible sub-initiative of the Appliance Recycling subprogram:

E.8.2.1 Weatherization (Direct Install)

There were not any surveys as part of the PY16 evaluation.

E.8.2.2 Appliance Rebate

There were not any surveys as part of the PY16 evaluation.

E.8.2.3 Behavioral Home Energy Report

There were not any surveys as part of the PY16 evaluation.

E.8.2.4 Multifamily (Residential)

There were not any surveys as part of the PY16 evaluation.

E.8.2.5 New Homes

There were not any surveys as part of the PY16 evaluation.

E.8.2.6 School Education

There were not any surveys as part of the PY16 evaluation.

E.8.2.7 EE Kits

There were not any surveys as part of the PY16 evaluation.

E.8.2.8 Appliance Recycling – Low-Income Sub-Initiative

The PY16 evaluation team completed 33 participant surveys with low-income customers.

E.8.3 Commercial & Industrial Programs

There are two C&I programs: Energy Solutions for Business-Small and Energy Solutions for Business-Large. Each program has five subprograms: Multifamily, Prescriptive, Custom, New Construction, and Energy Management. The subprograms use downstream, midstream, and direct install delivery channels. In PY16, ADM/Tetra Tech completed process evaluations of the nonresidential sub-initiative of the Appliance Recycling subprogram and the following subprograms:

- Energy Solutions for Business – Small
 - Custom
 - Energy Management
- Energy Solutions for Business – Large
 - Custom
 - Energy Management

E.8.3.1 C&I Energy Solutions for Business (Small) - Multifamily

There were not any surveys as part of the PY16 evaluation.

E.8.3.2 C&I Energy Solutions for Business (Large) – Multifamily

There were not any surveys as part of the PY16 evaluation.

E.8.3.3 C&I Energy Solutions for Business (Large) – Custom

Summary of Process Evaluations Results

For the process evaluation of this subprogram and the related subprogram for C&I Energy Solutions for Business (Small), ADM/Tetra Tech reviewed program documents, interviewed program and implementation staff. ADM/Tetra Tech also surveyed participating customers and vendors. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) including the effectiveness of program administration, implementation, and delivery as well as customer awareness and satisfaction with the subprogram.

The evaluators reported on the following key findings:

- *Satisfaction among participating customers and vendors remains high.*
- *Trade allies (contractors and vendors) continue to be the most common source of respondent awareness.*

- *The application process received positive feedback from the participating customers, but vendor respondents had some suggestions.*
- *Nearly two-thirds of the customer respondents had no recommendation improvements or changes to the program, while half of the vendor respondents offered suggestions.*
- *Incomplete and generic contact information limited survey reach.*

Summary of Process Evaluation Audit

The process evaluation of the Custom C&I (Large and Small) subprograms was generally consistent with the Phase IV evaluation plan. For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans. The SWE notes that the PY16 annual report presented high-level, key findings while the required tables showing the sampling strategy and detailed findings were reported in separate, supplemental memos.

The PY16 evaluation targeted 15⁸⁶ participant surveys for C&I (Large) Custom projects⁸⁷; the target was not met with 5⁸⁸ completed participant surveys. These participant surveys covered four projects with Met-Ed customers from the Custom C&I (Large) subprogram.

The PY16 evaluation also targeted 24 surveys with participating vendors across the C&I (Large and Small) Custom and Energy Management subprograms; the target was almost achieved with 23 complete surveys representing 25 projects.

The PY16 evaluation conducted one in-depth interview with program staff and three in-depth interviews with implementation staff.

The SWE also determined that the reporting followed the SWE guidelines. The FirstEnergy PY16 Annual Report included descriptions of the methods, summaries of conclusions, and a list of recommendations with a description of whether FirstEnergy was implementing or considering those recommendations. The associated memos included most of the necessary information for the SWE (and other readers) to assess the methods, conclusions, and recommendations. The SWE contacted the evaluation team to clarify the method for establishing survey targets and suggests that in the future, that process be described in greater detail. The SWE also noticed inconsistent assigning of measures to subprograms between the memos and the final report and recommends using consistent definitions moving forward.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

⁸⁶ The SWE calculated the survey targets by calculating the subprogram-level sample frame size, multiplying it by the expected 35% response rate from the PY16 C&I Process Evaluation sampling memo, and rounding to the nearest complete. This approach is consistent with the methodology established in the PY16 sampling memo.

⁸⁷ The PY16 completed 109 total participant surveys covering 139 projects in the C&I (Small and Large) Custom and Energy Management subprograms.

⁸⁸ The SWE calculated subprogram-level survey completes using subprogram definitions consistent with the PY16 annual report.

E.8.3.4 C&I Energy Solutions for Business (Small) – Custom

Summary of Process Evaluation Results

The process evaluation results for both C&I Energy Solutions for Business (Large and Small) Custom subprograms is presented in [Section E.8.3.3](#).

Summary of Process Evaluation Audit

The PY16 evaluation team targeted 45⁸⁹ participant surveys for C&I (Small) Energy Management projects⁹⁰; the target was not met with 19⁹¹ completed participant surveys. These participant surveys covered seven projects with Met-Ed customers from the Custom C&I (Small) subprogram.

E.8.3.5 C&I Energy Solutions for Business (Large) – Energy Management

Summary of Process Evaluations Results

For the process evaluation of this subprogram and the related subprogram for C&I Energy Solutions for Business (Small), ADM/Tetra Tech reviewed program documents, interviewed program staff, implementation staff, and participants in the Building Operator Training subprogram. ADM/Tetra Tech also surveyed participating customers and vendors. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) including the effectiveness of program administration, implementation, and delivery as well as customer awareness and satisfaction with the subprogram.

The evaluators reported on the following key findings:

- *Satisfaction among participating customers and vendors remains high.*
- *Trade allies (contractors and vendors) continue to be the most common source of respondent awareness.*
- *The application process received positive feedback from the participating customers, but vendor respondents had some suggestions.*
- *Nearly two-thirds of the customer respondents had no recommendation improvements or changes to the program, while half of the vendor respondents offered suggestions.*
- *Incomplete and generic contact information limited survey reach.*
- *Program motivated participation in the Building Operator Training (BOT). Participants were highly satisfied with the training and found it valuable.*

⁸⁹ The SWE recalculated the survey targets using subprogram definitions consistent with the PY16 annual report and recalculated the subprogram-level sample frame size, multiplying it by the expected 35% response rate, and rounding to the nearest complete. This approach is consistent with the methodology established in the PY16 sampling memo.

⁹⁰ The PY16 completed 109 total participant surveys covering 139 projects in the C&I (Small and Large) Custom and Energy Management subprograms.

⁹¹ The SWE recalculated subprogram-level survey completes using subprogram definitions consistent with the PY16 annual report.

Summary of Process Evaluation Audit

The process evaluation of the Custom C&I (Large and Small) subprograms appears to have been generally consistent with the Phase IV evaluation plan. For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans. The SWE notes that the PY16 annual report presented high-level, key findings while the required tables showing the sampling strategy and detailed findings were reported in separate, supplemental memos.

The PY16 evaluation team targeted 56⁹² participant surveys for C&I (Large) Energy Management projects,⁹³; and completed 26⁹⁴ participant surveys. These participant surveys covered two projects with Met-Ed customers from the Energy Management C&I (Large) subprogram. As questions on this survey were not relevant for the BOT participants, the evaluation team omitted them from the participant survey and instead conducted in-depth interviews. The team contacted all seven BOT participants and completed four interviews.

The PY16 evaluation team also targeted 24 surveys with participating vendors across the C&I (Large and Small) Custom and Energy Management subprograms; the target was almost achieved with 23 complete surveys representing 25 projects.

The PY16 evaluation team conducted one in-depth interview with program staff and three in-depth interviews with implementation staff.

The SWE also determined that the reporting followed the SWE guidelines. The FirstEnergy PY16 Annual Report included descriptions of the methods, summaries of conclusions, and a list of recommendations with a description of whether FirstEnergy was implementing or considering those recommendations. The associated memos included most of the necessary information for the SWE (and other readers) to assess the methods, conclusions, and recommendations. The SWE contacted the evaluation team to clarify the method for establishing survey targets and suggests that in the future, that process is described in greater detail. The SWE also noticed inconsistent assigning of measures to subprograms between the memos and the final report and recommends using consistent definitions moving forward.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer.

E.8.3.6 C&I Energy Solutions for Business (Small) – Energy Management Summary of Process Evaluation Results

⁹² The SWE recalculated the survey targets using subprogram definitions consistent with the PY16 annual report and recalculated the subprogram-level sample frame size, multiplying it by the expected 35% response rate, and rounding to the nearest complete. This approach is consistent with the methodology established in the PY16 sampling memo.

⁹³ The PY16 completed 109 total participant surveys covering 139 projects in the C&I (Small and Large) Custom and Energy Management subprograms.

⁹⁴ The SWE recalculated subprogram-level survey completes using subprogram definitions consistent with the PY16 annual report.

The process evaluation results for both C&I Energy Solutions for Business (Large and Small) Energy Management subprograms is presented in [Section E.8.3.5](#).

Summary of Process Evaluation Audit

The PY16 evaluation team targeted 226⁹⁵ participant surveys for C&I (Small) Energy Management projects⁹⁶; the target was not met with 89⁹⁷ completed participant surveys. These participant surveys covered two projects with Met-Ed customers from the Energy Management C&I (Small) subprogram. These participant surveys covered 19 Energy Management (Small) projects with Met-Ed Customers.

E.8.3.7 Appliance Recycling – Non-residential Sub Initiative

Summary of Process Evaluation Results

The process evaluation results for the Appliance Recycling subprogram is presented in [Section E.8.1.1](#).

Summary of Process Evaluation Audit

The PY16 evaluation team conducted in-depth interviews with six Met-Ed C&I (Small) customers participating in the Appliance Recycling subprogram.

⁹⁵ The SWE recalculated the survey targets using subprogram definitions consistent with the PY16 annual report and recalculated the subprogram-level sample frame size, multiplying it by the expected 35% response rate, and rounding to the nearest complete. This approach is consistent with the methodology established in the PY16 sampling memo.

⁹⁶ The PY16 completed 109 total participant surveys covering 139 projects in the C&I (Small and Large) Custom and Energy Management subprograms.

⁹⁷ The SWE recalculated subprogram-level survey completes using subprogram definitions consistent with the PY16 annual report.

Appendix F FirstEnergy: Pennsylvania Electric Company PY16 Audit Detail

F.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Penelec provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Penelec PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Penelec had ten active HER cohorts in PY16. Five of the cohorts consist of market-rate residential households and the other five cohorts consist of low-income households. Behavioral HER programming accounted for 4% of Penelec's total verified MWh savings in PY16 and 19% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with its approved EM&V plans.
 - Despite having a comparable number of treated homes, Penelec had one-third the incremental HER MWh savings of Met-Ed.
 - Penelec reintroduced three historical cohorts after a three-year pause, two low-income and one residential. ADM found that the treatment and control groups in one of these cohorts were equivalent in PY15, suggesting savings from prior HER exposure are not persistent and rebaselining is possible. As a result, one reintroduced cohort had their treatment date and baseline period updated. The other two cohorts retained their original treatment date and baseline period.
 - Penelec's rebaselined cohort had negative savings. The other reintroduced cohorts that were not rebaselined had positive savings.
 - One of Penelec's cohorts failed its equivalence test and required rebalancing using weights that were calculated using a propensity score matching approach. These weights are applied to the cohort throughout the analysis.
 - The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Penelec's Online Audit offering showed a higher average percent savings (2.3%) compared to market-rate participants (0.5%). However, participation in the program was much lower for low-income households (approximately 18% of market-rate households), so the margin of error around the billing analysis estimate was large.

- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Penelec's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Penelec's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data, but the SWE did not expect to be able to do so, and the SWE calculated directionally similar values for each program.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of Penelec's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Penelec's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.66. Penelec's PY16 gross TRC ratio was lower than its PY15 gross TRC ratio of 1.57.
- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.

F.2 EM&V PLAN REVIEWS

ADM, FirstEnergy's evaluation contractor, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, the ADM team submitted several memos detailing their sampling approach for program components selected for impact, process, and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 152](#) shows which Penelec programs produced verified impacts in PY16, and which used historic realization rates in PY16.

Table 152: PY16 Penelec Program Impact Evaluation Summary

Sector	Components	PY16 Impacts
Residential	EE Kits	Verified
	Home Energy Reports	Verified
	Midstream Appliances	Verified
	Midstream Electronics	NA
	New Homes	Verified
	Downstream HVAC	Verified
	LI Direct Install	Verified
	LI On-Line Audit	Verified
	Downstream Appliances	Verified
	LI - Home Energy Reports	Verified
	Audit and DI	Verified
	Online Audit	Verified
Cross-Cutting	Appliance Recycling	Verified
	Multifamily	Verified
C&I	Custom	Verified
	Prescriptive – Downstream Lighting, Midstream Lighting, Downstream Non-lighting	Verified
	Energy Management and New Construction – Building Improvements, Building Operations Training, Building Tune-ups and Commissioning. New Construction, MODIFY	Verified

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft survey instruments for multiple programs.

F.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework establishes a maximum level of sampling uncertainty of $\pm 15\%$ at the 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change was implemented specifically for EDCs like Penelec, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes due to program delivery channel or supported technology.

Penelec’s EE&C portfolio consists of five programs: Energy Efficient Homes, Energy Efficient Products, Low-Income Energy Efficiency, C&I Energy Solutions for Business – Large, and C&I Energy Solutions for Business – Small. The SWE performed its annual sample design review at

the initiative level, which sometimes spans multiple programs or sectors. In response to the annual data request, FirstEnergy's EM&V contractor provided the SWE with a sample disposition for each initiative detailing the project-level ex ante and ex post savings for each unit in the samples.

Table 153 shows the relative precision of PY16 energy and demand impacts by component at the 85% confidence level. In PY16, all programs were evaluated, none relied on historic realization rates. The Residential Online Audit and Behavioral Modifications programs, which were evaluated via regression analysis, have no uncertainty associated with sampling and thus is omitted from the below table.

Residential Upstream Electronics Initiative is also omitted as it was not offered in PY16.

Table 153: Relative Precision of PY16 Impacts by Program Component at the 85% Confidence Level

Sector	Components	Relative Precision (Energy)	Relative Precision (Demand)
Residential	EE Kits	5.3%	5.3%
	LI - EE Kits	6.0%	6.2%
	Direct Install	9.9%	10.6%
	LI Direct Install	10.1%	10.1%
	Multifamily Direct Install	9.1%	9.1%
	HVAC	12.0%	13.1%
	Appliance Recycling	4.6%	4.3%
	LI Appliance Recycling	0.0%	0.0%
	Appliances	9.0%	8.2%
	Midstream Appliances	0.0%	0.0%
	New Construction	10.3%	7.4%
C&I	Custom	10.0%	10.2%
	Prescriptive	12.4%	13.6%
	Energy Management and New Construction	11.1%	10.1%
	Multifamily Direct Install	11.9%	13.2%
	Appliance Recycling	0.0%	0.0%

All evaluated components met the 15% threshold for relative precision in both energy and demand.

ADM established in their Phase IV evaluation plan submitted to the SWE that they would use an assumed coefficient of variation (CV) derived from past program years for the initial sample design. However, ADM also used these planning CVs to calculate and report initiative-level relative precision. In PY16, ADM did calculate CV manually for the New Construction component but otherwise relied on assumed, rather than actual, CVs. The SWE recommends that ADM use manual variance calculations in place of planning coefficients of variation in their PY17 report to yield more accurate estimates of relative precision. Although the SWE still recommends leaving a hedge to guarantee that the $\pm 15\%$ relative precision threshold is met, ADM might be able to use fewer sample points than they did in PY16 for certain initiatives with low coefficients of variation.

The Behavioral Modification subprogram provides HERs to residential customers in the Penelec service territory. The subprogram is divided between market-rate residential customers and LI customers, and each is administered as an RCT. Participants are enrolled in experimental cohorts and a monthly billing analysis regression is used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model cannot fully capture the variation present in the data. Precision requirements for behavioral programs are unique, with the Phase IV Evaluation Framework requiring the solution-level verification to achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). Table 154 shows the absolute precision of PY16 Behavioral Modification impacts at the 95% confidence level.

Table 154: Absolute Precision of PY16 Impacts for Behavioral Modification Programs at the 95% Confidence Level

Program	Absolute Precision (Energy)
Behavioral Modification (Market Rate)	0.14%
Behavioral Modification (LI)	0.34%

The Online Audit component also relies on regression analysis of all participants and a matched control group of non-participants. While there is no sampling error, there is uncertainty associated with the regression model. The relative precision of the market-rate Online Audit energy savings was $\pm 50.3\%$ at the 85% confidence level and the relative precision of the Low-Income Online Audit energy savings was $\pm 30.0\%$ at the 85% confidence level. The relative precision of the low-income group was better than the market-rate group, despite a much smaller number of homes, because the savings estimate for low-income recipients was significantly higher. However, when the cluster robust standard errors are calculated based on the number of homes, instead of the number of observations, the relative precision exceeds $\pm 100\%$ at the 85% confidence level for both the market rate and the low-income results. To remedy the larger uncertainty, PY17 will use a rolling multi-year regression model to increase the number of homes included in the analysis.

F.4 REPORTED GROSS SAVINGS AUDITS

F.4.1 Tracking Data Review

This report section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penelec's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts
- Incentive dollars

The SWE leveraged Penelec's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset, rather a subset of the full tracking dataset tailored to

our PY16 quarterly data request. Also note that HER programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding the HER components of Penelec's Energy Efficient Homes and LIEEP can be found in [Appendix F.5.1](#).

[Table 155](#) summarizes our findings regarding reported gross energy savings. The "Match" column contains "Yes" if the tracking data supports the values in Penelec's PY16 Annual Report and "No" otherwise. For each program, the SWE was able to replicate the values reported by Penelec.

Table 155: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Energy Efficient Homes	13,763	13,763	Yes*
Energy Efficient Products	4,694	4,694	Yes
Low Income Energy Efficiency	3,808	3,808	Yes*
C&I Energy Solutions for Business - Small	55,680	55,680	Yes
C&I Energy Solutions for Business - Large	33,516	33,516	Yes
Portfolio Total	111,461	111,461	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

[Table 156](#) summarizes the SWE's findings regarding reported gross peak-demand savings, by program. The tracking data is provided at the meter-level. To facilitate the comparison, the SWE applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. Like with reported gross energy savings, the tracking data supports the Penelec PY16 Annual Report value exactly for all programs.

Table 156: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Energy Efficient Homes	1.45	1.45	Yes*
Energy Efficient Products	1.11	1.11	Yes
Low Income Energy Efficiency	0.49	0.49	Yes*
C&I Energy Solutions for Business - Small	13.20	13.20	Yes
C&I Energy Solutions for Business - Large	6.56	6.56	Yes
Portfolio Total	22.81	22.81	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

The SWE also used the tracking data to audit Penelec's reported participation counts and customer rebate amounts. Like with the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by Penelec. No substantive issues were discovered.

F.4.2 Project File Reviews

F.4.2.1 Residential

As part of the reported savings (i.e., ex ante) review, the SWE conducted a project file review of a sample Penelec's residential project files for PY16 using the project file documentation provided by Penelec, the program implementers, and ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included most of the documentation requested.

Table 157 presents a summary of the SWE's residential project file reviews.

Table 157: Penelec PY16 Residential Project File Review Summary

Program	Sub Program	Number of files reviewed ¹	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data? ²
EE Homes Program and LIEEP	Direct Install	-	-	-	-	-
EE Homes Program and LIEEP	EE Kits	40	✓	✓	✓	✓
EE Homes Program	Comprehensive Audits	40	✓	✓	✓	✓
EE Homes Program and LIEEP	New Homes	40	✓	✓	✓	✓
EE Products Programs and LIEEP	Appliance Rebates	20	✓	✓	✓	✓
EE Products Programs	Appliance Recycling	40	✓	✓	✓	✓
EE Products Programs	HVAC	20	✓	✓	✓	✓
EE Products Programs	Midstream Appliances	20	✓	✓	✓	✓
LIEEP	Appliance Recycling	10	✓	✓	✓	✓
LIEEP	LI WARM	40	✓	✓	✓	✓

¹ The number of files reviewed reflects the total number for all FirstEnergy EDCs.

² It should be noted that the Comprehensive Audits count includes audits performed at single-family and multifamily dwellings.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews.

Energy Efficient Homes Program and LIEEP: Direct Install

While the FirstEnergy companies offered the Direct Install subprogram of the EE products program in PY16, the SWE did not receive any project files for this program. The SWE acknowledges that this program was not evaluated in PY16 and will review project files in PY16.

Energy Efficient Homes Program: Energy Efficiency Kits

The Energy Efficiency Kits subprogram contains two sub-components: energy efficient kits and school education. The documentation for the Energy Efficiency Kits program consisted of

shipment data, specification sheets, and kit contents. The specification sheets include information on the wattage and wattage equivalence of LED bulbs (e.g., a 9-watt LED bulb replaces a 60-watt standard bulb), the wattage of LED nightlights, and the GPM rating of faucet aerators and low-flow showerheads. The shipment data was similar to the quarterly tracking data but was broken out by month and income status. The SWE did not find any discrepancies with quantities or measure descriptions between the project documentation and the tracking data. Project files do not contain data on some of the variables used in savings calculations, such as the number of people in the home, water heater setpoint temperature and fuel type, and HVAC system specifications.

Energy Efficient Homes Program: Comprehensive Audits (Single Family)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: Comprehensive Audits (Multifamily)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: New Homes

All project files contained builder certificates and REM/Rate or Ekotrope analysis reports, and most project files contained REM/Rate or Ekotrope modeling files. Project files, which included a REM/Rate or Ekotrope report contained the heating and cooling capacity and efficiency metrics for the HVAC equipment as well as the volume of the hot water heater at the newly constructed home.

Energy Efficient Products Program and LIEEP: Appliance Rebates

The Appliance Rebate program had project files containing either receipts for rebated appliances, appliance rebate application forms, or both. These project files were accompanied by tracking data that recorded the date the rebate amount, the appliance purchased, the appliance type, and the appliance's quantity.

Energy Efficient Products Program and LIEEP: Appliance Recycling

The Appliance Recycling program had project files containing photos of the participant's signatures, photos of the nameplates of the recycled appliances, and photos of the recycled appliances themselves. These project files were accompanied by tracking data that recorded the type of recycled appliances, the date it was recycled, the town it was from, and the quantity of

recycled appliances. Although some of the photos of the appliances did not include nameplates, the SWE notes the thoroughness of the documentation.

Energy Efficient Products Program: HVAC

The HVAC program was only in operation during Q1 and Q2 of PY16. The HVAC project files included AHRI certifications, invoices equipment registration and rebate application forms. There were no discrepancies found in the project files as compared to the tracking database. However, there were some instances where the SWE was unable to confirm the tracking data matched the project file due to missing documentation such as the AHRI certificate.

Energy Efficient Products Program: Midstream Appliances

The Midstream Appliances program was only in operation during Q1 and Q2 of PY16. The project files for Midstream Appliances were comprised of invoice-styled excel sheets with tracking data that could be easily matched to the sample data given for each quarter. The invoice data recorded the type of appliance rebated, quantity, the appliance price, and the rebate amount. The SWE review of the sampled files did not reveal any discrepancies between the project files and the tracking database.

Low-Income Energy-Efficiency Program: New Homes

The SWE review of LI New Homes files is summarized in the New Homes subsection above.

Energy Efficient Homes Program: LI WARM

Invoices, audit forms, preassessment, and post assessment forms were provided for sampled projects. The SWE notes that some projects had varying levels of documentation described above, but generally the necessary documentation existed for each sampled project reviewed by the SWE. A review of the sampled files did not reveal any discrepancies and the information provided within each project matched the tracking database. The SWE acknowledges that EDC collected data may be stored in solution specific datasets that were not requested as part of the quarterly data submission.

Low-Income Energy-Efficiency Program: Kits

The SWE review of LI kit files is summarized in the energy efficient kits subsection above.

F.4.2.2 Non-Residential

As part of its audit process, the SWE conducted a review of ex ante savings. This review involved assessing specific project files for a sample of Penelec's non-residential programs in PY16. Project file documentation was provided each quarter of the program year by Penelec, the program implementers, and the evaluation contractor to the SWE. Project documentation provided typically includes program rebate applications and approvals, letters of attestation, invoices for installed equipment, equipment specification or cut sheets, post-inspection forms, and calculation workbooks. The SWE reviewed these documents for completeness and consistency. The SWE also compared the data points in the documentation against the program tracking database to ensure values such as savings, rebate amounts, installation, approval, and invoice dates align.

Project files were generally well organized, complete, and accurate. [Table 158](#) presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 158: Penelec PY16 C&I Project File Review Summary

Program	Sub-Program	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Downstream	Custom - LCI	1	✓	✓	✓	✓	✓
Downstream	Custom - SCI	1	✓	✓	✓	✓	✓
Downstream	Energy Management - LCI	1	✓	✓	✓	✓	✓
Downstream	Energy Management - SCI	3	✓	✓	✓	✓	✓
Downstream	Prescriptive - LCI	2	✓	✓	✓	✓	✓
Downstream	Prescriptive - SCI	2	✓	✓	✓	✓	✓
Midstream	Prescriptive - LCI	1	✓	✓	N/A	N/A	N/A
Midstream	Prescriptive - SCI	2	✓	✓	N/A	N/A	N/A
Downstream	Multifamily	1	✓	✓	✓	✓	✓

F.5 VERIFIED GROSS SAVINGS AUDITS

F.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the Penelec portfolio of residential programs. Penelec's portfolio of residential programs includes the following: the Energy Efficient Homes Program, the Energy Efficient Products Program, and the LI Energy-Efficiency Program. Each program contains various subprograms, which are addressed separately below. Note that the SWE reports the residential savings in two sections: residential and behavior.

The SWE identified the evaluation activities used to verify savings for the residential programs. [Table 159](#) provides a summary of the evaluation and M&V approaches used by Penelec in their PY16 verified savings calculations.

Table 159: Residential Program Evaluation Activities - Penelec

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied Historic RR
Energy Efficient Homes					
Energy Efficiency Kits	✓	-	✓	-	-
HERs	-	-	-	✓	-
Residential Direct Install	-	-	✓	-	-
Residential Direct Install – Multifamily	-	-	✓	-	-
Residential New Construction	-	✓	✓	-	-
Energy Efficient Products					
Upstream Electronics	-	-	-	-	-
HVAC	✓	-	✓	-	-
Appliances	✓	-	✓	-	-
Appliance Turn-in	✓	-	✓	-	-
Midstream Appliances	-	-	✓	-	-
Low-Income Energy-Efficiency Program					
LI Direct Install	-	-	✓	-	-
LI Appliance Turn-in	✓	-	✓	-	-
LI Appliances	✓	-	✓	-	-
LI New Homes	-	✓	✓	-	-
LI Kits	✓	-	✓	-	-
^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.					

The SWE's review of verified savings for residential programs found that the verified savings followed proper TRM protocols and were accurate.

Energy Efficiency Kits Initiative: EE Kits and Low-Income Kits

The Energy Efficiency Kits (EE Kits) initiative has two sub-initiatives – EE Kits and Low-Income EE Kits. Each sub-initiative has two sub-components: EE Kits and School Education. The SWE reviewed school education kits for both the EE Kits and Low-Income EE Kits sub-initiatives. The kits provided through the School Education subprogram contained LED lamps, LED night lights, a furnace whistle, and electrical outlet gaskets. The Low-Income kits included advanced power strips in place of electrical outlet gaskets. The SWE confirmed the verified savings for each sub-initiative were in accordance with the TRM protocols for the relevant measures and worked with ADM to resolve any discrepancies prior to the filing of the FirstEnergy annual report. The SWE

also confirmed that participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Homes Program and LIEEP: New Homes

The SWE worked with evaluation contractor, ADM, to resolve some discrepancies in the evaluated savings prior to annual reporting. ADM reviewed and corrected the ex post energy models for a sample of PY16 projects to develop a realization rate for program-wide savings. ADM also revised the calculation method used for cooling demand savings to use hourly load results from the sampled models, which aligns with the approach used by other EDCs.

The Residential and Residential Low-Income Direct Install Initiatives

The Residential and Low-Income Direct Install Initiatives primarily used an SSRS Tracking and Reporting database for this evaluation as well as documentation from on-site QA/QC inspections. ADM used a stratified sampling approach to perform a desk review of a sample of participants in this program and rolled up the realization rates to the total program participant population. ADM provided the SWE with data from home inspections and with the subsequent savings calculations and roll up. The SWE confirmed the verified savings for each measure were in accordance with TRM protocol. The SWE also confirmed that the participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Products Program: HVAC

The HVAC subprogram includes measures such as: air-source heat pumps, central air conditioning, furnace fans, ground source heat pumps, HVAC tune-ups, mini-split heat pumps, packaged terminal heat pumps and air conditioning, connected thermostats, bathroom fans, and circulating pumps. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. The SWE confirmed that participation, verified savings, and realization rates were in alignment with those in the annual report.

Energy Efficient Products Program and LIEEP: Appliances

The appliance subprogram includes measures such as: refrigerators, freezers, clothes washers and dryers, dehumidifiers, dishwashers, window ACs, HPWHs, and connected thermostats. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. For the final report, Low-Income and Non-Low-Income Energy Efficient Products Programs were combined. The SWE confirmed that participation, energy savings, and energy realization rates were in alignment with those in the annual report.

The SWE notes that the appendix for this subprogram includes a list of the variables for each appliance, and where the data source came from. This was a helpful addition to the SWE audit.

Appliance Recycling and Low-Income Appliance Turn-In Initiative

The SWE conducted an early review of the Appliance Recycling and Low-Income Appliance Recycling Initiatives. Each initiative includes five measures: refrigerator recycling, freezer recycling, room air conditioner (RAC) recycling, dehumidifier recycling, and mini refrigerator recycling. ADM's evaluation included calculating measure level savings using program tracking data and survey data from PY16, including TRM inputs when necessary. The SWE did not observe any discrepancies with the application of TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Homes Program: Multifamily

Gross impact evaluation for the Res MF Initiative utilized a stratified sampling plan. Most projects are placed into one sampling stratum, with an additional stratum reserved for high-impact projects.

The program tracking and reporting system is at the measure level, and also identifies the rebate application and participant address associated with each measure. ADM aggregated all measures by unique address and then placed each household in one of the two strata: high-impact projects with reported energy savings above 2,000 kWh, and all other projects.

Due to the low participation and impacts in this initiative in Phase IV, desk reviews were the most appropriate evaluation activity. ADM evaluators compared audit reports and invoices to program tracking and reporting data to reconcile quantities of installed measures. The evaluators also independently calculated impacts for all measures according to their respective protocols in the 2021 PA TRM.

Energy Efficient Products Program: Midstream Appliances

The SWE conducted an early review of the Midstream Appliances subprogram. ADM's evaluation included a full review of the program tracking data and aligning savings estimates with the TRM and product-specific data. The SWE did not observe any discrepancies with the application of the TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Products Program: Upstream Electronics

The FirstEnergy companies did not offer the Upstream Electronics subprogram of the EE products program in PY16.

Energy Efficient Homes and LIEEP: Online Audit

In PY13, FirstEnergy launched an Online Audit component to the Behavioral subprogram included in both the Energy Efficient Homes (EEH) and Low-Income Energy Efficiency (LI) programs. The Online Audit component operates on an opt-in basis and offers residential customers a web-based platform featuring energy usage visualizations, energy-saving tips, and promotion of other FirstEnergy residential energy-efficiency programs. Participation is defined as logging into the online portal and completing the registration to receive an audit. A total of 3,608 market-rate residential and 640 low-income households participated in Online Audit in PY16, which is down from PY15 for both programs. Market-rate participants decreased by 11% and low-income participants decreased by 25% from PY15 to PY16.

The Phase IV Online Audit subprogram is an opt-in program, and the SWE team reviewed the propensity score matching ADM performed to create a matched control group using five pre-treatment consumption variables, latitude, longitude, and a categorical variable that identifies which HERs cohort a customer belongs. The comparison group matching was performed using a 1:1 treatment-to-comparison group ratio. Due to the non-RCT design of the Online Audit component, ADM included weather terms to improve model fit and control for potential differences in weather-sensitivity between the treatment group and matched control group. In PY15, ADM adhered to the guidance provided by the SWE in PY14 to run a pooled regression model across all four EDCs. Given the relatively small sample sizes at the individual EDC x Program level, ADM chose to consolidate analysis at the Program level across the four FirstEnergy EDCs. A single regression model was estimated for EE Homes across all four EDCs, and another model for LI programs. Estimated regression coefficients were allowed to vary with temperature, and the resulting impacts were then adjusted for each EDC using EDC-specific weather variables. The SWE team independently calculated per-household kWh savings from regression coefficients, active participant counts, and aggregate MWh and MW impacts. Our estimates match ADM's estimates.

Our savings estimates and standard errors matched ADM's estimates once a cluster robust standard error correction was included in both model specifications. This statistical technique deals with autocorrelation and computes uncertainty based on the number of homes in the analysis rather than the number of observations. Use of the cluster robust standard error corrections causes the relative precision to exceed $\pm 100\%$ at the 85% confidence level, which means neither the market-rate nor low-income results are statistically significant. The Pennsylvania Evaluation Framework discusses this potential outcome for impact evaluations that rely on billing analysis and asks evaluation contractors to explore remedial actions. The planned remedial action for PY17 is to rely on a rolling multi-year regression model to increase the overall number of homes included in the analysis.

The SWE also reviewed the dual participation analysis. Online Audit participants tend to participate in other Penelec EE&C programs at a higher rate than the matched control groups, so this adjustment is necessary to avoid double-counting. To calculate gross verified demand savings, ADM generated an Energy to Demand Factor (ETDF) using residential load profiles corresponding to the treatment group and then applied ETDF to energy savings to estimate. The SWE was able to replicate the verified demand savings for both the residential and residential low-income group.

Table 160 shows the aggregate PY16 verified gross MWh savings and MW reductions by program. The table also shows the number of participants and average percent savings per household by program group. Using the first impact estimate as an example, the practical interpretation is as follows: all treatment group homes in the EEH Program saved 196 MWh and each household lowered their annual electric consumption by 0.49% during PY16. It is unclear why the low-income households saved more energy per household than their market-rate counterparts in PY16. Higher per-household savings in the LI program could simply be a result of noise due to a relatively small number of participants.

Table 160: PY16 Penelec Online Audit Energy and Demand Savings

Program	Participants	Gross Energy Savings (MWh)	Gross Demand Savings (MW)	Average Percent Savings per Home
EEH Program	3,608	196	0.03	0.49%
LI Program	640	176	0.02	2.26%
Total	4,248	372	0.05	-

Behavior

Home Energy Reports were issued to around 157,000 residential and residential-LI households in PY16. Penelec's behavioral portfolio consists of both active waves and inactive legacy waves, which may be reactivated later in Phase IV. Ten waves, or cohorts, were active during PY16 and five of them targeted low-income households. [Table 161](#) summarizes the number of active households during PY16 by cohort and summarizes key features of the PY16 evaluation method.

Table 161: Penelec HER Cohort Summary

Cohort	Start Date	Treatment Group Homes	Control Group Homes	Reintroduced Cohort	Rebaselined Cohort	Weighted Regression
2012 Low-Income	7/1/2012	4,526	2,577	No	N/A	Yes
2012 Residential	7/1/2012	38,792	15,518	No	N/A	No
2014 Low-Income	12/1/2014	4,977	2,203	Yes	No	No
2014 Residential	12/1/2014	18,573	6,177	Yes	No	No
2021 Low-Income	9/26/2021	7,071	6,707	No	N/A	No
2022 Residential	5/29/2022	11,783	8,876	No	N/A	No
2023 Low-Income	6/4/2023	7,462	7,497	No	N/A	No
2023 Residential	6/4/2023	18,332	10,540	No	N/A	No
2014 Low-Income	5/12/2024	1,005	1,543	Yes	Yes	No
2024 Residential	5/12/2024	44,589	19,833	No	N/A	No
Total		157,110	81,471			

The program implementor, ICSP Oracle, administered all cohorts as randomized control trials (RCTs). Eligible households were identified and then randomly assigned to either a treatment or control group. Following randomization, ADM conducted statistical tests on the pre-treatment energy usage patterns to confirm equivalence between the treatment and control groups.

The SWE team conducted an audit of the pre-treatment equivalence test for all cohorts. To check the pre-treatment equivalence, the SWE team ran a Welch Two Sample T-Test on pre-period usage by treatment status for each cohort. The pre-period usage variables include the average annual, summer, and winter energy usage per household in the year prior to treatment. With these defined baselines and pre-treatment lag variables, the SWE team was able to replicate the same p-values for the t-test results as ADM.

As part of the PY16 implementation of the Home Energy Reports (HER) measure, three previously suspended historical Penelec cohorts were reintroduced into the program. ADM also assessed the equivalence of the treatment and control groups in these cohorts, 2014 Low-Income, 2014 Low-Income (12/1/2014 treatment) and 2014 Residential, during PY15 to determine if the HER impact had decayed sufficiently to allow PY15 data to be used as the pre-treatment period. ADM found that the treatment and control groups in two cohorts – 2014 Low-income and 2014 Residential cohorts – showed statistically significant differences, suggesting savings are persistent, rendering them unsuitable for rebaselining. These reintroduced Penelec cohorts retained their original baseline periods and treatment dates. ADM found the treatment and control groups in Penelec's 2014 Low-Income (original treatment date 1/1/2014) were not statistically different, meaning this cohort was suitable for rebaselining. This cohort was inactive for three consecutive program years and showed minimal evidence of persistent savings in PY15. As a result, Penelec's 2014 Low-Income cohort was assigned the same treatment start date as the new PY16 cohorts, 5/12/2024. For all analytical purposes, this cohort is treated as a new cohort, including the application of a regression-based approach to estimate peak demand, rather than the simple difference method used for other historical cohorts.

Both ADM and the SWE team found that one Penelec cohort failed the annual consumption equivalence check at the 90% confidence level. To accommodate this, ADM proposed using propensity score matching (PSM) on the three pre-treatment variables for this cohort, using with-replacement matching. Following ADM's approach, propensity score matching was used to rebalance the 2012 Low-Income cohort by providing a series of weights for the control customers in that cohort. With those weights, the 2012 Low-Income cohort passed the equivalence test. The SWE team was able to replicate the equivalence t-test results for this cohort using ADM's weights. Those weights are used in the linear regression to calculate consumption savings and used in the simple difference calculation to determine peak-demand reduction.

ADM provided the SWE team with both daily and monthly consumption data for all homes in the treatment and control groups. The monthly data served as the primary input in the estimation of HER impacts. The SWE team found the calculations and distribution of monthly kWh to be reasonable. Models used throughout the analysis rely on three pre-treatment lag variables: average usage, average summer usage, and average winter usage. As discussed, the pre-treatment period is 12 months prior to original treatment for all Penelec's cohorts, except the rebaselined cohort 2014 Low-Income, which used the 12 months prior to the new treatment period to create the lags. Using the daily consumption data, the SWE team was able to replicate the three lagged variables calculated by ADM for each customer. These lag terms were calculated for customers with 12 months of pre-treatment data, who also had no data issues as flagged by ADM (i.e. invalid hourly observations or outlier consumption amounts).

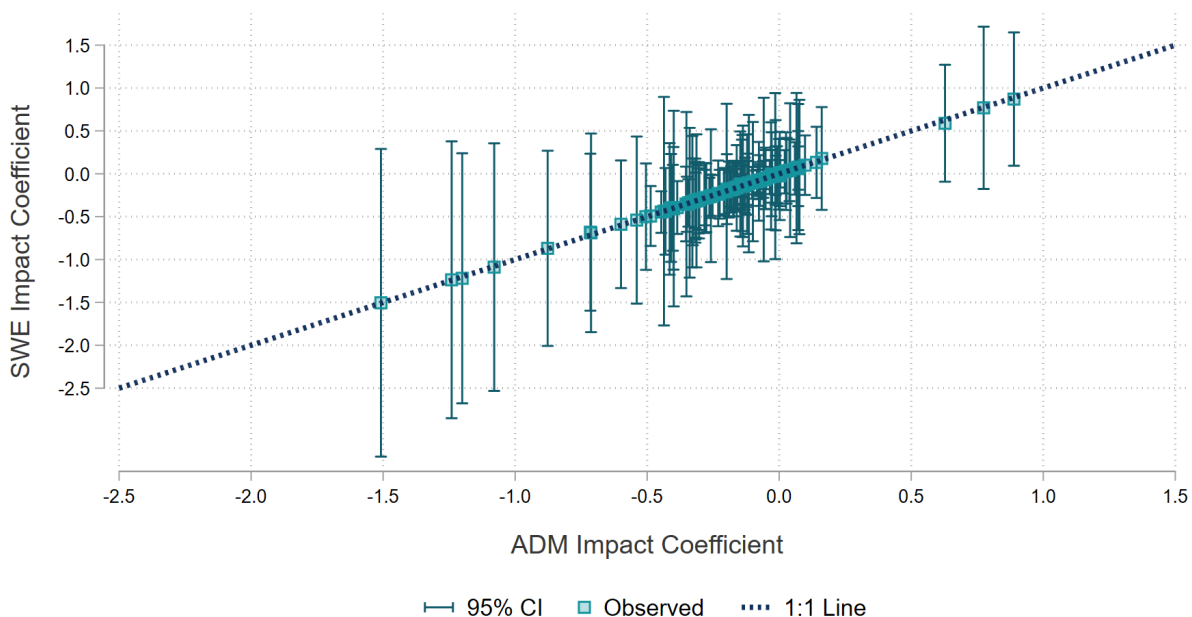
ADM obtained active customer counts for each month by tallying up the number of accounts that have daily interval data for the month. Only active accounts where HER delivery has begun are included in these calculations. Both ADM and the SWE team found an inconsequential number of accounts that were not counted because they either were placed in both the control group and treatment group or had multiple treatment starting dates. A few accounts were not included in the counts because Oracle never began HER delivery to these homes or due to pre-start date attrition.

The SWE team validated ADM's enrollment counts by performing a similar counting method on the daily consumption data. Customers are considered active through the end of the month that they last have interval data. For example, if a customer's final AMI record is from February 15th, the customer would be included in the count for February but not in March or any month following. The SWE team's final customer counts matched ADM's for each month and cohort.

Customers that do not have twelve months of pre-treatment data or were flagged as having a data issue were not included in the impact estimation (because the lagged seasonal variables for these customers were not calculated), but they were included in the customer counts.

ADM used a lagged seasonal (LS) regression model for the PY16 impact analysis. Using the monthly billing data, the LS model estimates the relationship between daily usage and pre-treatment variables. Unlike previous years, the regression included weights for the 2012 Low-Income cohort that failed the equivalence test without weighting. The SWE team was able to replicate ADM's coefficients with no notable differences in coefficients, as shown in [Figure 53](#). The SWE estimates all fell within the confidence interval for ADM's coefficients.

Figure 53: Penelec PY16 HER LS Coefficient Comparison



The SWE team independently calculated gross MWh savings using regression coefficients and active participant counts, and our estimates match those provided by ADM. [Table 162](#) shows the aggregate PY16 pre-adjustment gross MWh savings by cohort. The table also shows three

adjustments, which are discussed in greater detail later, and the PY16 incremental verified gross savings estimate.

Table 162: Penelec PY16 Energy Savings*

Cohort	Gross Savings (MWh)	Downstream Dual Participation (MWh)	Upstream Dual Participation (MWh)	Persistence (MWh)	Incremental Savings (MWh)
2012 Low-Income	1,061	70	30	582	380
2012 Residential	3,948	971	89	1,806	1,082
2014 Low-Income	363	-80	13	0	430
2014 Residential	1,112	86	31	0	995
2021 Low-Income	-18	-70	0	202	-150
2022 Residential	1,119	12	0	721	386
2023 Low-Income	513	40	0	0	474
2023 Residential	433	77	0	0	357
2014 Low-Income	4	6	0	0	-2
2024 Residential	1,063	103	0	0	960
Total	9,600	1,214	163	3,311	4,911

*Totals may not equal the sum of columns or rows due to rounding.

Home Energy Reports advertise other Penelec residential EE&C programs and measures such as ENERGY STAR appliances, water heaters, and high-efficiency HVAC rebates. To the extent that treatment group households participate in these programs more frequently than the control group homes, the incremental savings are captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings are adjusted to account for the incremental program participation observed in the treatment group compared to the control group. An upstream dual participation adjustment is only applied to the gross savings estimates of 2012 and 2014 cohorts that were not rebaselined.

The 2021 Pennsylvania TRM assumes an annual decay rate of 31.3% derived from Pennsylvania-specific research⁹⁸ on the persistent effects of behavioral energy efficiency treatment in the years after discontinuing treatment. Since Act 129 compliance goals are based on first-year incremental savings, these persistent impacts are subtracted from the measured savings to estimate incremental first-year savings (those directly due to the current program year of treatment).

⁹⁸ Addendum to Act 129 Home Energy Report Persistence Study. November 2018.

https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

For the first two years of HER exposure, persistence is assumed to be zero and the first-year savings average treatment effect (FYSATE) simply equals the average treatment effect (ATE). For year three and beyond of HER exposure, the FYSATE is calculated using Equation 3, which comes from the 2021 TRM. For year i of HER exposure:

Equation 3: First Year Savings Average Treatment Effect (FYSATE)

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

$$\Delta kWh_y = FYSATE_y * Treatment\ Accounts_y * Days_y$$

Where $FYSATE_y$ is the average daily savings attributable to HERs delivered in the current year (Y) and $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in year Y-X.

Because the 2023 and 2024 waves were launched during PY15 and PY16, their savings are considered incremental. Separating persistent savings from incremental savings was not necessary for these waves, but the 2012, 2021, and 2022 waves did require such an adjustment. The reintroduced historical cohorts did not have any persistence adjustment, as they were not treated for 3 years, so there is no persistence still in effect. The SWE team found that ADM correctly modeled persistence in accordance with TRM specifications for these waves.

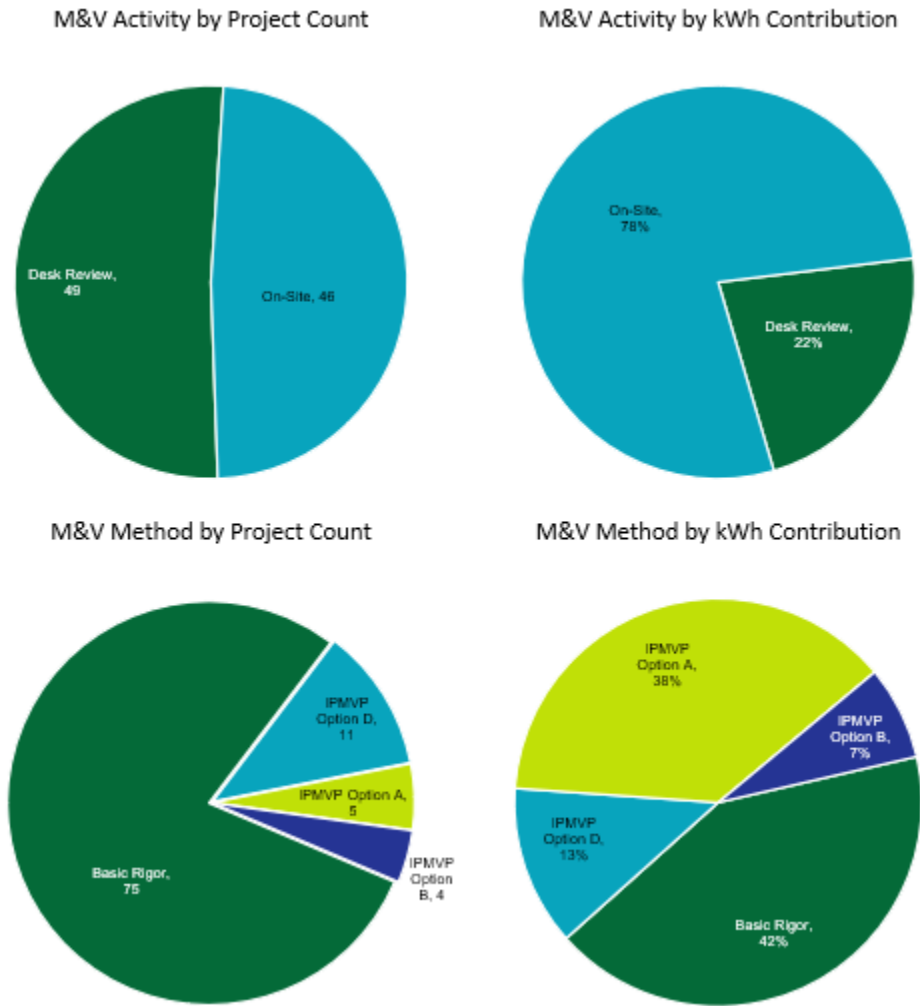
The Pennsylvania TRM defines peak-demand impacts as the average reduction in electric consumption from 2:00 p.m. to 6:00 p.m. Eastern Daylight Time on non-holiday weekdays during June, July, and August. The SWE team was able to replicate ADM's peak-demand impact estimate and peak-demand reduction for each cohort, with no noticeable differences between the SWE team and ADM impacts.

In conclusion, the SWE team successfully replicated ADM's findings for Penelec. Their methodology was transparent and reproducible, and any adjustments to the analysis were well-justified and reviewed collaboratively to ensure their validity.

F.5.2 Non-Residential Audit Activities

Figure 54 provides a summary of the evaluation activities and M&V approaches utilized by Penelec's evaluation contractor, ADM, in their PY16 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY16, Penelec's evaluation contractor completed site visits to 46 of 95 evaluated projects, and these on-sites represented 78% of total evaluated energy savings. IPMVP Options A, B, and D were employed for 58% of the total evaluated energy savings. Basic Rigor (verification only) was employed for the remaining 42% of the total evaluated savings, including the majority of prescriptive projects.

Figure 54: Summary of Penelec’s C&I Evaluation Activities



Penelec’s evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Penelec’s C&I programs are assigned to one of four initiatives, as Penelec’s programs target specific sectors of C&I customers, but offerings are often identical across the programs. [Table 163](#) provides a summary of the evaluation activities used across strata for all projects by initiative.

Table 163: Summary of Penelec's PY16 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR – Energy	RR – Demand	Desk Review	On-Site Verification
Appliance Recycling		103%	103%		
Custom	17	100%	119%	3	14
Custom-C	2	100%	123%	2	-
Custom-2	10	99%	116%	1	9
Custom-1	5	108%	121%	-	5
Prescriptive	44	95%	91%	27	17
Downstream Lighting-C	3	100%	100%	3	-
Downstream Lighting-2	8	82%	81%	5	3
Downstream Lighting-1	4	90%	88%	2	2
Downstream Non-lighting	4	99%	99%	1	3
Midstream Lighting-1	18	102%	74%	10	8
Midstream Lighting-2	6	94%	78%	6	-
EMNC	27	101%	92%	13	14
Building Tune-Ups-2	7	98%	99%	5	2
Building Tune-Ups-1	8	102%	112%	2	6
Building Tune-Ups-3	6	101%	87%	5	1
BOC-1	1	439%	439%	1	-
CBI-RCX-1	4	100%	98%	-	4
CNC-1	1	87%	99%	-	1
EMNC-C	-	-	-	-	-
Multifamily-1	7	93%	103%	3	4
TOTAL	95			46	49

The SWE's review of verified savings for non-residential programs found that, overall, the verified energy savings estimation was aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

F.5.2.1 Appliance Recycling Initiative

In PY16, projects in Penelec's Appliance Recycling subprograms were evaluated through a review of tracking and reporting data. The gross energy and demand realization rates for each evaluation stratum were taken to be the realization rates from the broader initiative-level evaluation, which included the residential and low-income residential subprograms.

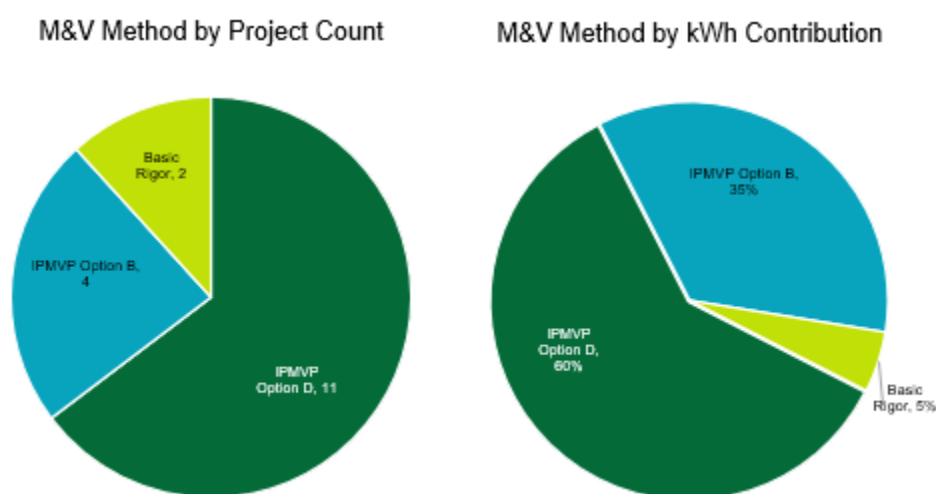
F.5.2.2 Custom Initiative

Evaluation activities for this initiative include desk reviews and/or IPMVP evaluation methods for all sampled projects. Site visits were conducted for three of seventeen PY16 custom sampled projects. The rest of the evaluation was conducted through desk reviews for all projects using data provided by the customer. Solar PV projects were evaluated through the Custom Initiative using NREL's SAM and PVWatts models. The SWE independently replicated savings calculations, applied caps based on actual utility billing data where appropriate, and verified correct definitions of peak hours.

Penelec's evaluation contractor employed two strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a "certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 14 of the Phase IV Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty. Enhanced rigor methods were employed to evaluate just over half the Custom projects, with IPMVP Options B or D applied to fifteen of seventeen projects, accounting for 95% of evaluated savings, as shown in Figure 55.

Figure 55: Summary of Penelec's C&I Custom Program M&V Methods



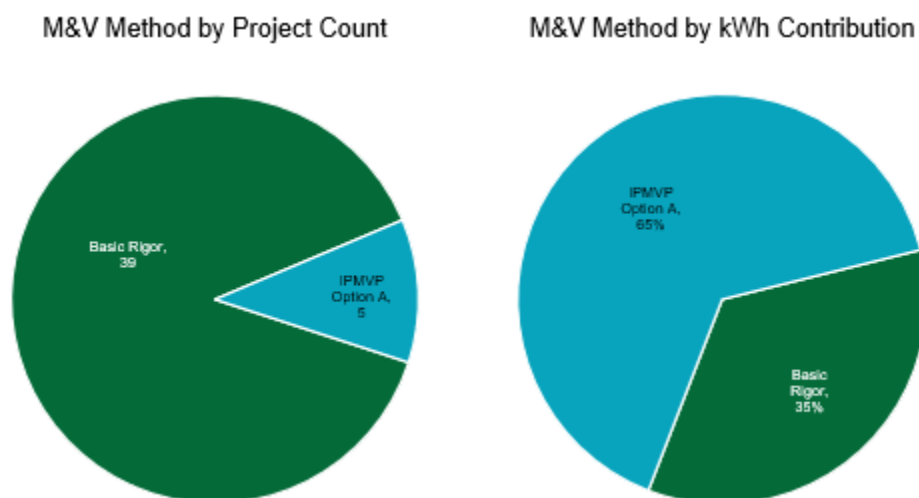
F.5.2.3 Prescriptive Initiative

Evaluation activities for this initiative include on-site visits for most projects (27 of 44) with on-site visits for the remaining seventeen sites. Primary data collection of lighting hours of use provided

site specific inputs for medium and high savings projects. TRM deemed hours of operation were applied in basic rigor desk reviews for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penelec's evaluation contractor employed six strata for projects in the Prescriptive initiative, covering both downstream and midstream offerings. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a "Downstream – Certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval ([Figure 56](#)).

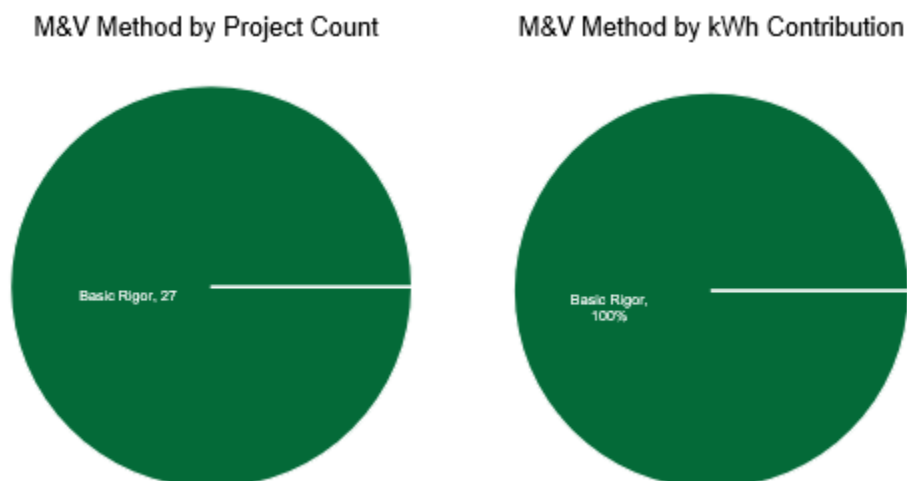
Figure 56: Summary of Penelec's C&I Prescriptive Program M&V Methods



F.5.2.4 Commercial and Industrial Energy Management and New Construction Initiative (CI EMNC)

The CI EMNC Initiative has five sub-components, and all of them were active in PY16. Evaluation activities for this initiative include desk reviews and on-site inspections. The evaluator opted to conduct on-site inspections for 12 of 21 sampled projects in the Building Tune-Up strata. Basic rigor M&V methods were applied to all evaluated projects, as seen in [Figure 57](#) below.

Figure 57: Summary of Penelec's C&I Energy Management and New Construction Initiative Program M&V Methods



F.5.2.5 Verified Savings Audits

The SWE audited the activities above through a detailed audit of ADM's evaluation work for a sample of their evaluated projects. The SWE audit for ADM's Penelec evaluation in PY16 included the review of seventeen projects, encompassing the following activities:

- Two field and analysis engineers audited
- Eleven custom, five prescriptive lighting, and one multifamily measures reviewed
- 18% of verified energy savings checked by SWE
- 30% of verified demand savings checked by SWE

Table 164 provides an overview of the SWE milestones for the verified savings audit review of evaluated Penelec projects.

Table 164: Penelec Verified Savings Audit Review Milestones

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
17	3,495,909	100%	1,044	100%

Overall, the SWE found that Penelec's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods for custom measures.

MODIFY C&I Direct Install

The MODIFY subprogram, offered for Met-Ed and Penelec only, provided direct delivery of 25 or 50 TLEDs to small commercial businesses. The SWE reviewed FirstEnergy's survey, tracking and reporting data of the MODIFY program. Activities included review of valid survey respondents, verified savings checked by the SWE and demand savings reviewed by the SWE.

The SWE found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper TRM protocols correctly, and were accurate.

F.6 NTG

Table 165 lists Penelec's PY16 NTG as listed in the First Energy PY16 Annual Report. Details concerning the methods and data used to estimate NTG values are in sections F.6.1 and F.6.2.

Table 165: Summary of Penelec PY16 NTG Results

Program Name	Component	NTG
Energy Efficient Products	Appliance Recycling	0.60
Energy Efficient Products	HVAC	0.70
Energy Efficient Products	Appliances	0.49
Energy Efficient Products	Midstream Appliances	0.48
Energy Efficient Homes	EE Kits	1.06
Energy Efficient Homes	Home Energy Reports	1.00
Energy Efficient Homes	Direct Install	0.99
Energy Efficient Homes	New Homes	0.72
Energy Efficient Homes	Multifamily Residential	1.00
Energy Efficient Homes	Comprehensive Audits	1.00
C&I Solutions for Business Programs – Small and Large	Multifamily	1.00
C&I Solutions for Business Programs – Small and Large	Prescriptive	0.64
C&I Solutions for Business Programs – Small and Large	Custom	0.78
C&I Solutions for Business Programs – Small and Large	EMNC	0.48
C&I Solutions for Business Programs – Small and Large	Appliance Recycling	0.60
Portfolio Total		0.77

F.6.1 Residential Programs

ADM planned and enacted NTG research for the Appliance Recycling component of the EE Products Program component of the EE Homes Program. ADM utilized participant surveys to estimate free-ridership and NTG for all components. Spillover is not calculated because the program is not designed to encourage customers to implement additional energy-efficiency projects. ADM utilized question batteries that were consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation (Table 166).

Table 166: Summary of Penelec's PY16 Residential NTG Results

Program Component	Approach	Sample Size	Free-Ridership	Spillover	NTG
Appliance Recycling	Participant Surveys	287	40.0%	0.0%	0.60

F.6.2 C&I Energy-Efficiency Programs

ADM planned and enacted NTG research for the C&I Custom and Energy Management subprograms of the Energy Solutions for Business (ESB) program for small and large commercial customers in PY16 (Table 167).

Table 167: Summary of Penelec's PY16 C&I NTG Results

Program Components	Approach	Sample Size	Free-ridership	Spillover	NTG
EMNC	Participant Surveys	120	0.24	0.27	0.78 ¹
Custom	Participant Surveys	24	0.55	0.03	0.48

¹ Includes the MODIFY program which alone had a FR of 0.18, SO of 0.0, and an NTG of 0.82%.

F.7 TRC

Table 168 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penelec's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY16 annual report, and the model itself was well-organized and documented.

Table 168: Summary of Penelec's PY16 TRC Results

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$11,278	\$3,973	2.84	\$7,306
Energy Efficient Products	\$3,082	\$3,597	0.86	(\$515)
Low Income Energy Efficiency	\$1,869	\$4,287	0.44	(\$2,417)
Residential Subtotal	\$16,230	\$11,856	1.37	\$4,374
C&I Energy Solutions for Business - Small	\$43,161	\$25,305	1.71	\$17,856
C&I Energy Solutions for Business - Large	\$19,740	\$10,503	1.88	\$9,237
Non-Residential Subtotal	\$62,901	\$35,808	1.76	\$27,093
Cross-cutting	\$0	\$0	--	\$0
Portfolio Total	\$79,131	\$47,664	1.66	\$31,467

¹ Totals may not equal the sum of columns or rows due to rounding.

Three of Penelec's five EE&C programs were found to be cost-effective when estimating the TRC using gross verified savings. The same three programs were found to be cost-effective using net

verified savings. The Energy Efficient Products and Low Income Energy Efficiency programs were not cost-effective on a gross or net verified basis.

F.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions. The SWE also verified the correct avoided costs from Penelec's EE&C Plan were used in the TRC Model.
- Penelec had the highest PY16 TRC ratio of the four FirstEnergy companies, in part due to higher capacity avoided costs than Penn Power or West Penn Power.
- To calculate the avoided cost of natural gas, Penelec used a three-segment approach outlined in the 2021 TRC Test Order. The SWE verified the TRC Model correctly applied the avoided costs to estimate TRC benefits.
- Pursuant to the 2021 TRC Test Order, the SWE verified that Penelec used a nominal discount rate of 5% to calculate the net present value of future program benefits. This discount rate is consistent with their EE&C plan. Line loss adjustment factors varied by sector. Residential (1.0945), Small C&I (1.072) and Large C&I (1.072).
- The incremental costs were derived from the SWE Incremental Cost Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumptions, and actual project costs as gathered from the PY16 evaluation. The SWE spot checked the incremental measure costs used in the TRC model and found them to be generally reasonable and consistent.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to calculate verified gross savings.
- The calculation of NTG using free-ridership and spillover, as well as the application of the NTG in the calculation of TRC benefits and costs, were consistent with the 2021 TRC Test Order directive for Phase IV. The TRC model followed the protocol pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The SWE found that the cost categories were handled correctly in the TRC model. Participant incentives were not considered TRC costs, while administrative costs, incremental costs, and kits were incorporated as costs.
- The SWE verified that the ex ante demand and capacity savings were accurate in the TRC model by comparing it to the Quarterly Tracking Data reported by Penelec.
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Fossil Fuel Impacts and Total NPV Lifetime Water Impacts. The SWE verified that the savings were accounted for in accordance with the 2021 TRC Test Order.

F.8 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including Penelec, so the annual evaluation

report of the four FirstEnergy EDCs reports identical information about the process evaluation. Details on survey targets and completes for Penelec are provided in the subsections below. [Appendix E.8](#) of the SWE's PY16 Final Annual Report, described previously for Met-Ed, applies to all four FirstEnergy utilities, including Penelec.

F.8.1 Residential Programs

F.8.1.1 Energy Efficient Products Program – Appliance Recycling

The PY16 evaluation team completed 288 participant surveys with Penelec customers.

F.8.1.2 Energy Efficient Products Homes – Comprehensive Audits

There were not any surveys as part of the PY16 evaluation.

F.8.1.3 Energy Efficient Products Homes – Multifamily Residential

There were not any surveys as part of the PY16 evaluation.

F.8.1.4 Energy Efficient Products Homes – School Education

There were not any surveys as part of the PY16 evaluation.

F.8.1.5 Energy Efficient Products Homes – EE Kits

There were not any surveys as part of the PY16 evaluation.

F.8.2 Residential Low-Income Program

F.8.2.1 Weatherization (Direct Install)

There were not any surveys as part of the PY16 evaluation.

F.8.2.2 Appliance Rebate

There were not any surveys as part of the PY16 evaluation.

F.8.2.3 Behavioral Home Energy Report

There were not any surveys as part of the PY16 evaluation.

F.8.2.4 Multifamily (Residential)

There were not any surveys as part of the PY16 evaluation.

F.8.2.5 New Homes

There were not any surveys as part of the PY16 evaluation.

F.8.2.6 School Education

There were not any surveys as part of the PY16 evaluation.

F.8.2.7 EE Kits

There were not any surveys as part of the PY16 evaluation.

F.8.2.8 Appliance Recycling – Low-Income Sub-Initiative

The PY16 evaluation team completed 38 participant surveys with Penelec, low-income customers.

F.8.3 Commercial & Industrial Programs

F.8.3.1 C&I Energy Solutions for Business (Small) - Multifamily

There were not any surveys as part of the PY16 evaluation.

F.8.3.2 C&I Energy Solutions for Business (Large) - Multifamily

There were not any surveys as part of the PY16 evaluation.

F.8.3.3 C&I Energy Solutions for Business (Large) – Custom

The PY16 evaluation team did not complete participant surveys covering any Custom projects with C&I (Large) Penelec customers.

F.8.3.4 C&I Energy Solutions for Business (Small) – Custom

The PY16 evaluation team completed participant surveys covering eight Custom projects with C&I (Small) Penelec customers.

F.8.3.5 C&I Energy Solutions for Business (Large) – Energy Management

The PY16 evaluation team completed participant surveys covering seven Energy Management projects with C&I (Large) Penelec customers.

F.8.3.6 C&I Energy Solutions for Business (Small) – Energy Management

The PY16 evaluation team completed participant surveys covering 40 Energy Management projects with C&I (Large) Penelec customers.

F.8.3.7 Appliance Recycling – Non-Residential Sub-Initiative

The PY16 evaluation team conducted in-depth interviews with four Penelec C&I (Small) customers participating in the Appliance Recycling subprogram.

Appendix G FirstEnergy: Pennsylvania Power Company PY16 Audit Detail

G.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- Penn Power provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the Penn Power PY16 Annual Report. In addition, the verified savings analyses were well organized, and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- Penn Power had five active HER cohorts in PY16. Four of the cohorts consist of market-rate residential households and the other cohort consists of low-income households. Behavioral HER programming accounted for 14% of Penn Power's total verified MWh savings in PY16 and 25% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with their approved EM&V plan.
 - Penn Power reintroduced two historical cohorts after a three-year pause, one low-income and one residential. ADM found that the treatment and control groups in these cohorts were not equivalent in PY15, suggesting savings are persistent and rebaselining is not possible. As a result, Penn Power's reintroduced cohorts retained their original treatment date and baseline period.
 - One of Penn Power's cohorts failed its pre-treatment equivalence test and required rebalancing using weights that were calculated using a propensity score matching approach. These weights are applied to the cohort throughout the analysis.
 - The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in Penn Power's Online Audit offering showed higher average percent savings (2.1%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 8% of market-rate households), so the margin of error around the billing analysis estimate was large.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of Penn Power's gross impact

evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.

- Penn Power's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.41. Penn Power's PY16 gross TRC ratio was slightly lower than its PY15 gross TRC ratio of 1.43. The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Penn Power's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE did not expect to and could not replicate incentives exactly using the tracking data, and the SWE calculated directionally similar values for each program.
- The SWE conducted a project file review for a sample of Penn Power's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.

G.2 EM&V PLAN REVIEWS

ADM, FirstEnergy's evaluation contractor, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, the ADM team submitted several memos detailing their sampling approach for program components selected for impact, process and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 169](#) shows which Penn Power programs produced verified impacts in PY16, and which used historic realization rates in PY16.

Table 169: PY16 Penn Power Program Impact Evaluation Summary

Sector	Components	PY16 Impacts
Residential	EE Kits	Verified
	Home Energy Reports	Verified
	Midstream Appliances	Verified
	Midstream Electronics	NA
	New Homes	Verified
	Downstream HVAC	Verified
	LI Direct Install	Verified
	LI On-Line Audit	Verified
	Downstream Appliances	Verified
	LI - Home Energy Reports	Verified
	Audit and DI	Verified
	Online Audit	Verified
	Appliance Recycling	Verified
	Multifamily	Verified
C&I	Custom	Verified
	Prescriptive – Downstream Lighting, Midstream Lighting, Downstream Non-lighting	Verified
	Energy Management and New Construction – Building Improvements, Building Operations Training, Building Tune-ups and Commissioning. New Construction	Verified

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft survey instruments for multiple programs.

G.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework establishes a maximum level of sampling uncertainty of $\pm 15\%$ at the 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change was implemented specifically for EDCs like Penn Power, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes due to program delivery channel or supported technology.

Penn Power’s EE&C portfolio consists of five programs: Energy Efficient Homes, Energy Efficient Products, Low-Income Energy Efficiency, C&I Energy Solutions for Business – Large, and C&I Energy Solutions for Business – Small. The SWE performed its annual sample design review at the initiative level, which sometimes spans multiple programs or sectors. In response to the

annual data request, FirstEnergy's EM&V contractor provided the SWE with a sample disposition for each initiative detailing the project-level ex ante and ex post savings for each unit in the sample.

Table 170 shows the relative precision of PY16 energy and demand impacts by component at the 85% confidence level. In PY16, all programs were evaluated, none relied on historic realization rates. The Residential Online Audit and Behavioral Modifications programs, which were evaluated via regression analysis, have no uncertainty associated with sampling and thus is omitted from the below table. Residential Upstream Electronics Initiative is also omitted as it was not offered in PY16.

Table 170: Relative Precision of PY16 Impacts by Program Component at the 85% Confidence Level

Sector	Components	Relative Precision (Energy)	Relative Precision (Demand)
Residential	EE Kits	5.4%	5.3%
	LI - EE Kits	0.0%	0.0%
	Direct Install	7.0%	6.3%
	LI Direct Install	11.3%	11.6%
	Multifamily Direct Install	10.8%	10.8%
	HVAC	14.7%	14.5%
	Appliance Recycling	6.6%	7.1%
	LI Appliance Recycling	0.0%	0.0%
	Appliances	10.7%	9.9%
	Midstream Appliances	0.0%	0.0%
	New Construction	7.3%	13.9%
	Custom	6.1%	6.7%
C&I	Prescriptive	9.8%	10.6%
	Energy Management and New Construction	9.6%	10.0%
	Multifamily Direct Install	0.0%	0.0%
	Appliance Recycling	0.0%	0.0%

All evaluated components met the 15% threshold for relative precision in both energy and demand. ADM established in their Phase IV evaluation plan submitted to the SWE that they would use an assumed coefficient of variation (CV) derived from past program years for the initial sample design. However, ADM also used these planning CVs to calculate and report initiative-level relative precision. In PY16, ADM did calculate CV manually for the New Construction component but otherwise relied on assumed, rather than actual, CVs. The SWE recommends that ADM use manual variance calculations in place of planning coefficients of variation in their PY17 report to yield more accurate estimates of relative precision. Although the SWE still recommends leaving a hedge to guarantee that the $\pm 15\%$ relative precision threshold is met, ADM might be able to use fewer sample points than they did in PY16 for certain initiatives with low coefficients of variation.

The Behavioral Modification subprogram provides HERs to residential customers in the Penn Power service territory. The subprogram is divided between market-rate residential customers

and LI customers, and each is administered as an RCT. Participants are enrolled in experimental cohorts and a monthly billing analysis regression is used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model cannot fully capture the variation present in the data. Precision requirements for behavioral programs are unique, as the Phase IV Evaluation Framework requires the solution-level verification achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). [Table 171](#) shows the absolute precision of PY16 Behavioral Modification impacts at the 95% confidence level.

Table 171: Absolute Precision of PY16 Impacts for Behavioral Modification Programs at the 95% Confidence Level

Program	Absolute Precision (Energy)
Behavioral Modification (Market Rate)	0.20%
Behavioral Modification (LI)	0.43%

The Online Audit component also relies on regression analysis of all participants and a matched control group of non-participants. While there is no sampling error, there is uncertainty associated with the regression model. The relative precision of the market-rate Online Audit energy savings was $\pm 78.5\%$ at the 85% confidence level and the relative precision of the Low-Income Online Audit energy savings was $\pm 30.5\%$ at the 85% confidence level. The relative precision of the low-income group was better than the market-rate group, despite a much smaller number of homes because the savings estimate for low-income recipients was significantly higher. However, when the cluster robust standard errors are calculated based on the number of homes, instead of the number of observations, the relative precision exceeds $\pm 100\%$ at the 85% confidence level for both the market rate and the low-income results. To remedy the larger uncertainty, PY17 will use a rolling multi-year regression model to increase the number of homes included in the analysis.

G.4 REPORTED GROSS SAVINGS AUDITS

G.4.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penn Power's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts
- Incentive dollars

The SWE leveraged Penn Power's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset, but rather a subset of the full tracking dataset tailored to our PY16 quarterly data request. Also note that HER programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's

findings regarding the HER components of Energy Efficient Homes and LIEEP can be found in [Appendix G.5.1](#).

[Table 172](#) summarizes our findings regarding reported gross energy savings. The “Match” column contains “Yes” if the tracking data supports the values in Penn Power’s PY16 Annual Report and “No” otherwise. For each program, the SWE was able to replicate the values reported by Penn Power.

Table 172: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Energy Efficient Homes	5,455	5,455	Yes*
Energy Efficient Products	1,859	1,859	Yes
Low Income Energy Efficiency	687	687	Yes*
C&I Energy Solutions for Business – Small	12,249	12,249	Yes
C&I Energy Solutions for Business – Large	8,881	8,881	Yes
Portfolio Total	29,131	29,131	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

[Table 173](#) summarizes the SWE’s findings regarding reported gross peak-demand savings, by program. The tracking data is provided at the meter-level. To facilitate the comparison, the SWE applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. Like with reported gross energy savings, the tracking data supports the Penn Power PY16 Annual Report value exactly for all programs.

Table 173: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Energy Efficient Homes	0.81	0.81	Yes*
Energy Efficient Products	0.38	0.38	Yes
Low Income Energy Efficiency	0.10	0.10	Yes*
C&I Energy Solutions for Business – Small	2.84	2.84	Yes
C&I Energy Solutions for Business – Large	1.43	1.43	Yes
Portfolio Total	5.56	5.56	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

The SWE also used the tracking data to audit Penn Power’s reported participation counts and customer rebate amounts. Like with the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by Penn Power. No substantive issues were discovered.

G.4.2 Project File Reviews

G.4.2.1 Residential

As part of the reported savings (i.e., ex ante) review, the SWE conducted a project file review of a sample of Penn Power's residential project files for PY16 using the project file documentation provided by Penn Power, the program implementers, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included a majority of the documentation requested.

Table 174 presents a summary of the SWE's residential project file reviews.

Table 174: Penn Power PY16 Residential Project File Review

Program	Sub Program	Number of files reviewed ¹	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data? ²
EE Homes Program and LIEEP	Direct Install	-	-	-	-	-
EE Homes Program and LIEEP	EE Kits	40	✓	✓	✓	✓
EE Homes Program	Comprehensive Audits	40	✓	✓	✓	✓
EE Homes Program and LIEEP	New Homes	40	✓	✓	✓	✓
EE Products Programs and LIEEP	Appliance Rebates	20	✓	✓	✓	✓
EE Products Programs	Appliance Recycling	40	✓	✓	✓	✓
EE Products Programs	HVAC	20	✓	✓	✓	✓
EE Products Programs	Midstream Appliances	20	✓	✓	✓	✓
LIEEP	Appliance Recycling	10	✓	✓	✓	✓
LIEEP	LI WARM	40	✓	✓	✓	✓

¹ The number of files reviewed reflects the total number for all FirstEnergy EDCs.

² It should be noted that the Comprehensive Audits count includes audits performed at single-family and multifamily dwellings.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews.

Energy Efficient Homes Program and LIEEP: Direct Install

While the FirstEnergy companies offered the Direct Install subprogram of the EE products program in PY16, the SWE did not receive any project files for this program. The SWE acknowledges that this program was not evaluated in PY16 and will evaluate project files in PY16.

Energy Efficient Homes Program and LIEEP: Energy Efficiency Kits

The Energy Efficiency Kits subprogram contains two sub-components: energy efficient kits and school education. The documentation for the Energy Efficiency Kits program consisted of shipment data, specification sheets, and kit contents. The specification sheets include information on the wattage and wattage equivalence of LED bulbs (e.g., a 9-watt LED bulb replaces a 60-watt standard bulb), the wattage of LED nightlights, and the GPM rating of faucet aerators and low-flow showerheads. The shipment data was similar to the quarterly tracking data but was broken out by month and income status. The SWE did not find any discrepancies with quantities or measure descriptions between the project documentation and the tracking data. Project files do not contain data on some of the variables used in savings calculations, such as the number of people in the home, water heater setpoint temperature and fuel type, and HVAC system specifications.

Energy Efficient Homes Program: Comprehensive Audits (Single Family)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: Comprehensive Audits (Multifamily)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program and LIEEP: New Homes

All project files contained builder certificates and REM/Rate or Ekotrope analysis reports, and most project files contained REM/Rate or Ekotrope modeling files. Project files, which included a REM/Rate or Ekotrope report contained the heating and cooling capacity and efficiency metrics for the HVAC equipment as well as the volume of the hot water heater at the newly constructed home.

Energy Efficient Products Program and LIEEP: Appliance Rebates

The Appliance Rebate program had project files containing either receipts for rebated appliances, appliance rebate application forms, or both. These project files were accompanied by tracking data that recorded the date the rebate amount, the appliance purchased, the appliance type, and the appliance's quantity.

Energy Efficient Products Program and LIEEP: Appliance Recycling

The Appliance Recycling program had project files containing photos of the participant's signatures, photos of the nameplates of the recycled appliances, and photos of the recycled

appliances themselves. These project files were accompanied by tracking data that recorded the type of recycled appliances, the date it was recycled, the town it was from, and the quantity of recycled appliances. Although some of the photos of the appliances did not include nameplates, the SWE notes the thoroughness of the documentation.

Energy Efficient Products Program: HVAC

The HVAC program was only in operation during Q1 and Q2 of PY16. The HVAC project files included AHRI certifications, invoices equipment registration and rebate application forms. There were no discrepancies found in the project files as compared to the tracking database. However, there were some instances where the SWE was unable to confirm the tracking data matched the project file due to missing documentation such as the AHRI certificate.

Energy Efficient Products Program: Midstream Appliances

The Midstream Appliances program was only in operation during Q1 and Q2 of PY16. The project files for Midstream Appliances were comprised of invoice-styled excel sheets with tracking data that could be easily matched to the sample data given for each quarter. The invoice data recorded the type of appliance rebated, quantity, the appliance price, and the rebate amount. The SWE review of the sampled files did not reveal any discrepancies between the project files and the tracking database.

Energy Efficient Homes Program: LI WARM

Invoices, audit forms, preassessment, and post assessment forms were provided for sampled projects. The SWE notes that some projects had varying levels of documentation described above, but generally the necessary documentation existed for each sampled project reviewed by the SWE. A review of the sampled files did not reveal any discrepancies and the information provided within each project matched the tracking database. The SWE acknowledges that EDC collected data may be stored in solution specific datasets that were not requested as part of the quarterly data submission.

G.4.2.2 Non-Residential

As part of its audit process, the SWE conducts a review of ex ante savings. This review involves assessing specific project files for a sample of Penn Power's non-residential programs in PY16. Project file documentation is provided each quarter of the program year by Penn Power, the program implementers, and the evaluation contractor to the SWE. Project documentation provided typically includes program rebate applications and approvals, letters of attestation, invoices for installed equipment, equipment specification or "cut" sheets, post-inspection forms, and calculation workbooks. The SWE reviews these documents for completeness and consistency. The SWE also compares the data points in the documentation against the program tracking database to ensure values such as savings, rebate amounts, installation approval, and invoice dates align.

Project files were generally well-organized, complete, and accurate. [Table 175](#) presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 175: Penn Power PY16 C&I Project File Review Summary

Program	Sub-Program	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Downstream	Custom - LCI	2	✓	✓	✓	✓	✓
Downstream	Custom - SCI	1	✓	✓	✓	✓	✓
Downstream	Energy Management - SCI	3	✓	✓	✓	✓	✓
Downstream	Prescriptive - LCI	2	✓	✓	✓	✓	✓
Downstream	Prescriptive - SCI	1	✓	✓	✓	✓	✓
Midstream	Prescriptive - LCI	2	✓	✓	N/A	N/A	N/A
Midstream	Prescriptive - SCI	1	✓	✓	N/A	N/A	N/A
Downstream	Custom - LCI	2	✓	✓	✓	✓	✓

G.5 VERIFIED GROSS SAVINGS AUDITS

G.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the Penn Power portfolio of residential programs. Penn Power's portfolio of residential programs includes the following: the Energy Efficient Homes Program, the Energy Efficient Products Program, and the LI Energy-Efficiency Program. Each program contains various subprograms, which are addressed separately below. Note that the SWE reports the residential savings in two sections: residential and behavior.

The SWE Identified the evaluation activities used to verify savings for the residential programs. [Table 176](#) provides a summary of the evaluation and M&V approaches used by Penn Power in their PY16 verified savings calculations.

Table 176: Residential Program Evaluation Activities – Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied Historic RR
Energy Efficient Homes					
Energy Efficiency Kits	✓	-	✓	-	-
HERs	-	-	-	✓	-
Residential Direct Install	-	-	✓	-	-
Residential Direct Install – Multifamily	-	-	✓	-	-
Residential New Construction	-	✓	✓	-	-
Energy Efficient Products					
Upstream Electronics	-	-	-	-	-
HVAC	✓	-	✓	-	-
Appliances	✓	-	✓	-	-
Appliance Turn-in	✓	-	✓	-	-
Midstream Appliances	-	-	✓	-	-
Low-Income Energy-Efficiency Program					
LI Direct Install	-	-	✓	-	-
LI Appliance Turn-in	✓	-	✓	-	-
LI Appliances	✓	-	✓	-	-
LI New Homes	-	✓	✓	-	-
LI Kits	✓	-	✓	-	-
^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.					

The SWE's review of verified savings for residential programs found that the verified savings generally followed proper TRM protocols and were accurate.

Energy Efficiency Kits Initiative: EE Kits and Low-Income Kits

The Energy Efficiency Kits (EE Kits) initiative has two sub-initiatives – EE Kits and Low-Income EE Kits. Each subprogram has two sub-components: EE Kits and School Education. The SWE reviewed school education kits for both the EE Kits and Low-Income EE Kits sub-initiatives. The kits provided through the School Education subprogram contained LED lamps, LED night lights, a furnace whistle, and electrical outlet gaskets. The Low-Income kits included advanced power strips in place of electrical outlet gaskets. The SWE confirmed that the verified savings for each sub-initiative were in accordance with the TRM protocols for the relevant measures and worked with ADM to resolve any discrepancies prior to the filing of the FirstEnergy annual report. The

SWE also confirmed that participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Homes Program and LIEEP: New Homes

The SWE worked with evaluation contractor, ADM, to resolve some discrepancies in the evaluated savings prior to annual reporting. ADM reviewed and corrected the ex post energy models for a sample of PY16 projects to develop a realization rate for program-wide savings. ADM also revised the calculation method used for cooling demand savings to use hourly load results from the sampled models, which aligns with the approach used by other EDCs.

The Residential and Residential Low-Income Direct Install Initiatives

The Residential and Low-Income Direct Install Initiatives primarily used an SSRS Tracking and Reporting database for this evaluation as well as documentation from on-site QA/QC inspections. ADM used a stratified sampling approach to perform a desk review of a sample of participants in this program and rolled up the realization rates to the total program participant population. ADM provided the SWE with data from home inspections and with the subsequent savings calculations and roll up. The SWE confirmed the verified savings for each measure were in accordance with TRM protocol. The SWE also confirmed that the participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Products Program: HVAC

The HVAC subprogram includes measures such as air-source heat pumps, central air conditioning, furnace fans, ground-source heat pumps, HVAC tune-ups, mini-split heat pumps, packaged terminal heat pumps and air conditioning, connected thermostats, bathroom fans, and circulating pumps. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. The SWE confirmed that participation, verified savings, and realization rates were in alignment with those in the annual report.

Energy Efficient Products Program and LIEEP: Appliances

The appliance subprogram includes measures such as: refrigerators, freezers, clothes washers and dryers, dehumidifiers, dishwashers, window ACs, HPWHs, and connected thermostats. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. For the final report, Low-Income and Non-Low-Income Energy Efficient Products Programs were combined. The SWE confirmed that participation, energy savings, and energy realization rates were in alignment with those in the annual report.

The SWE notes that the appendix for this subprogram includes a list of the variables for each appliance and the corresponding data sources. This was a helpful to the SWE audit.

Appliance Recycling and Low-Income Appliance Turn-In Initiative

The SWE conducted an early review of the Appliance Recycling and Low-Income Appliance Recycling Initiatives. Each initiative includes five measures: refrigerator recycling, freezer recycling, room air conditioner (RAC) recycling, dehumidifier recycling, and mini refrigerator recycling. ADM's evaluation included calculating measure-level savings using program tracking data and survey data from PY16, including TRM inputs when necessary. The SWE did not observe any discrepancies with the application of TRM algorithms or the application of EDC-gathered data. The SWE confirmed that participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Homes Program: Multifamily

Gross impact evaluation for the Res MF Initiative utilized a stratified sampling plan. Most projects are placed into one sampling stratum, with an additional stratum reserved for high-impact projects.

The program tracking and reporting system is at the measure level, and also identifies the rebate application and participant address associated with each measure. ADM aggregated all measures by unique address and then placed each household in one of the two strata: high-impact projects with reported energy savings above 2,000 kWh, and all other projects.

Due to the low participation and impacts in this initiative in Phase IV, desk reviews were the most appropriate evaluation activity. ADM evaluators compared audit reports and invoices to program tracking and reporting data to reconcile quantities of installed measures. The evaluators also independently calculated impacts for all measures according to their respective protocols in the 2021 PA TRM.

Energy Efficient Products Program: Midstream Appliances

The SWE conducted an early review of the Midstream Appliances subprogram. ADM's evaluation included a full review of the program tracking data and aligning savings estimates with the TRM and product-specific data. The SWE did not observe any discrepancies with the application of the TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Products Program: Upstream Electronics

The FirstEnergy companies did not offer the Upstream Electronics subprogram of the EE products program in PY16.

Energy Efficient Homes and LIEEP: Online Audit

In PY13, FirstEnergy launched an Online Audit component to the Behavioral subprogram included in both the Energy Efficient Homes (EEH) and Low-Income Energy Efficiency (LI) programs. The Online Audit component operates on an opt-in basis and offers residential customers a web-based platform featuring energy usage visualizations, energy-saving tips, and promotion of other FirstEnergy residential energy-efficiency programs. Participation is defined as logging into the online portal and completing the registration to receive an audit. A total of 1,279 market-rate residential and 110 low-income households participated in the Online Audit program in PY16, which is down from PY15 for both programs. Market-rate participants decreased by 17%, and low-income participants decreased by 39% from PY15 to PY16.

The Phase IV Online Audit subprogram is an opt-in program, and the SWE team reviewed the propensity score matching ADM performed to create a matched control group using five pre-treatment consumption variables, latitude, longitude, and a categorical variable that identifies to which HERs cohort a customer belongs. The comparison group matching was performed using a 1:1 treatment-to-comparison group ratio. Due to the non-RCT design of the Online Audit component, ADM included weather terms to improve model fit and control for potential differences in weather-sensitivity between the treatment group and matched control group. In PY15, ADM adhered to the guidance provided by the SWE in PY14 to run a pooled regression model across all four EDCs. Given the relatively small sample sizes at the individual EDC x Program level, ADM chose to consolidate the analysis at the Program level across the four FirstEnergy EDCs. A single regression model was estimated for EE Homes across all four EDCs, and another model was estimated for Low-Income programs. Estimated regression coefficients were allowed to vary with temperature, and the resulting impacts were then adjusted for each EDC using EDC-specific weather variables. The SWE team independently calculated per-household kWh savings from regression coefficients, active participant counts, and aggregate MWh and MW impacts. Our estimates match ADM's estimates.

Our savings estimates and standard errors matched ADM's estimates once a cluster robust standard error correction was included in both model specifications. This statistical technique deals with autocorrelation and computes uncertainty based on the number of homes in the analysis rather than the number of observations. Use of the cluster robust standard error corrections caused the relative precision to exceed $\pm 100\%$ at the 85% confidence level, which means neither the market-rate nor low-income results were statistically significant. The Pennsylvania Evaluation Framework discusses this potential outcome for impact evaluations that rely on billing analysis and asks evaluation contractors to explore remedial actions. The planned remedial action for PY17 is to rely on a rolling multi-year regression model to increase the overall number of homes included in the analysis.

The SWE also reviewed the dual participation analysis. Online Audit participants tend to participate in other Penn Power EE&C programs at a higher rate than the matched control groups, so this adjustment is necessary to avoid double-counting. To calculate gross verified demand savings, ADM generated an Energy to Demand Factor (ETDF) using residential load profiles corresponding to the treatment group and then applied ETDF to energy savings to estimate demand savings. The SWE was able to replicate the verified demand savings for both the residential and residential low-income group.

Table 177 shows the aggregate PY16 verified gross MWh savings and MW reductions by program. The table also shows the number of participants and average percent savings per household by program group. Using the first impact estimate as an example, the practical interpretation is as follows: all treatment group homes in the EEH Program saved 46 MWh and each household lowered their annual electric consumption by 0.26% during PY15. It is unclear why the low-income households saved more energy per household than their market-rate counterparts in PY16. Higher per-household savings in the LI program could simply be a result of noise due to a relatively small number of participants.

Table 177: PY16 Penn Power Online Audit Energy and Demand Savings

Program	Participants	Gross Energy Savings (MWh)	Gross Demand Savings (MW)	Average Percent Savings per Home
EEH Program	1,279	46	0.008	0.26%
LI Program	110	30	0.004	2.10%
Total	1,389	76	0.012	-

Behavior

Home Energy Reports were issued to around 57,000 residential and residential-LI households in PY16. Penn Power's behavioral portfolio consists of both active waves and inactive legacy waves, which may be reactivated later in Phase IV. Five waves, or cohorts, were active during PY16, and one of them targeted low-income households. [Table 178](#) summarizes the number of active households during PY16 by cohort and summarizes key features of the PY16 evaluation method.

Table 178: Penn Power HER Cohort Summary

Cohort	Start Date	Treatment Group Homes	Control Group Homes	Reintroduced Cohort	Rebaselined Cohort	Weighted Regression
2012 Residential	7/1/2012	13,510	9,660	Yes	No	Yes
2014 Residential	1/1/2014	5,418	4,879	Yes	No	No
2021 Residential	9/26/2021	14,759	9,305	No	N/A	No
2023 Low-Income	6/18/2023	7,117	6,746	No	N/A	No
2023 Residential	6/18/2023	16,263	10,835	No	N/A	No
Total		57,067	41,425			

The program ICSP, Oracle, administered all cohorts as randomized control trials (RCTs). Eligible households were identified and then randomly assigned to either a treatment or control group. Following randomization, ADM conducted statistical tests on the pre-treatment energy usage patterns to confirm equivalence between the treatment and control groups.

The SWE team conducted an audit of the pre-treatment equivalence test for all cohorts. To check the pre-treatment equivalence, the SWE team ran a Welch Two Sample T-Test on pre-period usage by treatment status for each cohort. The pre-period usage variables included the average annual, summer, and winter energy usage per household in the year prior to treatment. With these defined baselines and pre-treatment lag variables, the SWE team was able to replicate the same p-values for the t-test results as ADM.

As part of the PY16 implementation of the Home Energy Reports (HER) measure, two previously suspended historical Penn Power cohorts were reintroduced into the program. ADM also

assessed the equivalence of the treatment and control groups in these cohorts, 2012 Residential and 2014 Residential, during PY15 to determine if the HER impact had decayed sufficiently to allow PY15 data to be used as the pre-treatment period. ADM found that the treatment and control groups in these two cohorts showed statistically significant differences, suggesting savings were persistent, rendering them unsuitable for rebaselining. Both reintroduced Penn Power cohorts retained their original baseline periods and treatment dates.

Both ADM and the SWE team found that one Penn Power cohort failed the annual consumption equivalence check at the 90% confidence level. To accommodate this, ADM proposed using propensity score matching (PSM) on the three pre-treatment variables for this cohort, using with-replacement matching. Following ADM's approach, propensity score matching was used to rebalance the 2012 Residential cohort by providing a series of weights for the control customers in that cohort. With those weights, the 2012 Residential cohort passed the equivalence test. The SWE team was able to replicate the equivalence t-test results for this cohort using ADM's weights. Those weights were used in the linear regression to calculate consumption savings and in the simple difference calculation to determine peak-demand reduction.

ADM provided the SWE team with both daily and monthly consumption data for all homes in the treatment and control groups. The monthly data served as the primary input in the estimation of HER impacts. The SWE team found the calculations and distribution of monthly kWh to be reasonable. Models used throughout the analysis rely on three pre-treatment lag variables: average usage, average summer usage, and average winter usage. The pre-treatment period was 12 months prior to original treatment for all Penn Power's cohorts. Using the daily consumption data, the SWE team was able to replicate the three lagged variables calculated by ADM for each customer. These lag terms were calculated for customers with 12 months of pre-treatment data, who also had no data issues as flagged by ADM (i.e. invalid hourly observations or outlier consumption amounts).

ADM obtained active customer counts for each month by tallying up the number of accounts that had daily interval data for the month. Only active accounts where HER delivery had begun were included in these calculations. Both ADM and the SWE team found an inconsequential number of accounts that were not counted because they either were placed in both the control group and treatment group or had multiple treatment starting dates. A few accounts were not included in the counts because Oracle never began HER delivery to these homes or due to pre-start date attrition.

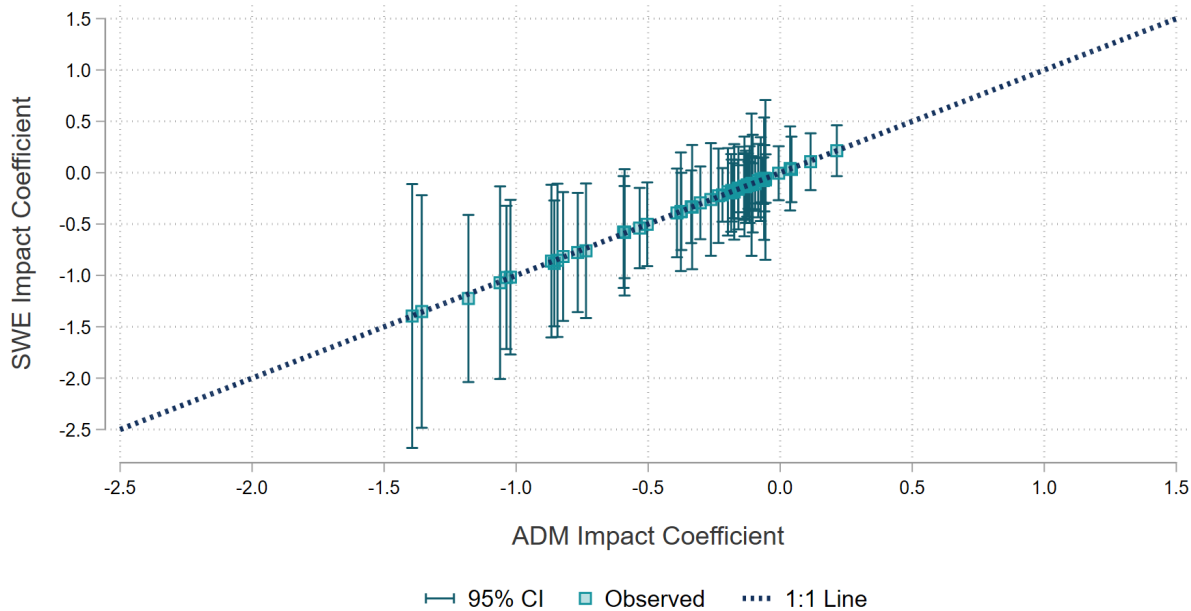
The SWE team validated ADM's enrollment counts by performing a similar counting method on the daily consumption data. Customers were considered active through the end of the month that they last have interval data. For example, if a customer's final AMI record was from February 15th, the customer would be included in the count for February but not in March or any month following. The SWE team's final customer counts matched ADM's for each month and cohort.

Customers that did not have twelve months of pre-treatment data or were flagged as having a data issue were not included in the impact estimation (because the lagged seasonal variables for these customers were not calculated), but they were included in the customer counts.

ADM used a lagged seasonal (LS) regression model for the PY16 impact analysis. Using the monthly billing data, the LS model estimates the relationship between daily usage and pre-treatment variables. Unlike previous years, the regression included weights for the 2012

Residential cohort that failed the equivalence test without weighting. The SWE team was able to replicate ADM's coefficients with no notable differences in coefficients, as shown in [Figure 58](#). The SWE estimates all fell within the confidence interval for ADM's coefficients.

Figure 58: Penn Power PY16 HER LS Coefficient Comparison



The SWE team independently calculated gross MWh savings using regression coefficients and active participant counts, and our estimates matched ADM's estimates. [Table 179](#) shows the aggregate PY16 pre-adjustment gross MWh savings by cohort. The table also shows three adjustments, which are discussed in greater detail later, and the PY16 incremental verified gross savings estimate.

Table 179: Penn Power PY16 Energy Savings*

Cohort	Gross Savings (MWh)	Downstream Dual Participation (MWh)	Upstream Dual Participation (MWh)	Persistence (MWh)	Incremental Savings (MWh)
2012 Residential	2,340	10	70	0	2,260
2014 Residential	1,798	51	52	0	1,695
2021 Residential	687	52	0	580	55
2023 Low-Income	315	51	0	0	264
2023 Residential	238	34	0	0	204
Total	5,378	197	122	580	4,478

* Totals may not equal the sum of columns or rows due to rounding.

Home Energy Reports advertise other Penn Power residential EE&C programs and measures such as ENERGY STAR appliances, water heaters, and high-efficiency HVAC rebates. To the extent that treatment group households participate in these programs more frequently than the control group homes, the incremental savings are captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings were adjusted to account for the incremental program participation observed in the treatment group compared to the control group. An upstream dual participation adjustment was only applied to the gross savings estimates of 2012 and 2014 cohorts.

The 2021 Pennsylvania TRM assumes an annual decay rate of 31.3% derived from Pennsylvania-specific research⁹⁹ on the persistence of behavioral energy efficiency treatment in the years after discontinuing treatment. Since Act 129 compliance goals are based on first-year incremental savings, these persistent impacts were subtracted from the measured savings to estimate incremental first-year savings (those directly due to the current program year of treatment).

For the first two years of HER exposure, persistence is assumed to be zero and the first-year savings average treatment effect (FYSATE) simply equals the average treatment effect (ATE). For year three and beyond of HER exposure, the FYSATE is calculated using Equation 4, which comes from the 2021 TRM. For year i of HER exposure:

Equation 4: First Year Savings Average Treatment Effect (FYSATE)

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

$$\Delta kWh_y = FYSATE_y * Treatment\ Accounts_y * Days_y$$

Where $FYSATE_y$ is the average daily savings attributable to HERs delivered in the current year (Y) and $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in year Y-X.

Because the 2023 waves were launched during PY15, their savings were considered incremental. Separating persistent savings from incremental savings was not necessary for these waves, but the 2021 wave did require such an adjustment. The reintroduced historical cohorts did not have any persistence adjustment, as they had not been treated for 3 years, so there was no persistence still in effect. The SWE team found that ADM correctly modeled persistence in accordance with TRM specifications for these waves.

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 SWE team replicated ADM's peak-demand impact estimate and peak-demand reduction for each cohort, with no noticeable differences between the SWE team and ADM impacts.

⁹⁹ Addendum to Act 129 Home Energy Report Persistence Study. November 2018.

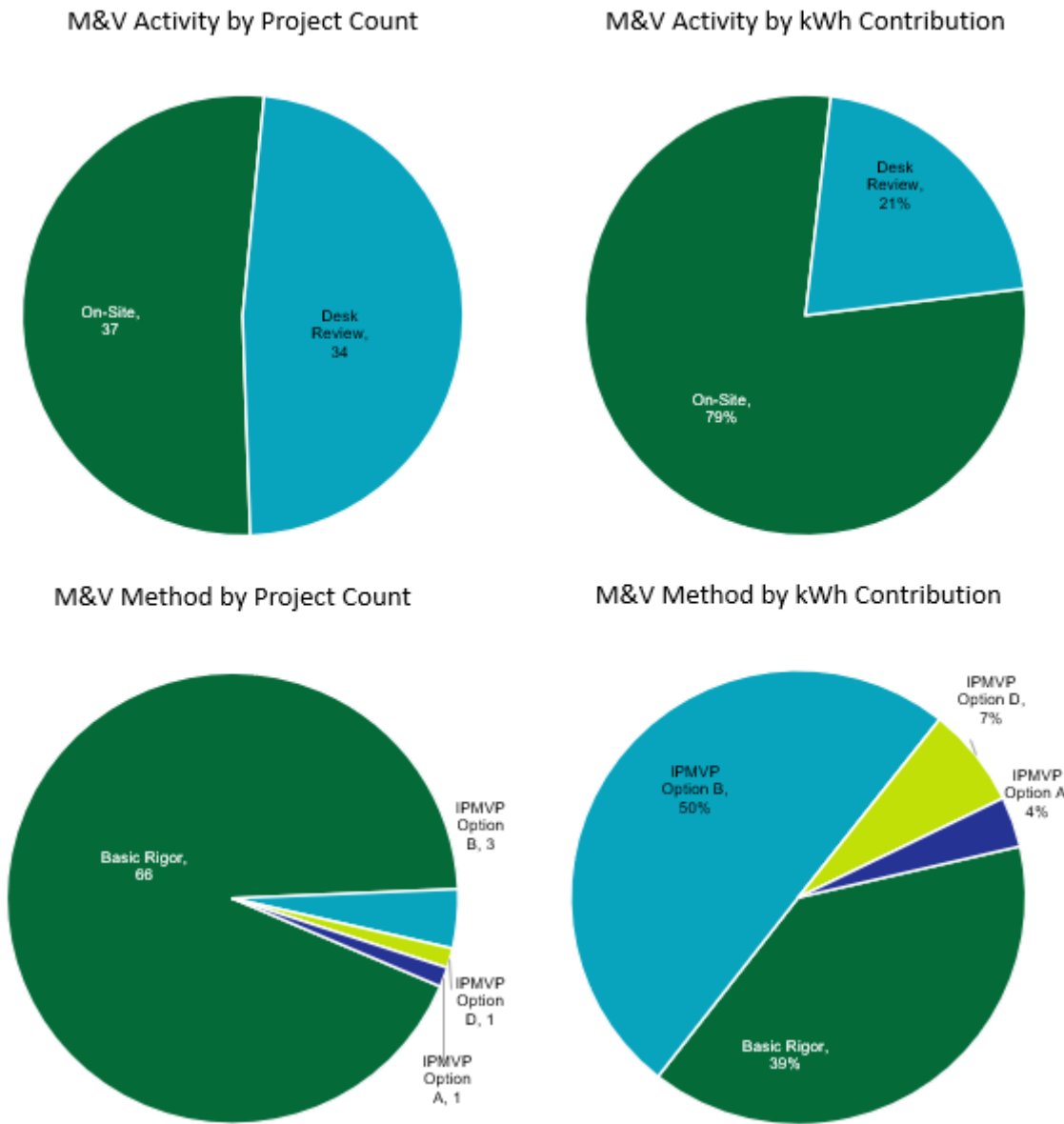
https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

In conclusion, the SWE team successfully replicated ADM's findings for Penn Power. Their methodology was transparent and reproducible, and any adjustments to the analysis were well-justified and reviewed collaboratively to ensure their validity.

G.5.2 Non-Residential Audit Activities

Figure 59 summarizes the evaluation activities and M&V approaches utilized by ADM in their PY16 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY16, Penn Power's evaluation contractor completed site visits for 37 out of 71 evaluated projects, 79% of the total evaluated energy savings. IPMVP Options A, B, and D were employed for 61% of the total evaluated energy savings. Basic Rigor (verification only) was employed for 39% of the total evaluated savings.

Figure 59: Summary of Penn Power’s C&I Evaluation Activities



Penn Power’s evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Penn Power’s C&I programs are assigned to one of four evaluation initiatives, as the programs target specific sectors of C&I customers, even though the offerings are often identical. [Table 180](#) provides a summary of the evaluation activities across strata for all projects by initiative.

Table 180: Summary of Penn Power's PY16 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR - Energy	RR - Demand	Desk Review	On-Site Verification
Appliance Recycling		108%	109%		
Custom	6	101%	108%	3	3
Custom-C	3	100%	106%	2	1
Custom-2	2	109%	194%	1	1
Custom-1	1	100%	100%	-	1
Prescriptive	39	90%	86%	23	16
Downstream Lighting-2	4	82%	78%	3	1
Downstream Lighting-1	7	87%	98%	4	3
Downstream Non-lighting	2	96%	96%	2	-
Midstream Lighting-1	18	100%	88%	7	11
Midstream Lighting-2	8	93%	88%	7	1
EMNC	23	93%	97%	11	12
Building Tune-Ups-2	8	96%	96%	6	2
Building Tune-Ups-1	8	90%	94%	5	3
CBI-RCX-1	5	27%	99%	-	5
CNC-1	2	130%	102%	-	2
Multifamily-1	3	102%	103%	0	3
TOTAL	71			37	34

The SWE's review of verified savings for non-residential programs found that the overall verified energy savings estimation was aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and correctly applied TRM protocols.

G.5.2.1 Appliance Recycling Initiative

In PY16, projects in Penn Power's Appliance Recycling Sub-Initiative were evaluated through a review of tracking and reporting data. The gross energy and demand realization rates for each evaluation stratum were taken to be the realization rates from the broader initiative-level evaluation that included the residential and low-income residential subprograms.

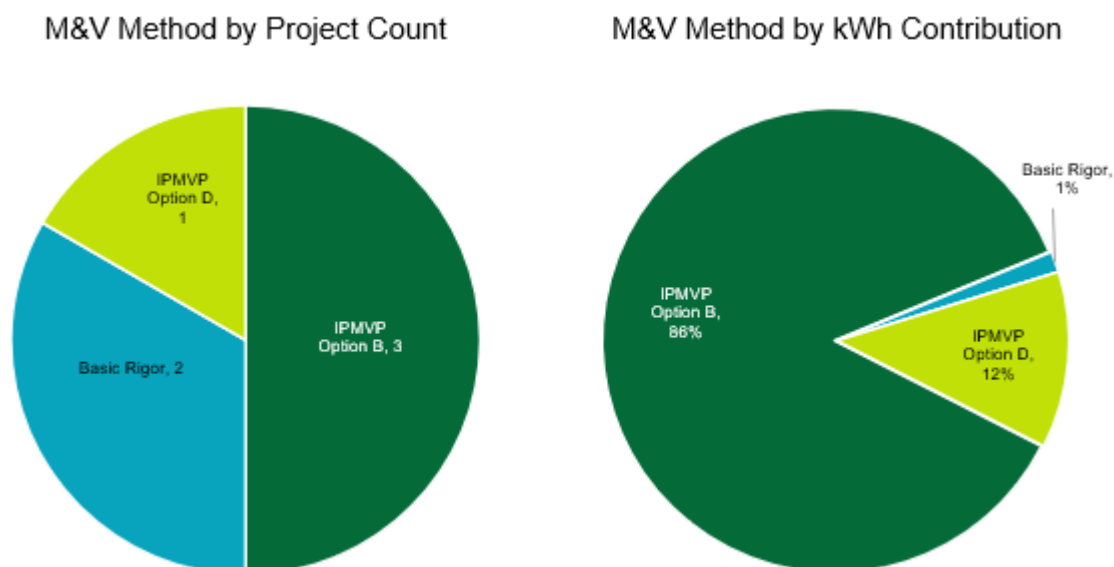
G.5.2.2 Custom Initiative

Penn Power's evaluation contractor employed two strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a "certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval. Solar PV projects were evaluated through the Custom Initiative using NREL's SAM and PVWatts models. The SWE independently

replicated savings calculations, applied caps based on actual utility billing data where appropriate, and verified correct definitions of peak hours.

Evaluation activities for this initiative include four projects that applied IPMVP Option B or Option D, plus two desk reviews. The distribution of rigor across the sample strata is in keeping with Table 14 of the Phase IV Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty. IPMVP Option B was selected as the primary enhanced M&V method for the largest custom project, accounting for 86% of evaluated savings in this stratum, as shown in [Figure 60](#).

Figure 60: Summary of Penn Power's C&I Custom Program M&V Methods



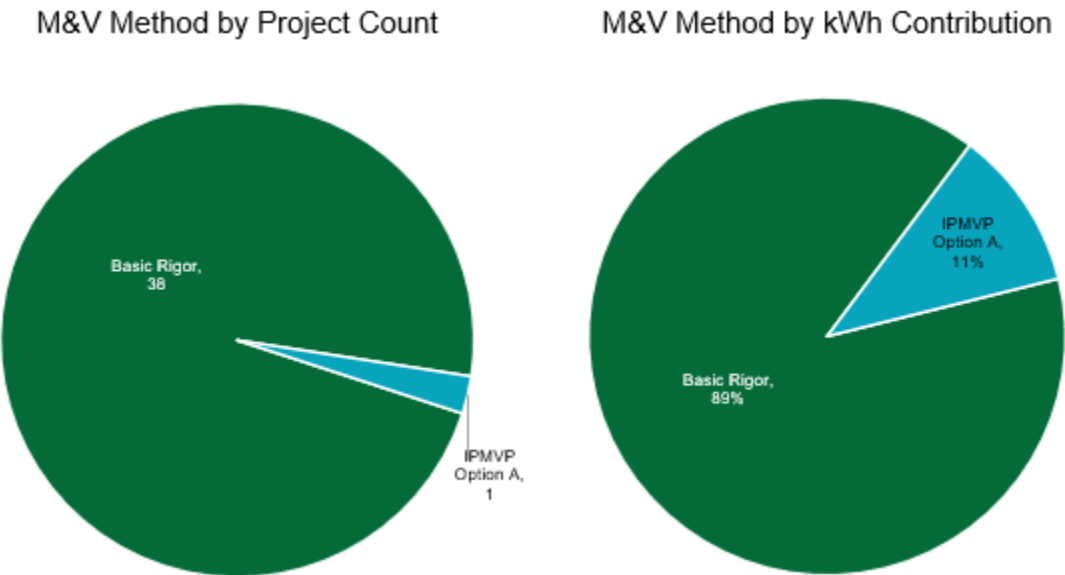
G.5.2.3 Prescriptive Initiative

Evaluation activities for this initiative include desk reviews for most projects and primary data collection of lighting hours of use for medium and high savings projects. TRM deemed hours of operation were applied in basic rigor desk reviews for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penn Power's evaluation contractor employed four strata for projects in the Prescriptive initiative, covering both downstream and midstream programs. Lighting savings from midstream were double the downstream savings and no PY16 projects were large enough to require enhanced M&V.

Basic rigor evaluation was applied for 89% of evaluated project savings in this initiative, with 11% of savings evaluated using IPMVP Option A, as seen in [Figure 61](#) below.

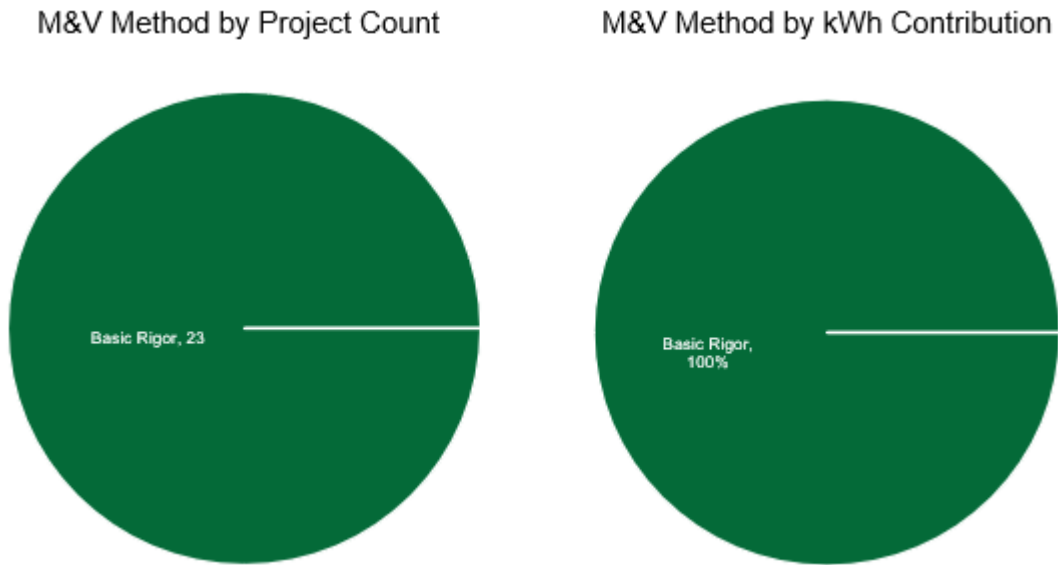
Figure 61: Summary of Penn Power’s C&I Prescriptive Program M&V Methods



G.5.2.4 Commercial and Industrial Energy Management and New Construction Initiative (CI EMNC)

The CI EMNC Initiative has five sub-components, three of which were active in PY16. Evaluation activities for this initiative were all completed through desk reviews and basic rigor, leveraging TRM algorithms and reconciliations of invoices with equipment specification sheets, as shown in [Figure 62](#) below. The evaluator opted to conduct on-site inspections for eleven of twenty-three sampled projects

Figure 62: Summary of Penn Power’s CI EMNC Program M&V Methods



G.5.2.5 Verified Savings Audits

The SWE audited the activities above through a detailed audit of ADM’s evaluation work for a sample of their evaluated projects. The SWE audit for ADM’s Penn Power evaluation in PY16 included review of fourteen projects, encompassing the following activities:

- Two field and analysis engineers audited
- Nine lighting, three EMNC, and two custom measures reviewed
- 29% of verified energy savings checked by SWE
- 40% of verified demand savings checked by SWE

Table 181 provides an overview of the SWE milestones for the verified savings audit review of evaluated Penn Power’s projects.

Table 181: Penn Power Verified Savings Audit Review Milestones

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
14	2,850,509	100%	665	100%

Overall, the SWE found that Penn Power’s evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods for custom measures.

G.6 NTG

Table 182 lists Penn Power's PY16 NTG as listed in the First Energy PY16 Annual Report. Details concerning the methods and data used to estimate NTG values are in sections G.6.1 and G.6.2.

Table 182: Penn Power PY16 NTG Results

Program Name	Component	NTG
Energy Efficient Products	Appliance Recycling	0.61
Energy Efficient Products	HVAC	0.55
Energy Efficient Products	Appliances	0.52
Energy Efficient Products	Midstream Appliances	0.50
Energy Efficient Homes	EE Kits	0.85
Energy Efficient Homes	Home Energy Reports	1.00
Energy Efficient Homes	Direct Install	0.94
Energy Efficient Homes	New Homes	0.72
Energy Efficient Homes	Multifamily Residential	1.00
Energy Efficient Homes	Comprehensive Audits	1.00
C&I Solutions for Business Programs – Small and Large	Multifamily	1.00
C&I Solutions for Business Programs – Small and Large	Prescriptive	0.77
C&I Solutions for Business Programs – Small and Large	Custom	0.56
C&I Solutions for Business Programs – Small and Large	EMNC	0.75
C&I Solutions for Business Programs – Small and Large	Appliance Recycling	0.61
Portfolio Total		0.76

G.6.1 Residential Programs

ADM planned and enacted NTG research for the Appliance Recycling component of the EE Products Program component of the EE Homes Program. ADM utilized participant surveys to estimate free-ridership and NTG for all components. Spillover is not calculated because the program is not designed to encourage customers to implement additional energy-efficiency projects. ADM utilized question batteries that were consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation (Table 183).

Table 183: Summary of Penn Power's PY16 Residential NTG Results

Program Component	Approach	Sample Size	Free-Ridership	Spillover	NTG
Appliance Recycling	Participant Surveys	98	0.39	0.00	0.61

G.6.2 C&I Energy-Efficiency Programs

ADM planned and enacted NTG research for the C&I Custom and Energy Management subprograms of the Energy Solutions for Business (ESB) program for small and large commercial customers in PY16. (Table 184)

Table 184: Summary of Penn Power's PY16 C&I NTG Results

Program Components	Approach	Sample Size	Free-ridership	Spillover	NTG
EMNC	Participant Surveys	120	0.28	0.03	0.75
Custom	Participant Surveys	24	0.49	0.05	0.56

G.7 TRC

Table 185 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penn Power's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY16 annual report, and the model itself was well-organized and documented.

Table 185: Summary of Penn Power's PY16 TRC Results

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$4,492	\$2,406	1.87	\$2,086
Energy Efficient Products	\$1,380	\$1,301	1.06	\$79
Low Income Energy Efficiency	\$274	\$1,308	0.21	(\$1,034)
Residential Subtotal	\$6,145	\$5,015	1.23	\$1,131
C&I Energy Solutions for Business - Small	\$8,420	\$4,117	2.05	\$4,304
C&I Energy Solutions for Business - Large	\$5,762	\$5,326	1.08	\$436
Non-Residential Subtotal	\$14,182	\$9,443	1.50	\$4,739
Cross-cutting	\$0	\$0	--	\$0
Portfolio Total	\$20,328	\$14,458	1.41	\$5,870

¹ Totals may not equal the sum of columns or rows due to rounding.

Four of Penn Power's five EE&C programs were found to be cost-effective when estimating the TRC using gross verified savings. Three of these programs were also found to be cost-effective using net verified savings. The Low Income Energy Efficiency program was not cost-effective on a gross verified or net verified basis. This is not uncommon for income-qualified programs due to the elevated program delivery costs.

G.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to each company.

- The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions. The SWE also verified the correct avoided costs from Penn Power's EE&C Plan were used in the TRC Model.

- To calculate the avoided cost of natural gas, Penn Power used a three-segment approach outlined in the 2021 TRC Test Order. The SWE verified the TRC Model correctly applied the avoided costs to estimate TRC benefits.
- Pursuant to the 2021 TRC Test Order, the SWE verified that Penn Power used a nominal discount rate of 5% to calculate the net present value of future program benefits, which is consistent with their EE&C plan. Line loss adjustment factors varied by sector: Residential (1.0949), Small C&I (1.0545), and Large C&I (1.0545).
- The incremental costs were derived from the SWE Incremental Cost Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumptions, and actual project costs as gathered from the PY16 evaluation. The SWE spot checked the incremental measure costs used in the TRC model and found them to be generally reasonable and consistent.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to calculate verified gross savings.
- The calculation of NTG using free-ridership and spillover, as well as the application of the NTG in the calculation of TRC benefits and costs, were consistent with the 2021 TRC Test Order directive for Phase IV. The TRC model followed the protocol pertaining to the treatment of free-rider participant costs; these are not included in net program costs.
- The SWE found that the cost categories were handled correctly in the TRC model. Participant incentives were not considered TRC costs, whereas administrative costs, incremental costs, and kits were included as costs.
- The SWE verified that the reported gross demand and capacity savings were accurate in the TRC model by comparing it to the Quarterly Tracking Data reported by Penn Power.
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Fossil Fuel Impacts and Total NPV Lifetime Water Impacts. The SWE verified that the savings were accounted for in accordance with the 2021 TRC Test Order.

G.8 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including Penn Power, resulting in identical information reported in the annual evaluation report for all four EDCs. Details on survey targets and completes for Penn Power are provided in the subsections below. [Appendix E.8](#) of the SWE's PY16 Final Annual Report, described previously for Met-Ed, applies to all four FirstEnergy utilities, including Penn Power.

G.8.1 Residential Programs

G.8.1.1 Energy Efficient Products Program – Appliance Recycling

The PY16 evaluation team completed 115 participant surveys with Penn Power customers

G.8.1.2 Energy Efficient Products Homes – Comprehensive Audits

There were not any surveys as part of the PY16 evaluation.

G.8.1.3 Energy Efficient Products Homes – Multifamily Residential

There were not any surveys as part of the PY16 evaluation.

G.8.1.4 Energy Efficient Products Homes – School Education

There were not any surveys as part of the PY16 evaluation.

G.8.1.1 Energy Efficient Products Homes – EE Kits

There were not any surveys as part of the PY16 evaluation.

G.8.2 Residential Low-Income Program**G.8.2.1 Weatherization (Direct Install)**

There were not any surveys as part of the PY16 evaluation.

G.8.2.2 Appliance Rebate

There were not any surveys as part of the PY16 evaluation.

G.8.2.3 Behavioral Home Energy Report

There were not any surveys as part of the PY16 evaluation.

G.8.2.4 Multifamily (Residential)

There were not any surveys as part of the PY16 evaluation.

G.8.2.5 New Homes

There were not any surveys as part of the PY16 evaluation.

G.8.2.6 School Education

There were not any surveys as part of the PY16 evaluation.

G.8.2.7 EE Kits

There were not any surveys as part of the PY16 evaluation.

G.8.2.8 Appliance Recycling – Low-Income Sub-Initiative

The PY16 evaluation team completed two participant surveys with Penn Power, low-income customers.

G.8.3 Commercial & Industrial Programs**G.8.3.1 C&I Energy Solutions for Business (Small) - Multifamily**

There were not any surveys as part of the PY16 evaluation.

G.8.3.2 C&I Energy Solutions for Business (Large) – Multifamily

There were not any surveys as part of the PY16 evaluation

G.8.3.3 C&I Energy Solutions for Business (Large) – Custom

The PY16 evaluation team completed participant surveys covering one Custom projects with C&I (Large) West Penn Power customers.

G.8.3.4 C&I Energy Solutions for Business (Small) – Custom

The PY16 evaluation team completed participant surveys covering three Custom projects with C&I (Small) West Penn Power customers.

G.8.3.5 C&I Energy Solutions for Business (Large) – Energy Management

The PY16 evaluation team completed participant surveys covering 11 Energy Management projects with C&I (Large) West Penn Power customers.

G.8.3.6 C&I Energy Solutions for Business (Small) – Energy Management

The PY16 evaluation team completed participant surveys covering 27 Energy Management projects with C&I (Small) West Penn Power customers.

G.8.3.7 Appliance Recycling – Non-Residential Sub-Initiative

The PY16 evaluation team did not complete any in-depth interviews with Penn Power C&I (Small) customers.

Appendix H FirstEnergy: West Penn Power Company PY16 Audit Detail

H.1 KEY AUDIT FINDINGS

- The SWE's review of PY16 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, and were generally accurate.
- West Penn Power provided their residential and low-income verified savings analyses prior to drafting their annual reports. This provided ample time for the SWE to conduct an early review and, therefore, allowed the opportunity to ask questions, discuss potential discrepancies, and review updated results that were directly incorporated into the West Penn Power PY16 Annual Report. In addition, the verified savings analyses were well organized and included the documentation required to conduct verified savings checks from the measure-level all the way to program-level savings.
- West Penn Power had seven active HER cohorts in PY16. Four of the cohorts consisted of market-rate residential households, and the other three cohorts consisted of low-income households. Behavioral HER programming accounted for 3% of West Penn Power's total verified MWh savings in PY16 and 3% of the verified low-income MWh savings. The SWE found that ADM's HER impact evaluation was entirely consistent with their approved EM&V plans.
 - West Penn Power reintroduced three historical cohorts, two low-income and one residential. ADM found that the treatment and control groups in two of these cohorts were equivalent in PY15, suggesting savings were not persistent and rebaselining was possible. As a result, two reintroduced cohorts had its treatment date and baseline period updated. The other cohort retained their original treatment date and baseline period.
 - Both West Penn Power's rebaselined cohorts had negative savings. The other reintroduced cohort that was not rebaselined had positive savings.
 - West Penn Power's 2014 Residential cohort was the only market-rate cohort to have negative savings across the FirstEnergy EDCs.
 - The SWE's review of PY16 HER savings found that the estimations were generally accurate. ADM provided detailed information that was coherent, and the analysis conducted was replicable and sound.
- Low-income participants in West Penn Power's Online Audit offering showed a higher average percent savings (1.6%) compared to market-rate participants (0.3%). However, participation in the program was much lower for low-income households (approximately 9% of market-rate households), so the margin of error around the billing analysis estimate was large.
- West Penn Power's portfolio was cost-effective in PY16 with a gross TRC ratio of 1.59. West Penn Power's PY16 gross TRC ratio was higher than its PY15 gross TRC ratio of 1.34.

- The SWE thoroughly audited the TRC model and found all elements to be properly calculated, including discounting, EUL, line losses, measure load profiles and avoided costs. O&M benefits were negative for West Penn Power's Large Commercial and Industrial component due to a high volume of large solar projects. The assumed early maintenance costs for solar projects led to negative O&M benefits at the portfolio level.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in West Penn Power's PY16 Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and participation counts. The SWE was unable to replicate incentives exactly using the tracking data; however, the SWE did not expect to be able to do so, and calculated directionally similar values for each program.
- The SWE reviewed the sampled design and realization rate calculations for initiatives that rely on observations from a sample of projects to make inferences about program performance. While the sample sizes and realization rate calculations were sound, the SWE observed that ADM used the expected coefficient of variation rather than the actual sample variance to compute the relative precision of West Penn Power's gross impact evaluation results. The SWE recommends that ADM use manual variance calculations in place of planning assumptions in their PY16 report to yield more accurate estimates of sampling uncertainty.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. There were minimal identified issues in the documentation review and no requested revisions for PY17.
- The SWE conducted a project file review for a sample of West Penn Power's residential and income-eligible solutions in PY16. In general, adequate numbers of project files were submitted, the sampled project file packages included the requested number of project files and supporting details, and the project files were found to match most of the tracking data.
- Overall, the ADM team estimated NTG following the recommended procedures outlined in the Phase IV Evaluation Framework and according to the approved EM&V plan.
- For the process evaluations, the ADM team completed all the PY16 activities detailed in the approved evaluation plan, and the reporting followed the SWE guidelines. The process evaluation discussion highlighted findings that should be of value to FirstEnergy and its CSPs.
- The SWE found that the Appliance Recycling NTG reported in the PY16 Annual Report for Met-Ed and West Penn Power is 0.01 higher than those shown in the Process and NTG Memo.

H.2 EM&V PLAN REVIEWS

ADM, FirstEnergy's evaluation contractor, submitted a redline version of their PY16 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, the ADM team submitted several memos detailing their sampling approach for program components selected for impact, process, and NTG evaluations in PY16.

As discussed in [Section 4.4](#), each EDC was given freedom to determine the appropriate cadence of impact verification for its programs. [Table 186](#) shows which West Penn Power programs produced verified impacts in PY16, and which used historic realization rates in PY16.

Table 186: PY16 West Penn Power Program Impact Evaluation Summary

Sector	Components	PY16 Impacts
Residential	EE Kits	Verified
	Home Energy Reports	Verified
	Midstream Appliances	Verified
	Midstream Electronics	NA
	New Homes	Verified
	Downstream HVAC	Verified
	LI Direct Install	Verified
	LI On-Line Audit	Verified
	Downstream Appliances	Verified
	LI - Home Energy Reports	Verified
	Audit and DI	Verified
	Online Audit	Verified
Cross-Cutting	Appliance Recycling	Verified
	Multifamily	Verified
C&I	Custom	Verified
	Prescriptive – Downstream Lighting, Midstream Lighting, Downstream Non-lighting	Verified
	Energy Management and New Construction – Building Improvements, Building Operations Training, Building Tune-ups and Commissioning. New Construction	Verified

In addition to the evaluation plans, the SWE also reviewed and provided comments on draft survey instruments for multiple programs.

H.3 SAMPLE DESIGN REVIEW

The Phase IV Evaluation Framework establishes a maximum level of sampling uncertainty of $\pm 15\%$ at the 85% confidence level for each “initiative.” Beginning in Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change was implemented specifically for EDCs like West Penn Power, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes due to program delivery channel or supported technology.

West Penn Power's EE&C portfolio consists of five programs: Energy Efficient Homes, Energy Efficient Products, Low-Income Energy Efficiency, C&I Energy Solutions for Business – Large, and C&I Energy Solutions for Business – Small. The SWE performed its annual sample design review at the initiative level, which sometimes spans multiple programs or sectors. In response to the annual data request, FirstEnergy's EM&V contractor provided the SWE with a sample disposition for each initiative detailing the project-level ex ante and ex post savings for each unit in the samples.

Table 187 shows the relative precision of PY16 energy and demand impacts by component at the 85% confidence level. In PY16, all programs were evaluated, none relied on historic realization rates. The Residential Online Audit and Behavioral Modifications programs, which were evaluated via regression analysis, have no uncertainty associated with sampling and thus is omitted from the below table.

Residential Upstream Electronics Initiative is also omitted as it was not offered in PY16.

Table 187: Relative Precision of PY16 Impacts by Program Component at the 85% Confidence Level

Sector	Components	Relative Precision (Energy)	Relative Precision (Demand)
Residential	EE Kits	6.3%	6.0%
	LI - EE Kits	7.6%	7.4%
	Direct Install	10.0%	9.3%
	LI Direct Install	9.8%	9.8%
	Multifamily Direct Install	12.3%	12.3%
	HVAC	12.3%	11.9%
	Appliance Recycling	4.1%	4.0%
	LI Appliance Recycling	0.0%	0.0%
	Appliances	9.4%	8.2%
	Midstream Appliances	0.0%	0.0%
	New Construction	12.2%	13.1%
C&I	Custom	2.5%	3.9%
	Prescriptive	10.2%	11.0%
	Energy Management and New Construction	10.7%	10.4%
	Multifamily Direct Install	0.0%	0.0%
	Appliance Recycling	0.0%	0.0%

All evaluated components met the 15% threshold for relative precision in both energy and demand.

ADM established in their Phase IV evaluation plan submitted to the SWE that they would use an assumed coefficient of variation (CV) derived from past program years for the initial sample design. However, ADM also used these planning CVs to calculate and report initiative-level relative precision. In PY16, ADM did calculate CV manually for the New Construction component but otherwise relied on assumed, rather than actual, CVs. The SWE recommends that ADM use manual variance calculations in place of planning coefficients of variation in their PY17 report to

yield more accurate estimates of relative precision. Although the SWE still recommends leaving a hedge to guarantee that the $\pm 15\%$ relative precision threshold is met, ADM might be able to use fewer sample points than they did in PY16 for certain initiatives with low coefficients of variation.

The Behavioral Modification subprogram provides HERs to residential customers in the West Penn Power service territory. The subprogram is divided between market-rate residential customers and LI customers, and each is administered as an RCT. Participants are enrolled in experimental cohorts and a monthly billing analysis regression is used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model cannot fully capture the variation present in the data. Precision requirements for behavioral programs are unique, with the Phase IV Evaluation Framework requiring the solution-level verifications to achieve an absolute precision of $\pm 0.5\%$ at the 95% confidence level (two-tailed). [Table 188](#) shows the absolute precision of PY16 Behavioral Modification impacts at the 95% confidence level.

Table 188: Absolute Precision of PY16 Impacts for Behavioral Modification Programs at the 95% Confidence Level

Program	Absolute Precision (Energy)
Behavioral Modification (Market Rate)	0.23%
Behavioral Modification (LI)	0.27%

The Online Audit component also relies on regression analysis of all participants and a matched control group of non-participants. While there is no sampling error, there is uncertainty associated with the regression model. The relative precision of the market-rate Online Audit energy savings was $\pm 69.3\%$ at the 85% confidence level and the relative precision of the Low-Income Online Audit energy savings was $\pm 37.1\%$ at the 85% confidence level. The relative precision of the low-income group was better than the market-rate group, despite a much smaller number of homes because the savings estimate for low-income recipients was significantly higher. However, when the cluster robust standard errors are calculated based on the number of homes, instead of the number of observations, the relative precision exceeds $\pm 100\%$ at the 85% confidence level for both the market rate and the low-income results. To remedy the larger uncertainty, PY17 will use a rolling multi-year regression model to increase the number of homes included in the analysis.

H.4 REPORTED GROSS SAVINGS AUDITS

H.4.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in West Penn Power's PY16 Annual Report. Specifically, the SWE examined the following values for each program:

- Reported gross energy savings (MWh/yr)
- Reported gross peak-demand savings (MW/yr)
- Participation counts

- Incentive dollars

The SWE leveraged West Penn Power's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking dataset; rather, a subset of the full tracking dataset tailored to our PY16 quarterly data request. Also note that HER programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding the HER components of the Energy Efficient Homes and LIEEP can be found in [Appendix H.5.1](#).

[Table 189](#) summarizes our findings regarding reported gross energy savings. The "Match" column contains "Yes" if the tracking data supports the values in West Penn Power's PY16 Annual Report and "No" otherwise. For each program, the SWE was able to replicate the values reported by West Penn Power.

Table 189: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Energy Efficient Homes	18,135	18,135	Yes*
Energy Efficient Products	5,609	5,609	Yes
Low Income Energy Efficiency	4,745	4,745	Yes*
C&I Energy Solutions for Business - Small	43,683	43,683	Yes
C&I Energy Solutions for Business - Large	81,848	81,848	Yes
Portfolio Total	154,020	154,020	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

[Table 190](#) summarizes the SWE's findings regarding reported gross peak-demand savings, by program. The tracking data is provided at the meter-level. To facilitate the comparison, the SWE applied the same line loss factors as the EDCs to adjust for transmission and distribution losses. Like with reported gross energy savings, the tracking data supports the West Penn Power PY16 Annual Report value exactly for all programs.

Table 190: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Energy Efficient Homes	2.40	2.40	Yes*
Energy Efficient Products	1.27	1.27	Yes
Low Income Energy Efficiency	0.62	0.62	Yes*
C&I Energy Solutions for Business - Small	9.58	9.58	Yes
C&I Energy Solutions for Business - Large	12.71	12.71	Yes
Portfolio Total	26.58	26.58	Yes*

*The Energy Efficient Homes and LIEEPs have HER components that are not represented in this table.

The SWE also used the tracking data to audit West Penn Power's reported participation counts and customer rebate amounts. Like with the energy and peak-demand audits, the SWE found strong alignment between the tracking data sums and the values reported by West Penn Power. No substantive issues were discovered.

H.4.2 Project File Reviews

H.4.2.1 Residential

As part of the reported savings (i.e., ex ante) review, the SWE conducted a project file review of a sample of West Penn's residential project files for PY16 using the project file documentation provided by West Penn, the program implementers, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included most of the documentation requested.

[Table 191](#) presents a summary of the SWE's residential project file reviews.

Table 191: West Penn Power PY16 Residential Project File Review Summary

Program	Sub Program	Number of files reviewed ¹	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data? ²
EE Homes Program and LIEEP	Direct Install	-	-	-	-	-
EE Homes Program and LIEEP	EE Kits	40	✓	✓	✓	✓
EE Homes Program	Comprehensive Audits	40	✓	✓	✓	✓
EE Homes Program and LIEEP	New Homes	40	✓	✓	✓	✓
EE Products Programs and LIEEP	Appliance Rebates	20	✓	✓	✓	✓
EE Products Programs and LIEEP	Appliance Recycling	40	✓	✓	✓	✓
EE Products Programs	HVAC	20	✓	✓	✓	✓
EE Products Programs	Midstream Appliances	20	✓	✓	✓	✓
LIEEP	Appliance Recycling	10	✓	✓	✓	✓
LIEEP	LI WARM	40	✓	✓	✓	✓

¹ The number of files reviewed reflects the total number for all FirstEnergy EDCs.

² It should be noted that the Comprehensive Audits count includes audits performed at single-family and multifamily dwellings.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews.

Energy Efficient Homes Program and LIEEP: Direct Install

While the FirstEnergy companies offered the Direct Install subprogram of the EE products program in PY16, the SWE did not receive any project files for this program. The SWE acknowledges that this program was not evaluated in PY16.

Energy Efficient Homes Program and LIEEP: Energy Efficiency Kits

The Energy Efficiency Kits subprogram contains two sub-components: energy efficient kits and school education. The documentation for the Energy Efficiency Kits program consisted of shipment data, specification sheets, and kit contents. The specification sheets include information on the wattage and wattage equivalence of LED bulbs (e.g., a 9-watt LED bulb replaces a 60-watt standard bulb), the wattage of LED nightlights, and the GPM rating of faucet aerators and low-flow showerheads. The shipment data was similar to the quarterly tracking data but was broken out by month and income status. The SWE did not find any discrepancies with quantities or measure descriptions between the project documentation and the tracking data. Project files do not contain data on some of the variables used in savings calculations, such as the number of people in the home, water heater setpoint temperature and fuel type, and HVAC system specifications.

Energy Efficient Homes Program: Comprehensive Audits (Single Family)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program: Comprehensive Audits (Multifamily)

The project documentation for the Comprehensive Audits program included customer invoices, customer utility billing histories, and audit reports that included information on the installed measures and what potential additional measures could improve efficiency outcomes. The SWE found no discrepancies between the tracking data and the project file documentation in the reviewed sample projects. The SWE acknowledges that there may be additional EDC-gathered data stored in datasets that were not requested as part of the quarterly data submission.

Energy Efficient Homes Program and LIEEP: New Homes

All project files contained builder certificates and REM/Rate or Ekotrope analysis reports, and most project files contained REM/Rate or Ekotrope modeling files. Project files, which included a REM/Rate or Ekotrope report contained the heating and cooling capacity and efficiency metrics for the HVAC equipment as well as the volume of the hot water heater at the newly constructed home.

Energy Efficient Products Program and LIEEP: Appliance Rebates

The Appliance Rebate program had project files containing either receipts for rebated appliances, appliance rebate application forms, or both. These project files were accompanied by tracking data that recorded the date the rebate amount, the appliance purchased, the appliance type, and the appliance's quantity.

Energy Efficient Products Program and LIEEP: Appliance Recycling

The Appliance Recycling program had project files containing photos of the participant's signatures, photos of the nameplates of the recycled appliances, and photos of the recycled

appliances themselves. These project files were accompanied by tracking data that recorded the type of recycled appliances, the date it was recycled, the town it was from, and the quantity of recycled appliances. Although some of the photos of the appliances did not include nameplates, the SWE notes the thoroughness of the documentation.

Energy Efficient Products Program: HVAC

The HVAC program was only in operation during Q1 and Q2 of PY16. The HVAC project files included AHRI certifications, invoices equipment registration and rebate application forms. There were no discrepancies found in the project files as compared to the tracking database. However, there were some instances where the SWE was unable to confirm the tracking data matched the project file due to missing documentation such as the AHRI certificate.

Energy Efficient Products Program: Midstream Appliances

The Midstream Appliances program was only in operation during Q1 and Q2 of PY16. The project files for Midstream Appliances were comprised of invoice-styled excel sheets with tracking data that could be easily matched to the sample data given for each quarter. The invoice data recorded the type of appliance rebated, quantity, the appliance price, and the rebate amount. The SWE review of the sampled files did not reveal any discrepancies between the project files and the tracking database.

Low-Income Energy Efficiency Program: LI WARM

Invoices, audit forms, preassessment, and post assessment forms were provided for sampled projects. The SWE notes that some projects had varying levels of documentation described above, but generally the necessary documentation existed for each sampled project reviewed by the SWE. A review of the sampled files did not reveal any discrepancies and the information provided within each project matched the tracking database. The SWE acknowledges that EDC collected data may be stored in solution specific datasets that were not requested as part of the quarterly data submission.

H.4.2.2 Non-Residential

As part of its audit process, the SWE conducts a review of ex ante savings. This review involves assessing specific project files for a sample of West Penn Power's non-residential programs in PY16. Project file documentation is provided each quarter of the program year by West Penn Power, the program implementers, and the evaluation contractor to the SWE. Project documentation provided typically includes program rebate applications and approvals, letters of attestation, invoices for installed equipment, equipment specification or "cut" sheets, post-inspection forms, and calculation workbooks. The SWE reviews these documents for completeness and consistency. The SWE also compares the data points in the documentation against the program tracking database to ensure values such as savings, rebate amounts, installation, approval, and invoice dates align.

Project files were generally well-organized, complete, and accurate. [Table 192](#) presents an overview of the results of the SWE's C&I project file reviews. Despite minor issues with some project files, the SWE found that most projects contained sufficient data to review and understand the project, and they had confidence that the reported savings were being assessed accurately.

Table 192: West Penn Power PY16 C&I Project File Review Summary

Program	Sub-Program	Number of Projects Reviewed	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for SWE to follow?	Are correct algorithms and inputs used for TRM measures?
Downstream	Custom - LCI	1	✓	✓	✓	✓	✓
Downstream	Custom - SCI	2	✓	✓	✓	✓	✓
Downstream	Energy Management - LCI	2	✓	✓	✓	✓	✓
Downstream	Energy Management - SCI	1	✓	✓	✓	✓	✓
Downstream	Prescriptive - LCI	1	✓	✓	✓	✓	✓
Downstream	Prescriptive - SCI	3	✓	✓	✓	✓	✓
Midstream	Prescriptive - LCI	1	✓	✓	N/A	N/A	N/A
Midstream	Prescriptive - SCI	3	✓	✓	N/A	N/A	N/A

H.5 VERIFIED GROSS SAVINGS AUDITS

H.5.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the West Penn Power portfolio of residential programs. West Penn Power's portfolio of residential programs includes the following: the Energy Efficient Homes Program, the Energy Efficient Products Program, and the LI Energy-Efficiency Program. Each program contains various subprograms, which are addressed separately below. Note that the SWE reports the residential savings in two sections: residential and behavior.

The SWE identified the evaluation activities used to verify savings for the residential programs. [Table 193](#) provides a summary of the evaluation and M&V approaches used by West Penn Power in their PY16 verified savings calculations.

Table 193: Residential Program Evaluation Activities – West Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied Historic RR
Energy Efficient Homes					
Energy Efficiency Kits	✓	-	✓	-	-
HERs	-	-	-	✓	-
Residential Direct Install	-	-	✓	-	-
Residential Direct Install – Multifamily	-	-	✓	-	-
Residential New Construction	-	✓	✓	-	-
Energy Efficient Products					
Upstream Electronics	-	-	-	-	-
HVAC	✓	-	✓	-	-
Appliances	✓	-	✓	-	-
Appliance Turn-in	✓	-	✓	-	-
Midstream Appliances	-	-	✓	-	-
Low-Income Energy-Efficiency Program					
LI Direct Install	-	-	✓	-	-
LI Appliance Turn-in	✓	-	✓	-	-
LI Appliances	✓	-	✓	-	-
LI New Homes	-	✓	✓	-	-
LI Kits	✓	-	✓	-	-
^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.					

The SWE's review of verified savings for residential programs found that the verified savings followed proper TRM protocols and were accurate.

Energy Efficiency Kits Initiative: EE Kits and Low-Income Kits

The Energy Efficiency Kits (EE Kits) initiative has two sub-initiatives – EE Kits and Low-Income EE Kits. Each subprogram has two sub-components: EE Kits and School Education. The SWE reviewed school education kits for both the EE Kits and Low-Income EE Kits sub-initiatives. The kits provided through the School Education sub-component contained LED lamps, LED night lights, a furnace whistle, and electrical outlet gaskets. The Low-Income kits included advanced power strips in place of electrical outlet gaskets. The SWE confirmed that the verified savings for each sub-initiative was in accordance with the TRM protocols for the relevant measures and worked with ADM to resolve any discrepancies prior to the filing of the FirstEnergy annual report.

The SWE also confirmed that participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Homes Program and LIEEP: New Homes

The SWE worked with evaluation contractor, ADM, to resolve some discrepancies in the evaluated savings prior to annual reporting. ADM reviewed and corrected the ex post energy models for a sample of PY16 projects to develop a realization rate for program-wide savings. ADM also revised the calculation method used for cooling demand savings to use hourly load results from the sampled models, which aligns with the approach used by other EDCs.

The Residential and Residential Low-Income Direct Install Initiatives

The Residential and Low-Income Direct Install Initiatives primarily used an SSRS Tracking and Reporting database for this evaluation as well as documentation from on-site QA/QC inspections. ADM used a stratified sampling approach to perform a desk review of a sample of participants in this program and rolled up the realization rates to the total program participant population. ADM provided the SWE with data from home inspections and with the subsequent savings calculations and roll up. The SWE confirmed the verified savings for each measure were in accordance with TRM protocol. The SWE also confirmed that the participation, energy and demand savings, and energy realization rates were in alignment with those in the annual report.

Energy Efficient Products Program: HVAC

The HVAC component includes measures such as: air-source heat pumps, central air conditioning, furnace fans, ground source heat pumps, HVAC tune-ups, mini-split heat pumps, packaged terminal heat pumps and air conditioning, connected thermostats, bathroom fans, and circulating pumps. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC-collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. The SWE confirmed that participation, verified savings, and realization rates were in alignment with those in the annual report.

Energy Efficient Products Program and LIEEP: Appliances

The appliance component includes measures such as: refrigerators, freezers, clothes washers and dryers, dehumidifiers, dishwashers, window ACs, HPWHs, and connected thermostats. ADM used a combination of verification surveys, invoice and application reviews, and applied EDC collected data, such as efficiency and capacity data, to program tracking data inputs when deemed appropriate by the TRM. The SWE was able to conduct an early review and confirmed that the savings values were correctly calculated using the TRM protocols. For the final report, Low-Income and Non-Low-Income Energy Efficient Products Programs were combined. The SWE confirmed that participation, energy savings, and energy realization rates were in alignment with those in the annual report.

The SWE notes that the appendix for this component includes a list of the variables for each appliance, and where the data source came from. This was a helpful to the SWE audit.

Appliance Recycling and Low-Income Appliance Turn-In Initiative

The SWE conducted an early review of the Appliance Recycling and Low-Income Appliance Recycling Initiatives. Each initiative includes five measures: refrigerator recycling, freezer recycling, room air conditioner (RAC) recycling, dehumidifier recycling, and mini-refrigerator recycling. ADM's evaluation included calculating measure-level savings using program tracking data and survey data from PY16, including TRM inputs when necessary. The SWE did not observe any discrepancies with the application of TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Homes Program: Multifamily

Gross impact evaluation for the Res MF Initiative utilized a stratified sampling plan. Most projects are placed into one sampling stratum, with an additional stratum reserved for high-impact projects.

The program tracking and reporting system is at the measure level, and also identifies the rebate application and participant address associated with each measure. ADM aggregated all measures by unique address and then placed each household in one of the two strata: high-impact projects with reported energy savings above 2,000 kWh, and all other projects.

Due to the low participation and impacts in this initiative in Phase IV, desk reviews were the most appropriate evaluation activity. ADM evaluators compared audit reports and invoices to program tracking and reporting data to reconcile quantities of installed measures. The evaluators also independently calculated impacts for all measures according to their respective protocols in the 2021 PA TRM.

Energy Efficient Products Program: Midstream Appliances

The SWE conducted an early review of the Midstream Appliances component. ADM's evaluation included a full review of the program tracking data and aligning savings estimates with the TRM and product-specific data. The SWE did not observe any discrepancies with the application of the TRM algorithms or the application of EDC-gathered data. The SWE confirmed participation counts, realization rates, and verified savings were reported accurately.

Energy Efficient Products Program: Upstream Electronics

The FirstEnergy companies did not offer the Upstream Electronics component of the EE products program in PY16.

Energy Efficient Homes and LIEEP: Online Audit

In PY13, FirstEnergy launched an Online Audit component to the Behavioral subprogram included in both the Energy Efficient Homes (EEH) and Low-Income Energy Efficiency (LI) programs. The Online Audit component operates on an opt-in basis and offers residential customers a web-based platform featuring energy usage visualizations, energy-saving tips, and promotion of other FirstEnergy residential energy-efficiency programs. Participation is defined as logging into the online portal and completing the registration to receive an audit. A total of 4,724 market-rate residential and 447 low-income households participated in the Online Audit in PY16, which is down from PY15 for both programs. Market-rate participants decreased by 20% and low-income participants decreased by 22% from PY15 to PY16.

The Phase IV Online Audit subprogram is an opt-in program, and the SWE team reviewed the propensity score matching ADM performed to create a matched control group using five pre-treatment consumption variables, latitude, longitude, and a categorical variable that identifies which HERs cohort a customer belongs. The comparison group matching was performed using a 1:1 treatment-to-comparison group ratio. Due to the non-RCT design of the Online Audit component, ADM included weather terms to improve model fit and control for potential differences in weather-sensitivity between the treatment group and matched control group. In PY15, ADM adhered to the guidance provided by the SWE in PY14 to run a pooled regression model across all four EDCs. Given the relatively small sample sizes at the individual EDC Program level, ADM chose to consolidate analysis at the Program level across the four FirstEnergy EDCs. A single regression model was estimated for EE Homes across all four EDCs, and another model for LI programs. Estimated regression coefficients were allowed to vary with temperature, and the resulting impacts were then adjusted for each EDC using EDC-specific weather variables. The SWE team independently calculated per-household kWh savings from regression coefficients, active participant counts, and aggregate MWh and MW impacts. Our estimates match ADM's estimates.

Our savings estimates and standard errors matched ADM's estimates once a cluster robust standard error correction was included in both model specifications. This statistical technique deals with autocorrelation and computes uncertainty based on the number of homes in the analysis rather than the number of observations. Use of the cluster robust standard error corrections causes the relative precision to exceed $\pm 100\%$ at the 85% confidence level, which means neither the market-rate nor low-income results are statistically significant. The Pennsylvania Evaluation Framework discusses this potential outcome for impact evaluations that rely on billing analysis and asks evaluation contractors to explore remedial actions. The planned remedial action for PY17 is to rely on a rolling multi-year regression model to increase the overall number of homes included in the analysis.

The SWE also reviewed the dual participation analysis. Online Audit participants tend to participate in other West Penn Power EE&C programs at a higher rate than the matched control groups, so this adjustment is necessary to avoid double-counting. To calculate gross verified demand savings, ADM generated an Energy to Demand Factor (ETDF) using residential load profiles corresponding to the treatment group and then applied ETDF to energy savings to estimate. The SWE was able to replicate the verified demand savings for both the residential and residential low-income group.

Table 194 shows the aggregate PY16 verified gross MWh savings and MW reductions by program. The table also shows the number of participants and average percent savings per household by program group. Using the first impact estimate as an example, the practical interpretation is as follows: all treatment group homes in the EEH Program saved 192 MWh and each household lowered their annual electric consumption by 0.27% during PY16. It is unclear why the low-income households saved more energy per household than their market-rate counterparts in PY16. Higher per-household savings in the LI program could simply be a result of noise due to a relatively small number of participants.

Table 194: PY16 West Penn Power Online Audit Energy and Demand Savings

Program	Participants	Gross Energy Savings (MWh)	Gross Demand Savings (MW)	Average Percent Savings per Home
EEH Program	4,724	192	0.03	0.27%
LI Program	447	103	0.02	1.57%
Total	5,171	295	0.05	-

Behavior

Home Energy Reports were issued to around 178,000 residential and residential low-income (LI) households in PY16. West Penn Power's behavioral portfolio consists of both active waves and inactive legacy waves, which may be reactivated later in Phase IV. Seven waves, or cohorts, were active during PY16, and three of them targeted low-income households. [Table 195](#) summarizes the number of active households during PY16 by cohort and summarizes key features of the PY16 evaluation method.

Table 195: West Penn Power HER Cohort Summary

Cohort	Start Date	Treatment Group Homes	Control Group Homes	Reintroduced Cohort	Rebaselined Cohort	Weighted Regression
2012 Residential	6/1/2012	91,452	14,124	Yes	No	No
2014 Residential	1/1/2014	13,919	7,523	No	N/A	No
2021 Low-Income	9/26/2021	6,154	6,259	No	N/A	No
2023 Low-Income	6/4/2023	9,610	8,040	No	N/A	No
2014 Low-Income	5/12/2024	2,357	2,410	Yes	Yes	No
2014 Residential	5/12/2024	20,082	5,777	Yes	Yes	No
2024 Residential	5/12/2024	34,964	19,983	No	N/A	No
Total		178,538	64,116			

The program implementor, ICSP Oracle, administered all cohorts as randomized control trials (RCTs). Eligible households were identified and then randomly assigned to either a treatment or control group. Following randomization, ADM conducted statistical tests on the pre-treatment energy usage patterns to confirm equivalence between the treatment and control groups.

The SWE team conducted an audit of the pre-treatment equivalence test for all cohorts. To check the pre-treatment equivalence, the SWE team ran a Welch Two-Sample T-Test on pre-period usage by treatment status for each cohort. The pre-period usage variables include the average annual, summer, and winter energy usage per household in the year prior to treatment. With these

defined baselines and pre-treatment lag variables, the SWE team was able to replicate the same p-values for the t-test results as ADM.

As part of the PY16 implementation of the Home Energy Reports (HER) measure, three previously suspended historical West Penn Power cohorts were reintroduced into the program. ADM also assessed the equivalence of the treatment and control groups in these cohorts, 2012 Residential, 2014 Low-Income, and 2014 Residential, during PY15 to determine if the HER impact had decayed sufficiently to allow PY15 data to be used as the pre-treatment period. ADM found that the treatment and control groups in the 2012 Residential cohort showed statistically significant differences, suggesting savings are persistent, rendering them unsuitable for rebaselining. This reintroduced West Penn Power cohort retained their original baseline periods and treatment dates. ADM found the treatment and control groups in West Penn Power's 2014 Low-Income and 2014 Residential cohorts were not statistically significantly different, meaning they were suitable for rebaselining. These cohorts had been inactive for three consecutive program years and showed minimal evidence of persistent savings overlapping with the new baseline period. As a result, West Penn Power's 2014 Low-Income and 2014 Residential cohorts were assigned the same treatment start date as the new PY16 cohorts, 5/12/2024. For all analytical purposes, these cohorts are treated as a new cohort, including the application of a regression-based approach to estimate peak demand, rather than the simple difference method used for other historical cohorts.

Both ADM and the SWE team found that none of West Penn Power's cohorts failed the annual consumption equivalence check at the 90% confidence level. Therefore, no propensity score matching or weighting was necessary in the PY16 West Penn Power impact analysis.

ADM provided the SWE team with both daily and monthly consumption data for all homes in the treatment and control groups. The monthly data served as the primary input in the estimation of HER impacts. The SWE team found the calculations and distribution of monthly kWh to be reasonable. Models used throughout the analysis rely on three pre-treatment lag variables: average usage, average summer usage, and average winter usage. As discussed, the pre-treatment period is 12 months prior to original treatment for all West Penn Power's cohorts, except the rebaselined cohorts 2014 Low-Income and Residential, which used the 12 months prior to the new treatment period to create the lags. Using the daily consumption data, the SWE team was able to replicate the three lagged variables calculated by ADM for each customer. These lag terms were calculated for customers with 12 months of pre-treatment data, who also had no data issues as flagged by ADM (i.e. invalid hourly observations or outlier consumption amounts).

ADM obtained active customer counts for each month by tallying up the number of accounts that have daily interval data for the month. Only active accounts where HER delivery has begun are included in these calculations. Both ADM and the SWE team found an inconsequential number of accounts that were not counted because they either were placed in both the control group and treatment group or had multiple treatment starting dates. A few accounts were not included in the counts because Oracle never began HER delivery to these homes or due to pre-start date attrition.

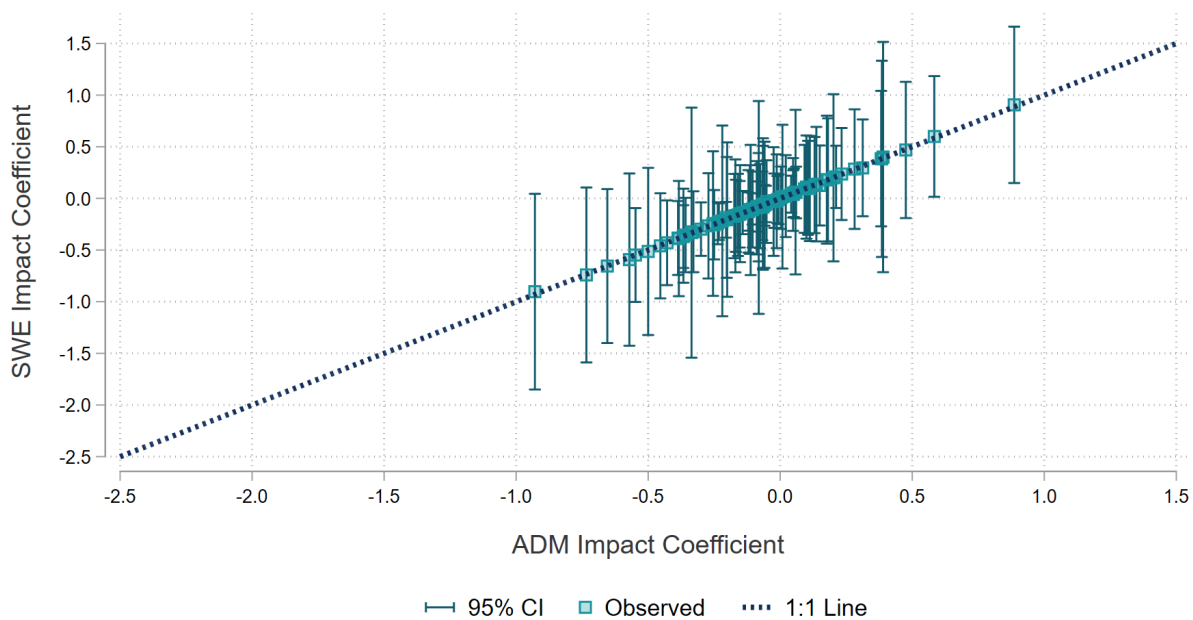
The SWE team validated ADM's enrollment counts by performing a similar counting method on the daily consumption data. Customers are considered active through the end of the month that they last have interval data. For example, if a customer's final AMI record is from February 15th,

the customer would be included in the count for February but not in March or any month following. The SWE team's final customer counts matched ADM's for each month and cohort.

Customers that do not have twelve months of pre-treatment data or were flagged as having a data issue were not included in the impact estimation (because the lagged seasonal variables for these customers were not calculated), but they were included in the customer counts.

ADM used a lagged seasonal (LS) regression model for the PY16 impact analysis. Using the monthly billing data, the LS model estimates the relationship between daily usage and pre-treatment variables. The SWE team was able to replicate ADM's coefficients with no notable differences in coefficients, as shown in [Figure 63](#). The SWE estimates all fell within the confidence interval for ADM's coefficients.

Figure 63: West Penn Power PY16 HER LS Coefficient Comparison



The SWE team independently calculated gross MWh savings using regression coefficients and active participant counts, and our estimates match those provided by ADM. [Table 196](#) shows the aggregate PY16 pre-adjustment gross MWh savings by cohort. The table also shows three adjustments, which are discussed in greater detail later, and the PY16 incremental verified gross savings estimate.

Table 196: West Penn Power PY16 Energy Savings*

Cohort	Gross Savings (MWh)	Downstream Dual Participation (MWh)	Upstream Dual Participation (MWh)	Persistence (MWh)	Incremental Savings (MWh)
2012 Residential	4,601	1,300	99	0	3,203
2014 Residential	933	106	25	476	327
2021 Low-Income	638	-11	0	289	360
2023 Low-Income	-50	6	0	0	-56
2014 Low-Income	-166	-14	0	0	-152
2014 Residential	-316	45	0	0	-361
2024 Residential	2,183	57	0	0	2,126
Total	7,824	1,488	124	765	5,446

* Totals may not equal the sum of columns or rows due to rounding.

Home Energy Reports advertise other West Penn Power residential EE&C programs and measures, such as ENERGY STAR appliances, water heaters, and high-efficiency HVAC rebates. To the extent that treatment group households participate in these programs more frequently than the control group homes, the incremental savings are captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings are adjusted to account for the incremental program participation observed in the treatment group compared to the control group. An upstream dual participation adjustment is only applied to the gross savings estimates of 2012 and 2014 cohorts that were not rebaselined.

The 2021 Pennsylvania TRM assumes an annual decay rate of 31.3% derived from Pennsylvania-specific research¹⁰⁰ on the persistent effects of behavioral energy efficiency treatment in the years after discontinuing treatment. Since Act 129 compliance goals are based on first-year incremental savings, these persistent impacts are subtracted from the measured savings to estimate incremental first-year savings (those directly due to the current program year of treatment).

For the first two years of HER exposure, persistence is assumed to be zero and the first-year savings average treatment effect (FYSATE) simply equals the average treatment effect (ATE). For year three and beyond of HER exposure, the FYSATE is calculated using Equation 5, which comes from the 2021 TRM. For year i of HER exposure:

¹⁰⁰ Addendum to Act 129 Home Energy Report Persistence Study. November 2018.

https://www.puc.pa.gov/Electric/pdf/Act129/SWE_Res_Behavioral_Program-Persistence_Study_Addendum2018.pdf

Equation 5: First Year Savings Average Treatment Effect (FYSATE)

$$FYSATE_y = ATE_y - \sum_{x=1}^{x=i-2} FYSATE_{y-x} - FYSATE_{y-x} * Decay * (X - 0.5)$$

$$\Delta kWh_y = FYSATE_y * Treatment\ Accounts_y * Days_y$$

Where $FYSATE_y$ is the average daily savings attributable to HERs delivered in the current year (Y) and $FYSATE_{y-x}$ is the average daily savings attributable to HERs delivered in an earlier year Y-X.

Because the 2023 and 2024 waves were launched during PY15 and PY16, their savings are considered incremental. Separating persistent savings from incremental savings was not necessary for these waves, but the 2014 and 2021 waves did require such an adjustment. The reintroduced historical cohorts did not have any persistence adjustment, as they were not treated for 3 years, so there is no persistence still in effect. The SWE team found that ADM correctly modeled persistence in accordance with the TRM specifications for these waves.

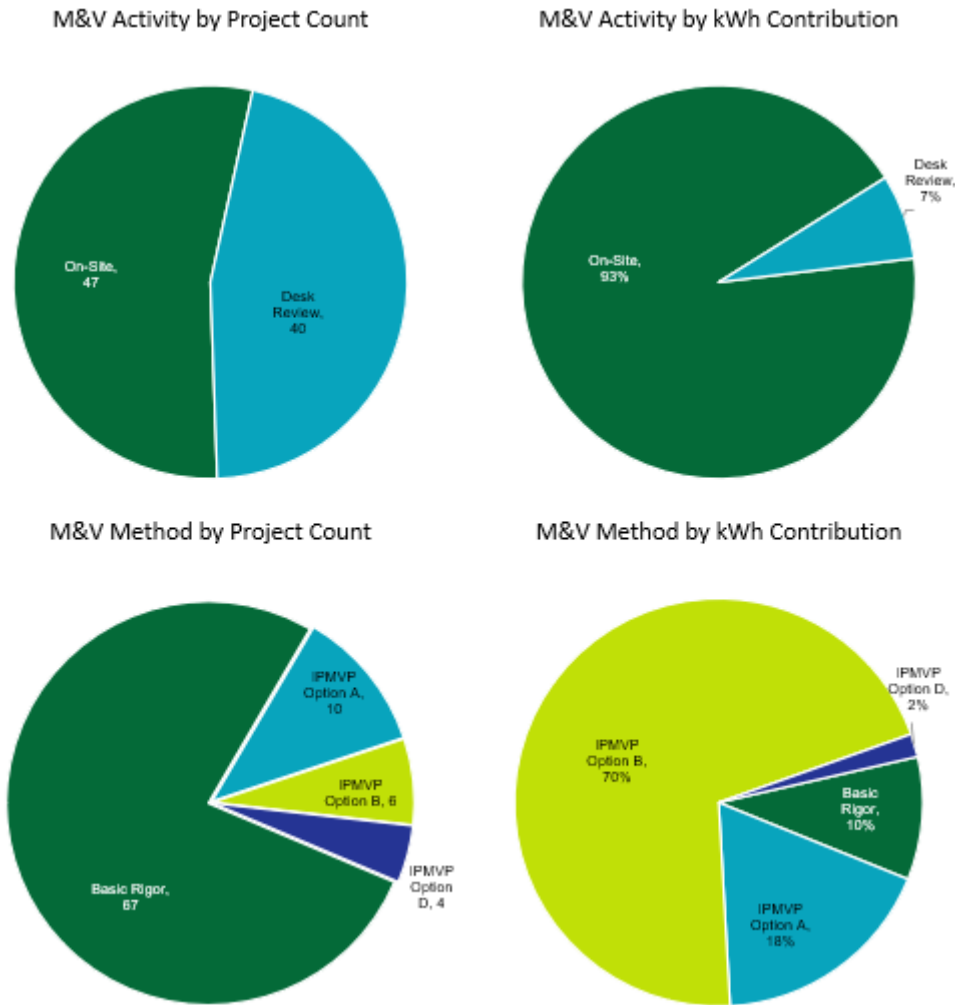
The Pennsylvania TRM defines peak-demand impacts as the average reduction in electric consumption from 2:00 p.m. to 6:00 p.m. Eastern Daylight Time on non-holiday weekdays during June, July, and August. The SWE team was able to replicate ADM's peak-demand impact estimate and peak-demand reduction for each cohort, with no noticeable differences between the SWE team and ADM impacts.

In conclusion, the SWE team successfully replicated ADM's findings for West Penn Power. Their methodology was transparent and reproducible, and any adjustments to the analysis were well justified and reviewed collaboratively to ensure their validity.

H.5.2 Non-Residential Audit Activities

Figure 64 provides a summary of the evaluation activities and M&V approaches utilized by West Penn Power's evaluation contractor, ADM, in their PY16 verified savings calculations. The summary is broken down by total evaluated project counts and by energy savings contribution. For PY16, West Penn Power's evaluation contractor completed site visits to 47 of 87 of evaluated projects, and these on-sites represented 93% of total evaluated energy savings. IPMVP Options A, B, and D were employed for 90% of the total evaluated energy savings. Basic Rigor (verification only) was employed for 10% of the total evaluated savings.

Figure 64: Summary of West Penn Power’s C&I Evaluation Activities



West Penn Power’s evaluation contractor conducted sampling within defined evaluation initiatives. Measures across West Penn Power’s C&I programs are assigned to one of four evaluation initiatives, as West Penn Power’s programs target specific sectors of C&I customers, though offerings are often identical across them. [Table 197](#) provides a summary of the evaluation activities across strata for all projects by initiative.

Table 197: Summary of West Penn Power's PY16 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR - Energy	RR - Demand	Desk Review	On-Site Verification
Appliance Recycling		109%	109%		
Custom	11	100%	101%	7	4
Custom-C	7	100%	101%	7	-
Custom-2	2	93%	106%	-	2
Custom-1	2	213%	112%	-	2
Prescriptive	35	100%	97%	24	11
Downstream Lighting-C	3	100%	100%	3	-
Downstream Lighting-2	4	115%	108%	4	-
Downstream Lighting-1	3	111%	110%	2	1
Downstream Non-lighting	3	91%	92%	2	1
Midstream Lighting-1	15	97%	88%	9	6
Midstream Lighting-2	6	75%	68%	4	2
EMNC	37	124%	100%	15	22
Building Tune-Ups-2	12	94%	84%	6	6
Building Tune-Ups-1	9	92%	91%	4	5
Building Tune-Ups-3	4	214%	146%	2	2
BOC-1	1	103%	103%	-	1
CBI-RCX-1	6	74%	22%	-	6
CNC-1	2	90%	94%	1	1
EMNC-C	3	99%	100%	2	1
Multifamily-1	4	101%	105%	1	3
TOTAL	87			47	40

The SWE's review of verified savings for non-residential programs found that, overall, the verified energy savings estimation was aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

H.5.2.1 Appliance Recycling Initiative

In PY16, projects in West Penn Power's Appliance Recycling Sub-Initiative were evaluated through a review of tracking and reporting data. The gross energy and demand realization rates for each evaluation stratum were taken to be the realization rates from the broader initiative-level evaluation, which included the residential and low-income residential components.

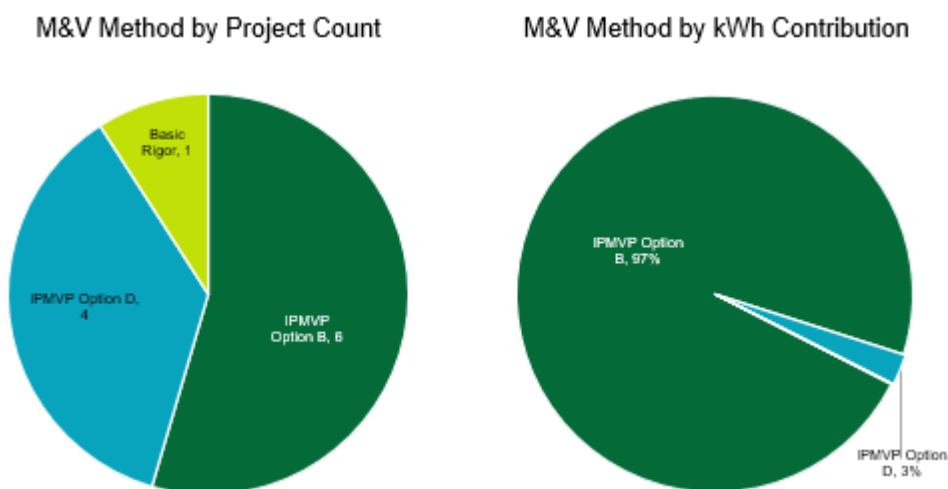
H.5.2.2 Custom Initiative

Evaluation activities for this initiative include desk reviews and/or IPMVP evaluation methods for all sampled projects. Site visits were conducted for seven of eleven PY16 custom sampled projects. The evaluation was satisfactorily conducted through these site visits for all projects using data provided by the customer or through TRM analysis. Solar PV projects were evaluated through the Custom Initiative using NREL's SAM and PVWatts models. The SWE independently replicated savings calculations, applied caps based on actual utility billing data where appropriate, and verified correct definitions of peak hours.

West Penn Power's evaluation contractor employed two strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a "certainty" stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 14 of the Phase IV Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty. Enhanced rigor methods were employed to evaluate 91% of the projects, accounting for nearly all evaluated custom project savings (the basic rigor project provided less than 0.1% of initiative savings and has been excluded from the energy chart), as shown in [Figure 65](#).

Figure 65: Summary of West Penn Power's C&I Custom Program M&V Methods



H.5.2.3 Prescriptive Initiative

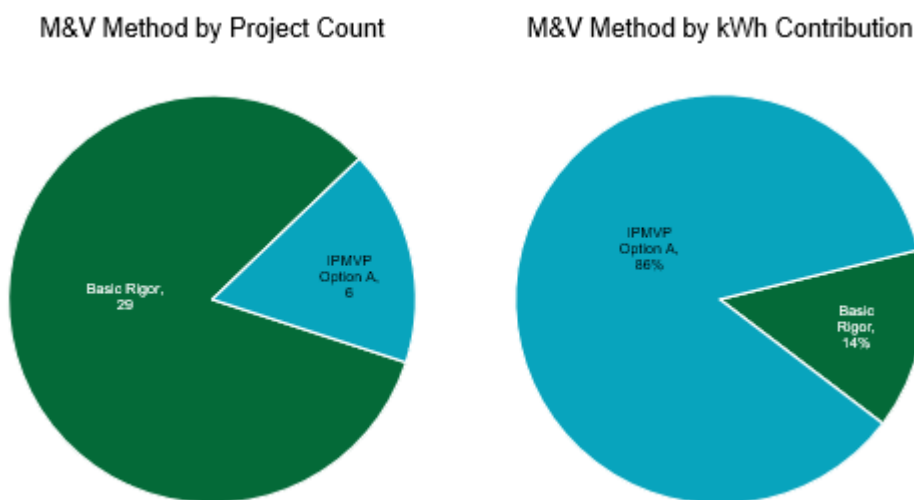
Evaluation activities for this initiative include site visits for 24 of 35 projects and primary data collection of lighting hours of use for medium and high savings projects. Primary data collection of lighting hours of use provided site specific inputs for medium and high savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

West Penn Power's evaluation contractor employed three strata for projects in the Prescriptive initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated

into a “Downstream - Certainty” stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

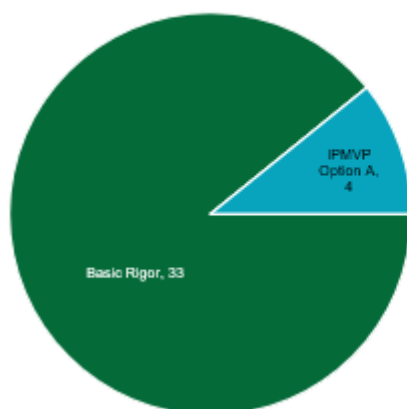
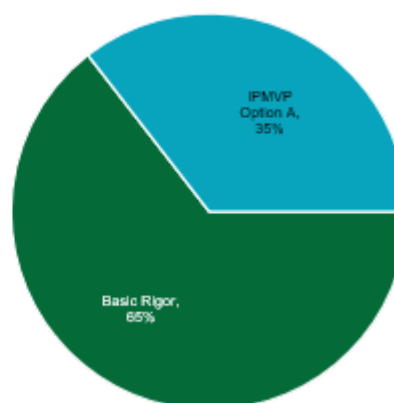
IPMVP Option A was used for 86% of evaluated project savings in this initiative with the remaining projects using Basic Rigor, as seen in [Figure 66](#) below.

Figure 66: Summary of West Penn Power’s C&I Prescriptive Program M&V Methods



H.5.2.4 Commercial and Industrial Energy Management and New Construction Initiative (CI EMNC)

The CI EMNC Initiative has five sub-components, all of which were active in PY16 except for New Construction. Evaluation activities for this initiative include on-site inspections for all fifteen evaluated projects. IPMVP Option A was applied to four of these site visits with basic rigor M&V methods were applied to the rest, incorporating TRM algorithms and reconciliations of invoices with equipment specification sheets. IPMVP Option A was in use for 35% of evaluated project savings in this initiative with the remaining projects using basic rigor (65%), as seen in [Figure 67](#) below.

Figure 67: Summary of West Penn Power's CI EMNC Program M&V Methods**M&V Method by Project Count****M&V Method by kWh Contribution**

H.5.2.5 Verified Savings Audits

The SWE audited the activities above through a detailed audit of ADM's evaluation work for a sample of their evaluated projects. The SWE audit for ADM's West Penn Power evaluation in PY16 included review of nineteen projects, encompassing the following activities:

- Three field and analysis engineers audited
- Eight EMNC measures, seven custom, and four prescriptive lighting projects reviewed
- Ten in-person ride-alongs conducted
- 21% of Verified Energy Savings reviewed
- 26% of Verified Demand Savings reviewed

Table 198 provides an overview of the SWE milestones for the verified savings audit review of evaluated West Penn Power's projects.

Table 198: West Penn Power Verified Savings Audit Review Milestones

Projects Audited	Energy Savings Audited (kWh)	Energy Attainment Percentage	Demand Savings Audited (kW)	Demand Attainment Percentage
19	15,213,547	100%	2,487	100%

Overall, the SWE found that West Penn Power's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods for custom measures. SWE found one issue with the calculation of demand savings for a project and ADM revised their analysis to align with the SWE recommendation. The overall attainment percentages of West Penn Power's reviewed projects were 100% for both energy and demand.

H.6 NTG

Table 199 lists West Penn's PY16 NTG as listed in the First Energy PY16 Annual Report. Details concerning the methods and data used to estimate NTG values are in sections H.6.1 and H.6.2.

Table 199: Summary of West Penn Power's PY16 NTG Results

Program Name	Component	NTG
Energy Efficient Products	Appliance Recycling	0.65*
Energy Efficient Products	HVAC	0.55
Energy Efficient Products	Appliances	0.52
Energy Efficient Products	Midstream Appliances	0.50
Energy Efficient Homes	EE Kits	0.96
Energy Efficient Homes	Home Energy Reports	1.00
Energy Efficient Homes	Direct Install	0.91
Energy Efficient Homes	New Homes	0.72
Energy Efficient Homes	Multifamily Residential	1.00
Energy Efficient Homes	Comprehensive Audits	1.00
C&I Solutions for Business Programs – Small and Large	Multifamily	1.00
C&I Solutions for Business Programs – Small and Large	Prescriptive	0.68
C&I Solutions for Business Programs – Small and Large	Custom	0.56
C&I Solutions for Business Programs – Small and Large	EMNC	0.72
C&I Solutions for Business Programs – Small and Large	Appliance Recycling	0.65*
Portfolio Total		0.76

* NTG is from the Process and NTG Memo.

H.6.1 Residential Programs

ADM planned and enacted NTG research for the Appliance Recycling component of the EE Products Program component of the EE Homes Program. ADM utilized participant surveys to estimate free-ridership and NTG for all components. Spillover is not calculated because the program is not designed to encourage customers to implement additional energy-efficiency projects. ADM utilized question batteries that were consistent with the recommendations in the Phase IV Evaluation Framework NTG methodologies and applied the common NTG calculation (Table 200).

The SWE reviewed FirstEnergy's Phase IV EMV Plan, all surveys, analyses code and data used to estimate NTG and found that the NTG reported in the PY16 Annual Report is 0.01 higher than that shown in the Appliance Recycling NTG analysis and the Process and NTG Memo.

Table 200: Summary of West Penn Power's PY16 Residential NTG Results

Program Component	Approach	Sample Size	Free-Ridership	Spillover	NTG
Appliance Recycling	Participant Surveys	333	0.35	0.00	0.65*

* NTG for Appliance Recycling is from the Process and NTG Memo.

H.6.2 C&I Energy-Efficiency Programs

ADM planned and enacted NTG research for the C&I Custom and Energy Management subprograms of the Energy Solutions for Business (ESB) program for small and large commercial customers in PY16. (Table 201)

Table 201: Summary of West Penn Power's PY16 C&I NTG Results

Program Components	Approach	Sample Size	Free-ridership	Spillover	NTG
EMNC	Participant Surveys	120	0.31	0.03	0.72
Custom	Participant Surveys	24	0.48	0.05	0.56

H.7 TRC

Table 202 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for West Penn Power's PY16 individual EE&C programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the West Penn Power PY16 Annual Report. Additionally, the model itself was well-organized and documented.

Table 202: Summary of West Penn Power's PY16 TRC Results

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits– Costs)
Energy Efficient Homes	\$13,868	\$6,340	2.19	\$7,528
Energy Efficient Products	\$3,167	\$4,635	0.68	(\$1,468)
Low Income Energy Efficiency	\$2,638	\$3,874	0.68	(\$1,236)
Residential Subtotal	\$19,673	\$14,849	1.32	\$4,824
C&I Energy Solutions for Business - Small	\$30,431	\$16,334	1.86	\$14,097
C&I Energy Solutions for Business - Large	\$34,337	\$21,871	1.57	\$12,467
Non-Residential Subtotal	\$64,769	\$38,205	1.70	\$26,564
Cross-cutting	\$0	\$0	--	\$0
Portfolio Total	\$84,441	\$53,054	1.59	\$31,388

¹ Totals may not equal the sum of columns or rows due to rounding.

Three of West Penn Power's five EE&C programs were found to be cost-effective when estimating the TRC using gross verified savings. The same three programs were also found to be cost-effective using net verified savings. The Energy Efficient Products program was not cost-effective on a gross or net basis, partly due to the high incremental costs relative to energy savings for certain ENERGY STAR products.

H.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to each company.

- The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions. The SWE also verified that the correct avoided costs from West Penn Power's EE&C Plan were used in the TRC Model.
- To calculate the avoided cost of natural gas, West Penn Power used a three-segment approach outlined in the 2021 TRC Test Order. The SWE verified that the TRC Model correctly applied the avoided costs to estimate TRC benefits.
- Pursuant to the 2021 TRC Test Order, the SWE verified that West Penn Power used a nominal discount rate of 5% to calculate the net present value of future program benefits. This discount rate is consistent with their EE&C plan and the 2021 TRC Test Order. Line loss adjustment factors varied by sector: Residential (1.0943), Small C&I (1.079), and Large C&I (1.079).
- The incremental costs were derived from the SWE Incremental Cost Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumptions, and actual project costs as gathered from the PY16 evaluation. The SWE spot checked the incremental measure costs used in the TRC model and found them to be generally reasonable and consistent.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to calculate verified gross savings.
- The calculation of NTG using free-ridership and spillover, as well as the application of the NTG in the calculation of TRC benefits and costs, were consistent with the 2021 TRC Test Order directive for Phase IV. The TRC model followed the protocol pertaining to the treatment of free-rider participant costs; these costs are not included in net program costs.
- The SWE found that the cost categories were handled correctly in the TRC model. Participant incentives were not considered TRC costs, while administrative costs, incremental costs, and kits were incorporated as costs.
- The SWE verified that the reported demand and capacity savings were accurate in the TRC model by comparing it to the Quarterly Tracking Data reported by West Penn Power.
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Fossil Fuel Impacts and Total NPV Lifetime Water Impacts. The SWE verified that the savings were accounted for in accordance with the 2021 TRC Test Order. The total O&M benefits were negative in PY16 due to the assumed yearly maintenance expense of solar PV projects.

H.8 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to the programs across the four FirstEnergy EDCs, including West Penn Power, so the annual evaluation report of the four FirstEnergy EDCs reports identical information about the process evaluation. Details on survey targets and completes for West Penn Power are provided in the subsections below. [Appendix E.8](#) of the SWE's PY16 Final Annual Report, described previously for Met-Ed, applies to all four FirstEnergy utilities, including West Penn Power.

H.8.1 Residential Programs

H.8.1.1 Energy Efficient Products Program – Appliance Recycling

The PY16 evaluation team completed 115 participant surveys with West Penn Power customers.

H.8.1.2 Energy Efficient Products Homes – Comprehensive Audits

There were not any surveys as part of the PY16 evaluation.

H.8.1.3 Energy Efficient Products Homes – Multifamily Residential

There were not any surveys as part of the PY16 evaluation.

H.8.1.4 Energy Efficient Products Homes – School Education

There were not any surveys as part of the PY16 evaluation.

H.8.1.5 Energy Efficient Products Homes – EE Kits

There were not any surveys as part of the PY16 evaluation.

H.8.2 Residential Low-Income Program

H.8.2.1 Weatherization (Direct Install)

There were not any surveys as part of the PY16 evaluation.

H.8.2.2 Appliance Rebate

There were not any surveys as part of the PY16 evaluation.

H.8.2.3 Behavioral Home Energy Report

There were not any surveys as part of the PY16 evaluation.

H.8.2.4 Multifamily (Residential)

There were not any surveys as part of the PY16 evaluation.

H.8.2.5 New Homes

There were not any surveys as part of the PY16 evaluation.

H.8.2.6 School Education

There were not any surveys as part of the PY16 evaluation.

H.8.2.7 EE Kits

There were not any surveys as part of the PY16 evaluation.

H.8.2.8 Appliance Recycling – Low-Income Sub-Initiative

The PY16 evaluation team completed 34 participant surveys with West Penn Power, low-income customers.

H.8.3 Commercial & Industrial Programs**H.8.3.1 C&I Energy Solutions for Business (Small) - Multifamily**

There were not any surveys as part of the PY16 evaluation.

H.8.3.2 C&I Energy Solutions for Business (Large) – Multifamily

There were not any surveys as part of the PY16 evaluation.

H.8.3.3 C&I Energy Solutions for Business (Large) – Custom

The PY16 evaluation team completed participant surveys covering one Custom project with C&I (Large) West Penn Power customers.

H.8.3.4 C&I Energy Solutions for Business (Small) – Custom

The PY16 evaluation team completed participant surveys covering three Custom projects with C&I (Small) West Penn Power customers.

H.8.3.5 C&I Energy Solutions for Business (Large) – Energy Management

The PY16 evaluation team completed participant surveys covering 11 Energy Management projects with C&I (Large) West Penn Power customers.

H.8.3.6 C&I Energy Solutions for Business (Small) – Energy Management

The PY16 evaluation team completed participant surveys covering 27 Energy Management projects with C&I (Small) West Penn Power customers.

H.8.3.7 Appliance Recycling – Non-Residential Sub-Initiative

The PY16 evaluation team conducted in-depth interviews with five West Penn Power C&I (Small) customers participating in the Appliance Recycling subprogram.

Appendix I ACEEE Scorecard

The tables in this appendix provide the data needed for the ACEEE State Energy Efficiency Scorecard, including Pennsylvania's statewide energy-efficiency budgets and expenditures, verified gross annual and lifetime savings, and verified net annual and lifetime savings.

Table 203: PA Statewide Energy Efficiency Budgets and Expenditures

EDC	Actual PY16 Expenditures	Approved Budget for PY16
PECO	\$88,650	\$68,950
PPL	\$64,829	\$63,938
Duquesne Light	\$16,139	\$17,361
FE: Met-Ed	\$30,544	\$25,066
FE: Penelec	\$29,121	\$23,189
FE: Penn Power	\$7,915	\$6,695
FE: West Penn Power	\$31,242	\$23,714
Statewide	\$268,440	\$228,913

Table 204: PA Statewide Gross Verified Annual and Lifetime MWh Savings

EDC	Gross Verified Annual Savings (PY16)	Gross Verified Lifetime Savings (PY16)
PECO	321,861	3,005,434
PPL	299,784	4,052,474
Duquesne Light	72,031	889,695
FE: Met-Ed	163,063	2,107,734
FE: Penelec	110,670	1,464,116
FE: Penn Power	32,615	396,285
FE: West Penn Power	160,670	2,181,241
Statewide	1,160,694	14,096,979

Table 205: PA Statewide Net Verified Annual and Lifetime MWh Savings

EDC	Net Verified Annual Savings (PY16)	Net Verified Lifetime Savings (PY16)
PECO	224,891	2,014,486
PPL	213,662	2,853,648
Duquesne Light	62,649	764,025
FE: Met-Ed	108,697	1,324,662
FE: Penelec	81,147	1,041,369
FE: Penn Power	24,717	284,925
FE: West Penn Power	110,136	1,452,738
Statewide	825,899	9,735,852

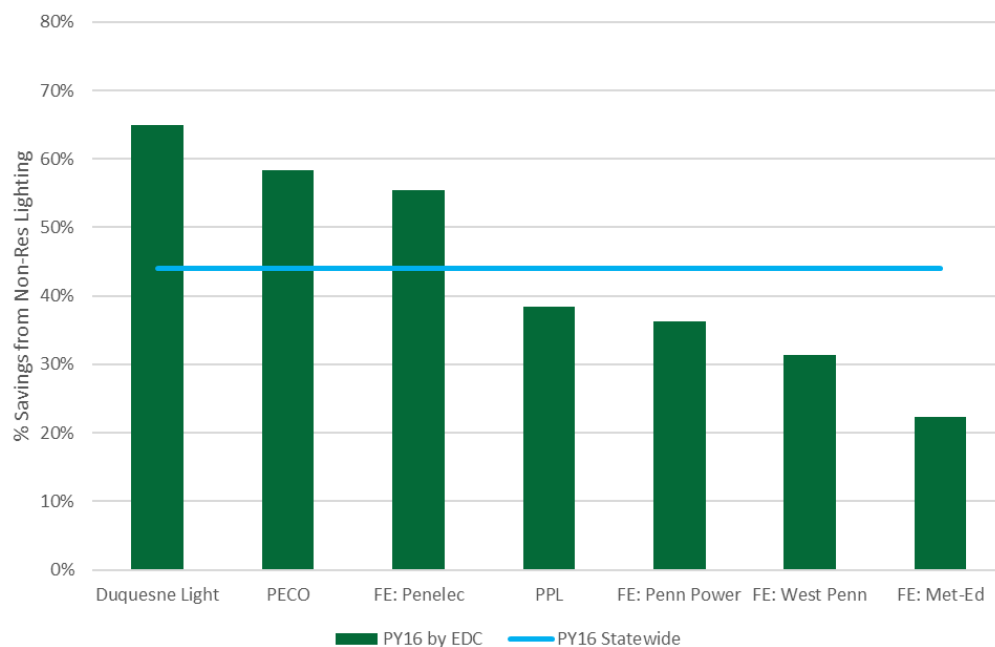
Appendix J Top Savings Programs for PY16

J.1 NON-RESIDENTIAL LIGHTING

Non-residential lighting improvements accounted for 44% of statewide PY16 energy savings. These projects primarily utilized TRM provided measure methodologies, with additional shares of savings being achieved through midstream lighting programs and custom measure protocols. Light emitting diode (LED) technologies have continued to increase in market share in the last several years, now accounting for a significant majority of all PY16 non-residential lighting improvements in both downstream and midstream programs.

Variation in the non-residential lighting share across the seven EDCs was observed. As shown in Figure 68, non-residential lighting contributed 65% of PY16 energy savings for Duquesne Light, 58% for PECO, and 38% for PPL. The FirstEnergy companies had the third highest contribution from non-residential lighting (Penelec, 55%) along with the three lowest, ranging from 22-36%.

Figure 68: EDC Non-Residential Lighting Savings Shares



J.2.3.1 Downstream Lighting Programs

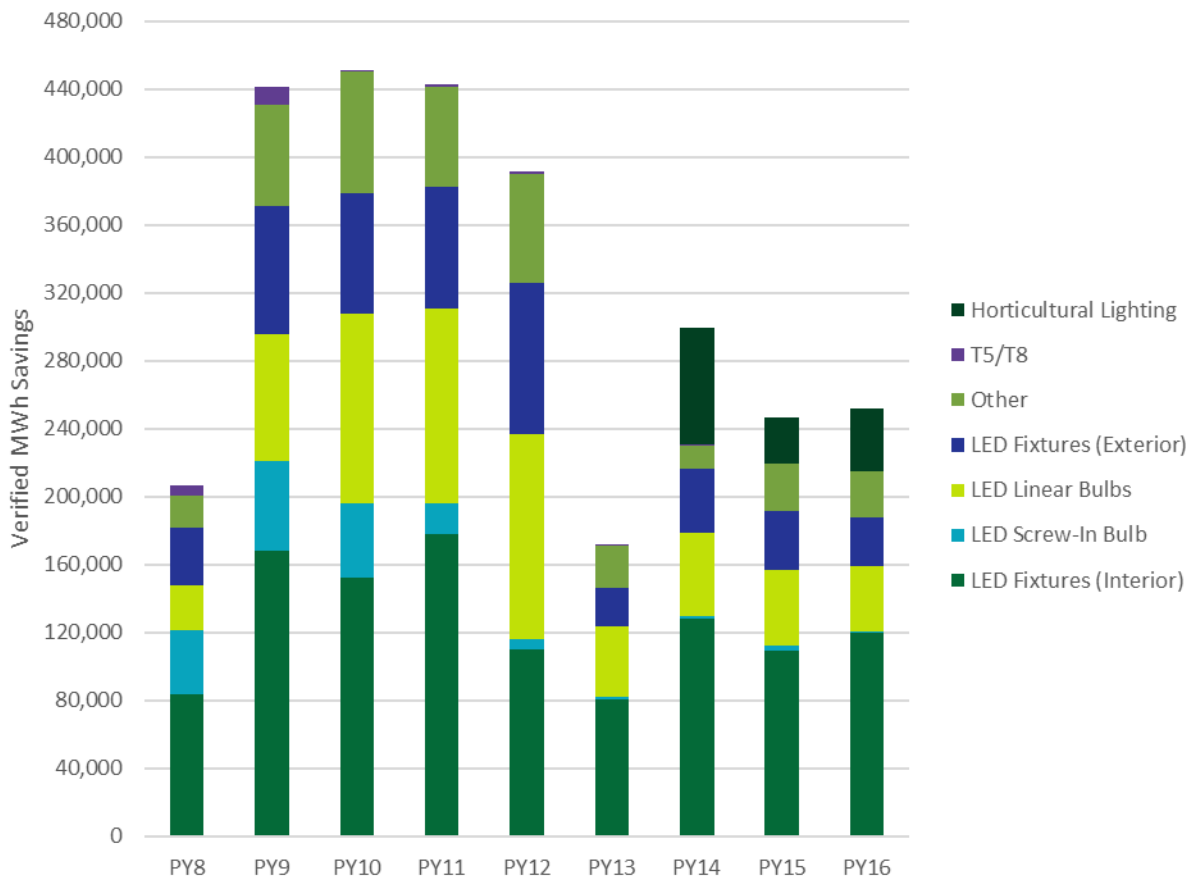
Downstream lighting offerings were the second largest source of non-residential savings in PY16, as they were narrowly outperformed by the midstream lighting programs. Downstream programs provide direct incentives for business customers who upgrade their facilities with energy efficient equipment. Typically, pre-determined incentives are made available to customers for common energy-efficiency measures to facilitate the implementation of cost-effective energy-efficiency improvements. To participate in a downstream program, a customer typically applies with

requested project documentation, such as invoices, project specification sheets, and other applicable information.

LED technology improvements have rapidly matured in the last several years, which have been readily accepted by non-residential customers and lighting contractors. LED technologies include direct lamp replacement options for linear, screw-in, and high-intensity applications, along with integral LED fixture replacements for interior low-bay and high-bay applications, exterior lighting, and street lighting. Overall, LED technologies accounted for nearly 100% of PY16 verified non-residential downstream lighting energy savings. In addition to LED lighting lamps and fixture technologies, the availability of enhanced control options integrated with LED fixtures continues to expand. Following its introduction in PY14 horticultural lighting remained a limited part of the PY16 downstream lighting offerings.

Figure 69 shows verified energy savings for PY8 through PY16 for downstream lighting equipment. The level of achieved energy savings in PY16 increased slightly relative to the savings achieved in PY15 due to additional contributions from horticulture lighting and interior LED fixtures. Savings from interior LED fixtures were the largest share of PY16 downstream lighting savings, though most technologies showed flat or decreasing verified savings in PY16.

Figure 69: PY8 to PY16 Downstream Lighting Technologies



J.2.3.2 Midstream Lighting Programs

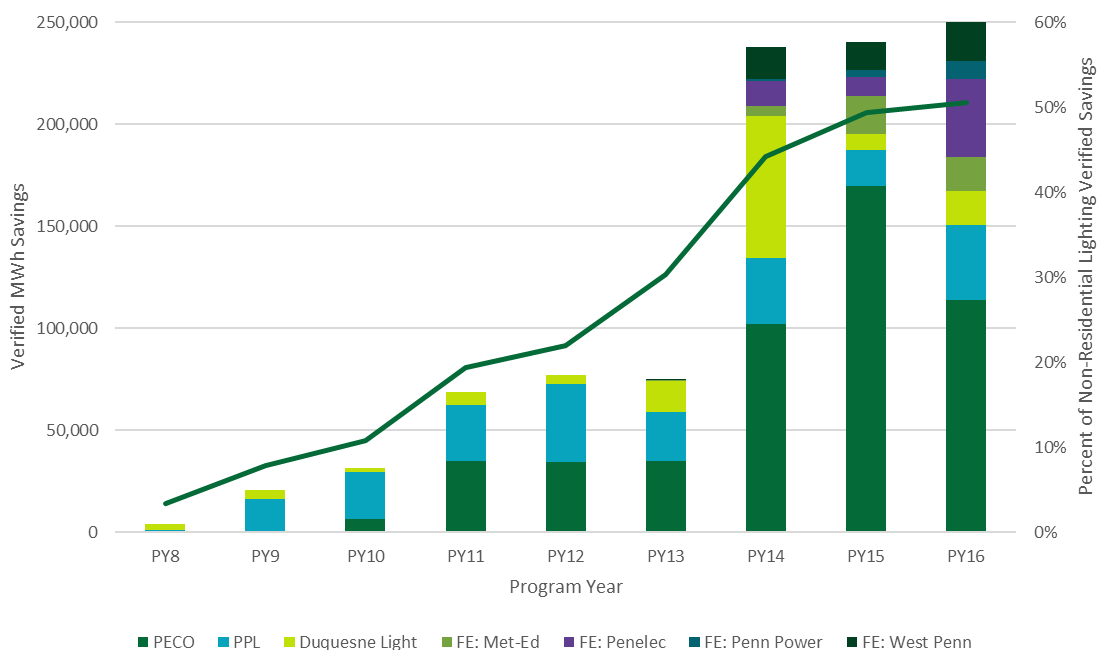
All seven EDCs offered a midstream lighting program in PY16. Energy savings contribution results are presented in [Table 206](#). Savings contributions from midstream lighting narrowly exceeded downstream programs with 51% of all verified non-residential lighting savings in PY16.

Table 206: Midstream Lighting Verified Energy Savings by EDC

EDC	Total Non-Residential Lighting (MWh/yr)	Midstream Lighting (MWh/yr)	% of Total Non-Residential Lighting
FE: Penn Power	11,841	9,066	77%
FE: Penelec	61,425	38,396	63%
PECO	187,810	113,904	61%
FE: West Penn	50,370	26,811	53%
FE: Met-Ed	36,340	16,616	46%
Duquesne Light	46,804	16,655	36%
PPL	115,251	36,526	32%
TOTAL	509,841	257,974	51%

[Figure 70](#) illustrates how the midstream components of non-residential lighting have expanded since PY8 and shows signs of modest growth in PY16. Individual EDCs exhibit broad performance differences with big midstream savings increases for some EDCs and flat to decreasing savings for others. Penelec's midstream verified energy savings tripled in PY16, with Penn Power (159%), Duquesne Light (120%), PPL (104%) all more than doubled their midstream lighting saving. Verified savings from PECO (-33%) and Met-Ed (-12%) decreased slightly PY16.

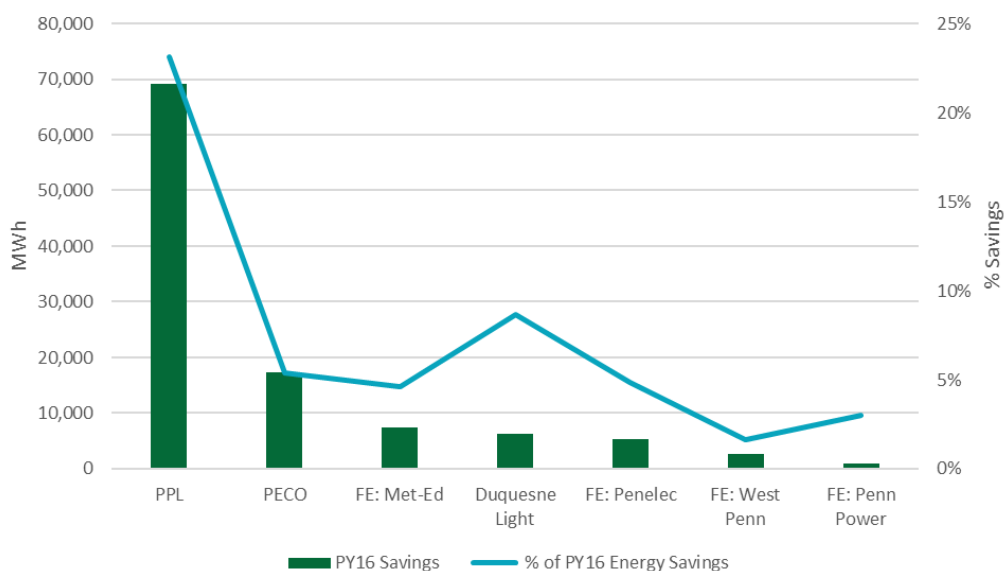
Figure 70: PY8 – PY16 Midstream Non-Residential Lighting Programs



J.2 SOLAR PV

In PY16 savings from the Solar PV measure shifted from a limited portion of verified savings to the second biggest measure in the programs after non-residential lighting. Changes in Pennsylvania net metering rules in October 2022 provided an opportunity for increased installation of solar PV across the state. Installation decisions resulted in a substantial increase in these projects across all Act 129 EDCs. Development of interim measure protocols and M&V guidance for large solar PV systems encouraged the completion of these projects that had often passed through custom programs with enhanced M&V requirements in prior years. As part of verified savings audit activities, the SWE conducted comprehensive reviews of Solar PV projects in PY16. Each project was reviewed to ensure adherence to the Solar PV IMP and associated M&V requirements. Energy generation values were also checked against historical consumption to ensure the systems will offset existing facility loads. For all EDCs, the SWE independently replicated the evaluators' models and verified that input values, assumptions, and data were accurate and consistent. The SWE concluded that evaluators performed their due diligence, and verified savings are reliable, consistent, and in accordance with Act 129 requirements. Solar PV projects contributed between 2% to 23% of energy savings for the EDCs and just under 10% of all PY16 savings (Figure 71).

Figure 71: PY16 Verified MWh from Solar PV



J.3 HERs

Approximately 1.7 million Pennsylvania households received Home Energy Reports in PY16. As Table 207 shows, this represents 34% of residential customers for the EDCs subject to Act 129.¹⁰¹

¹⁰¹ Data on residential customers includes bundled and delivery service in 2024 EIA Form 861 filings by the listed PA EDCs.

Participation in HER programs for PY16 doubled relative to PY15. Over one-third of all homes in each of the seven EDCs received a Home Energy Report, including those in PPL. PPL had not implemented an HER program in Phase IV prior to PY16. PPL launched the program this year, with over 361,000 homes in the HER treatment group.

Table 207: PY16 Statewide HER Program Participation

EDC	Residential Premises	PY16 HER Recipients	Percent of Homes Receiving HERs
PECO	1,535,000	540,700	35%
PPL	1,295,000	361,810	28%
Duquesne Light	550,000	277,296	50%
FE: Met-Ed	519,000	163,867	32%
FE: Penelec	498,000	157,110	32%
FE: Penn Power	150,000	57,067	38%
FE: West Penn Power	634,000	178,538	28%
Total	5,181,000	1,736,388	34%

While HERs generate smaller savings per participant than other energy-efficiency programs, they are relatively low-cost interventions and affect many customers. HERs can reach the full range of customers, including low-income households, whose impacts are detailed in the next section. The reports also give tailored information for each customer individually. For each of the evaluated EDCs, HER programs are set up as randomized control trials, with customers randomly assigned to treatment or control groups. Using the randomly selected control group in comparisons nets out any trends in energy use directly, so no adjustments are made for free-ridership or spillover. “Recipients” listed above are customers in treatment groups only.

Table 208 shows evaluated PY16 savings per HER recipient as well as participants’ baseline annual electric usage (with HER savings added back in) and percentage reductions. The average statewide energy savings in PY16 were 41 kWh per home (0.3%), which is comparable to PY15 results.

Table 208: Average HER Impacts per Participant

EDC	PY16 kWh Usage (HER Recipients)	Average PY16 kWh Savings per Recipient	Average Percentage Reduction
PECO	11,512	50	0.4%
PPL	13,337	20	0.1%
Duquesne Light	7,752	29	0.4%
FE: Met-Ed	13,202	85	0.6%
FE: Penelec	10,001	37	0.4%
FE: Penn Power	12,009	107	0.9%
FE: West Penn Power	14,034	13	0.1%
Combined	11,590	41	0.3%

The average savings per HER recipient in PY16 shown here are incremental savings rather than the observed savings at the meter. For cohorts older than two years, the Phase IV HER accounting framework separates persistent impacts from new savings generated by additional continued HER exposure. Removing persistent impacts isolates the incremental effect of HER exposure during the program year only. This accounting was required for Phase IV of Act 129 compliance and a departure from prior phases where all measured savings were considered first-year incremental savings. Pennsylvania HER participants are thus saving more energy than the amounts shown in [Table 208](#), but a portion of the savings are not attributed to PY16.

J.3.1 HER Contribution to LI Targets

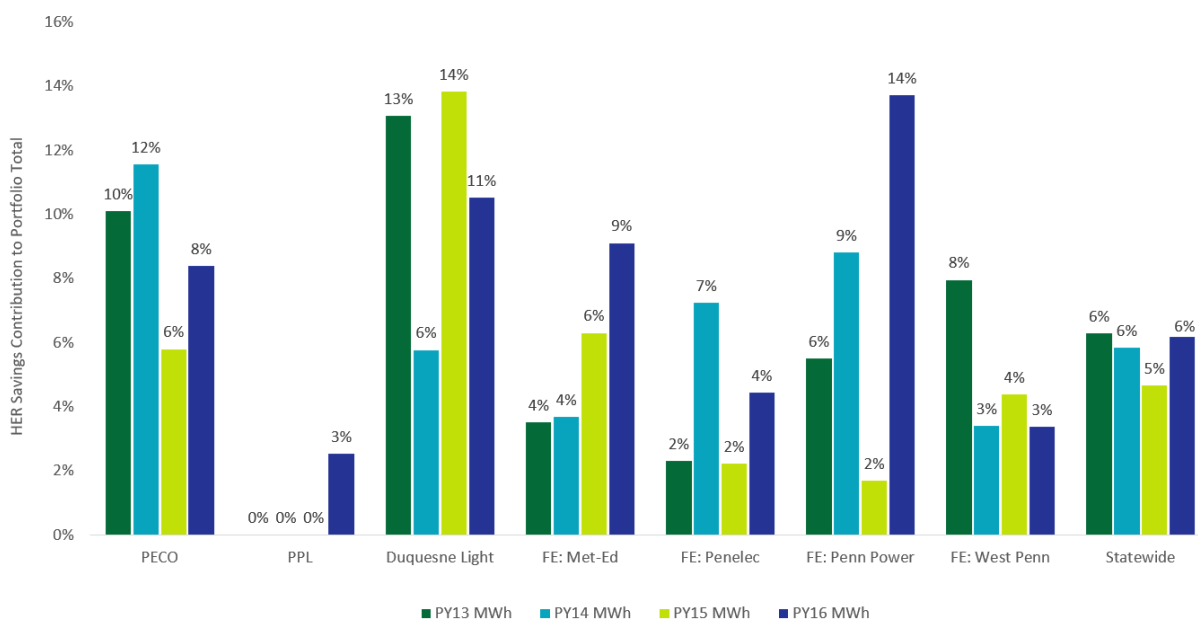
In PY16, six of the seven EDCs with HER offerings counted savings from HERs issued to low-income households toward their LI compliance target. In each case, HER participants were randomly chosen from the full pool of customers, with low-income treatment and control households separated out afterwards to measure savings toward the targets. Low-income households may also receive reports including energy-saving suggestions with little to no direct costs to implement. [Table 209](#) shows the PY16 verified gross LI savings for each EDC and the percentage of total LI savings coming from HER programs. Met-Ed achieved the largest share of its LI savings from HERS (27.3%), while West Penn Power saw the lowest savings from its Income-Eligible HER program (3.0%). Unlike in PY15, no EDCs experienced negative savings from their low-income HER programs.

Table 209: HER Contribution Toward Low-Income Targets

EDC	PYVTD LI MWh	PYVTD LI MWh from HERs	Percentage of PY16 LI Savings from HERs
PECO	19,535	807	4.1%
PPL	15,530	0	0.0%
Duquesne Light	3,308	696	21.0%
FE: Met-Ed	6,694	1,825	27.3%
FE: Penelec	5,990	1,131	18.9%
FE: Penn Power	1,059	264	24.9%
FE: West Penn Power	5,124	152	3.0%
Total	57,240	4,875	8.5%

J.3.2 HER Portfolio Savings across Phase IV

Over the four years in Phase IV, HER savings have contributed significantly to each EDC's portfolio. [Figure 72](#) illustrates the trend in HER savings contribution to total savings in PY13 through PY16. Statewide HER savings contributions hover around 6%. EDCs with an active HER program have observed portfolio savings ranging from 2% to 14% in a given program year. PY16 saw the largest HER savings contribution for both Met-Ed and Penn Power. PY16 also welcomed the first year of HER savings with the inaugural year of Home Energy Reports in PPL.

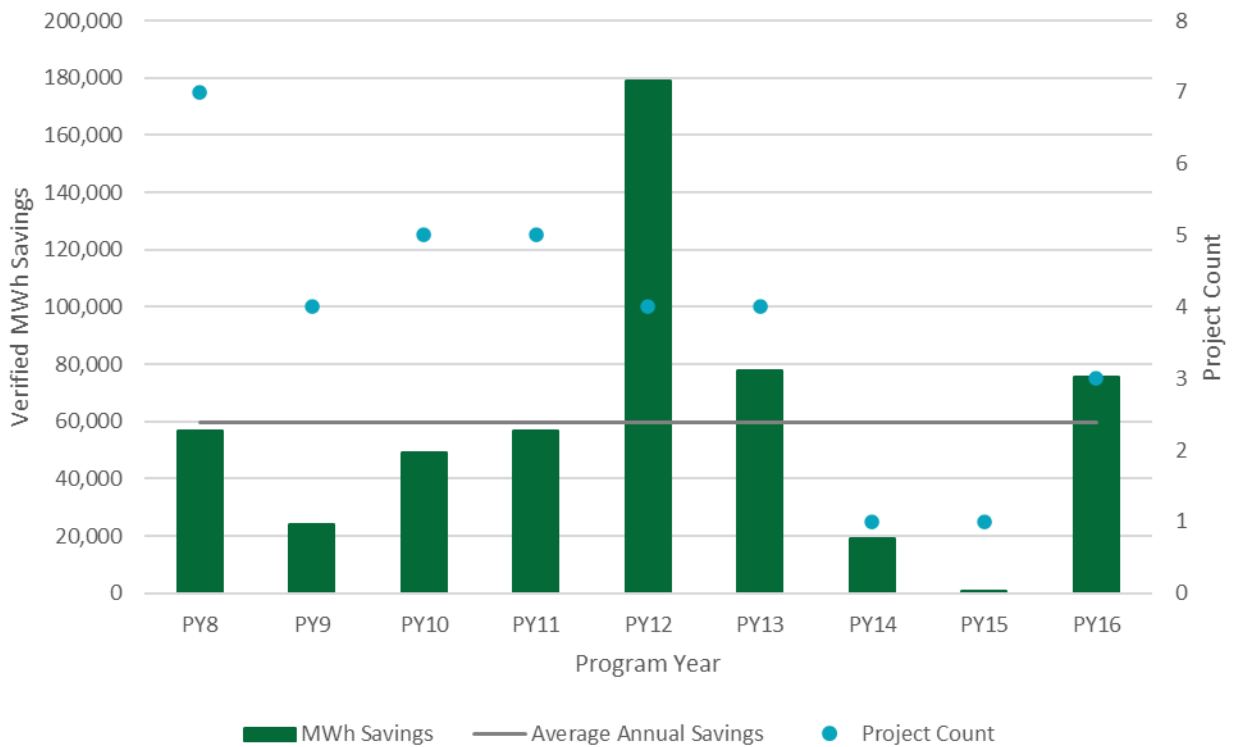
Figure 72: HER Savings Contribution to Portfolio Across Phase IV

J.4 COMBINED HEAT AND POWER (CHP)

The PUC has made a commitment to advance the prevalence of CHP and released a Final Policy Statement on CHP in April 2018, designed to encourage the deployment of CHP technology throughout Pennsylvania. This statement sought out to encourage EDCs to make CHP a part of their energy-efficiency and resiliency plans and design interconnection processes and rates for owners and operators of CHP facilities. The three CHP projects completed in PY16 accounted for 6.5% of the statewide gross verified savings.

Figure 73 shows the energy savings contributions from Act 129 CHP projects over the past seven years. The average CHP contribution is 59,837 MWh per program year, with notable variation observed from year to year as the number and size of completed projects fluctuates. The variance of annual impacts from CHP projects is largely due to the long development timelines for these projects, often exceeding 24 months for planning, construction, and financing. The three CHP projects reported in PY16 are a notable increase in projects and savings from the previous two years. SWE has already been made aware of five new CHP projects that are expected to come online before the end of the next program year and Act 129's Phase IV cycle.

Figure 73: PY8 – PY16 CHP Savings



In PY16, two CHP projects were completed by PPL with an additional project brought on-line by Met Ed as shown in [Table 210](#).

Table 210: PY16 CHP Verified Energy Savings and Realization Rate by EDC

EDC	Qty	Verified Savings (MWh)	Realization Rate
Met Ed	1	59,195	100%
PPL	2	16,345	100%
Total	3	75,540	100%