

SWE Annual Report

Act 129 Program Year 8

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Acknowledgments

The Act 129 Phase III Statewide Evaluator (SWE) thanks the Energy Association of Pennsylvania, Pennsylvania's investor-owned electric distribution companies (EDCs), and the EDCs' Act 129 program staff and evaluation contractors for their timely provision of data and information for this report, and for timely response to questions during the SWE's Act 129 auditing and reporting. The SWE recognizes the many hours that the EDCs' staff and contractors have devoted to the design and implementation of the EDCs' Phase III Act 129 energy efficiency and demand reduction programs, and to monitoring the progress of these programs.

The Phase III 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 III, including updating the SWE Evaluation Framework for Phase III of Act 129 and continuing the refinement of developing efficient processes for the review and approval of Interim Measure Protocols for the Pennsylvania Technical Reference Manual (TRM).

This SWE Phase III Program Year 8 Final Report presents the findings, conclusions, and recommendations of the Phase III 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, such as future updates to the Pennsylvania TRM, Total Resource Cost Test Order, and individual EDC energy efficiency and conservation plan revision proceedings.

Background Information

ACRONYMS

BDR	Behavioral Demand Response
C&I	Commercial and Industrial
CFL	Compact Fluorescent Lamp
CSP	Conservation Service Provider or Curtailment Service Provider
CV	Coefficient of Variation
DLC	Direct Load Control
DR	Demand Response
EDC	Electric Distribution Company
EDT	Eastern Daylight Time
EE&C	Energy Efficiency and Conservation
EM&V	Evaluation, Measurement, and Verification
EUL	Effective Useful Life
GNI	Government, Non-Profit, Institutional
HER	Home Energy Report
HIM	High Impact Measure
HVAC	Heating, Ventilating, and Air Conditioning
ICSP	Implementation Conservation Service Provider
ISR	In-service Rate
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
LI	Low-Income
LIURP	Low-Income Usage Reduction Program
M&V	Measurement and Verification
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NTG	Net-to-Gross
NTGR	Net-to-Gross Ratio
P3TD	Phase III to Date
PA PUC	Pennsylvania Public Utility Commission
PSA	Phase III to Date Preliminary Savings Achieved; equal to VTD + PYRTD
PSA+CO	PSA savings plus Carryover from Phase II
PY	Program Year: e.g. PY8, from June 1, 2016, to May 31, 2017
PYRTD	Program Year Reported to Date
PYVTD	Program Year Verified to Date
RTD	Phase III to Date Reported Gross Savings
SO	Spillover
SWE	Statewide Evaluator

TRC	Total Resource Cost
TRM	Technical Reference Manual
VTD	Phase III 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 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 non-participant spillover, and other causes of changes in energy consumption or demand not directly attributable to the EE&C program.

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

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

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

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

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

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

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

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

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

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

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

Phase III to Date Preliminary Savings Achieved (PSA): The sum of the verified gross savings (VTD) from previous program years in Phase III where the impact evaluation is complete plus the reported gross savings from the current program year (PYTD). For PY8, the PSA savings will always equal the PYTD savings because PY8 is the first program year of the phase (no savings will be verified until the PY8 final annual report).

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

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

Executive Summary

Program Year 8 (PY8), June 1, 2016 to May 31, 2017, is the first year of Phase III of Pennsylvania's Act 129 Energy Efficiency and Conservation program. Over the five-year phase, the seven Electric Distribution Companies (EDCs) subject to Act 129 have a collective, cumulative incremental annual energy savings goal of 5.7 million MWh/year. Phase III goals were established on an incremental annual basis, meaning that progress towards goals is assessed by summing the *annual* energy savings of new measure installations in a program year. The seven EDCs subject to Act 129 were forecast to sell approximately 145 million MWh per year from 2016 to 2021¹. Act 129 programs are expected to achieve nearly a 4% cumulative reduction in annual electricity use statewide over the five-year phase (or approximately 0.8% per year).

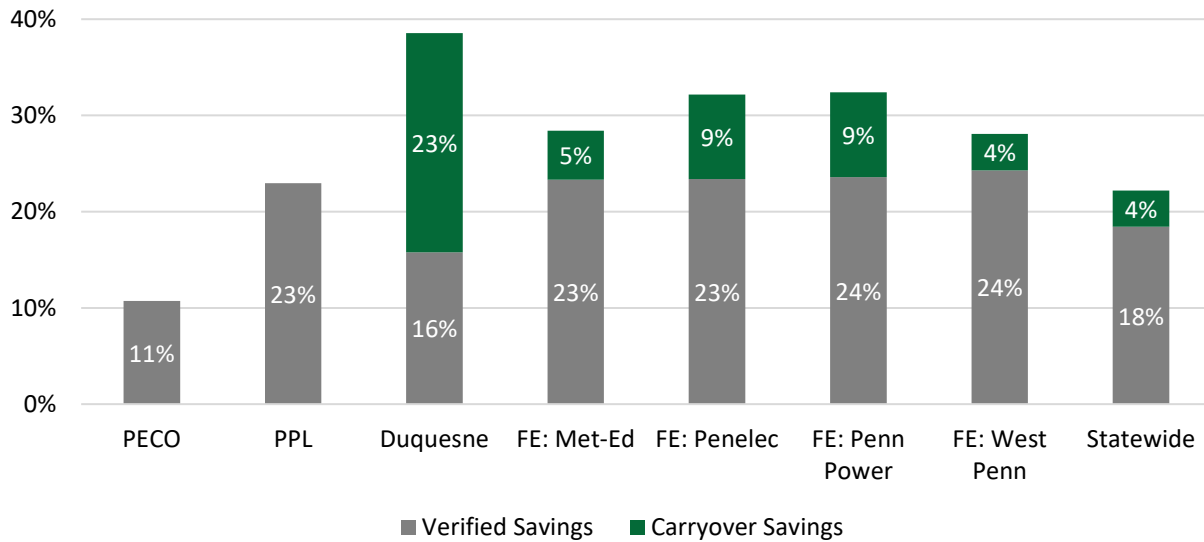
In their PY8 annual reports to the PUC, the seven EDCs claimed a total of 1,056,689 MWh/year of verified gross energy savings (approximately 19% of the statewide Phase III target). The Statewide Evaluator (SWE) performed a detailed review of the research methods, assumptions, and calculations utilized by EDC evaluation contractors to determine verified gross savings for PY8. The SWE audit validated most of the savings calculations. Errors were discovered in the Home Energy Report analysis completed by PECO and Duquesne's evaluation contractor that led to both increases and decreases in the MWh and MW totals for those EDCs and a revised gross verified statewide total of 1,052,410 MWh/year (approximately 18% of the statewide Phase III target). The totals presented in this report reflect adjustments to these values. Minor audit findings were noted for other programs, but did not result in changes to the verified savings. The errors were within acceptable limits specified in the Evaluation Framework (less than 1%), but the EDCs are expected to update their processes to correct the issues in PY9 and beyond.²

PROGRESS TOWARDS PORTFOLIO TARGETS

Progress toward the individual EDC Phase III compliance targets in PY8 verified gross energy savings ranged from 11% (PECO) to 24% (Penn Power and West Penn) (see [Figure 1](#)). Including carryover savings from Phase II, total progress toward Phase III targets ranged from 11% (PECO) to 39% (Duquesne Light). More detailed summary tables of progress toward Phase III targets can be found in [Appendix A](#) and the EDC's program-level impacts can be found in [Section 3](#).

¹ Energy Efficiency Potential Study for Pennsylvania. February 2015. Figure ES-2. Docket No. M-2014-2424864. <http://www.puc.pa.gov/pdocs/1345079.pdf>

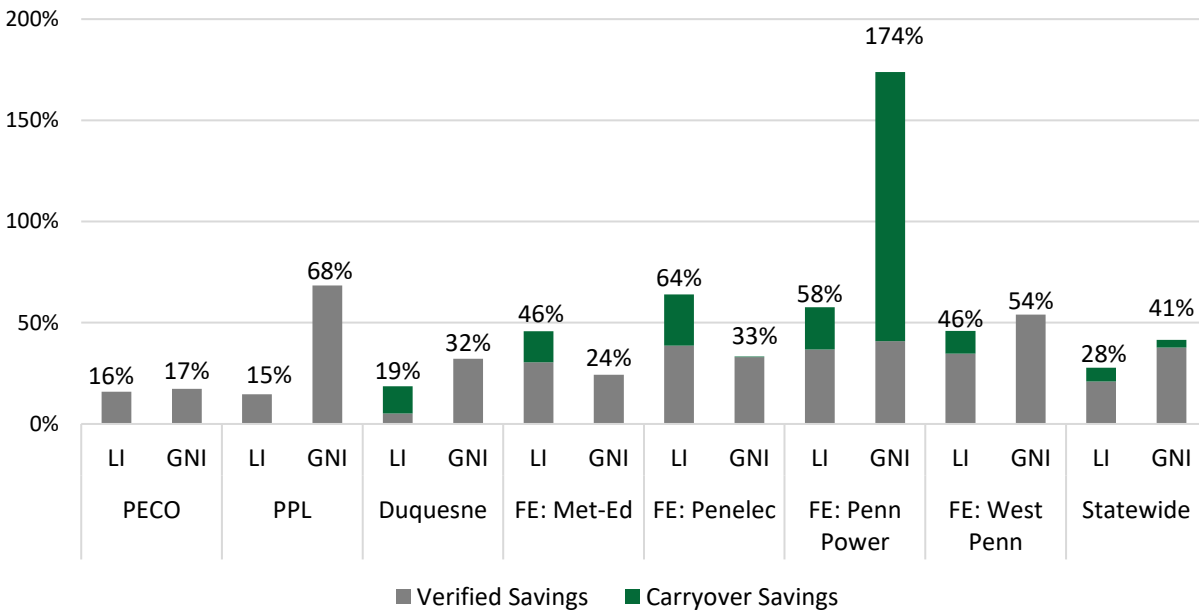
² The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Figure 1: PY8 Verified Savings Progress Toward Phase III Compliance Target, by EDC and Statewide*

* The overall progress to target may not be equal to the sum of verified and carryover savings due to rounding.

Progress Towards Low-Income and Government, Non-Profit, Institutional (GNI) Targets

Each EDC must obtain at least 5.5% of its consumption reduction requirements from programs solely directed at low-income customers or low-income-verified participants in multifamily housing programs and at least 3.5% of all consumption reduction requirements from GNI entities. [Figure 2](#) reports EDC progress toward their targets. Progress toward the low-income target ranged from 5% (Duquesne Light) to 39% (Penelec) in PY8 verified gross savings and 15% (PPL) to 64% (Penelec) when Phase II carryover savings are included. Progress toward the GNI target ranged from 17% (PECO) to 68% (PPL) in PY8 verified gross savings and 17% (PECO) to 174% (Penn Power) when Phase II carryover savings are included.

Figure 2: PY8 Progress Toward Phase III Low-income and GNI Targets

The Phase III Implementation Order also directed EDCs to offer conservation measures to the low-income customer segment based on the proportion of electric sales attributable to low-income households.³ 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 low-income consumption relative to the total energy usage in the service territory. A low-income measure is defined as a measure that is targeted to low-income customers and is available at no cost to low-income customers. The SWE found that each EDC complied with the low-income proportionality requirement. [Table 1](#) reports the required minimum proportions and results of the SWE’s verification analysis. The SWE’s verification analysis can be found in [Appendix A](#).

³ Phase III Implementation Order

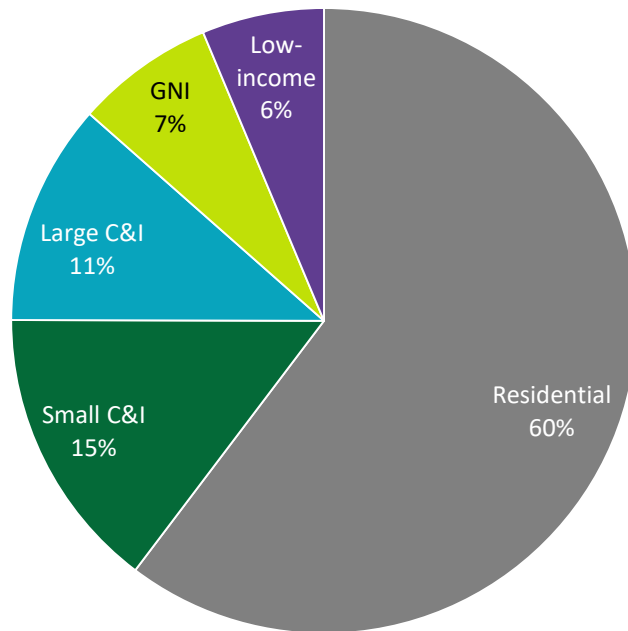
Table 1: Low-Income Measure Proportionality Targets and SWE Verification Results

EDC	Proportionate Number of Measures Target	PY8 Proportionate Number of Measures, Reported	PY8 Proportionate Number of Measures, SWE Verified
PECO	8.80%	43.5%	26.3%
PPL	9.95%	22%	23.9%
Duquesne Light	8.40%	19.8%	23.1%
FE: Met-Ed	8.79%	37%	40.5%
FE: Penelec	10.23%	37%	40.5%
FE: Penn Power	10.64%	37%	40.5%
FE: West Penn	8.79%	37%	40.5%

Phase III Performance by Customer Segment

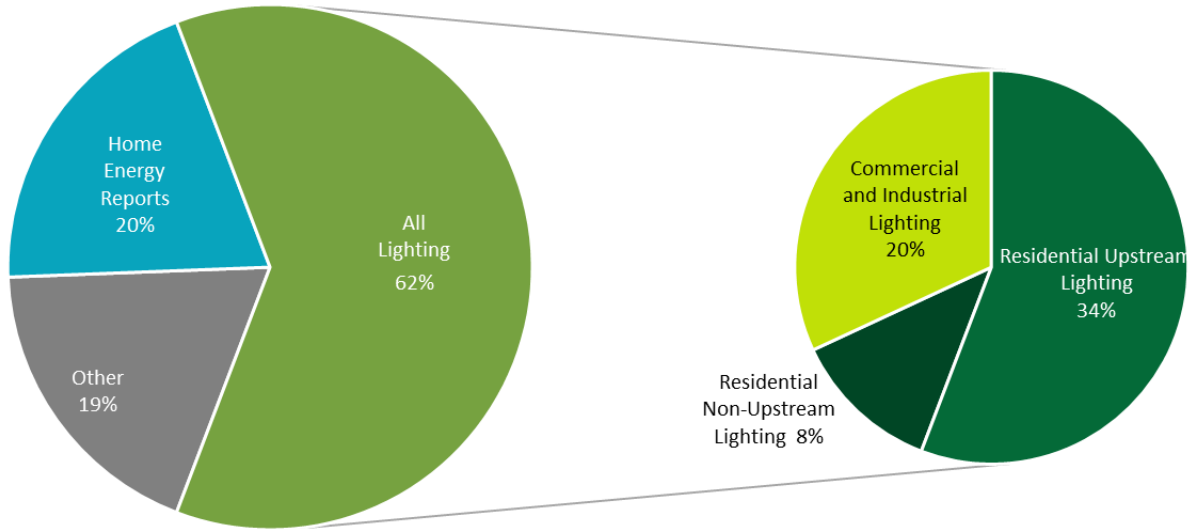
Figure 3 presents the PY8 verified gross savings by customer segment. The residential, small C&I, and large C&I segments were defined by EDC tariff, and the low-income and GNI segments were defined by statute (66 Pa. C.S. § 2806.1).⁴ Residential customers (including low-income customers) accounted for two-thirds (66%) of verified gross savings in PY8.

⁴ The low-income segment is almost entirely a subset of the residential customer class, but can include a limited number of low-income-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.

Figure 3: PY8 Verified Gross Savings by Customer Segment, Statewide

TOP SAVING PROGRAMS

The Pennsylvania EDCs support a wide range of energy efficient equipment and technology in their Phase III EE&C plans. Despite the diverse set of offerings, PY8 gross verified energy savings came overwhelmingly from three offerings: residential upstream lighting, Home Energy Reports (HERs), and non-residential lighting. These three initiatives are offered by each of the seven EDCs in Phase III, and, in PY8, the three offerings contributed 74% of the verified gross energy savings in the Commonwealth. The SWE notes that non-upstream residential lighting, such as lighting distributed through kits and direct install offerings, accounts for another 8% of statewide PY8 verified gross savings, reinforcing the reliance on three primary offerings: residential lighting, HERs, and non-residential lighting. Overall, lighting accounts for 62% of statewide PY8 verified gross savings. [Figure 4](#) shows the contribution to PY8 verified gross portfolio savings from lighting, HERs and all other offerings combined. Additionally, [Figure 4](#) details the contribution of upstream residential lighting, non-residential lighting and non-upstream residential lighting to PY8 verified gross portfolio savings.

Figure 4: Top Savings Program Types in PY8*

* The percentages in the figure do not add to 100% due to rounding

Section 2 of this report explores each of these core programs in detail. Based on a statewide review, the SWE compares the different ways EDCs delivered these programs in PY8. We also examine the rapidly changing lighting market that EDC programs are working to transform and the implications these market changes have on program delivery.

COST-EFFECTIVENESS SUMMARY

Pennsylvania has adopted the Total Resource Cost (TRC) test as its preferred perspective for benefit-cost modeling. The TRC test examines cost-effectiveness from the perspective of the utility, participant, and non-participant. In preparation for Phase III, the PUC issued the 2016 TRC Test Order⁵ to document the methodology and assumptions EDCs should use when calculating the costs and benefits of Phase III EE&C portfolios.

Table 2 shows the net present value (NPV) costs and benefits for each EDC portfolio in PY8, as well as the TRC ratio (benefits divided by costs). TRC results are presented on both a gross and net savings basis. Per the 2016 TRC 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 the EDC weighted average cost of capital (WACC) as a discount rate. The use

⁵ Pennsylvania Public Utility Commission, *Final 2016 TRC Test Order*. From the Public Meeting of June 11, 2015, at Docket No. M-2015-2468992 (2016 TRC Order). Entered June 22, 2015.
<http://www.puc.pa.gov/pcdocs/1367195.docx>

of WACC is based on the Commission's instructions in the 2016 TRC Order, which stated *"The EDC's weighted average cost of capital is the correct basis for the discount rate so that supply-side and demand-side alternatives are placed on a level playing field. Accordingly, EDCs shall continue to use the EDC's weighted average cost of capital as the discount rate used in TRC calculations for all measures and programs that are eligible for Act 129 funding."*⁶ On a gross basis, PY8 programs saved the Commonwealth almost \$133 million dollars (benefits minus costs). On a net basis, statewide savings from PY8 programs are estimated at \$56 million dollars.

Table 2: PY8 TRC Test Results by EDC

EDC	Gross Benefits (\$1000)	Gross Costs (\$1000)	Gross TRC	Net Benefits (\$1000)	Net Costs (\$1000)	Net TRC
PECO	\$75,535	\$68,836	1.10	\$44,535	\$58,785	0.76
PPL	\$160,299	\$95,804	1.67	\$128,778	\$80,951	1.59
Duquesne	\$34,195	\$16,418	2.08	\$24,304	\$14,037	1.73
FE: Met-Ed	\$48,755	\$33,712	1.45	\$28,656	\$23,845	1.20
FE: Penelec	\$45,964	\$30,041	1.53	\$29,740	\$23,765	1.25
FE: Penn Power	\$13,339	\$8,600	1.55	\$8,631	\$6,413	1.35
FE: West Penn	\$40,069	\$31,752	1.26	\$24,265	\$24,854	0.98
Statewide	\$418,156	\$285,163	1.47	\$288,909	\$232,650	1.24
Statewide (Water and Fossil Fuel Sensitivity)	\$448,482	\$285,163	1.57	N/A	N/A	N/A

PY8 TRC ratios are down slightly from previous phases of Act 129. Contributing factors include the following:

- **Phase start-up costs** – several EDCs completely re-designed their EE&C portfolio for Phase III. These programmatic changes can lead to upfront administrative costs.
- **Low avoided cost of energy** – projections of the avoided cost of electric power generation (the primary TRC benefit) are increasingly driven by natural gas futures, which were low at the time of EE&C plan development.
- **Changing codes and standards** – The residential lighting baseline shifted to halogen for most lamps in Phase III and the non-residential baseline shifted to T8 for general service lighting in PY8. These changes reduce the energy savings associated with the dominant end-use across EDC portfolios.

While reviewing the PY8 annual reports and TRC models, the SWE noted that none of the EDCs included any TRC benefits from fossil fuel or water savings achieved by installed measures. The 2016 TRC Order clearly separated fossil fuel and water impacts from other non-electric benefits and directed EDCs to include these benefits in the Phase III TRC Test, while prohibiting the inclusion of other non-electric benefits. A Joint Motion from Commissioners Cawley and Witmer⁷ submitted with the Final 2016 TRC Order suggested that *"while we are not supportive of a general*

⁶ 2016 TRC Order. Page 66.

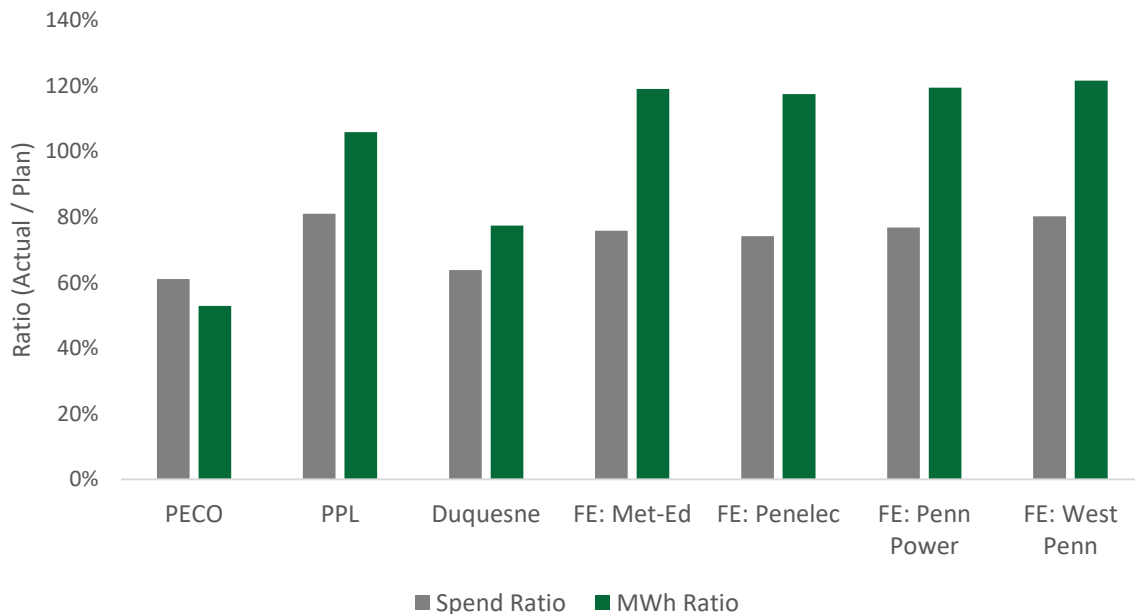
⁷ <http://www.puc.pa.gov/pdocs/1365561.pdf>

adder, we do believe it appropriate to include all reasonably quantifiable savings associated with water and fossil fuel costs”. Omitting water and fossil fuel benefit streams means that the EDC-reported TRC benefits and TRC ratios are understated. To test the sensitivity of the TRC test results to this omission, the SWE calculated the water and fossil fuel savings associated with the 66,000 faucet aerators and 39,000 low-flow showerheads installed statewide in PY8. Using avoided costs of \$0.02/gallon and \$0.40/therm, the SWE calculated an additional \$30 million in TRC benefits from just these two measures. Including the water and fuel benefits from these two measures increased the statewide gross TRC by 7.3% – from 1.47 to 1.57.

COMPARISON OF SAVINGS AND EXPENDITURES TO PLAN

In preparation for Phase III, each EDC filed an EE&C plan to the PUC 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 PY8 expenditures and verified gross energy savings to the EE&C plan projections for PY8. The SWE calculated a ratio of each (actual/planned) to develop the values shown in Figure 5. PPL and the four FirstEnergy companies are ahead of projected energy savings totals despite spending less than projected. Duquesne Light’s PY8 spending and energy savings were both lower than planned. In PY8, PECO is the only EDC with a PY8 spending ratio (61%) that is higher than the PY8 energy savings ratio (53%).

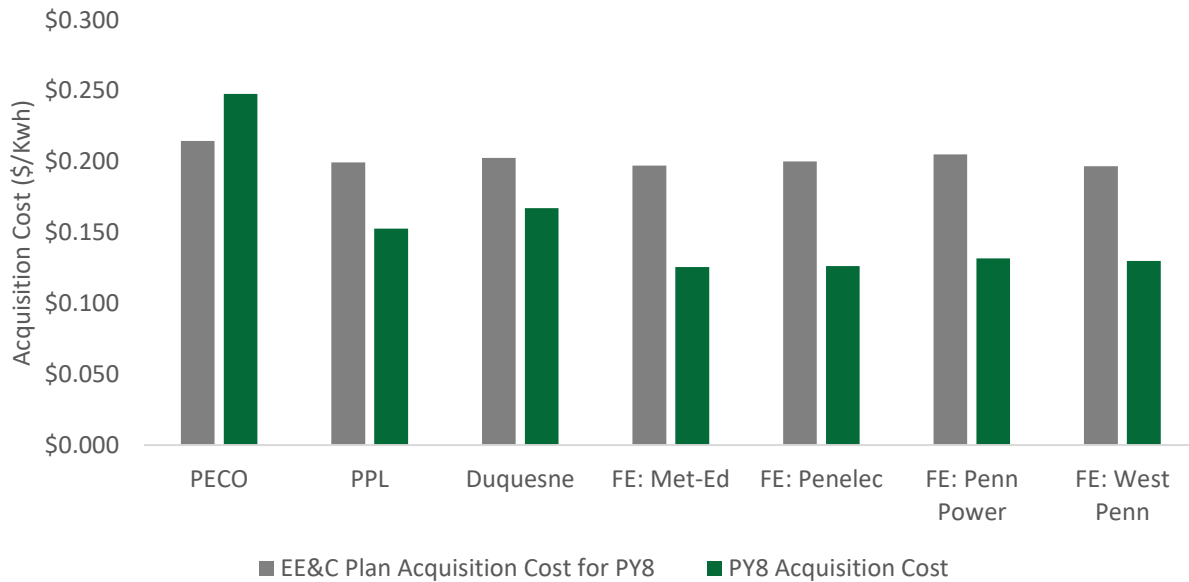
Figure 5: PY8 Actual Spending and Savings Compared to EE&C Plan for PY8



Because of the emphasis on 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 – or spending divided by verified gross savings. Figure 6 compares the projected PY8 acquisition cost from the Phase III EE&C plan to actual PY8

acquisition costs. All EDCs except PECO delivered energy savings at a lower cost than projected in PY8. PECO's actual PY8 acquisition cost was above the EE&C plan projections for PY8.

Figure 6: Planned vs. Actual Acquisition Cost



PECO's PY8 annual report provided limited information on the causes of low performance values relative to the plan. Most of the shortfall comes from the C&I sectors. PECO will need to see an increase in verified gross savings and a reduction in acquisition cost in subsequent program years to meet its Phase III portfolio reduction target.

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. Table 3 was compiled using the gross verified first-year and lifetime MWh savings in PY8 and an average of the 2016 marginal on-peak and off-peak CO₂ emissions rate in PJM's spring 2017 Emissions Report.⁸

⁸ <https://www.pjm.com/~media/library/reports-notice/special-reports/20170317-2016-emissions-report.ashx>

Table 3: PY8 Carbon Dioxide Emission Impacts

Performance Metric	Value
PY8 Verified Gross MWh/yr	1,052,410
PY8 Verified Gross Lifetime MWh	9,130,332
Weighted Average Measure Life (years)	8.7
Marginal Off-Peak CO ₂ Emissions Rate (lbs./MWh)	1,544
First-Year Avoided Tons of CO ₂	812,461
Lifetime Avoided Tons CO ₂	7,048,616

The lifetime emission impacts in [Table 3](#) are calculated using the 2016 CO₂ emission rates. If the generation fuel mix in the region becomes cleaner over the life of the measures installed in PY8, the emissions rate would decrease, and the lifetime CO₂ impacts would be lower.

PROCESS EVALUATION

[Table 4](#) provides an overview of the PY8 process evaluations conducted by each EDC.

Table 4: PY8 Process Evaluations by EDC

EDC	# of PY8 Programs	# Evaluated	# of Findings	# of Recommendations	% of Satisfied Residential Customers*	% of Satisfied C&I Customers*
PECO**	8	4	296	25	89%	83%
PPL	10	9	29	18	87%	97%
Duquesne Light	13	3	19	10	n/a	n/a
FirstEnergy EDCs***	9	7	30	22	n/a	n/a

* Average across all programs for which participant surveys were conducted. Average is weighted by number of PY8 participants in each program.

** The eight programs include 21 program solutions within four PECO energy efficiency target areas: residential, low-income, small C&I, and large C&I. For PY8, 12 of these 21 program solutions were evaluated. Four additional PECO programs that were not evaluated for PY8 include: Residential Demand Response, Small C&I Demand Response, Large C&I Demand Response, and Combined Heat & Power.

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

As can be seen in [Table 4](#), the SWE is not able to report on overall participant satisfaction for the PY8 programs evaluated by Duquesne Light and the FirstEnergy EDCs. The reason for this is that these EDCs provide mean satisfaction ratings rather than the percentage distribution of responses to the satisfaction questions.

SUMMARY OF SWE FINDINGS AND RECOMMENDATIONS

- **Finding:** The TRC ratios reported by the Pennsylvania EDCs in PY8 were systematically understated because of asymmetric handling of fossil fuel impacts. Increased fossil fuel consumption from fuel-switching measures was monetized as a TRC cost, but decreased fossil fuel consumption from energy efficiency measures that saved space heating and water heating fuel were ignored. Reasonably quantifiable water savings from measures like faucet aerators and low-flow showerheads were also excluded from the calculation of TRC benefits for the six EDCs that offered these two measures (Duquesne Light offers neither). The SWE performed a sensitivity analysis in which water and natural gas savings from faucet aerators and low-flow showerheads were monetized as TRC benefits. This analysis showed an additional \$30 million⁹ in TRC benefits and increased the statewide PY8 TRC ratio by 7.3%.
 - **Recommendation:** In PY9, EDCs and their evaluation contractors should align their cost-effectiveness procedures with the Commission's 2016 TRC Order, which stated, *"the 2016 TRC Test calculation shall include such benefits only to the extent reasonably quantifiable. It should be noted that increased operating fossil fuel cost expense is already factored into fuel switching TRC test protocols, so the reflection of fossil fuel cost benefits should not be unreasonably difficult to estimate."*¹⁰ Appropriate handling of fossil fuel and water impacts will more accurately reflect the cost-effectiveness of Act 129 EE&C programs. The SWE will provide guidance to the EDCs on water and fossil fuel impacts we believe to be 'reasonably quantifiable'.
- **Finding:** Behavioral programs (Home Energy Reports or HERs) accounted for approximately 20% of the verified gross energy savings in PY8. The SWE audit activities uncovered a variety of issues with the HERs analysis for six of seven EDCs. Additional detail on the issues is included in Chapter 3 and the section 4.1.3 of the EDC-specific report appendices.
 - **Recommendation:** Given the significant contribution of Home Energy Reports to Phase III goals, EDC evaluation contractors need to show improved attention to detail in these analyses in PY9 and beyond to ensure careless errors do not bias impact estimates.
- **Finding:** All seven EDCs are heavily reliant on the lighting measures, with over 60% of PY8 verified gross energy savings coming from the lighting end-use. While the vast majority of lighting measures are ENERGY STAR qualified, some upstream lighting measures could not be verified as ENERGY STAR lamps in PY8.
 - **Recommendation:** Changing baselines in the residential sector are going to necessitate a significant shift in program focus in PY12. It will be important for

⁹ \$29.1 million of water benefits and \$1.3 million of incidental gas benefits from assumed gas water heaters.

¹⁰ Pennsylvania Public Utility Commission, *Final 2016 TRC Test Order*. From the Public Meeting of June 11, 2015, at Docket No. M-2015-2468992 (2016 TRC Order). Entered June 22, 2015. Page 15.
<http://www.puc.pa.gov/pcdocs/1367195.docx>

EDCs to capitalize on the residential lighting program opportunity in PY9 through PY11. The SWE also notes that the TRM for residential lighting clearly states that LEDs must be ENERGY STAR qualified. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs¹¹ be assigned zero kWh savings.¹²

- **Finding:** Commercial midstream programs are new initiatives in Act 129 and are expected to grow substantially in Phase III. The programs are currently focused on lighting and account for 1.4% of the non-residential PY8 savings, but the EDCs are interested in expanding them to include non-lighting equipment, such as Packaged Terminal Air Conditioning (PTAC) units, heat pumps, and variable frequency drives (VFDs). Significant savings are expected to shift from downstream to midstream in the commercial sector. These programs offer customers more convenient access to rebates, but the program design creates difficulties for evaluation of savings. The SWE found significant leakage of bulbs into another EDC's service territory for one midstream program in PY8, and the EDC evaluator faced difficulties in identifying the locations of equipment sold through the program.
 - **Recommendation:** Midstream programs are an excellent way to engage the market, and offer convenient access to rebates, but verified savings are less accurate than downstream programs, which require a detailed assessment of savings parameters in the program application. The SWE recommends the EDCs ensure that their program designs minimize opportunities for leakage and maximize evaluators' abilities to identify locations of equipment installations. The SWE will monitor the progress of midstream programs and update the Evaluation Framework to strengthen the savings verification procedures for these initiatives.
- **Finding:** Non-residential project file reviews showed varying levels of evidence of appropriate selection of algorithms and assumptions for TRM-based and custom measures by the ICSPs of the seven EDCs.
 - **Recommendation:** The SWE recommends all evaluation contractors perform more thorough audits of documentation for off-TRM assumptions. This would ensure that reported savings are not calculated in error due to minor oversights, and that evaluation contractors urge their corresponding ICSPs to supply unlocked versions of calculators to ensure transparency in the savings calculations performed.

¹¹ Value line LED models are LEDs that have not been ENERGY STAR certified and typically have estimated lifetimes of 10,000 hours – which is below the ENERGY STAR requirement. Under Version 1.1 of the ENERGY STAR lamps specification, the required lifetime of LEDs was 25,000 hours. Effective January 2017, Version 2.0 of the ENERGY STAR specification lowered the rated lifetime requirement to 15,000 hours. ENERGY STAR certified LEDs are subject to specific energy efficiency and design requirements, have met quality and performance standards, have been tested by accredited labs and certified by a third party https://www.energystar.gov/products/lighting_fans/light_bulbs

¹² The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the eligibility requirements of the 2016 TRM will be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

Section 1 Background and Legislative History

1.1 REQUIREMENTS FROM THE PHASE III IMPLEMENTATION ORDER

Act 129 requires the PUC to establish an energy efficiency and conservation program that includes the following characteristics:

- Adopt an “energy efficiency and conservation program to require electric distribution companies¹³ to adopt and implement cost-effective energy efficiency and conservation plans to reduce energy demand and consumption within the service territory of each electric distribution company in this commonwealth.”¹⁴
- Adopt additional incremental reductions in consumption if the benefits of the EE&C Program exceed its costs.
- Evaluate the costs and benefits of the Act 129 EE&C programs in Pennsylvania by November 30, 2013, and every five years thereafter.
- Ensure 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.”¹⁵

Further, the Phase I implementation order detailed that the PUC is responsible for “establishing the standards each plan must meet and providing guidance on the procedures to be followed for submittal, review, and approval of all aspects of EDC energy efficiency and conservation (EE&C) plans.”¹⁶ Based on findings from the Phase II Market Potential Study, dated February 2015, the PUC determined that the benefits of a Phase III Act 129 program would exceed its costs, and therefore adopted additional required incremental reductions in consumption and peak demand for another EE&C Program term of June 1, 2016 through May 31, 2021 (program years eight, nine, ten, eleven, and twelve). In its Phase III Implementation Order, the PUC established targets for those incremental reductions in electricity consumption for each of the seven EDCs in Pennsylvania; established demand response targets for six of the seven EDCs; 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 EDC EE&C plans for Phase III.¹⁷

1.1.1 Phase III Energy Reduction Targets for Each EDC

The PUC’s June 2015 Implementation Order explained that it was required to establish electric energy consumption reduction compliance targets for Phase III of Act 129. [Table 5](#) contains these targets as percentages and five-year cumulative totals in MWh/year for each of the seven EDCs.

¹³ This Act 129 requirement does not apply to an electric distribution company with fewer than 100,000 customers.

¹⁴ 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.

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 51.

¹⁶ Pennsylvania Public Utility Commission, Phase III Final Implementation Order. From the Public Meeting of June 11, 2015, at page 4. Docket No. M-2014-2424864, (Phase III Implementation Order).

<http://www.puc.pa.gov/pcdocs/1367313.doc>

¹⁷ Phase III Implementation Order.

Table 5: Act 129 Phase III Five-Year Energy Efficiency Reduction Compliance Targets

EDC	Portfolio EE Budget Allocation (Million \$)	Program Acquisition Costs (\$/1st-YR MWh Saved)	Five-Year Value of Reductions (MWh)	% of 2010 Forecast
PECO	\$384.3	\$195.8	1,962,659	5.0%
PPL	\$292.1	\$202.4	1,443,035	3.8%
Duquesne	\$88.0	\$199.5	440,916	3.1%
FE: Met-Ed	\$114.4	\$190.9	599,352	4.0%
FE: Penelec	\$114.9	\$202.9	566,168	3.9%
FE: Penn Power	\$30.0	\$190.4	157,371	3.3%
FE: West Penn	\$106.0	\$196.0	540,986	2.6%
Statewide	\$1,129.6	\$197.8	5,710,488	3.9%

The final Phase III Implementation Order also established demand response targets for each EDC covered by Act 129 (with no DR target for Penelec). The percentage reduction targets, as well as the value of reductions in MW, are reported in [Table 6](#). It is important to note that the EDCs are not required to obtain peak demand reductions in the first program year of Phase III (PY8). The targets reported in [Table 6](#) are for the other four program years in Phase III.

Table 6: Act 129 Phase III Five-Year Energy Demand Response Reduction Compliance Targets

EDC	5-Year DR Spending Allocation (Million \$)	Program Acquisition Costs (\$/MW/year)	Average Annual Potential Savings (MW)	% Reduction (Relative to 2007-2008 Peak Demand)
PECO	\$42.70	\$66,370	161	2.0%
PPL	\$15.38	\$41,622	92	1.4%
Duquesne	\$9.77	\$57,976	42	1.7%
FE: Met-Ed	\$9.95	\$51,210	49	1.8%
FE: Penelec	\$0.00	\$50,782	0	0.0%
FE: Penn Power	\$3.33	\$49,349	17	1.7%
FE: West Penn	\$11.78	\$46,203	64	1.8%
Statewide	\$92.90	\$54,714	424	1.6%

1.1.2 Standards Each EDC's Phase III EE&C Plan Must Meet

The PUC requires that each EDC's plan for Phase III meet several standards, including the following:

1. EDCs must include in their filing an EE&C Plan that obtains at least 3.5% of all consumption reduction requirements from the federal, state, and local governments, including municipalities, school districts, institutions of higher education, and nonprofit entities (GNI).
2. Each EDC Phase III EE&C Plan must obtain at least 5.5% of its consumption reduction requirements 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 residential programs, will not be counted for compliance. More details about the low-income targets and requirements are provided in [Section 1.1.6](#). Act 129 also includes legislative requirements to include several 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.
3. EDCs will be awarded credit for all new, first-year, incremental savings delivered in each year of the Phase (rather than focusing on a cumulative approach, as was done in Phase II).
4. EDCs are to develop EE&C Plans that are designed to achieve at least 15% of the target amount in each program year.
5. EDCs are to include at least one comprehensive program for residential customers and at least one comprehensive program for non-residential customers.
6. 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 III EE&C Plan must ensure that the utility offers each customer class at least one energy efficiency program.
7. Demand response programs will meet the following criteria:
 - a. The EDCs will obtain no less than 85% of the target in any one event.
 - b. Curtailment events shall be limited to the months of June through September.
 - c. Curtailment events shall be called for the first six days that a peak hour of PJM's day-ahead forecast for the PJM RTO is greater than 96% of the PJM RTO summer peak demand forecast for the months of June through September for each year of the program.
 - d. Each curtailment event shall last four consecutive hours.

- e. Each curtailment event shall be called such that it will occur during the day's forecasted highest peak hour above 96% of PJM's RTO summer peak demand forecast.
- f. Once six curtailment events have been called in a program year, the peak demand reduction program shall be suspended for that program year.
- g. The reductions attributable to a four-consecutive-hour curtailment event will be based on the average MW reduction achieved during each hour of an event.
- h. Compliance will be determined based on the average MW reductions achieved from events called in the last four years of the program.
- i. The EDCs, in their plans, must demonstrate that the cost to acquire MWs from customers who participate in PJM's ELRP is no more than half the cost to acquire MWs from customers in the same rate class that are not participating in PJM's ELRP. In addition, EDCs' DR programs are to allow for dual participation in Act 129 and PJM's ELRP; dual enrolled participants will have a 50% discount on Act 129 DR incentives imposed.

1.1.3 Carryover Savings from Phase II

The PUC's June 2015 Implementation Order for Phase III specifies that the EDCs are allowed to use savings attained in Phase II in excess of their targets for application toward Phase III targets. These carryover savings may only be savings actually attained in Phase II.¹⁸ The PUC's August 2017 Compliance Order further clarified that in order to carry over savings for the low-income and GNI carveouts, an EDC must attain savings in Phase II that are in excess of their Phase II targets for application towards Phase III targets.¹⁹

1.1.4 Incremental Annual Accounting

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 EUL before the end of the phase does not impact compliance savings.

1.1.5 Net-to-Gross Ratio for Phase III of Act 129

The PUC's Phase III Implementation Order specifies that compliance will be based on gross verified savings rather than net savings, and that EDCs will continue to perform NTG research. Results of the NTG evaluations should be used to inform program modifications and program

¹⁸ Qualifying low-income savings from multifamily housing may be counted toward the low-income-specific savings, as well as savings from any program that was directly targeted to low-income customers. This includes all weatherization programs, energy efficiency kits and home energy report programs, and specifically targeted compact fluorescent lighting (CFL) and light-emitting diode (LED) lighting giveaway programs.

¹⁹ Pennsylvania Public Utility Commission. *Act 129 Phase II Final Compliance Order*. From the public meeting held August 3, 2017. Docket No. M-2012-2289411. (<http://www.puc.pa.gov/pcdocs/1530728.docx>)

planning (e.g., program design, modifying program incentive levels, and eligibility requirements), as well as determinations of program cost-effectiveness.

1.1.6 Low-Income and GNI Customer Savings

As noted earlier in [Section 1.1.2](#), each EDC Phase III EE&C Plan must obtain at least 5.5% of its consumption reduction requirements from programs solely directed at low-income customers or low-income-verified participants in multifamily housing programs and at least 3.5% of all consumption reduction requirements from GNI entities. Savings from non-low-income programs, such as general residential programs, will not be counted for compliance. Low-income customers are defined as households whose incomes are at or below 150% of the Federal Poverty Income Guideline. As noted earlier in [Section 1.1.3](#), low-income & GNI carryover for Phase III were based on attained savings in Phase II that were in excess of overall Phase II targets and the individual Phase II carveout targets. If an EDC exceeded the low-income or GNI target in Phase II, but did not exceed the portfolio target, the EDC was not permitted to carry over savings for the carveout(s) in Phase III.²⁰

A summary of the low-income and GNI carve-out information is provided in [Table 7](#).

Table 7: Act 129 Phase III Low-income (LI) and GNI Carve-out Information

EDC	Proportionate Number of Measures (LI)	2016-2021 Potential Savings (MWh)	5.5% Low-Income Savings Target (MWh)	3.5% GNI Savings Target (MWh)
PECO	8.80%	1,962,659	107,946	68,693
PPL	9.95%	1,443,035	79,367	50,507
Duquesne	8.40%	440,916	24,250	15,432
FE: Met-Ed	8.79%	599,352	32,964	20,977
FE: Penelec	10.23%	566,168	31,139	19,816
FE: Penn Power	10.64%	157,371	8,655	5,508
FE: West Penn	8.79%	540,986	29,754	18,935
Statewide		5,710,488	314,075	199,868

²⁰ Act 129 Phase II Final Compliance Order.

Section 2 Top Offerings

The Pennsylvania EDCs support a wide range of energy efficient equipment and technology in their Phase III EE&C plans. Despite the diverse set of offerings, PY8 gross verified energy savings came overwhelmingly from three offerings: residential upstream lighting, Home Energy Reports (HERs), and non-residential lighting. These three initiatives are offered by each of the seven EDCs in Phase III; in PY8, the three offerings contributed 74% of the verified gross energy savings in the Commonwealth. [Table 8](#) shows the contribution to PY8 portfolio savings from each of the three primary offerings by EDC.

Table 8: PY8 Energy Savings from Three Top Offerings

EDC	PY8 Verified Gross (MWh/yr)	Upstream Lighting (MWh/yr)	HER (MWh/yr)	Commercial Lighting (MWh/yr)	Percent of PY8 MWh from Big 3
PECO	210,689	72,123	63,385	33,753	80%
PPL	331,344	145,929	29,931	67,246	73%
Duquesne	69,593	35,496	8,269	15,040	84%
FE: Met-Ed	139,875	28,761	36,253	28,723	67%
FE: Penelec	132,449	37,706	25,293	26,168	67%
FE: Penn Power	37,130	7,346	7,587	9,822	67%
FE: West Penn	131,330	34,457	37,637	26,155	75%
Statewide	1,052,410	361,818	208,355	206,907	74%

The following sections explore the key issues for each of the primary offerings. Differences in delivery strategy across the EDCs are highlighted and discussed.

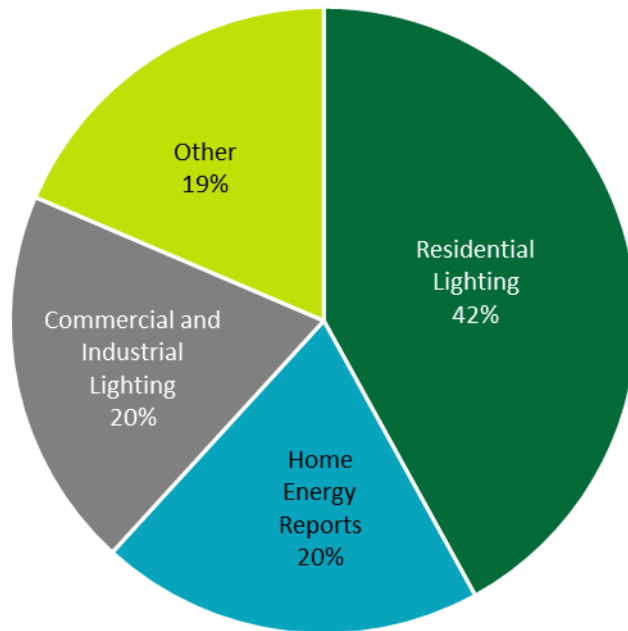
2.1 UPSTREAM LIGHTING

Residential upstream lighting is the single largest program offering among the EDCs, accounting for 34% of statewide PY8 verified gross energy savings statewide. But residential lighting accounts for an even larger share of statewide savings when non-upstream lighting, such as kits and direct install measures, is considered. Non-upstream residential lighting accounted for another 8% of statewide PY8 verified gross savings, and residential lighting programs overall equaled 42% of statewide PY8 verified gross savings (see [Table 9](#)). Only 19% of statewide savings occurred outside of residential lighting, non-residential lighting, and HERs (see [Figure 7](#)).

Table 9: PY8 Energy Savings, All Residential Lighting, and Three Top Offerings

EDC	PY8 Verified Gross (MWh/yr)	Upstream Lighting (MWh/yr)*	Non-upstream Lighting (Res) (MWh/yr)	All Residential Lighting (MWh/yr)	Percent of PY8 MWh from Big 3 + Non-upstream Res Lighting
PECO	210,689	72,123	12,216	84,339	86%
PPL	331,344	145,929	8,204	154,133	76%
Duquesne	69,593	35,496	1,898	37,394	87%
FE: Met-Ed	139,875	28,761	17,958	46,719	80%
FE: Penelec	132,449	37,706	20,143	57,849	83%
FE: Penn Power	37,130	7,346	5,351	12,697	81%
FE: West Penn	131,330	34,457	13,907	48,364	85%
Statewide	1,052,410	361,818	79,677	441,495	81%

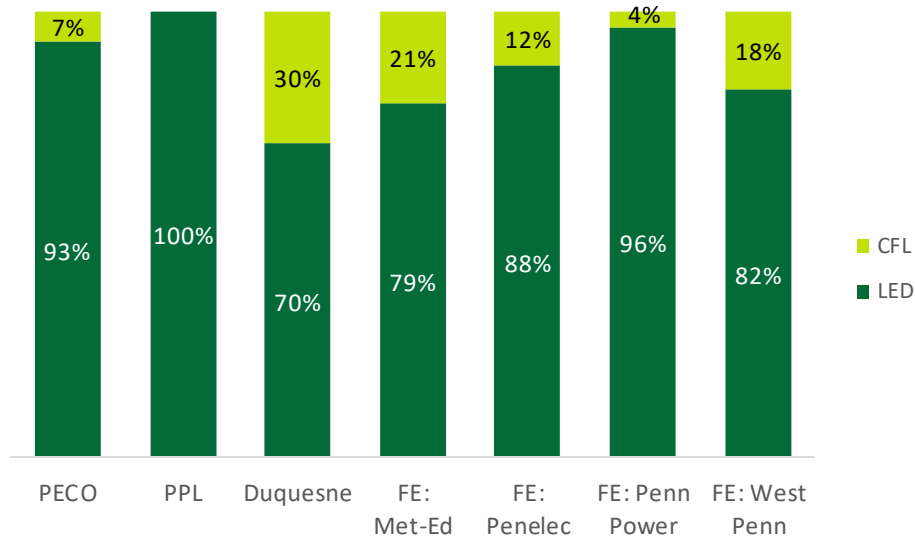
* The SWE notes that upstream lighting include savings from cross-sector sales (i.e., upstream lighting customers install in commercial settings).

Figure 7: Residential Lighting and Top Savings Programs in PY8

2.1.1 Upstream Lighting: Lighting Technologies and Sales Channels

Ninety percent of statewide PY8 upstream lighting products sold were LEDs, while only 10% were CFLs. [Figure 8](#) displays the distribution of lighting technologies by EDC. The proportion of PY8 LEDs ranged from 70% for Duquesne to 100% for PPL, which stopped supporting CFLs in PY5.

Figure 8: PY8 Upstream Lighting Technologies by EDC



PY8 continued the shift from CFLs to LEDs in the EDC's upstream programs ([Figure 9](#)). A sharp drop in LED prices (discussed in [Section 2.1.3](#)) helps explain the dramatic shift from 55% LED in PY7 to 90% in PY8.

Figure 9: PY5-PY8 Upstream Lighting Technologies

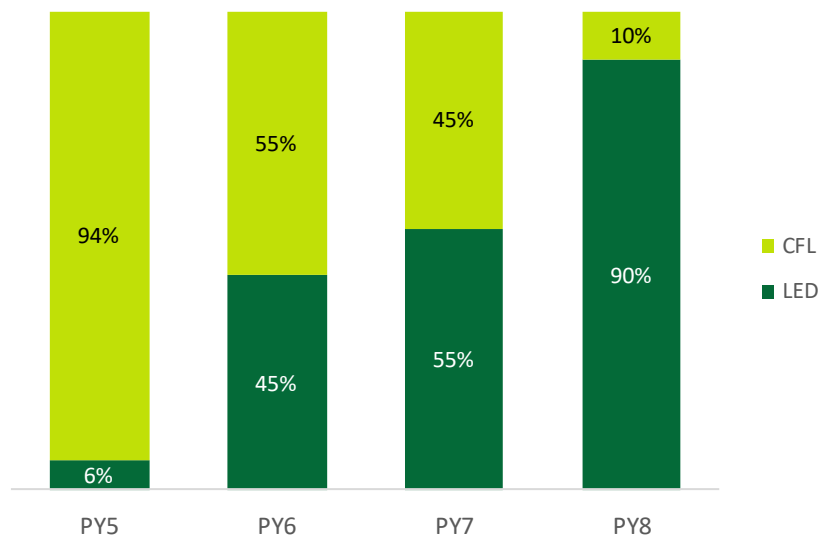
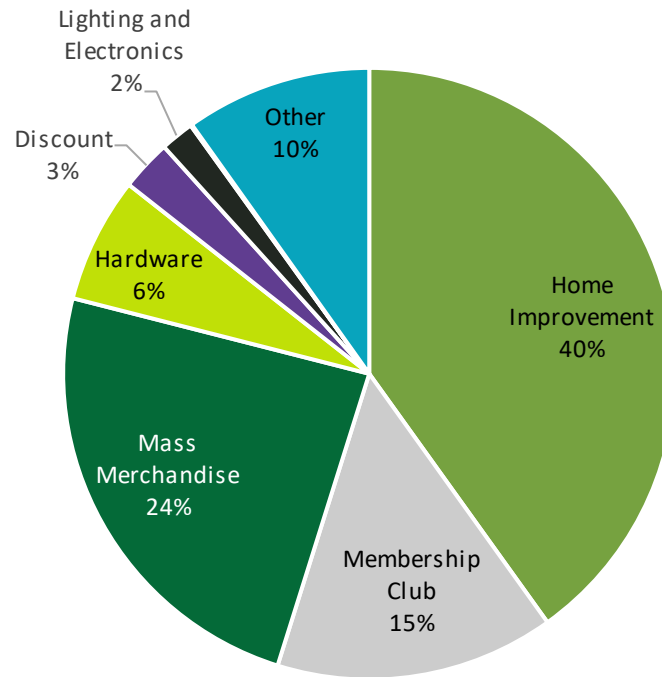
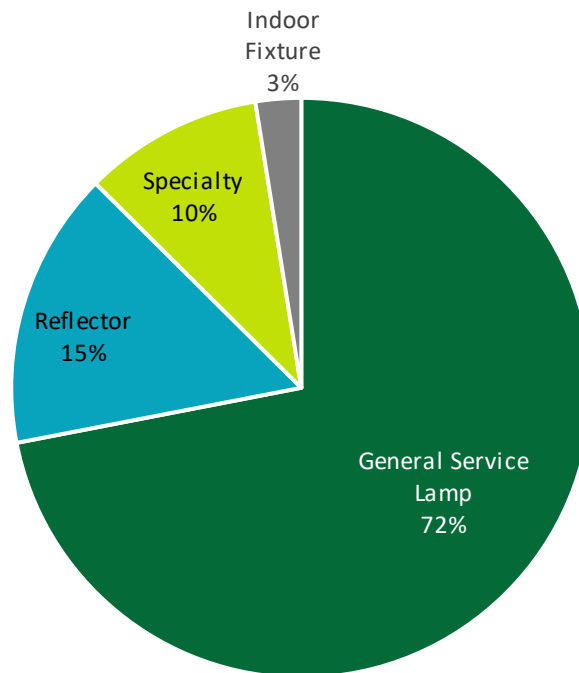


Figure 10 displays the distribution of statewide PY8 upstream lighting products by retail channel. Almost two-thirds (64%) of upstream lighting products were sold through home improvement and mass merchandise stores. Primary sales channels varied by EDC. See the Upstream Lighting & Cross-Sector Sales sections of the appendices for EDC-specific distributions of sales by retail channel.

Figure 10: PY8 Upstream Lighting Sales by Retail Channel



Nearly three-quarters (72%) of PY8 upstream lighting products were general service lamps, followed by reflectors (15%) and specialty bulbs (10%). Three percent of PY8 upstream lighting products were indoor fixtures (Figure 11).

Figure 11: PY8 Upstream Lighting Sales by Product Type

2.1.2 Cross-Sector Sales

Cross-sector sales rates represent the proportion of residential upstream program bulbs customers install in small commercial settings. Bulbs installed in commercial settings are subject to higher HOU, resulting in higher kWh and kW savings. Cross-sector sales rates determine the share of program savings and costs attributable to the small commercial class. PECO, PPL, and FirstEnergy conducted cross-sector sales research in PY8. The proportion of PY8 residential upstream light bulbs and fixtures estimated to have been installed in small commercial settings ranged from 1.5% for PECO to 10% for PPL. The FirstEnergy Companies were in between at 8.3%.²¹ (Table 10). Duquesne, which did not conduct cross-sector sales research in PY8, assumed the cross-sector sales rate of 0% estimated in PY7. The cross-sector sales rates of 0% (Duquesne) and 1.5% (PECO) are based on in-store intercept surveys, while the cross-sector sales rates of 8.3% (FirstEnergy) and 10% (PPL) are based on general population surveys. While FirstEnergy's survey targeted only residential customers, PPL administered one survey targeting residential customers and another targeting small commercial customers.

²¹ FirstEnergy applies the same cross-sector sales rate to each of its four PA companies.

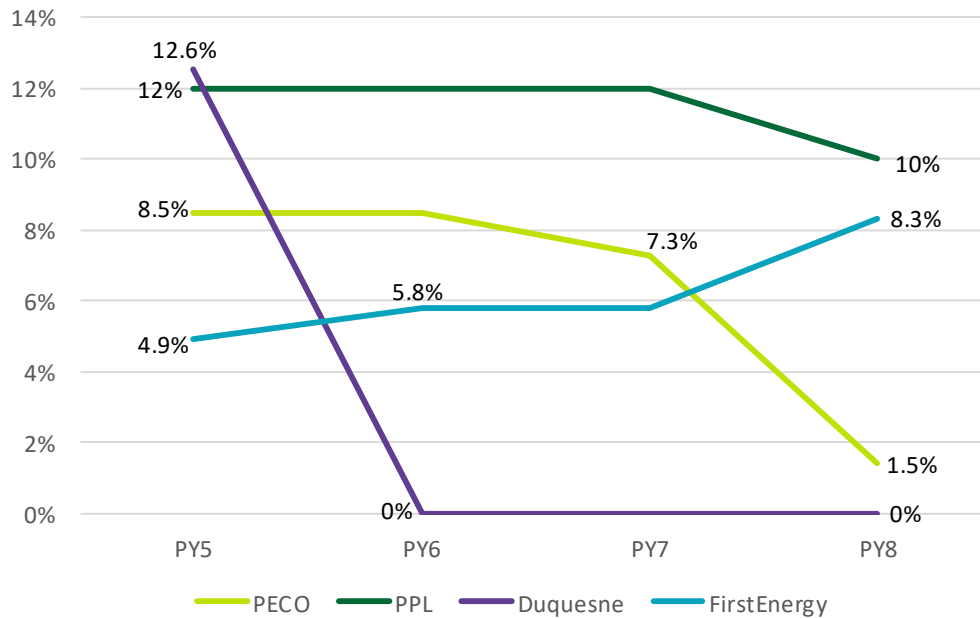
Table 10: PY8 Upstream Lighting Cross-Sector Sales Rates

EDC	Cross-Sector Sales Rate	Study Period	Method
PECO	1.5%*	PY8	in-store intercept survey
PPL	10%	PY8	general population surveys of residential and small business customers
Duquesne	0%	PY6 - PY7	in-store intercept survey
FE Companies	8.3%	PY8	general population survey of residential customers

* Respondent bulb weighted average of 0.73% for standard LEDs and 2.0% for specialty LEDs.

Figure 12 displays the cross-sector sales rates for each EDC from PY5 to PY8. The EDCs did not conduct primary cross-sector sales research for each program year in Figure 12, but tended to conduct primary research every other year and assume the same cross-sector rate for a two-year period.²² In addition, the EDCs consistently used the same research methods from PY5 to PY8: in-store intercept surveys for PECO and Duquesne, and telephone surveys for PPL and FirstEnergy. The 12% cross-sector sales rate applied to PPL's PY5 upstream lighting is the lower range of the PY4 point estimate of 17%. Similarly, the 12% rate applied to PPL's PY6 and PY7 upstream lighting is the lower range of the PY6 point estimate of 20%. As discussed in more detail in Appendix A, the SWE suspects that at least some of the differences in cross-sector sales rates are due to research method.

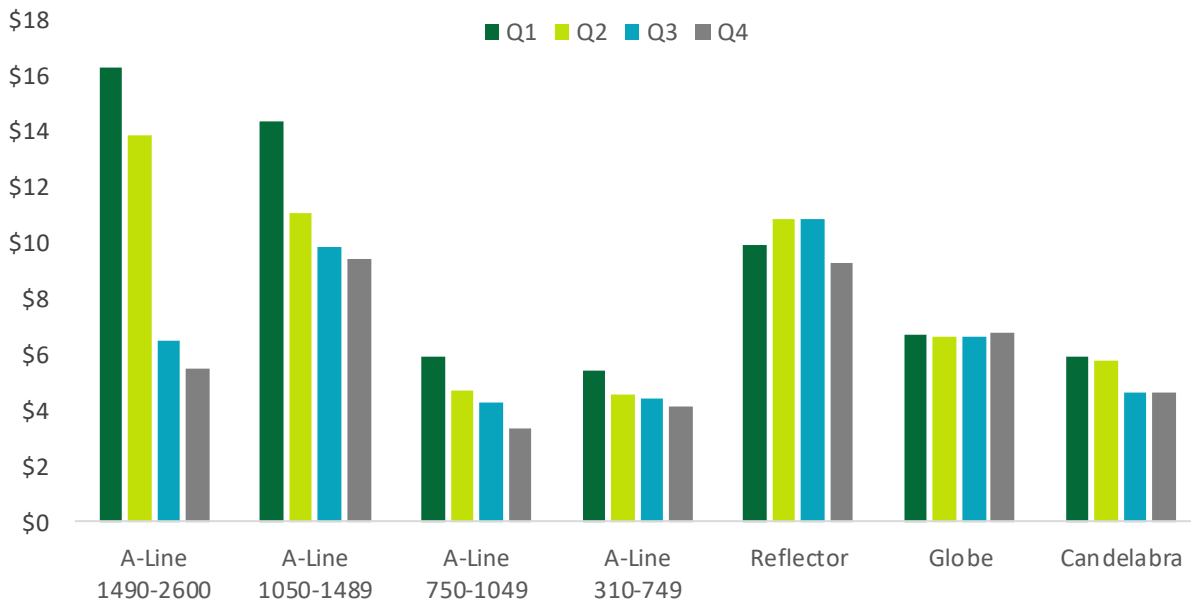
²² PECO and Duquesne conducted primary research on cross-sector sales in PY5 and PY7. PPL and FirstEnergy conducted primary research on cross-sector sales in PY6. PECO, PPL, and FirstEnergy conducted primary research on cross-sector sales in PY8.

Figure 12: Cross-Sector Sales Rates over Time

2.1.3 LED Price Trends, PY8

Figure 13 shows quarterly sales-weighted average manufactured suggested retail prices (MSRPs) by bulb types for EDCs that provided bulb price data.²³ The most dramatic price decrease was among A-line LEDs with 1490-2600 lumens (100W equivalents). Between Q1 and Q4, the average price of a 100W equivalent A-line LED declined from \$16.28 to \$5.44. A-line LEDs with 1050-1489 lumens (75W equivalents) also declined noticeably during PY8, from an average of \$14.36 in Q1 to \$9.39 in Q4. The quarterly sales-weighted average MSRP declined for most other bulb types during PY8, but not as significantly as for 100W and 75W equivalent A-lines.

²³ FirstEnergy did not provide MSRP data in PY8.

Figure 13: PY8 Quarterly LED Prices

Under Version 1.1 of the ENERGY STAR lamps specification, the required lifetime of LEDs was 25,000 hours. This created a large price gap between ENERGY STAR lamps and non-ENERGY STAR lamps, and a market opportunity for the program among value line bulbs. The SWE confirmed that approximately one-fifth of bulbs sold through the FirstEnergy EDCs' upstream programs were not ENERGY STAR certified.²⁴ In addition, the SWE was unable to verify approximately 2% of bulbs sold through the PECO, PPL, and Duquesne upstream programs as ENERGY STAR certified.²⁵ Effective January 2017, Version 2.0 of the ENERGY STAR specification lowered the rated lifetime requirement to 15,000 hours. TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Because Version 2.0 of the ENERGY STAR specification has significantly reduced the technical requirements (and associated cost) and only ENERGY STAR-qualified LEDs are eligible for consideration when using the 2016 TRM methodology, the EDCs should treat any savings from residential LEDs sold in PY9 and later program years that are not ENERGY STAR qualified as off-TRM.²⁶

²⁴ The SWE notes that the FirstEnergy EDCs began supporting exclusively ENERGY STAR qualified LEDs in PY9.

²⁵ The SWE did not conclusively rule out these products as ENERGY STAR qualified, nor confirm that PECO, PPL, and Duquesne included non-ENERGY STAR products in their PY8 upstream lighting programs. See Appendices B.4.1.1.1, C.4.1.1.1, and D.4.1.1.1 for details.

²⁶ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the eligibility requirements of the 2016 TRM will be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

2.1.4 EDC Upstream Lighting Incentive Levels, Sales Volume, and NTGR

The SWE compared the PY8 free-ridership rates with the incentive levels and found higher free-ridership rates for EDCs with lower upstream incentive levels. As shown in Table 11, PPL offered the largest average discount per bulb (60%) and the highest NTGR (0.83). Duquesne offered the second largest average discount per bulb (31%) and had the second highest NTGR (0.69).²⁷ PECO offered the third largest average discount per bulb (21%) and had the third highest NTGR (0.47). FirstEnergy (which has not yet provided the SWE with MSRP data) offered the second lowest average incentive per bulb (\$1.46) and had the lowest NTGR (0.33). Higher incentives generate more sales lift, which reduces free-ridership. The SWE notes that FirstEnergy included several value line LED²⁸ models in the PY8 program. These non-ENERGY STAR certified bulbs are generally less expensive, which helps explain the high sales-volume for FirstEnergy despite a relatively low incentive.

Table 11: Variation in LED Incentives and NTGR Across EDCs

EDC	MSRP	Discounted Price	Incentive	% Discount	PY8 LED Bulbs*	Bulbs / Household	NTGR (upstream lighting)
PECO	\$6.64	\$5.33	\$1.31	21%	1,135,289	0.9	0.47
PPL	\$5.42	\$2.35	\$3.08	60%	2,954,978	2.4	0.83
Duquesne	\$6.82	\$4.81	\$2.00	31%	567,012	1.1	0.69
FirstEnergy Companies	NA	NA	\$1.46	NA	2,388,383 **	1.5	0.33

* Bulb counts exclude low-income upstream and records with manufacturer incentives.

** Includes non-ES LEDs.

2.2 HOME ENERGY REPORTS

Over 1.1 million Pennsylvania homes received Home Energy Reports in PY8. This represents approximately 27% of the residential electric accounts served by the EDCs subject to Act 129. Table 12 summarizes the number of residential and PY8 HER recipients by EDC.

²⁷ Note that the Duquesne Light NTGR was estimated in PY7.

²⁸ Value line LED models are LEDs that have not been ENERGY STAR certified and typically have estimated lifetimes of 10,000 hours – which is below the ENERGY STAR requirement. Under Version 1.1 of the ENERGY STAR lamps specification, the required lifetime of LEDs was 25,000 hours. Effective January 2017, Version 2.0 of the ENERGY STAR specification lowered the rated lifetime requirement to 15,000 hours. ENERGY STAR certified LEDs are subject to specific energy efficiency and design requirements, have met quality and performance standards, have been tested by accredited labs and certified by a third party https://www.energystar.gov/products/lighting_fans/light_bulbs

Table 12: Statewide HER Summary Statistics

EDC	Residential Premises	PY8 HER Recipients	Percent of Homes Receiving HER
PECO	1,268,000	396,000	31%
PPL ²⁹	1,241,000	125,000	10%
Duquesne	536,000	80,000	15%
FE: Met-Ed	466,000	156,000	33%
FE: Penelec	454,000	165,000	36%
FE: Penn Power	135,000	28,000	21%
FE: West Penn	571,000	184,000	32%
Total	4,671,000	1,134,000	24%

In addition to the homes receiving HERs, many additional Pennsylvania homes are part of HER control groups. Home Energy Report programs are delivered using an experimental design known as a randomized control trial (RCT). In an RCT, eligible homes are randomly assigned into either a treatment or a control group. Random assignment ensures that the two groups use energy the same way prior to HER exposure. It also means that the only plausible explanation for observed differences in energy consumption following HER exposure is the program intervention.

Table 13 presents the average evaluated PY8 kWh savings per HER recipient, as well as the total electric usage (with HER savings added back) and percent reduction. Average percent savings ranged from 1% to 2% per household.

Table 13: HER Average Impacts by EDC

EDC	PY8 kWh Usage (HER Recipients)	Average PY8 kWh Savings per Recipient	Average Percent Reduction
PECO	13,996	163	1.2%
PPL	19,300	239	1.2%
Duquesne	10,194	103	1.0%
FE: Met-Ed	13,554	232	1.7%
FE: Penelec	9,788	153	1.5%
FE: Penn Power	13,364	271	2.0%
FE: West Penn	14,881	205	1.4%
Statewide Total	13,766	185	1.3%

Because of the RCT design, HER impact evaluations directly estimate verified net savings. No adjustments for free-ridership or spillover are needed because the control group does everything the treatment “would have done” absent program exposure.

²⁹ PPL participant totals do not include the approximately 90,000 households in two low-income cohorts that began receiving HERs in the final month of PY8.

2.2.1 HER Contribution to Low-Income Targets

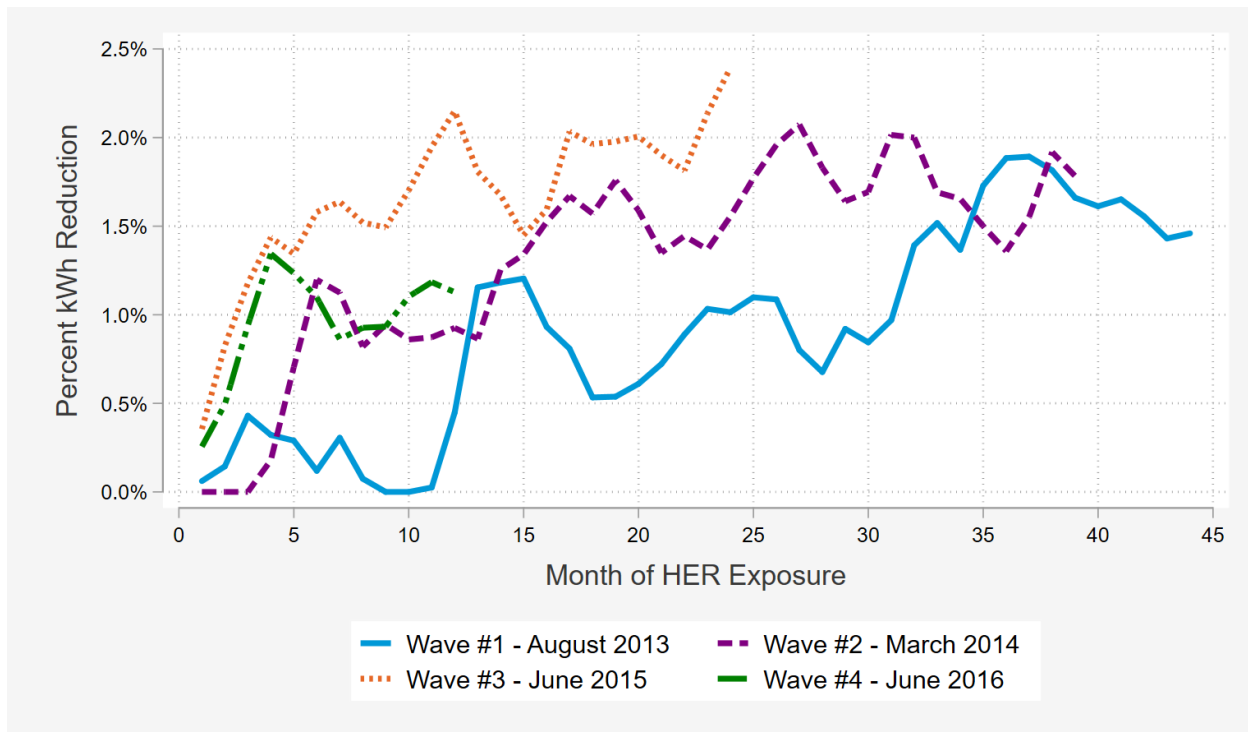
Five of the seven EDCs use Home Energy Reports mailed to known low-income households to achieve energy savings towards their low-income compliance target. PECO is the only EDC who did not have one or more cohorts of low-income households in PY8. PPL began PY8 with no low-income cohorts, but in May 2017, began mailing HERs to two cohorts of low-income households that were active in Phase II. However, PPL did not claim the 523 MWh of savings achieved by these cohorts toward the low-income target. [Table 14](#) shows the PY8 verified gross low-income savings for each EDC and how much of the energy savings came from HER programs.

Table 14: Contribution Towards LI Targets from Home Energy Reports

EDC	PYVTD Low-Income MWh	PYVTD Low-Income MWh from Home Energy Reports	Percent of PY8 LI Savings from HER
PECO	17,174	0	0.0%
PPL	11,655	0	0.0%
Duquesne	1,240	1,107	89.3%
FE: Met-Ed	10,069	4,041	40.1%
FE: Penelec	12,039	4,273	35.5%
FE: Penn Power	3,190	801	25.1%
FE: West Penn	10,344	3,680	35.6%
Statewide Total	65,711	13,902	21.2%

2.2.2 Duration of Exposure

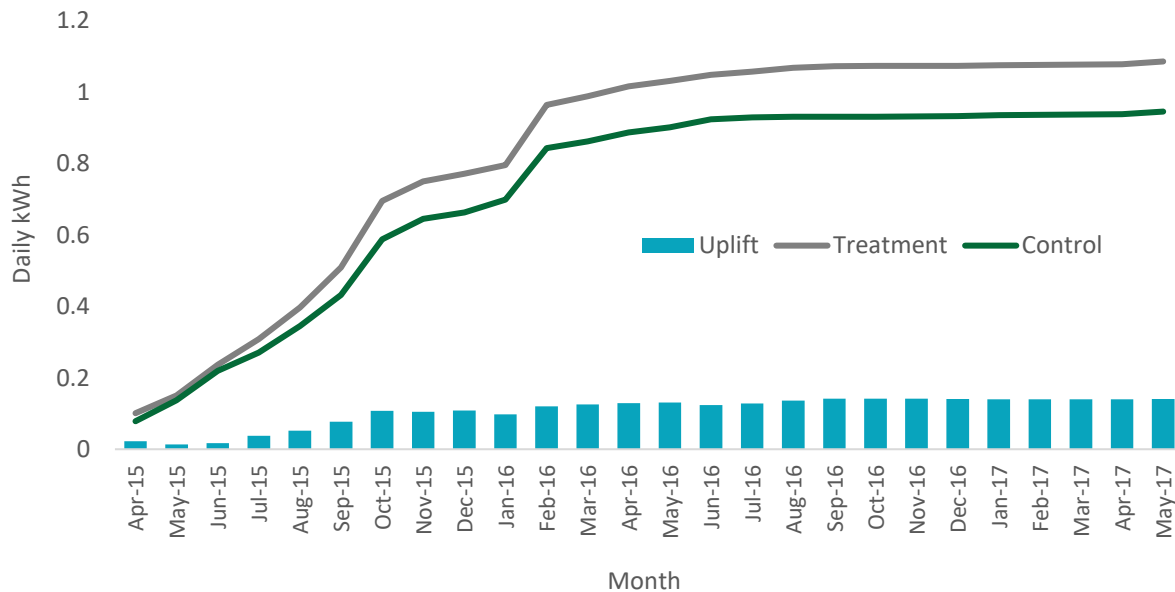
There was a clear relationship in PY8 between the average savings per recipient and how long the home had been receiving HERs. The average savings per home consistently grew over time. [Figure 14](#) shows average monthly savings on a percent basis for the four RCT waves of PECO's Behavioral Solution. Homes in Wave 1 have been receiving HERs for close to four years, while the homes in Wave 4 received their first HER in June 2016. Although the trend is noisy, there is a definite upward trajectory as the length of exposure increases.

Figure 14: Percent Impacts Over Time - PECO

Based on this relationship – which has been observed across all Pennsylvania EDCs and in numerous other jurisdictions – the SWE expects HER savings to increase in subsequent program years. While PECO’s Wave 4 (which includes over 200,000 treatment group homes) showed average savings of just 0.84% in PY8, we expect the measured savings to exceed 1% in PY9 and beyond as the HER exposure matures.

2.2.3 Uplift in Other EE&C Programs

One of the attractive features of Home Energy Reports is that they provide EDCs with a platform to promote other program offerings. This marketing message can be particularly effective because it is coupled with the increased awareness of energy consumption and motivation to conserve triggered by the HER. Studies have consistently shown that treatment group homes participate in other energy efficiency programs at a higher rate than control group homes. While this “uplift” is a net positive for EDCs, it could potentially lead to double-counting of savings if the savings uplift is not subtracted either from the regression-based HER impact estimates or from the program that originally recorded the impacts. The Evaluation Framework provided EDC evaluation contractors with a standard process to deduct the savings from incremental EE participation in the treatment group. [Figure 15](#) illustrates the calculation for Duquesne Light’s 2015 Market Rate (non-LI) wave.

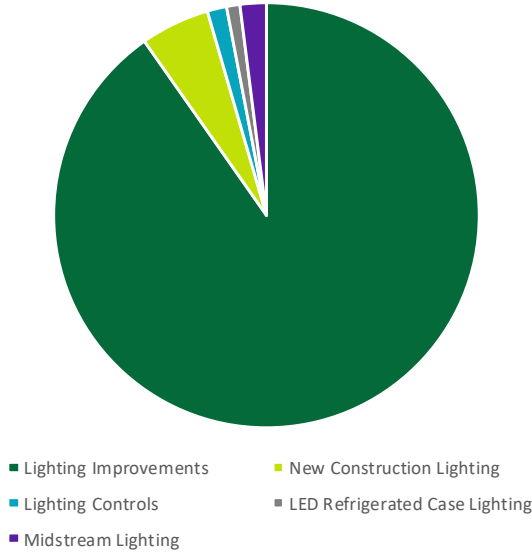
Figure 15: Dual Participation Adjustment – Duquesne 2015 Residential Wave

The two lines in [Figure 15](#) show the average daily kWh savings from EE measures installed through Duquesne EE&C programs in the treatment group and control group. Over time, the treatment group homes adopt more EE measures than the control group. The difference between the two groups (the bars labeled “uplift”) is subtracted from the HER impact estimates because those incremental savings were already counted by other EE&C programs. On average, most HER waves saw their savings reduced by 5%-10% to prevent double-counting from overlapping participation. Although the other EE&C program gets the “credit” for these savings, the increased awareness of energy consumption and program opportunities to save energy created by the HER programs are a key driver of these energy savings.

2.3 NON-RESIDENTIAL LIGHTING

Non-residential lighting accounted for 20% of statewide PY8 energy savings, accruing savings from 13,534 discrete projects.³⁰ The 2016 TRM provides seven different available non-residential lighting measures. Lighting savings can also be achieved off-TRM through custom and midstream program offerings. The statewide contributions of each measure offering to the total lighting savings are detailed in [Figure 16](#).

³⁰ Excludes midstream lighting, which is reported by bulb distributed, not by project.

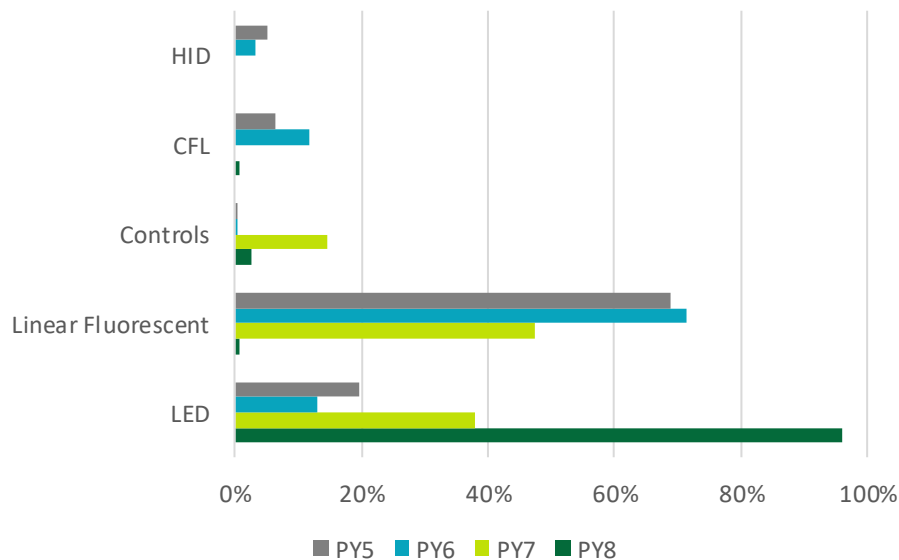
Figure 16: Energy Savings by Lighting Project Type

Measure	Energy Savings Contribution
3.1.1 Lighting Improvements	90%
3.1.2 New Construction Lighting	5%
3.1.3 Lighting Controls	1%
3.1.4 Traffic Lights	0%
3.1.5 LED Exit Signs	<1%
3.1.6 LED Channel Signage	<1%
3.1.7 LED Refrigerated Case Lighting	1%
Custom Lighting	<1%
Midstream Lighting	2%

2.3.1 Lighting Improvements

While a small share of savings came from lighting controls projects, lighting equipment continues to contribute the majority of the total lighting savings. PY8 saw a shift in rebated lighting equipment away from fluorescents towards LED technology. As an example, [Figure 17](#) shows the energy savings contributions from known³¹ lighting technologies over the past four years from Duquesne Light.

³¹ Lighting technology cannot be discerned from many tracking data line items, such as new construction lighting, which is rebated on a whole-building level, or items listed by bulb shape or application rather than technology (e.g. "PAR Lamp", "high-bay lighting").

Figure 17: PY5 through PY8 Energy Savings by Lighting Technology

The shift in technologies was noted in both linear applications, where T8s previously dominated energy savings, and non-linear applications, where CFLs previously contributed the majority of the savings. The move away from compact and linear fluorescents towards LEDs stems from two market and energy efficiency program changes:

- Changing of the Linear Fluorescent Baseline:** The Energy Policy Act of 2005 (“EPACT 2005”) and Energy Independence and Security Act (“EISA”) 2007 standards introduced new efficacy standards for linear fluorescent bulbs and ballasts, effectively phasing out magnetic ballasts (effective October 1, 2010) and most T-12 bulbs (effective July 14, 2012). To accommodate this shift in equipment availability, the 2016 TRM set standard T-8s as the baseline for all T-12 linear fluorescent retrofits beginning June 1, 2016. This results in no savings for the installation of any standard T-8 lamps.
- Decreases in LED equipment costs:** The SWE completed an analysis of LED market prices to update the Incremental Cost Database. The analysis revealed a steady and significant decline in LED costs over the past few years, even within PY8. More details on the analysis and results can be found in [Section 4.9.1](#).

2.3.2 New Construction Lighting

Through TRM Measure 3.1.2, new construction lighting incentives are provided to encourage decision-makers in new construction projects to incorporate greater energy efficiency into their building design and construction practices that will result in a permanent reduction in electrical (kWh) usage above baseline practices. New construction lighting requires applicants to calculate the lighting power density (LPD), or lighting wattage per square foot of building, of their facility. The energy savings are calculated as the difference in the installed LPD and the code allowable maximum LPD for the specified building type and size.

Participation in measure 3.1.2 was low in PY8, with only 69 completed projects across all seven EDCs. Yet, per-project energy savings for new construction projects are more than ten times greater than that of retrofit lighting projects. [Table 15](#) provides a comparison of participation and energy saving between retrofit and new construction lighting projects.

Table 15: Per-Project Energy Savings

Project Type	Percent Participation	Average Per Project Energy Savings
New Construction	<1%	169,745 kWh
Retrofit	>99%	15,187 kWh

While the most current version of the International Building Code (IBC) is dated 2015, Pennsylvania's "Uniform Construction Code" mimics IBC 2009. With the lag in construction code uptake, it is expected that much new construction in Pennsylvania is likely more efficient than Pennsylvania's current code minimum. In PY9, the SWE and the EDCs should work to understand the market barriers to participation in the new construction measure.

2.3.3 Midstream Lighting

In PY8, two EDCs offered a midstream lighting program, through which EDCs directly engage commercial lighting suppliers to increase the adoption of energy efficient lighting technologies. The goal of this delivery channel is to provide incentives to encourage distributors to stock, promote, and sell higher efficiency lighting. Program eligible lighting only includes products that appear on either the Design Lights Consortium (DLC) or ENERGY STAR® qualified products lists. Evaluation guidelines for the program are detailed in the *Lighting Improvements for Midstream IMP* (approved Aug 24, 2016).

Midstream projects tended to provide less savings than their downstream counterparts, averaging only 4,000 kWh per project (compared to 8,000 kWh per downstream project). Energy savings contribution results from the two EDCs offering midstream lighting programs are presented in [Table 16](#).

Table 16: Lighting Energy Savings Contributions[†] by Program Type

Program Type	Duquesne	PPL	Combined
Midstream	13%	3%	5%
Downstream	87%	97%	95%

[†]Contributions are based on reported savings as PPL's midstream lighting program savings are unverified for PY8.

As is expected with new offerings, EDC program management took some time to stabilize, and participation remained relatively low, leading to an inflated acquisition cost in the infancy of the program. In addition, PPL experienced a high leakage rate to neighboring service areas for one

project in the evaluation sample. This was treated as one-off case in PY8, but PPL was directed to improve leakage control procedures in future program years. The SWE will review the leakage study results and make further recommendations on the midstream initiatives in PY9.

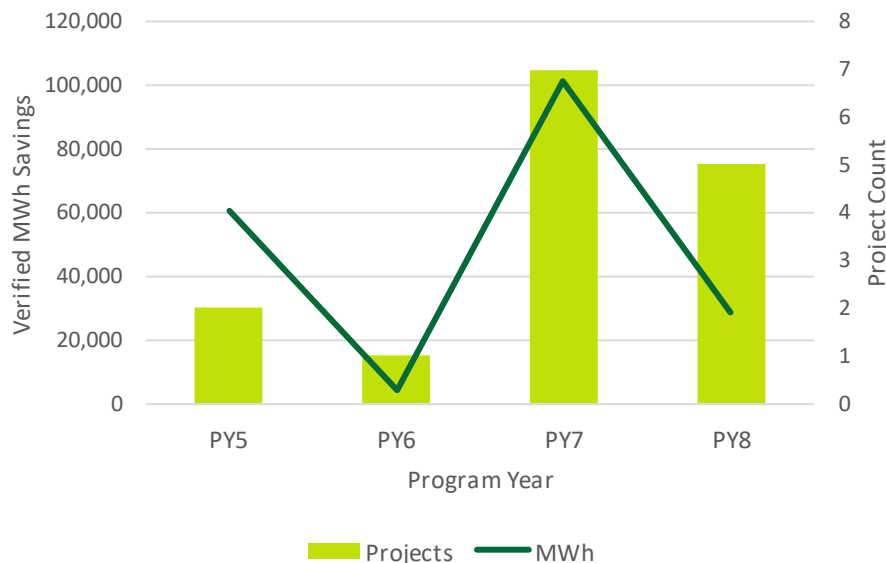
While there is work to be done in fine-tuning the midstream lighting program offerings, the program delivery method is expected to make positive impacts on sales and installations of efficient lighting products by reducing administrative constraints and making purchasing discounted lighting more attractive to a wider variety of customers. In addition to current offerings by PPL and Duquesne, PECO is expected to offer a midstream lighting program in PY9 and beyond. The SWE expects significant non-residential savings will shift from downstream lighting programs to midstream programs in later program years.

2.4 COMBINED HEAT AND POWER

While not a top offering in PY8, Combined Heat and Power (CHP) projects accounted for just under 3% of the statewide gross verified savings. CHP contributions have been inconsistent over the past four program years, but are expected to increase significantly with many known large projects in the pipeline for Phase III.

Figure 18 shows the energy savings contributions from known CHP projects over the past four years. Note that CHP is a fuel switching measure and should be reported as such by the EDCs in their annual reports. PPL reported CHP as part of their custom program and did not call it out as a fuel switching measure. As such, PPL's PY5 through PY7 CHP contributions could not be discerned from their reporting and have been excluded from the following figure.

Figure 18: Historical Combined Heat and Power Savings



The PUC has made a commitment to advancing the prevalence of CHP by signing on to the U.S. Department of Energy's Better Buildings Combined Heat and Power Resiliency Partnership, whose stated purpose is "to examine the perceptions and technology gaps of CHP among

resiliency planners, and support the development of plans for communities to increase the adoption of CHP as a reliable, high efficiency, lower emissions electricity and thermal energy source for critical infrastructure.” Additionally, the PUC released a Proposed Policy Statement on Combined Heat and Power in February of 2016, designed to promote CHP investments throughout Pennsylvania. The increased interest in CHP has been reflected in the EDC’s Phase III EE&C plans. As an example, PECO’s Phase III EE&C Plan details that they expect to contribute 363,535 MWh to Phase III energy savings from CHP projects alone, which is 18% of their planned Phase III savings.

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, and TRC benefit-cost ratios for each EDC.

3.1 PECO

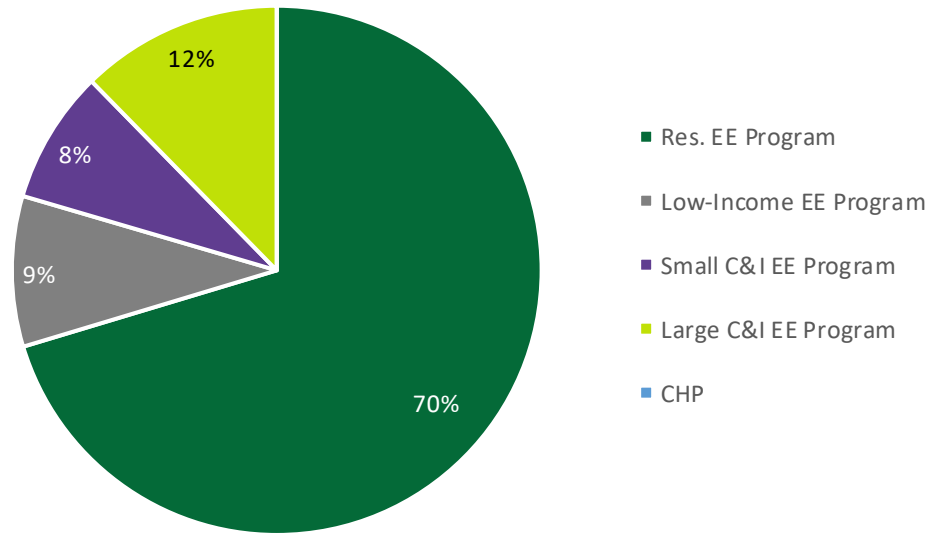
3.1.1 Impact Evaluation

A summary of energy impacts by program through PY8 is presented in [Table 17](#). The bulk of savings (70%) is attributable to the Residential EE Program, which is an umbrella program containing solutions for lighting, appliances, and HVAC; appliance recycling; whole home; new construction; multifamily; and behavioral adjustment (see [Figure 19](#)). The program is designed to give customers the option to save electricity across all residential end-uses. Given this comprehensive approach, the program has a much wider reach and higher participation than other programs in the portfolio.

Table 17: Incremental Annual Energy Savings by Program (MWh/Year)*

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Res. EE Program	147,919	1.00	148,202	0.70	103,993
LI EE Program	19,865	0.98	19,385	1.0	19,385
Small C&I EE Program	17,783	0.96	17,137	0.75	12,804
Large C&I EE Program	25,966	1.00	25,966	0.64	16,625
CHP	-	N/A	-	N/A	-
Portfolio Total	211,532	1.00	210,689	0.73	152,808

* PYVTD Gross and Net for the Res EE Program have been adjusted to correct for errors in PECO's Home Energy Report savings totals. Res LI EE PYVTD Net is reported by the SWE as being equal to PYVTD Gross, assuming a NTG of 1.0.

Figure 19: Percent of Portfolio PY8VTD Gross Savings, by Program – PECO

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 18](#).

Table 18: Peak Demand Savings by Energy Efficiency Program (MW/Year)*

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Res. EE Program	11.7	1.68	19.7	0.67	13.2
LI EE Program	2.2	0.97	2.2	1.00	2.2
Small C&I EE Program	2.9	0.94	2.8	0.71	2.0
Large C&I EE Program	3.9	1.01	3.9	0.64	2.5
CHP	-	N/A	-	N/A	-
Portfolio Total	20.8	1.38	28.6	0.70	19.9

* PYVTD Gross and Net for the Res EE Program have been adjusted to correct for errors in PECO's Home Energy Report savings totals. Res LI EE PYVTD Net is reported by the SWE as being equal to PYVTD Gross, assuming a NTG of 1.0

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 19](#) shows the TRC ratios by program and for the

portfolio. The benefits in Table 19 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 19: PY8 Gross TRC Ratios by Program (\$1,000)*

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
Residential EE	\$48,290	\$26,830	1.80	\$21,460
Low-Income EE	\$6,310	\$7,605	0.83	-\$1,295
Residential DR	\$0	\$3,201	0	-\$3,201
Residential Total	\$54,600	\$37,636	1.45	\$16,964
Small C&I EE	\$8,485	\$7,805	1.09	\$680
Large C&I EE	\$12,450	\$12,611	0.99	-\$161
CHP	\$0	\$15	0.00	-\$15
Small C&I DR	\$0	\$75	0.00	-\$75
Large C&I DR	\$0	\$1,742	0.00	-\$1,742
Non-Residential Subtotal	\$20,935	\$22,248	0.94	-\$1,313
Cross-Cutting	\$0	\$8,952	0.00	-\$8,952
Portfolio Total	\$75,535	\$68,836	1.10	\$6,699

* The TRC benefits and TRC ratios have been adjusted to correct for errors in PECO's Home Energy Report savings totals, and TRC costs have been corrected for a reporting error in the PECO PY8 Annual Report. PECO will be filing a revised PY8 report with corrections by February 28, 2018.

3.1.3 Process Evaluation

Navigant reported on PY8 process evaluations for the following PECO programs and program solutions.

Table 20: PY8 Process Evaluations Conducted for Program Solutions*

Programs and Program Solutions	
Residential EE Program³²	Low-Income EE Program
Lighting, Appliances, & HVAC Solution	Whole Home Solution
Appliance Recycling Solution	Lighting Solution
Multifamily Targeted Market Segment Solution ³³	
Small C&I EE Program³⁴	Large C&I EE Program³⁵
Equipment and Systems Solution	Equipment and Systems Solution
New Construction Solution	New Construction Solution
Whole Building Solution	Multifamily Targeted Market Segment ³³
Multifamily Targeted Market Segment ³³	

* Navigant did not conduct a PY8 process evaluation for the following programs as they had no participation in PY8: Residential Demand Response, Combined Heat & Power, Small C&I Demand Response, and Large C&I Demand Response programs.

For PY8, Navigant evaluated and reported on a total of 13 program solutions within the PECO residential, low-income, and C&I programs.³³ From these evaluations, it produced a total of 29 process evaluation findings, which resulted in 25 recommendations, 21 of which were accepted and four are under consideration. A key cross-program finding was program satisfaction from participant surveys, which were conducted for two residential program solutions, one low-income program solution, and the Multifamily Targeted Segment. On average, across these participant surveys, 89% of residential and low-income participants and 83% of C&I participants were satisfied with the programs overall.³⁶

For the *PECO Residential EE program*, the PY8 process evaluation provided a total of 17 findings and 17 recommendations. Four of the recommendations were cross-cutting for all residential programs, and 13 were for the Lighting, Appliances, & HVAC Solution and the Appliance Recycling Solution. All four cross-cutting recommendations were accepted. For the individual residential program solutions, 11 of the 13 recommendations were accepted and two are under

³² Navigant did not conduct a process evaluation for the Residential New Construction Solution, the Residential Whole Home Solution, or the Residential Demand Response program in PY8. For the Residential Behavior Solution, Navigant is in the process of conducting a survey of participants and will provide those results in a follow-up memo.

³³ The evaluation of the Multifamily Targeted Market Segment was a single evaluation across residential and small and large C&I programs.

³⁴ The Small C&I Behavioral Solution was not implemented in PY8 and the Small C&I Data Centers Targeted Market Segment had no participation in PY8. Thus, these program components had no PY8 evaluation activities for the SWE to review.

³⁵ The Large C&I Data Centers Targeted Market Segment had no participation in PY8 and, therefore, had no PY8 evaluation activities for the SWE to review.

³⁶ Weighted by the number of PY8 participants in each solution. Residential and low-income participants include tenant survey responses from Multifamily Targeted Market Segment. C&I participant survey responses based on landlord survey responses from Multifamily Targeted Market Segment.

consideration. A key cross-program finding was program satisfaction from participant surveys, which were conducted for the Appliances & HVAC components of the residential Lighting, Appliances, & HVAC Solution, and for the residential Appliance Recycling Solution. On average, for both these solutions, 90% of the participants were satisfied with the programs overall.³⁷ Solution-specific findings for these residential program solutions addressed a broad range of topics, including the following:³⁸

- Primary sources of program information
- Strengths and weaknesses in program outreach
- Uptake of efficient lighting
- Drivers and barriers of program success
- Barriers to program delivery
- Customer or trade ally perceptions of incentive amounts or processing time
- Assessment of availability of trained trade allies
- Program paperwork requirements
- Participant recall of program offerings or recommendations

For the PECO *Low-Income EE program*, the PY8 process evaluation provided a total of six findings and six recommendations. Three of the recommendations were for the Lighting Solution and three were for the Whole Home Solution. All of the recommendations were accepted. A key cross-program finding was program satisfaction from participant surveys, which were conducted for the Home Energy Check Up and Free CFL Bulbs components of the Whole Home Solution. On average, for both these components, 90% of the participants were satisfied with the program overall. Solution-specific findings for the Low-Income Lighting and Whole Home solutions addressed two topics: strengths and weaknesses in program outreach, and drivers and barriers of program success.

For the PECO *Multifamily Targeted Market Segment*, the PY8 process evaluation provided one finding and two recommendations, both of which are under consideration. A key cross-program finding was program satisfaction from participant surveys, which included both tenants and landlords. On average, for both participant groups, 83% of the participants were satisfied with the program overall. Solution-specific findings addressed three topics: drivers and barriers of program success, barriers to program delivery, and assessment of availability of trained trade allies.

For the PECO *Small and Large C&I EE programs*, the PY8 process evaluation provided a total of six findings and two recommendations. Both recommendations were for the *Multifamily Targeted Market Segment* mentioned above. There were no findings regarding program satisfaction, particularly because participant surveys were not conducted for the PY8 process evaluation. As

³⁷ Weighted by the number of PY8 participants in each solution.

³⁸ The PECO annual report provides further detail regarding these topics.

noted earlier, the only solution-specific findings were for the *Multifamily Targeted Market Segment*, which was mentioned in the preceding paragraph.

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 PY8 Annual Report and the supporting detail provided by PECO's evaluation contractor. The detailed audit findings can be found in [Appendix B](#).

- The SWE identified three issues with the PY8 HER analysis. (1) Peak demand impacts were not calculated, (2) The coding of the post-period was misaligned with the calculation of aggregate impacts for Wave 4, and (3) Weights were applied incorrectly for the matched control group of the AC Saver wave. The SWE worked with Navigant to remedy these issues and the impacts in this report reflect corrected totals.
- The SWE notes that the TRC model does not include any benefits from fossil fuel and/or water savings. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio.
- The SWE's review of verified savings for non-HER residential solutions found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix B](#) with recommendations for improvement.
- Adequate numbers of project files were submitted for the residential solutions in PY8 and were generally accurate. The SWE notes that the project files could not be matched to the tracking database in a number of cases and in a small number of cases (three), there were discrepancies between the project files and tracking data.
- Overall, Navigant estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, for one solution, Navigant appeared to ignore evidence of spillover (SO) due to incomplete data to estimate SO. The SWE recommends that Navigant make extra effort to collect the data needed to estimate spillover in future NTG evaluations.
- In general, for all the process evaluations, the SWE determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a description of whether PECO was implementing or considering those recommendations. The report included sufficient detail to assess the methods, findings, and recommendations. The evaluation methods were largely consistent with those described in the Phase III Evaluation Plan. Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings. Below is the SWE's sole notable comment regarding the process evaluation.

- Process Evaluation of Residential Programs: Lighting, Appliances, & HVAC Solution. There were no references to the statistical test(s) used to assess the significance of differences reported between PY8 and prior program years. It would have been useful to know, for example, whether the proportion of respondents aware that PECO provided LED store discounts was statistically significantly different from PY7 to PY8. The reporting could have benefitted from this additional level of detail.

3.2 PPL

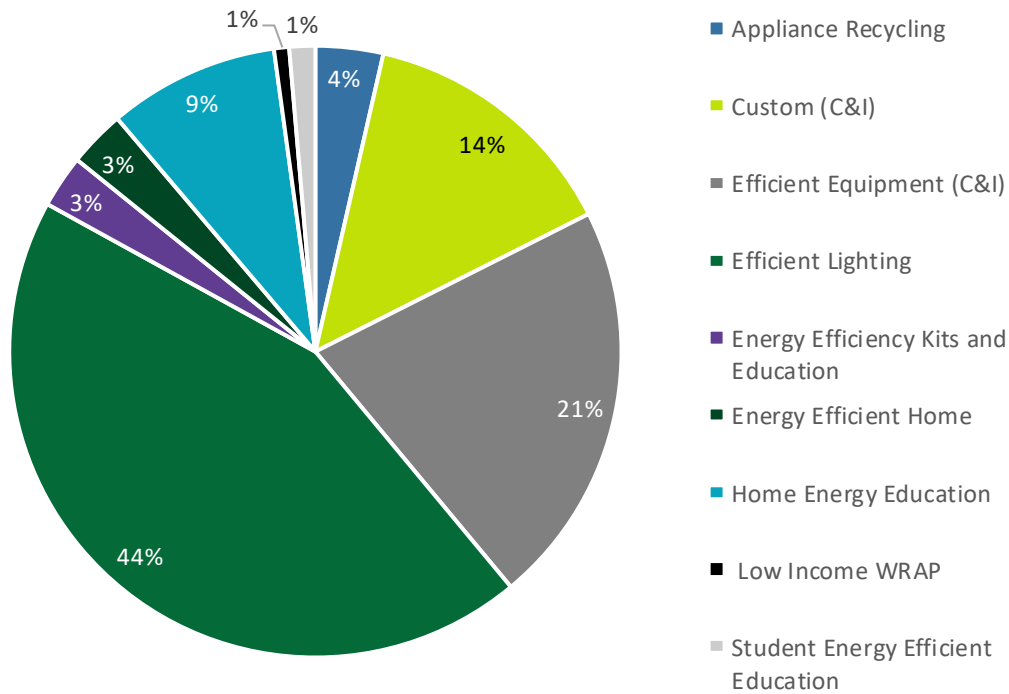
3.2.1 Impact Evaluation

A summary of energy impacts by program through PY8 is presented in [Table 21](#). The largest portion of savings (44%) is attributable to the Efficient Lighting Program, an upstream program that provides incentives to retailers to discount the prices of LED bulbs sold at local retail stores, followed by the Efficient Equipment and Custom programs (see also [Figure 20](#)).

Table 21: Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTGR	PYVTD Net (MWh/yr)
Appliance Recycling	12,035	0.98	11,844	0.66	7,770
Custom (C&I)	71,332	1.00	46,368	0.79	36,631
Efficient Equipment (C&I)	76,169	0.96	70,917	0.77	54,643
Efficient Lighting	150,376	0.97	145,929	0.83	121,121
EE Kits and Education	10,420	0.88	9,219	1.00	9,219
EE Home	10,621	0.94	9,943	0.66	6,736
Home Energy Education	40,467	0.74	29,931	1.00	29,931
LI WRAP	3,491	0.76	2,652	1.00	2,652
SEEE	5,118	0.89	4,539	1.00	4,539
Portfolio Total	380,028	0.94*	331,344	0.83	277,638

* The realization rate was calculated by removing 27,432 MWh of PY8 unverified gross savings from PYRTD.

Figure 20: Percent of Portfolio PY8VTD Gross Savings, by Program - PPL

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 22](#).

Table 22: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTGR	PYVTD Net (MW/yr)
Appliance Recycling	1.7	0.99	1.6	0.60	1.07
Custom (C&I)	9.0	0.83	5.3	0.79	4.19
Efficient Equipment (C&I)	10.2	1.02	9.9	0.77	7.60
Efficient Lighting	22.2	0.89	19.8	0.83	16.45
EE Kits and Education	0.8	1.18	0.9	1.0	0.88
EE Home	2.0	0.92	1.8	0.68	1.16
Home Energy Education	54.4	0.12	6.8	1.00	6.75
LI WRAP	0.3	0.86	0.3	1.00	0
SEEE	0.5	1.06	0.5	1.0	0.49
Portfolio Total	100.8	0.46	46.8	0.83	39.0

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 23 shows the TRC ratios by program and for the portfolio. The benefits in Table 23 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 23: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Appliance Recycling	\$4,032	\$1,945	2.07	\$2,087
Efficient Lighting	\$73,711	\$14,787	4.98	\$58,924
EE Kits & Education	\$2,380	\$1,894	1.26	\$485
EE Home	\$6,176	\$12,315	0.5	-\$6,139
Home Energy Education	\$1,611	\$845	1.91	\$766
LI WRAP	\$899	\$4,012	0.22	-\$3,113
SEEE	\$1,765	\$905	1.95	\$860
Residential (Including LI) Subtotal	\$90,574	\$36,703	2.47	\$53,871
Custom	\$25,904	\$26,245	0.99	-\$341
Efficient Equipment	\$43,822	\$25,234	1.74	\$18,587
Non-Residential Subtotal	\$69,725	\$51,479	1.35	\$18,246
Common Portfolio Costs	-	\$7,622	-	-\$7,622
Portfolio Total	\$160,299	\$95,804	1.67	\$64,495

3.2.3 Process Evaluation

Cadmus reported on PY8 process evaluations for the following PPL programs.

Table 24: PY8 Process Evaluations

Residential and C&I Programs ³⁹	
Residential Programs	Residential Low-Income Programs
Appliance Recycling	Weatherization Relief Assistance (WRAP)
Energy Efficient Home	Energy efficiency Kits and Education
Home Energy Education	C&I Programs
Student Energy Efficient Education	Efficient Equipment
Efficient Lighting	Custom

For PY8, Cadmus evaluated and reported on a total of nine programs within the PPL residential, low-income, and C&I sectors. From these evaluations, it produced a total of 29 process evaluation findings, which resulted in 18 recommendations, seven of which were accepted and 11 are under consideration. A key cross-program finding was program satisfaction from participant surveys, which were conducted for all programs. On average, across all participant surveys, 87% of residential and low-income participants and 97% of C&I participants were satisfied with the programs or program measures overall.⁴⁰

For the *PPL Residential programs*, the PY8 process evaluation provided a total of 16 findings and eight recommendations. Two of the recommendations were accepted and six are under consideration. A key cross-program finding was program satisfaction from participant surveys. On average, across all five residential program solutions, 86% of the participants were satisfied with the programs or program measures overall.⁴⁰ Program-specific findings for these residential program solutions addressed a broad range of topics, including the following:⁴¹

- Primary sources of program information
- Program efforts to promote program success
- Strengths and weaknesses in program outreach
- Uptake of efficient lighting
- Drivers and barriers of program success
- Program paperwork requirements

For the *PPL Residential Low-Income programs*, the PY8 process evaluation provided a total of five findings and five recommendations. Four of the recommendations were accepted and one is under consideration. A key cross-program finding was program satisfaction from participant

³⁹ PPL also has a Demand Response program. However, no curtailment events occurred in PY8.

⁴⁰ Weighted by the number of PY8 participants in each program.

⁴¹ The PPL annual report provides further detail regarding these topics.

surveys. On average, across both the WRAP and Kits programs, 96% of the participants were satisfied with the program overall.⁴⁰ Program-specific findings for the low-income programs addressed three topics: strengths and weaknesses in program outreach, uptake of efficient lighting, and drivers and barriers of program success.

For the PPL C&I programs, the PY8 process evaluation provided a total of eight findings and five recommendations. One recommendation was accepted and four are under consideration. A key cross-program finding was program satisfaction from participant surveys. On average, across both the Efficient Equipment and Custom programs, 97% of the participants were satisfied with the program overall.⁴⁰ Program-specific findings for the C&I programs primarily addressed drivers and barriers of program success.

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 PY8 Annual Report and the supporting detail provided by PPL's evaluation contractor. The detailed audit findings can be found in [Appendix C](#).

- The TRC model, as provided to the SWE, lacks documentation and transparency in the source data on which the calculations are based. The model, as provided, does not show the incremental cost basis for any measure. In an email, the contact for PPL states the SWE incremental cost database was the primary source for per unit incremental costs, but there is no direct evidence of this in the TRC model provided.
- The SWE notes that the TRC model does not include any benefits from fossil fuel and/or water savings. For example, measures like low-flow showerheads and faucet aerators save water as well as electricity; the gallons saved is part of the TRM savings algorithm. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio.
- Energy savings from dual participation in the Home Energy Education program and other programs were calculated correctly. In the future, dual participation totals should be subtracted prior to calculating demand impacts. The energy savings from dual participation should also be subtracted at the program-level and reflected in the program and portfolio TRC test results in future program years. The PY8 TRC Test results double-counted this ~ 4 GWh.
- PY8 residential project files responses were adequate and the supporting details were provided. In a limited number of cases, project files could not be matched to the tracking data, and for one program, in a small number of cases, there were discrepancies between the project files and tracking data. These issues are being addressed by Cadmus.
- 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 notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix C](#) with recommendations for improvement.

- The SWE notes that Cadmus relied on TRM defaults for open variables to calculate verified savings for the Appliance Recycling Program rather than using the available customer-specific data. While this follows the 2016 TRM protocols, the 2016 TRM also encourages EDCs to apply the customer-specific or program-specific data that has been collected for as many open variables as possible to reflect the most accurate savings values.
- Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, for the Custom (C&I) program, the large C&I strata was represented by a single respondent despite Cadmus' efforts at recruitment. The SWE recommends a continued targeted effort at stratified data gathering to ensure no strata specific estimates are based on a single participant.
- In general, for all process evaluations, the SWE determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a description of whether PPL was implementing or considering those recommendations. The report included sufficient detail to assess the methods, findings, and recommendations. Wherever there were deviations from the Phase III Evaluation Plan, Cadmus provided a satisfactory explanation for those deviations. Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

3.3 DUQUESNE

3.3.1 Impact Evaluation

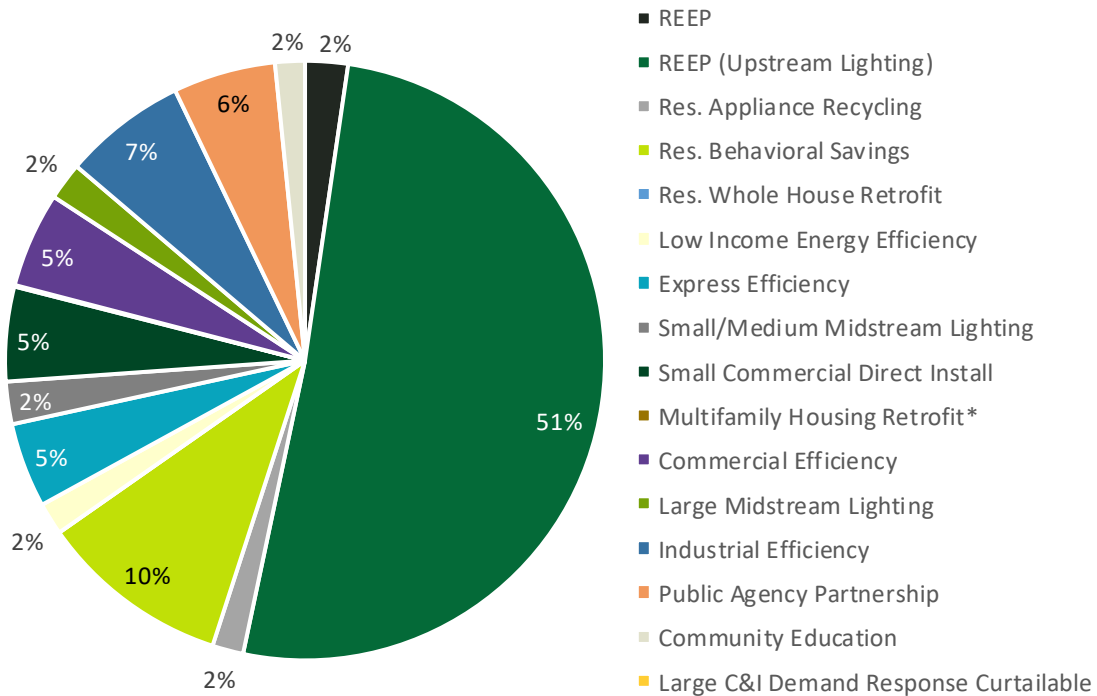
A summary of energy impacts by program through PY8 is presented in [Table 25](#). The bulk of savings (51%) is attributable to the upstream lighting portion of the REEP Program, where incentives are provided to retailers to discount the prices of LED bulbs sold at local retail stores (see also [Figure 21](#)).

Table 25: Incremental Annual Energy Savings by Program (MWh/Year)*

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
REEP	2,326	0.69	1,606	0.58	926
REEP (Upstream Lighting)	34,358	1.03	35,496	0.69	24,572
Res. Appliance Recycling	1,261	0.92	1,165	0.47	543
Res. Behavioral Savings*	6,536	1.10	7,162	1.00	7,162
Res. Whole House Retrofit	0	N/A	0	N/A	0
LI Energy Efficiency*	1,132	1.07	1,208	0.96	1,165
Express Efficiency	3,239	0.98	3,183	0.56	1,773
Small/Medium Midstream Lighting	1,025	1.56	1,595	0.88	1,412
Small Commercial Direct Install	3,626	0.98	3,546	0.99	3,521
Multifamily Housing Retrofit	159	0.36	57	0.71	41
Commercial Efficiency	3,642	0.98	3,579	0.56	1,993
Large Midstream Lighting	904	1.56	1,407	0.88	1,245
Industrial Efficiency	4,651	0.99	4,627	0.68	3,166
Public Agency Partnership	3,793	1.01	3,845	0.80	3,093
Community Education	1,084	1.03	1,115	0.8	897
Large C&I Demand Response Curtailable	0	N/A	0	N/A	0
Portfolio Total	67,737	1.03	69,593	0.74	51,510

* PYVTD Gross and Net for the Res Behavioral and LI Energy Efficiency Programs have been adjusted to correct for errors in Duquesne Light's Home Energy Report savings totals.

Figure 21: Percent of Portfolio PY8VTD Gross Savings, by Program – Duquesne Light



A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 26](#).

Table 26: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realizati on Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
REEP	0.4	0.8	0.3	0.58	0.2
REEP (Upstream Lighting)	3.5	1.03	3.6	0.69	2.5
Res. Appliance Recycling	0.1	0.92	0.1	0.47	0.1
Res. Behavioral Savings	3.5	0.23	0.8	1.0	0.8
Res. Whole House Retrofit	0	N/A	0	N/A	0
LI Energy Efficiency	0.5	1.06	0.6	0.96	0.6
Express Efficiency	0.4	1.02	0.4	0.56	0.2
Small/Medium Midstream Lighting	0.2	1.66	0.3	0.88	0.2
Small Commercial Direct Install	0.4	1.02	0.4	0.99	0.4
Multifamily Housing Retrofit	0	0.27	0	0.71	0
Commercial Efficiency	0.3	1.02	0.3	0.56	0.1
Large Midstream Lighting	0.2	1.66	0.3	0.88	0.2
Industrial Efficiency	0.6	0.98	0.6	0.68	0.4
Public Agency Partnership	0.4	0.87	0.3	0.8	0.3
Community Education	0.2	0.98	0.2	0.8	0.2
Large C&I Demand Response Curtailable	0	N/A	0	N/A	0
Portfolio Total	10.6	0.77	8.1	0.76	6.2

* PYVTD Gross and Net for the Res Behavioral and LI Energy Efficiency Programs have been adjusted to correct for errors in Duquesne Light's Home Energy Report savings totals.

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 27](#) shows the TRC ratios by program and for the portfolio. The benefits in [Table 27](#) were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 27: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
REEP	\$19,885	\$7,717	2.6	\$12,167
Res. Appliance Recycling	\$364	\$228	1.6	\$136
Res. Behavioral Savings	\$358	\$143	2.5	\$215
Res. Whole House Retrofit	\$0	\$68	0.0	-\$68
LI Energy Efficiency	\$104	\$343	0.3	-\$239
Residential Subtotal	\$20,711	\$8,499	2.4	\$12,211
Express Efficiency	\$1,993	\$995	2.0	\$999
Small/Medium Midstream Lighting	\$908	\$153	6.0	\$755
Small Commercial Direct Install	\$1,824	\$983	1.9	\$841
Multifamily Housing Retrofit	\$32	\$310	0.1	-\$278
Commercial Efficiency	\$1,839	\$1,428	1.3	\$411
Large Midstream Lighting	\$962	\$426	2.3	\$535
Industrial Efficiency	\$2,945	\$988	3.0	\$1,957
Public Agency Partnership	\$2,179	\$1,518	1.4	\$662
Community Education	\$926	\$633	1.5	\$293
Large C&I Demand Response Curtailable	\$0	\$485	0.0	-\$485
Non-Residential Subtotal	\$13,609	\$7,919	1.7	\$5,690
Portfolio Total	\$34,319	\$16,418	2.1	\$17,901

* The SWE found inconsistencies in the verified kWh for the market rate and low-income home energy report measures, which impact the Residential Behavioral Savings and Low-Income Energy Efficiency Programs, respectively.

3.3.3 Process Evaluation

Navigant reported on PY8 process evaluations for the following Duquesne Light programs.

Table 28: PY8 Process Evaluations

Residential and C&I Programs	
Residential Programs ⁴²	C&I Programs ⁴³
Residential Energy Efficiency Program (REEP)	Midstream Lighting Program
Residential Appliance Recycling Program (RARP)	

⁴² Navigant did not conduct a PY8 process evaluation for the following three residential programs: Whole Home Energy Audits Program (WHEAP), Home Energy Report Program, and Low-Income Energy Efficiency Program (LIEEP).

⁴³ Navigant did not conduct a PY8 process evaluation for the following seven C&I programs: the Express Efficiency Program (EXP), the Commercial Efficiency Program (CEP), the Small Commercial Direct Install Program (SCDI), the Multifamily Housing Retrofit Program (MFHR), the Industrial Efficiency Program (IEP), the Public Agency Partnership Program (PAPP), and the Community Education Efficiency Program (CEEP).

For PY8, Navigant evaluated and reported on a total of three programs within the Duquesne Light residential and C&I sectors.⁴⁴ From these evaluations, it produced a total of 19 process evaluation findings, which resulted in ten recommendations, six of which were accepted, two are under consideration, one was rejected, and the disposition of one recommendation was not reported.

For the *Duquesne Light Residential programs*, the PY8 process evaluation provided a total of ten findings and five recommendations, one of which was accepted, two are under consideration, one was rejected, and the disposition of one recommendation was not reported. A key cross-program finding was program satisfaction from participant surveys. However, the report provided only means for satisfaction ratings; it will be useful to be able to view the percentage distribution of responses to the satisfaction questions. Program-specific findings for these residential programs addressed topics that included the following:⁴⁵

- Primary sources of program information
- Customer or trade ally perceptions of incentive amounts or processing time
- Customer experience with program application system

For the Duquesne Light C&I Midstream Lighting program, the PY8 process evaluation provided nine findings and five recommendations, all of which were accepted. A key cross-program finding was program satisfaction from participant surveys. However, the report provided only means for satisfaction ratings; it will be useful to be able to view the percentage distribution of responses to the satisfaction questions. Program-specific findings for this program addressed topics that included the following:⁴⁵

- Barriers to program delivery
- Barriers to program participation
- Customer experience with program application system
- Customer perceptions of qualifying measures

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 PY8 Annual Report and the supporting detail provided by Duquesne's evaluation contractor. The detailed audit findings can be found in [Appendix D](#).

- The SWE identified several key issues with the PY8 HER analysis. (1) Peak demand impacts were calculated incorrectly and significantly overstated, (2) a gap in the billing data was not detected and not accounted for in the calculation of aggregate impacts, and (3) the description of methods in the PY8 Annual Report did not match the techniques

⁴⁴ The Duquesne Light PY8 evaluation plan noted that "Duquesne Light's program effort is somewhat small, and consequently, so are the resources earmarked for evaluation. The primary focus of evaluation efforts and resources will be on ensuring that all impact evaluation and compliance research is conducted properly and in a timely manner." This suggests a limited effort for the process evaluations and is reflected in the associated activities and the report for PY8.

⁴⁵ The Duquesne Light annual report provides further detail regarding these topics.

used to analyze the data. The energy and demand impacts presented in this report have been corrected by the SWE in collaboration with Duquesne's evaluation contractor.

- Duquesne did not offer energy efficient measures that might have resulted in space heating and water heating fuel savings from reduced fossil fuel consumption. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. The SWE recommends the TRC model account for quantifiable water and fossil fuel avoided costs in future PY reporting should the relevant program measures become available.
- PY8 residential project files responses were adequate and the supporting details were provided. In a very limited number of cases, project files details could not be matched to the tracking data.
- The SWE's review of verified savings for non-HER residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor difference in savings – well under 1% of portfolio savings – which are detailed in [Appendix D](#) with recommendations for improvement.
- The SWE notes that Navigant relied on TRM defaults for open variables to calculate verified savings for the Residential Appliance Recycling Program rather than using the available customer-specific data. While this follows the 2016 TRM protocols, the 2016 TRM also encourages EDCs to apply the customer-specific or program-specific data that has been collected for as many open variables as possible to reflect the most accurate savings values.
- Overall, Navigant estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.
- In general, for all of the process evaluations, the SWE determined that, with some exceptions (noted below), the reporting followed the SWE guidelines. The annual report included descriptions of the methods, a summary of findings, and a table of recommendations with a description of whether Duquesne Light was implementing or considering those recommendations. The report included sufficient detail to assess the methods, findings, and recommendations. With some exceptions (noted below), the process evaluations generally were consistent with the Phase III evaluation plans. Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings. However, as observed previously, the Navigant report did not indicate whether these recommendations were accepted, rejected, or were still under consideration.
- Further, as observed previously, showing mean satisfaction ratings does not provide as much insight as showing the range of responses. This report showed mean satisfaction ratings, but it will be more valuable and appropriate to report the percentage of respondents selecting each point on the satisfaction scale. At minimum, this will provide

a simple yet essential process evaluation metric – the percentage that are satisfied (and dissatisfied) with the programs. There were also some other notable exceptions.

- Process Evaluation of Residential Appliance Recycling Program (RARP).
 - Although the final sample size of 159 appears to be a large enough to yield acceptable confidence/precision levels, the Navigant report does not discuss how the sample was selected (e.g., random, quota, or convenience).
 - Also, for the PY8 evaluation, Navigant noted that it “redesigned its survey from a 5-point scale to a 10-point scale for Phase III to allow for more granularity in responses and to be consistent with other surveys Duquesne Light administers to its customers.” This is inconsistent with the scale that is being used by the other EDCs, which continue to use a 5-point scale. The SWE recommends that Navigant consider reverting to a 5-point scale as this will facilitate development of comparative satisfaction levels across EDCs. Should Navigant choose to continue using a 10-point scale, future audit reports will show those satisfaction levels, but they will not be directly comparable to those reported by the other six EDCs.
- Process Evaluation of Low-Income Energy Efficiency Program (LIEEP).
 - The Navigant report states up front that it “examined the program tracking data for additional programs and components including” the Low-Income Energy Efficiency Program (LIEEP) and particularly Low-Income kit handouts at specific low-income outreach events. However, the report does not describe any such activities or related results. The PY8 evaluation plan states only that “the low-income specific program component participants will comprise separate strata” in the evaluations of the Whole House Retrofit program and the Residential Behavioral Savings Program.
- Process Evaluation of Home Energy Report program.
 - The Navigant report states that they did not conduct process evaluation activities for the Home Energy Report program (both market rate and low-income components). However, the evaluation plan proposed program manager and implementer interviews in PY8. The report does not indicate if these interviews were conducted and does not provide any process-related results from them.
- Process Evaluation of C&I Midstream Lighting program.
 - The EM&V plan noted that this “is a new program and so will receive additional attention.” The report also noted that “this program launched in January 2017 with the goal of providing customers with easy access to efficient lighting. The results of the first program year will inform future program development.” However, a process evaluation of a new program such as this would typically include providing the program administrator

with early feedback to facilitate its working out any hiccups in initial program delivery. Despite the recognition in the plan of the need for “additional attention” for a new program such as this, the evaluation does not appear to have either planned or provided any early feedback.⁴⁶

- Finally, the evaluation switched from a 5-point satisfaction scale for the participant survey to a 10-point satisfaction scale for the distributor interviews. The evaluator should use a consistent satisfaction scale. As noted previously, the SWE recommends that Navigant consider using a 5-point scale. Should Navigant choose to continue using a 10-point scale, future audit reports will show those satisfaction levels, but they will not be directly comparable to those reported by the other six EDCs. The SWE also recommends that future evaluation reports provide the percentage distribution of responses for each point on the satisfaction scale.

3.4 MET-ED

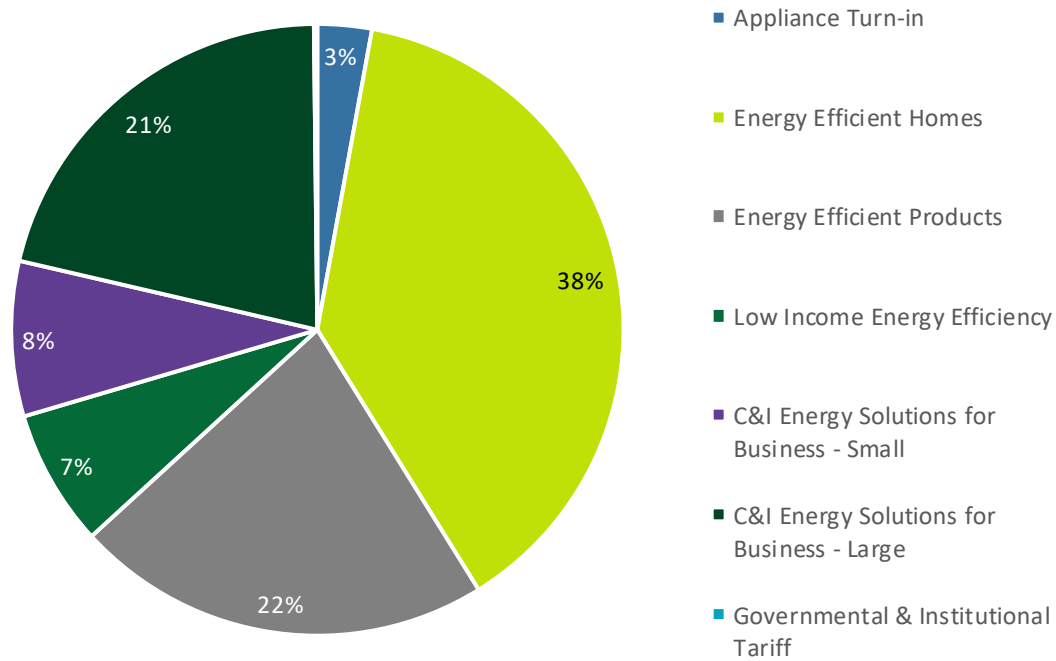
3.4.1 Impact Evaluation

A summary of energy impacts by program through PY8 is presented in [Table 29](#). The bulk of savings is attributable to the Energy Efficient Homes Program, The Large C&I Energy Solutions for Business Program, and the Energy Efficient Products Program (see also [Figure 22](#)).

Table 29: Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Appliance Turn-in	4,009	1.00	4,014	0.50	2,007
Energy Efficient Homes	48,126	1.11	53,569	0.92	49,445
Energy Efficient Products	25,460	1.21	30,825	0.38	11,656
LI Energy Efficiency	9,107	1.11	10,105	1.00	10,105
C&I Energy Solutions for Business (Small)	12,526	0.92	11,469	0.65	7,441
C&I Energy Solutions for Business (Large)	30,919	0.96	29,643	0.55	16,188
Governmental & Institutional Tariff	274	0.91	250	0.66	166
Portfolio Total	130,422	1.07	139,875	0.69	97,008

⁴⁶ The evaluator remarked in subsequent communications that “the program began in the middle of the third quarter of the program year. Early process work to provide early feedback was not possible.” However, the SWE sees no reason why early feedback should not be possible, regardless of when the program began.

Figure 22: Percent of Portfolio PY8VTD Gross Savings, by Program – Met-Ed

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 30](#).

Table 30: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Appliance Turn-in	0.6	0.95	0.5	0.5	0.3
Energy Efficient Homes	6.6	0.95	6.2	0.92	5.6
Energy Efficient Products	3.2	1.31	4.2	0.38	1.6
LI Energy Efficiency	1.1	1.01	1.2	1.00	1.2
C&I Energy Solutions for Business (Small)	1.9	1.05	2.0	0.65	1.3
C&I Energy Solutions for Business (large)	4.1	1.04	4.3	0.55	2.3
Governmental & Institutional Tariff	0.0	1.04	0.0	0.66	0.0
Portfolio Total	17.5	1.05	18.4	0.67	12.2

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 31 shows the TRC ratios by program and for the portfolio. The benefits in Table 31 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 31: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
Appliance Turn-in	\$1,513	\$652	2.32	\$861.13
Energy Efficient Homes	\$10,004	\$7,154	1.40	\$2,850
Energy Efficient Products	\$13,647	\$7,070	1.93	\$6,577
LI Energy Efficiency	\$2,563	\$3,409	0.75	-\$847
Residential Subtotal	\$27,727	\$18,285	1.52	\$9,442
C&I Energy Solutions for Business (Small)	\$5,872	\$4,136	1.42	\$1,736
C&I Energy Solutions for Business (Large)	\$15,060	\$10,778	1.40	\$4,282
Governmental & Institutional Tariff	\$96	\$115	0.84	-\$18.36
C&I Demand Response Program (Small)	\$0	\$40	0.00	-\$40
C&I Demand Response Program (Large)	\$0	\$360	0.00	-\$360
Non-Residential Subtotal	\$21,028	\$15,428	1.36	\$5,600
Portfolio Total	\$48,755	\$33,712	1.45	\$15,042

3.4.3 Process Evaluation

Four EDCs – Met-Ed, Penelec, Penn Power, and West Penn – operate an identical set of nine energy efficiency programs. 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. Therefore, the SWE's audit summary described in this section pertains to all four FirstEnergy utilities.

ADM/Tetra Tech reported on PY8 process evaluations for the following FirstEnergy Utilities programs.

Table 32: PY8 Process Evaluations

Residential and C&I Programs	
Residential Programs	C&I Programs ⁴⁷
Appliance Turn-In	Energy Solutions for Business-Small
Energy Efficient Homes ⁴⁸	Energy Solutions for Business-Large
Energy Efficient Products ⁴⁹	Governmental & Institutional Tariff
Low-Income Energy Efficiency ⁵⁰	

For PY8, ADM/Tetra Tech evaluated and reported on a total of seven programs within the MetEd residential and C&I sectors. From these evaluations, it produced a total of 30 process evaluation findings, which resulted in 22 recommendations, 15 of which were accepted, six are under consideration, and one was rejected.

For the *Met-Ed Residential programs*, the PY8 process evaluation provided a total of 26 findings and 18 recommendations, eleven of which were accepted, six are under consideration, and one was rejected. A key cross-program finding was program satisfaction from participant surveys. However, the report provided only means for satisfaction ratings; it will be useful to be able to view the percentage distribution of responses to the satisfaction questions.⁵¹ Program-specific findings addressed topics that included the following:

- Primary sources of program information
- Customer perceptions of incentive amounts or processing time
- Customer experience with program databases or tracking systems

For the *Met-Ed C&I programs*, the PY8 process evaluation provided four findings and four recommendations, all of which were accepted. A key cross-program finding was program satisfaction from participant surveys. However, the report provided only means for satisfaction ratings; it will be useful to be able to view the percentage distribution of responses to the satisfaction questions.⁵¹ Program-specific findings addressed topics that included barriers to program delivery and sources of program awareness.

⁴⁷ ADM/Tetra Tech PY8 evaluation plan did not propose to evaluate the C&I Small and Large Demand Response programs and therefore did not report any process evaluation findings.

⁴⁸ In PY8, ADM/Tetra Tech conducted process evaluations for two of four program components: Energy Efficiency Kits (EE Kits) and Home Energy Reports. The program components for which process evaluation were not conducted in PY8 are: Residential Direct Install, and New Homes.

⁴⁹ In PY8, ADM/Tetra Tech conducted process evaluations for three of four program components: Appliances, HVAC, and Lighting. A process evaluation was not conducted for the Upstream Electronics program component.

⁵⁰ The Low Income (LI) Energy Efficiency Program (LIEEP) has six distinct components: LI Direct Install (WARM Plus, WARM Extra Measures, and WARM Multifamily), LI Appliance Turn-In, LI Kit, LI Appliance Rebates, LI Home Energy Reports, and LI New Homes. For PY8, ADM/Tetra Tech conducted a separate process evaluation of the LI Direct Install program and the process evaluations for the Appliance Rebate, Behavioral, and Kits sub-programs were conducted with the similar Non-Low-Income programs in the Energy Efficient Products and Energy Efficient Homes programs. The report notes that the findings and recommendations for those program components were reported in those sections.

⁵¹ The evaluator indicated in subsequent communications that they will provide this additional information.

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's PY8 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in [Appendix E](#).

- FirstEnergy's evaluation contractor submitted all supporting data and code for HERs to the SWE for review prior to filing the PY8 Final Annual Report. While reviewing the analysis, the SWE noticed that the "pre" and "post" indicator variables were coded incorrectly for two months of data. Thanks to the timely submission of audit materials, ADM was able to correct the impact estimates prior to filing the PY8 annual report for the FirstEnergy EDCs.
- The FirstEnergy companies incented approximately 600,000 non-ENERGY STAR lamps in PY8. Prior to the change in the ENERGY STAR specification on January 1, 2017, there was a program opportunity for the "value-line" bulbs, but after the softening of ENERGY STAR standards, EDCs should only support ENERGY STAR qualified lighting products. The SWE also notes that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.⁵²
- PY8 residential project files responses were adequate and, overall, the supporting details were provided. In a very limited number of cases, project files details could not be matched to the tracking data.
- The SWE's review of verified savings for non-HER residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix E](#) with recommendations for improvement.
- The SWE notes that there appear to have been errors in the EDC data collection process for dehumidifier recycling and incorrect capacity data was collected. The SWE agrees with ADM's decision to use default IMP values to calculate verified savings and recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.
- Overall, ADM/Tetra Tech estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, a NTG of 0.5 was applied to the Direct Install and New Homes components of the Energy Efficient Homes Program as a placeholder. The rationale for the selection of the NTG placeholder value was not included

⁵² The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to of lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the SWE propose the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

in the report and the SWE recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation in the future reports.

- Met-Ed's TRC model ignored space heating and water heating fuel savings from reduced fossil fuel consumption from energy- efficient measures, which resulted in underestimated program benefits. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio. The SWE recommends the TRC model account for quantifiable water and fossil fuel avoided costs in future PY reporting.
- In general, the process evaluation reporting was very sparse. For almost all the programs, it was not possible from the evaluation report to assess the extent to which the process evaluation adhered to the Phase III process evaluation plan. Also, for all programs, the report only provided participant survey sample sizes, key findings, and recommendations, but did not provide any details on the results of the participant surveys. While noting that these process evaluations also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), the report did not provide any further information on these interviews or associated findings.⁵³
- Further, as observed previously, showing mean satisfaction ratings do not provide as much insight as showing the range of responses. This report showed mean satisfaction ratings; it will be more valuable and appropriate to report the percentage of respondents selecting each point on the satisfaction scale.⁵⁴ At minimum, this will provide a simple yet essential process evaluation metric – the percentage that are satisfied (and dissatisfied) with the programs. Other program-specific exceptions uncovered by the SWE audit are listed below.
 - Process Evaluation of Residential Programs.
 - The report combined results for the Low-Income and non-Low-Income components for the Appliance Rebate, Behavioral, and Kits sub-programs of the Energy Efficient Products and Energy Efficient Homes programs. It notes that the findings and recommendations for those program components were reported in those sections. However, aside from a few passing mentions of low-income participant survey responses in findings for the Behavioral component of the Energy Efficient Homes program, the relevant report sections for the Energy Efficient Products and Energy Efficient Homes programs did not provide any indication or evidence that they had evaluated the applicable low-income program components. Additionally, the descriptions of the participant survey sample sizes for those programs do not mention whether they included a low-income

⁵³ The evaluator provided the following comment in subsequent communications: "We provided what was available at the time in the report. We will provide significantly more detail in the PY9 annual report; however, we wanted to show progress made by the PY8 annual report."

⁵⁴ The evaluator indicated in subsequent communications that they will provide this additional information.

sample. Therefore, it was not possible to assess if the sample sizes for any of the Residential Programs satisfied the needed levels of confidence/precision.⁵⁵

- The process evaluation plan identified a wide range of researchable questions and data collection activities to support answering them; it goes on to note that these “issues will be refined to address individual sub-programs through interviews with FirstEnergy implementation and ICSP staff.” However, the report does not include any description of which questions were addressed and what data collection was performed to answer them.
- Process Evaluation of C&I Program.
 - The data collection activities described in the ADM/FirstEnergy report were limited to interviews with FirstEnergy and ICSP staff, a participant survey, and contractor interviews. However, the PY8 evaluation plan also proposed to collect data from numerous additional data sources, including a review of data tracking systems, program data/documentation review, trade ally interviews (participant, non-participant, and wait-listed trade allies), wait-listed customer interviews, a benchmarking study, and an audit review. The report does not mention having conducted any of these data collection activities that were described in the PY8 evaluation plan. It also is not clear from the report if the contractor interviews discussed in it included any of the trade ally groups identified in the evaluation plan.⁵⁶

3.5 PENELEC

3.5.1 Impact Evaluation

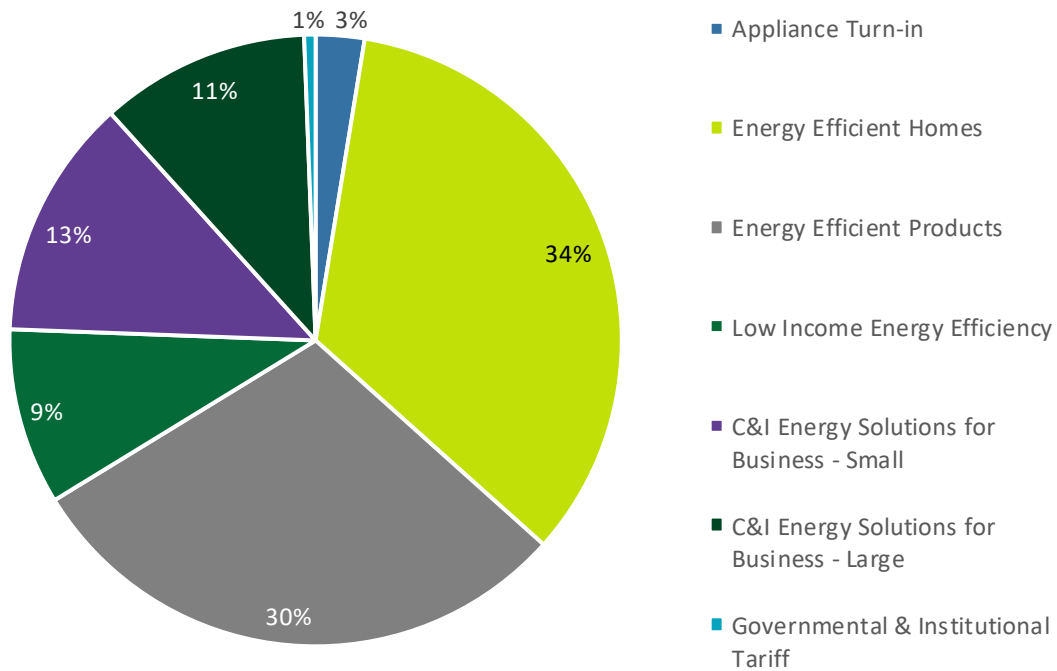
A summary of energy impacts by program through PY8 is presented in [Table 33](#). The bulk of savings is attributable to the Energy Efficient Homes Program and the Energy Efficient Products Program (see also [Figure 23](#)).

⁵⁵ The evaluator indicated in subsequent communications that they will provide additional detail in the PY9 annual report,

⁵⁶ The evaluator provided additional information in subsequent communications and indicated that “full detail on process evaluation methodology and results will be included in interim memos and the PY9 annual report.”

Table 33: Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Appliance Turn-in	3,826	0.89	3,407	0.43	1,465
Energy Efficient Homes	38,523	1.17	45,106	0.91	40,962
Energy Efficient Products	33,501	1.17	39,241	0.34	13,528
LI Energy Efficiency	10,950	1.13	12,359	1.00	12,359
C&I Energy Solutions for Business (Small)	18,071	0.93	16,874	0.82	13,889
C&I Energy Solutions for Business (large)	15,811	0.93	14,666	0.76	11,106
Governmental & Institutional Tariff	852	0.93	796	0.85	673
Portfolio Total	121,535	1.09	132,449	0.71	93,982

Figure 23: Percent of Portfolio PY8VTD Gross Savings, by Program - Penelec

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 34](#).

Table 34: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Appliance Turn-in	0.5	0.88	0.4	0.43	0.2
Energy Efficient Homes	5	0.99	4.9	0.91	4.4
Energy Efficient Products	3.6	1.32	4.7	0.34	1.7
LI Energy Efficiency	1.3	1.02	1.3	1	1.3
C&I Energy Solutions for Business (Small)	3	0.98	2.9	0.82	2.4
C&I Energy Solutions for Business (large)	1.9	0.89	1.7	0.76	1.3
Governmental & Institutional Tariff	0	1.02	0	0.85	0
Portfolio Total	15.2	1.05	16	0.71	11.4

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 35 shows the TRC ratios by program and for the portfolio. The benefits in Table 35 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 35: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
Appliance Turn-in	\$1,156	\$648	1.78	\$508
Energy Efficient Homes	\$9,626	\$6,126	1.57	\$3,500
Energy Efficient Products	\$16,916	\$6,565	2.58	\$10,350
LI Energy Efficiency	\$3,048	\$3,504	0.87	-\$455
Residential Subtotal	\$30,746	\$16,842	1.83	\$13,904
C&I Energy Solutions for Business (Small)	\$8,449	\$6,291	1.34	\$2,159
C&I Energy Solutions for Business (Large)	\$6,485	\$6,571	0.99	-\$86
Governmental & Institutional Tariff	\$283	\$336	0.84	-\$54
Non-Residential Subtotal	\$15,218	\$13,198	1.15	\$2,020
Portfolio Total	\$45,964	\$30,041	1.53	\$15,923

3.5.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including Penelec, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described for Met-Ed previously applies to all four FirstEnergy utilities, including Penelec.

3.5.4 Key Audit Findings

In this section, the SWE provides a summary of key audit findings of the SWE's audit of the Penelec's PY8 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in [Appendix F](#).

- FirstEnergy's evaluation contractor submitted all supporting data and code for HERs to the SWE for review prior to filing the PY8 Final Annual Report. While reviewing the analysis, the SWE noticed that the "pre" and "post" indicator variables were coded incorrectly for two months of data. Thanks to the timely submission of audit materials, ADM was able to correct the impact estimates prior to filing the PY8 annual report for the FirstEnergy EDCs.
- The FirstEnergy companies incented approximately 600,000 non-ENERGY STAR lamps in PY8. Prior to the change in the ENERGY STAR specification on January 1, 2017, there was a program opportunity for the "value-line" bulbs, but after the softening of ENERGY STAR standards, EDCs should only support ENERGY STAR qualified lighting products. The SWE also notes that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.⁵⁷
- PY8 residential project files responses were adequate and, overall, the supporting details were provided. In a very limited number of cases, project files details could not be matched to the tracking data.
- The SWE's review of verified savings for non-HER residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix F](#) with recommendations for improvement.
- The SWE notes that there appear to have been errors in the EDC data collection process for dehumidifier recycling and incorrect capacity data was collected. The SWE agrees with ADM's decision to use default IMP values to calculate verified savings and recommends

⁵⁷ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to of lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the SWE propose the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.

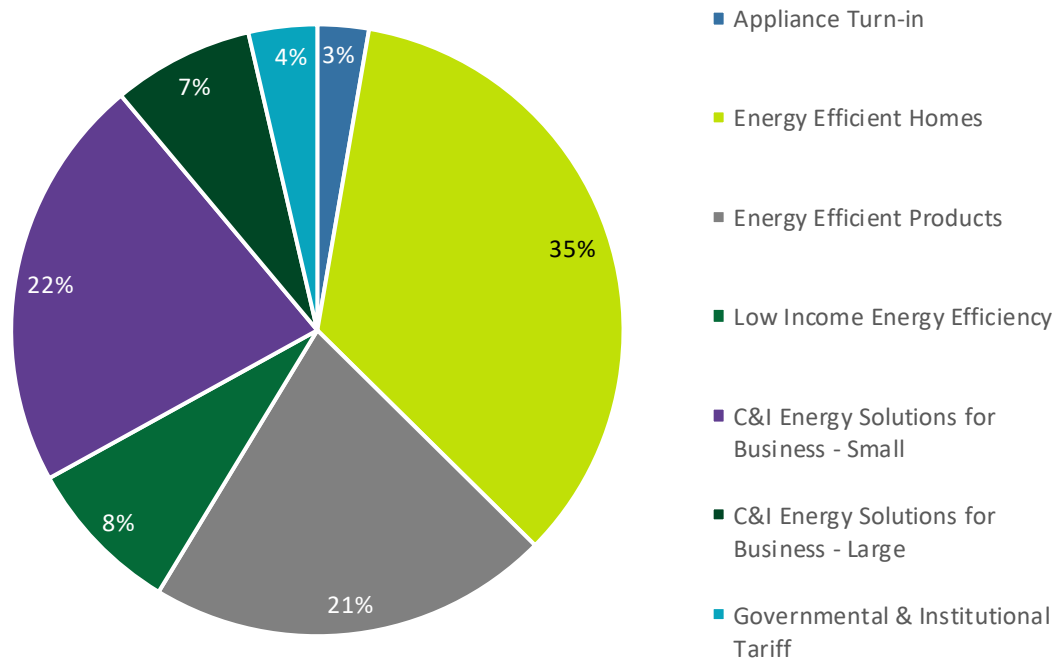
- Overall, ADM/Tetra Tech estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, a NTG of 0.5 was applied to the Direct Install and New Homes components of the Energy Efficient Homes Program, but the SWE could not determine the reason for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.
- Penelec's TRC model ignored space heating and water heating fuel savings from reduced fossil fuel consumption from energy- efficient measures, which resulted in underestimated program benefits. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio. The SWE recommends the TRC model account for quantifiable water and fossil fuel avoided costs in future PY reporting.

3.6 PENN POWER

3.6.1 Impact Evaluation

A summary of energy impacts by program through PY8 is presented in [Table 36](#). The bulk of savings is attributable to the Energy Efficient Homes Program, the Small C&I Energy Solutions for Business Program, and the Energy Efficient Products Program (see also [Figure 24](#)).

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Appliance Turn-in	1,288	0.78	1,007	0.50	503
Energy Efficient Homes	10,902	1.18	12,883	0.90	11,564
Energy Efficient Products	6,202	1.27	7,896	0.40	3,130
LI Energy Efficiency	3,280	0.94	3,080	1.00	3,080
C&I Energy Solutions for Business (Small)	8,703	0.94	8,151	0.72	5,880
C&I Energy Solutions for Business (large)	3,046	0.91	2,768	0.60	1,661
Governmental & Institutional Tariff	1,424	0.94	1,345	0.75	1,012
Portfolio Total	34,846	1.07	37,130	0.72	26,831

Figure 24: Percent of Portfolio PY8VTD Gross Savings, by Program – Penn Power

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 37](#).

Table 37: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Appliance Turn-in	0.2	0.80	0.1	0.50	0.1
Energy Efficient Homes	1.7	1.02	1.7	0.90	1.4
Energy Efficient Products	0.7	1.39	1.0	0.40	0.4
LI Energy Efficiency	0.4	0.80	0.3	1.00	0.3
C&I Energy Solutions for Business (Small)	1.4	1.05	1.5	0.72	1.1
C&I Energy Solutions for Business (Large)	0.3	1.10	0.3	0.60	0.2
Governmental & Institutional Tariff	0.1	1.04	0.1	0.75	0.0
Portfolio Total	4.8	1.06	5.1	0.70	3.6

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 38](#) shows the TRC ratios by program and for the portfolio. The benefits in [Table 38](#) were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 38: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
Appliance Turn-in	\$319	\$226	1.41	\$93
Energy Efficient Homes	\$2,752	\$2,433	1.13	\$319
Energy Efficient Products	\$3,432	\$1,739	1.97	\$1,694
LI Energy Efficiency	\$788	\$973	0.81	-\$185
Residential Subtotal	\$7,292	\$5,371	1.36	\$1,920
C&I Energy Solutions for Business (Small)	\$4,210	\$1,793	2.35	\$2,418
C&I Energy Solutions for Business (Large)	\$1,317	\$1,065	1.24	\$252
Governmental & Institutional Tariff	\$520	\$247	2.10	\$273
C&I Demand Response Program (Small)	\$0	\$12	0.00	-\$12
C&I Demand Response Program (Large)	\$0	\$111	0.00	-\$111
Non-Residential Subtotal	\$6,048	\$3,229	1.87	\$2,819
Portfolio Total	\$13,339	\$8600	1.55	\$4,739

3.6.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including Penn Power, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described for Met-Ed previously applies to all four FirstEnergy utilities, including Penn Power.

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's PY8 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in [Appendix G](#).

- FirstEnergy's evaluation contractor submitted all supporting data and code for HERs to the SWE for review prior to filing the PY8 Final Annual Report. While reviewing the analysis, the SWE noticed that the "pre" and "post" indicator variables were coded incorrectly for two months of data. Thanks to the timely submission of audit materials,

ADM was able to correct the impact estimates prior to filing the PY8 annual report for the FirstEnergy EDCs.

- The FirstEnergy companies incented approximately 600,000 non-ENERGY STAR lamps in PY8. Prior to the change in the ENERGY STAR specification on January 1, 2017, there was a program opportunity for the “value-line” bulbs, but after the softening of ENERGY STAR standards, EDCs should only support ENERGY STAR qualified lighting products. The SWE also notes that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.⁵⁸
- PY8 residential project files responses were adequate and, overall, the supporting details were provided. In a very limited number of cases, project files details could not be matched to the tracking data.
- The SWE’s review of verified savings for non-HER residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix G](#) with recommendations for improvement.
- The SWE notes that there appear to have been errors in the EDC data collection process for dehumidifier recycling and incorrect capacity data was collected. The SWE agrees with ADM’s decision to use default IMP values to calculate verified savings and recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.
- Overall, ADM/Tetra Tech estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, a NTG of 0.5 was applied to the Direct Install and New Homes components of the Energy Efficient Homes Program, but the SWE could not determine the reason for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.
- Penn Power’s TRC model ignored space heating and water heating fuel savings from reduced fossil fuel consumption from energy- efficient measures, which resulted in underestimated program benefits. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio. The SWE recommends the TRC model account for quantifiable water and fossil fuel avoided costs in future PY reporting.

⁵⁸ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to of lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the SWE propose the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

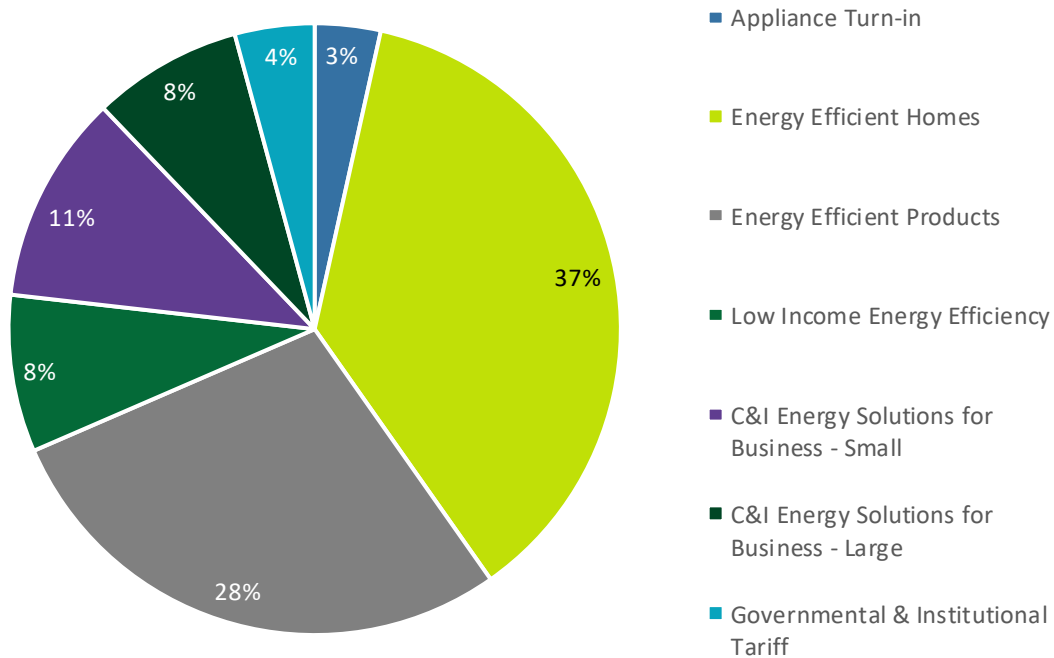
3.7 WEST PENN

3.7.1 Impact Evaluation

A summary of energy impacts by program through PY8 is presented in [Table 39](#). The bulk of savings is attributable to the Energy Efficient Homes Program and the Energy Efficient Products Program (see also [Figure 25](#)).

Table 39: Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Appliance Turn-in	4,999	0.91	4,565	0.45	2,054
Energy Efficient Homes	45,219	1.07	48,291	0.94	45,324
Energy Efficient Products	31,349	1.18	37,095	0.28	10,456
LI Energy Efficiency	10,388	1.05	10,915	1.00	10,915
C&I Energy Solutions for Business (Small)	14,540	1.00	14,523	0.82	11,919
C&I Energy Solutions for Business (large)	10,477	0.99	10,414	0.74	7,673
Governmental & Institutional Tariff	5,489	1.01	5,528	0.83	4,580
Portfolio Total	122,460	1.07	131,330	0.71	92,922

Figure 25: Percent of Portfolio PY8VTD Gross Savings, by Program – West Penn

A summary of the peak demand impacts by energy efficiency program through the current reporting period are presented in [Table 40](#).

Table 40: Peak Demand Savings by Energy Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
Appliance Turn-in	0.6	0.96	0.6	0.45	0.3
Energy Efficient Homes	7.0	0.85	5.9	0.94	5.4
Energy Efficient Products	4.1	1.25	5.2	0.28	1.5
LI Energy Efficiency	1.4	0.91	1.3	1.00	1.3
C&I Energy Solutions for Business (Small)	2.3	0.96	2.2	0.82	1.8
C&I Energy Solutions for Business (large)	1.5	0.96	1.5	0.74	1.0
Governmental & Institutional Tariff	0.2	1.02	0.2	0.83	0.1
Portfolio Total	17.2	0.98	16.8	0.68	11.4

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 41](#) shows the TRC ratios by program and for the portfolio. The benefits in [Table 41](#) were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 41: PY8 Gross TRC Ratios by Program (\$1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits - Costs)
Appliance Turn-in	\$1,444	\$775	1.86	\$670
Energy Efficient Homes	\$7,111	\$6,547	1.09	\$564
Energy Efficient Products	\$15,324	\$7,776	1.97	\$7,548
LI Energy Efficiency	\$2,599	\$3,573	0.73	-\$974
Residential Subtotal	\$26,478	\$18,670	1.42	\$7,808
C&I Energy Solutions for Business (Small)	\$6,974	\$6,173	1.13	\$801
C&I Energy Solutions for Business (Large)	\$4,582	\$4,173	1.10	\$409
Governmental & Institutional Tariff	\$2,035	\$2,178	0.93	-\$143
C&I Demand Response Program (Small)	\$0	\$56	0.00	-\$56
C&I Demand Response Program (Large)	\$0	\$502	0.00	-\$502
Non-Residential Subtotal	\$13,591	\$13,082	1.04	\$509
Portfolio Total	\$40,069	\$31,752	1.26	\$8,317

3.7.3 Process Evaluation

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including West Penn, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described for previously applies to all four FirstEnergy utilities, including West Penn.

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's PY8 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in [Appendix H](#).

- FirstEnergy's evaluation contractor submitted all supporting data and code for HERs to the SWE for review prior to filing the PY8 Final Annual Report. While reviewing the

analysis, the SWE noticed that the “pre” and “post” indicator variables were coded incorrectly for two months of data. Thanks to the timely submission of audit materials, ADM was able to correct the impact estimates prior to filing the PY8 annual report for the FirstEnergy EDCs.

- The FirstEnergy companies incented approximately 600,000 non-ENERGY STAR lamps in PY8. Prior to the change in the ENERGY STAR specification on January 1, 2017, there was a program opportunity for the “value-line” bulbs, but after the softening of ENERGY STAR standards, EDCs should only support ENERGY STAR qualified lighting products. The SWE also notes that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.⁵⁹
- PY8 residential project files responses were adequate and, overall, the supporting details were provided. In a very limited number of cases, project files details could not be matched to the tracking data.
- The SWE’s review of verified savings for non-HER residential programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in [Appendix H](#) with recommendations for improvement.
- The SWE notes that there appear to have been errors in the EDC data collection process for dehumidifier recycling and incorrect capacity data was collected. The SWE agrees with ADM’s decision to use default IMP values to calculate verified savings and recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.
- Overall, ADM/Tetra Tech estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, a NTG of 0.5 was applied to the Direct Install and New Homes components of the Energy Efficient Homes Program, but the SWE could not determine the reason for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.
- West Penn Power’s TRC model ignored space heating and water heating fuel savings from reduced fossil fuel consumption from energy- efficient measures, which resulted in underestimated program benefits. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of

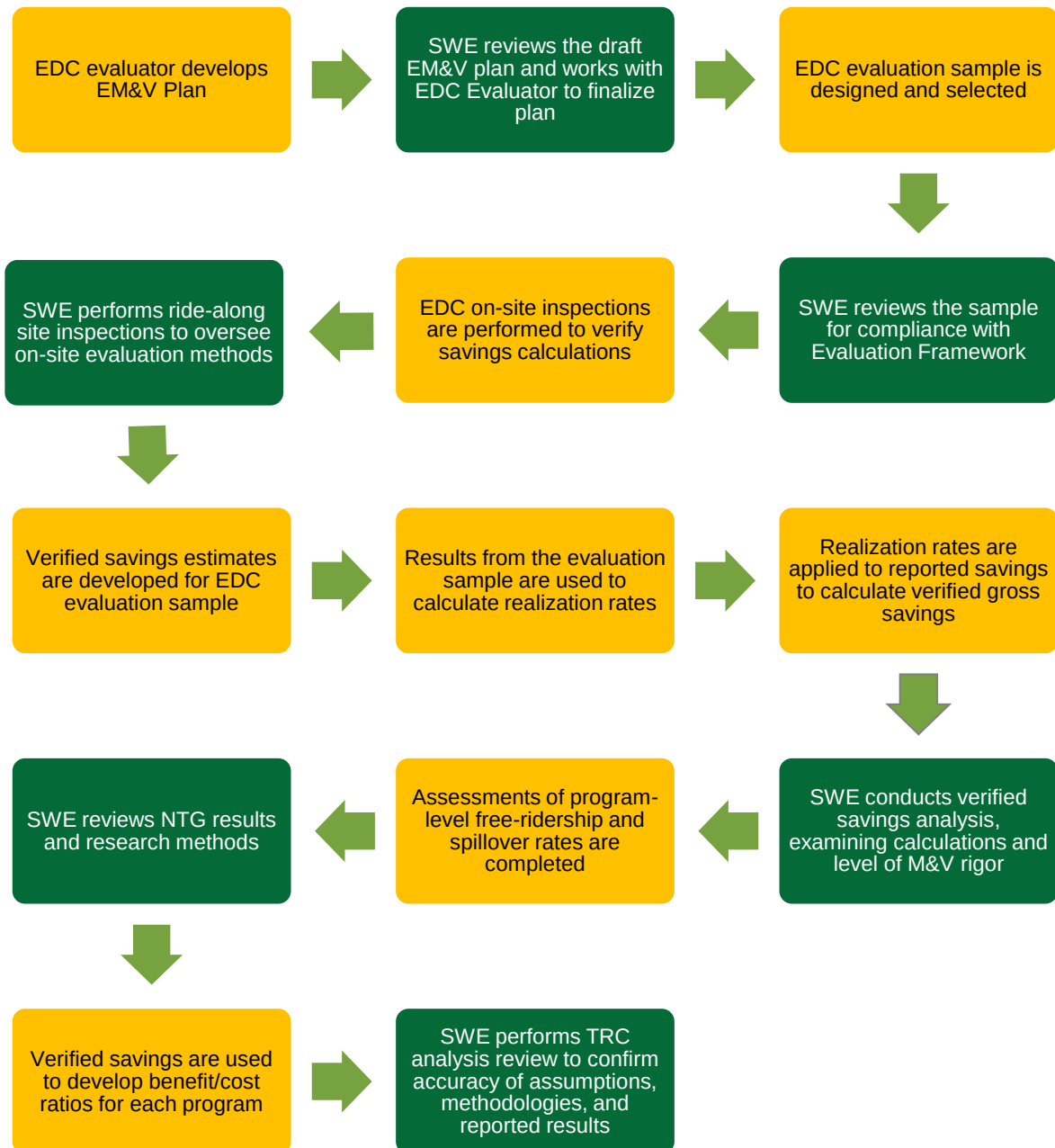
⁵⁹ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to of lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the SWE propose the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

fossil fuel costs and benefits understates the TRC ratio. The SWE recommends the TRC model account for quantifiable water and fossil fuel avoided costs in future PY reporting.

Section 4 Cross-Cutting SWE Activities

This section presents a summary of the audit and cross-cutting activities conducted by the SWE during PY8, 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 26](#) shows the C&I sector specific SWE audit activities and their correspondence to the evaluation steps.

Figure 26: The SWE Audit Activities



4.1 EVALUATION FRAMEWORK UPDATE

The Phase III Evaluation Framework⁶⁰ retained most Phase II requirements, except for revisions in a few areas like net-to-gross research, frequency of impact and process evaluations, and EDC reporting. The SWE also developed new demand response and behavioral (Home Energy Reports and Business Energy Reports) evaluation protocols.

During the development of the Evaluation Framework, the SWE worked directly with TUS staff to identify new subject areas and content that would be incorporated in Phase III. The framework update task began with a review of the Phase II Evaluation Framework and focused on building a more streamlined document that combines the content of a technical evaluation framework with policy directives from TUS staff. The SWE reorganized the framework into mandatory versus discretionary protocols for the EDCs and their evaluators, while emphasizing the need to standardize protocols across the Commonwealth and between the Conservation Service Providers (CSP) and evaluators for each EDC. The new framework provided two main sections – guidelines and requirements for EDC independent evaluations and audit activities conducted by the SWE.

The Evaluation Framework is a living document that will be updated or modified as appropriate. SWE's goal in the first program year of Phase III was to continue to segregate the technical and policy aspects of the Evaluation Framework as we encountered evaluation issues specific to the Act 129 programs.

Below is a summary of topics that we were addressed in the Phase III Evaluation Framework. The new version was built on the previous version and retained key areas for consistency and continuity.

- **Demand Response.** The Phase II Evaluation Framework did not address Demand Response because Phase II did not have Demand Response goals. The PA TRM has two high-level protocols (Residential and Non-Residential) discussing acceptable methods, but does not offer a lot of technical guidance. The SWE provided technical guidance on the acceptable methods, outlined what the SWE's DR audit activities will be, and prescribed the DR reporting requirements.
- **Home Energy Reports.** The Phase II Evaluation Framework had a protocol that was submitted by PPL in 2010 and was augmented with some guidance provided by the Phase II SWE pertaining to calculating a downward adjustment for incremental participation in other programs. The protocol was updated in Phase III. The SWE addressed two critical topics in the treatment of HERs: (1) added the lagged dependent variable (LDV) model for regression analysis and (2) added a requirement for EDCs to submit all pre- and post-participation billing data to the SWE. The EDC evaluators are required to specify the regression model and validate the randomization in their EM&V plans. The definition of persistence for HER programs is an evolving issue for Act 129 programs. The SWE included recommended methods for the EDCs to measure savings persistence of HERs in the new Framework.

⁶⁰ http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework102616.pdf

- **Net-to-Gross.** The Phase III SWE felt that a disproportionate amount of effort was expended on measuring NTG in Phase II. Act 129 gives very little weight to NTG, and EDCs have voiced concern about the NTG research costs to programs when the results are not used to assess program performance. That said, NTG research, if optimally designed and conducted at a measure or end-use level, can provide simple and meaningful insights into market transformation. This enables the EDCs to make decisions on program modification to follow the market's naturally occurring or induced measure adoption, or retire programs if a market is saturated or fully transformed. The SWE retained the guidance from Phase II, which required the EDCs to conduct NTG research for High Impact Measures (HIMs) on an annual basis. The Framework updates emphasized the use of consistent methods over time and across EDCs, identified the Uniform Methods Project (UMP) as a key reference outside of the Framework, stressed the importance of incorporating market progress indicators when assessing NTG for upstream lighting, and added a more detailed discussion of market effects studies.
- **Frequency of Evaluation.** In previous Phases, evaluation contractors conducted annual gross impact evaluations, but the SWE believes this may not always be necessary, especially in a five-year phase. The Phase III Evaluation Framework changed the required frequency of evaluation. The EDCs were given the flexibility to stage the evaluations based on the following criteria subject to approval by the SWE.
 - Amount of program energy and demand savings
 - Program continuity / discontinuity
 - Market of technology continuity / discontinuity
 - Uniformity of measures
 - Expected uncertainty in savings
 - Underperforming program expectations

Gross impact evaluations can be staged in Phase III for better use of evaluation funds in research areas of higher priority and prospective value. Initiative population from two program years can be combined into a single sample frame for initiatives that do not receive an impact evaluation every year. Depending on the EDC's evaluation plan, a single statistically valid realization rate may be applied to the sum of reported savings for the two program years and the first of the two program years will then be reported as un-verified savings in the EDC annual report. Or an EDC may apply the most recently estimated realization rate. Every program (or initiative) should have at least one process evaluation in every funding cycle or phase; EDCs, appropriately, have not typically conducted process evaluations of every program or initiative every year. Similarly, most EDCs have not typically conducted net impact evaluations annually for every program or initiative. The EDCs are now required to use the above criteria to propose preliminary five-year evaluation schedules for every program and initiative; the proposed schedules will be reviewed by the SWE. The EDC EM&V plans should include the rationales for the schedule for each program and initiative. The Framework notes that reducing the frequency of some evaluations does not necessarily equate with conducting fewer evaluations overall. In particular, sampling

requirements for certain programs may necessitate larger samples than some EDCs have relied on in the past.

- **Sampling requirements.** The Phase III Evaluation Framework required the EDCs to better define programs or solutions for evaluation purposes. In previous Phases, EDCs grouped programs or solutions to create umbrella programs, resulting in smaller sample sizes and lower evaluation rigor for solutions under the umbrella. Program definitions might be different for evaluation than implementation.
- **Evaluation Protocols.** The 2016 TRM enforced customer specific data collection requirements for projects above the TRM thresholds. Site Specific Measurement & Verification Plans (SSMVP) are required for all project above the thresholds. The Phase III Evaluation Framework clarified that the EDCs should submit SSMVPs for SWE review two weeks before the on-site inspection is performed by the EDC evaluator.
- **Reporting.** The SWE revised the reporting requirements to shift from quarterly to semi-annual reporting for the EDCs. This will reduce the reporting burden for the EDCs, but has implications for the SWE data requests and audit activities. Phase III moved from cumulative first-year to annual incremental accounting, and appropriate guidance on reporting changes and savings accounting mechanisms was added to the Evaluation Framework.
- **Cost-Effectiveness.** The SWE identified and addressed two cost-effectiveness topics in the Evaluation Framework: (1) the 2016 TRC Order laid out all of the ground rules for calculating TRC in Act 129, and the Evaluation Framework was updated to reflect changes implemented since the 2013 TRC Order and (2) the Framework was updated to clarify the inclusion of appropriate benefits, incremental measure costs, and measure lives, and SWE's auditing requirements for the cost effectiveness analysis.

The Phase III Evaluation Framework also includes detailed descriptions of the audit activities the SWE will conduct for verification of the EDCs' progress toward savings goals. Clear documentation of the data requirements and planned validation exercises was provided to limit the chances for contentious situations between EDCs and the SWE when the SWE implements its audit activities.

4.2 INTERIM MEASURE PROTOCOLS (IMPs)

As described in the Evaluation Framework, Interim Measure Protocols (IMPs) are used for measures that do not exist in the TRM, and for additions that expand the applicability of an existing 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, in order to maintain a database for new/revised measure protocols that should be included in subsequent TRM updates. This catalogue is also for EDCs to use to claim reported savings, and for evaluators to follow when determining verified savings.

Table 42 presents the 31 IMPs the SWE reviewed and approved to be effective during PY8 (30 of which will continue to be effective for the remainder of Phase III).

Table 42: IMPs Approved During PY8

IMP	Effective as of:
Variable Speed Air Compressor	PY8
Advanced Power Strips	PY8
Combination Oven	PY8
ENERGY STAR Commercial Fryers	PY8
ENERGY STAR Commercial Hot Holding Cabinet	PY8
Air Cooled Refrigeration Condenser	PY8
ENERGY STAR Air Purifier	PY8
All Electric Chillers IMP	PY8
Computer Room Air Conditioner	PY8
Uninterruptible Power Supply	PY8
ENERGY STAR Commercial Convection Oven	PY8
Circulation Fan: High-Volume Low-Speed	PY8
ENERGY STAR Bathroom Ventilation Fan	PY8
Computer Room Air Handler	PY8
Window Film (e.g., low-e coating and/or low SHGC)	PY8
Window Repair	PY8
Permanent Fixture Removal	PY8
Permanent Lamp Removal	PY8
Maintenance: Furnace	PY8
Basement Wall Insulation	PY8
Floor Insulation	PY8
Case Light Occupancy Controls	PY8
Computer Room AC-Handler VSD on AC Fan Motors	PY8
Computer Room AC-Handler EC Plug Fans	PY8
Refrigerator Replacement IMP Phase III	PY8
Lighting Improvements for Midstream Delivery Programs (Midstream Lighting)	PY8
Dehumidifier Retirement IMP	PY8
Residential Upstream Occupancy Sensors IMP	PY8
ENERGY STAR Heat Pump Clothes Dryers	PY8
Ground Source Heat Pump Maintenance	PY8
Residential Thermostat IMP	PY8*

* Note that an updated Residential Thermostat IMP went into effect in PY9.

4.3 TRM ERRATA

The PUC determined in its Phase III Final Implementation Order that the Technical Reference Manual (TRM) will be adopted as a component of the EE&C Program again,⁶¹ and on July 8, 2015, the Commission entered the final Order updating the 2016 TRM⁶². Unlike previous phases of the EE&C Programs, in which the TRM was updated annually, the Commission determined that the 2016 TRM would be applicable for the entirety of Phase III, unless a mid-phase update was deemed necessary by the Commission.

Because there will not be an annual update to the 2016 TRM in Phase III, the SWE prepared an Errata and guidance memo to correct errors and clarify questions or unclear elements of the 2016 TRM identified by the SWE and the EDCs in the early stages of Phase III. The guidance memo was developed in parallel to Errata and was meant to address issues in the 2016 TRM that are not incorrect but warrant clarification.

The Secretarial Letter for the TRM Errata was released by the PUC on March 10, 2017.⁶³ The letter included an attachment with a detailed, itemized account of Errata changes. More than 70 separate errata were identified and addressed by the SWE. Errata typically fit into one of the following broad categories, in general order of occurrence:

- typographical errors
- inconsistencies (often due to prior, partial updates of common/repeated values)
- algorithm/equation errors (missing parentheses, redundant conversion factors)
- mathematical errors (incorrectly-calculated default savings values)
- Appendix C Lighting Audit & Design Tool for C&I Projects errors
- Appendix D Motor & VFD Audit & Design Tool errors

Other, less-common, errata included broken links and outdated or missing sources.

Most errata were minor – for instance, typographical corrections and revisions to unit descriptors or variable names – and will have little or no impact on savings estimates or program administration.

More significant errata included the following:

- Correction to default ENERGY STAR Clothes Washer annual savings values (Section 2.4.4)
- Correction of baseline heating system reference values for ENERGY STAR Manufactured Homes (2.6.5)

⁶¹ See *Energy Efficiency and Conservation Program* Final Implementation Order, at Docket No. M-2014-2424864 (entered June 19, 2015) (Phase III Final Implementation Order), at 95.

⁶² The TRM Final Order and 2016 TRM update are posted on the Commission's website at http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

⁶³ <http://www.puc.pa.gov/pdocs/1512235.docx>

- Corrections to savings algorithms and terms used for Water Source and Geothermal Heat Pumps (3.2.3)
- Corrections to minimum efficiency standards for ENERGY STAR Room Air Conditioners in commercial buildings (3.2.7)
- Corrections to default cooling and heating baselines for Economizer Controls (3.2.9)
- Corrections to algorithms and default savings values for ENERGY STAR Electric Steam Cookers (3.7.4)

The guidance memo clarified other TRM items not addressed by the Errata. The guidance was organized by section of the TRM and first presented the question or issue needing clarification, followed by an explanation providing guidance on the issue. A detailed listing of the items addressed in the guidance memo is included in [Appendix I](#) of this report.

4.4 EE&C PLAN REVIEW

In preparation for the evaluation plan reviews and audit activities, the SWE conducted a detailed review of each of the EDCs' Phase III EE&C plans. Projected energy savings and spending levels were organized electronically at the measure and program level to facilitate different views into portfolio organization and allow quick comparisons across EDCs. Based on this review of contributions of different program delivery approaches and efficient technologies, the SWE began to form opinions on the allocation of evaluation resources. This upfront review expedited the review process when EDC evaluation contractors submitted their EM&V plans for review early in PY8.

4.5 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 the gross impact evaluation, NTG analysis, process evaluation, and cost-effectiveness evaluation activities and outcomes separately.

In previous phases of Act 129, a gross impact evaluation was required annually for each program in an EDC portfolio. At times, this required frequency came at the expense of the depth of the investigation. For Phase III, the SWE allowed EDC evaluation contractors the flexibility to propose the frequency of evaluation activities in their evaluation plans.⁶⁴ Evaluation contractors were also given the opportunity to organize evaluation activities differently from the EE&C plan by defining "initiatives" based on delivery channel or end-use. Multiple initiatives could be identified and

⁶⁴ In the Evaluation Framework, the SWE identified several criteria to use when proposing the frequency of evaluation activities. (1) Amount of energy and demand savings; (2) Program continuity / discontinuity; (3) Market or technology continuity / discontinuity; (4) Uniformity of measures; (5) Uncertainty and the risk of being wrong; and (6) Underperforming expectations

evaluated separately within a given program, or similar components could be identified across multiple programs and evaluated together. The Evaluation Framework provides the following example: “an EE&C plan may include a small C&I program, a large C&I program, and a GNI program that all include prescriptive lighting rebates. Evaluation contractors may elect to define prescriptive lighting as an initiative and combine projects from multiple programs into a single evaluation sample.”⁶⁵ The SWE further specified that if a program in an approved EE&C plan includes multiple initiatives with different delivery channels or end uses, the initiatives should be evaluated separately. For example, an EE&C plan may include a large Residential Energy Efficiency program composed of rebates for efficient equipment, kits of measures distributed via mail, and upstream lighting. The SWE considers these to be three distinct initiatives that should be sampled and evaluated separately.

The SWE reviews the draft evaluation plan submissions and provides suggestions and requests for clarification. EDC evaluation contractors address the feedback and prepare a revised plan for review and approval. The process repeats until the SWE approves the plan. The EDC-specific appendices of this report each include an “EM&V Plan Review” section that documents the evaluation plan review and approval process with a brief discussion of the key technical issues.

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. For Phase III, 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 measure transactions. This independent validation of reported gross program impacts also ensures that the tracking records archived by the SWE – which are a foundation of other audit activities – are consistent with the EDC’s records.

The PY8 tracking data review uncovered a minor procedural issue, which the SWE is working to resolve with several EDCs. Quarterly tracking data is submitted 45 days following the close of each quarter, so the last PY8 submission occurred on July 15, 2017. Between the final submission of the tracking data and the preparation of the EDC final annual reports in November, slight modifications were made to the EDC tracking data to correct for errors or update missing information. When the SWE initially compared the July 15th extracts to the EDC reported totals in the final annual reports, small discrepancies were observed. These discrepancies were almost exclusively a function of the vintage of the data being compared. In preparation of this report, the

⁶⁵ PA Evaluation Framework. Page 72.

SWE was able to acquire updated ‘final’ tracking extracts from the EDCs to resolve differences and will formalize the process for this data exchange for PY9.

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.⁶⁶ The SWE cross-checks 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.

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. 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.

1. The SWE agrees with the verified savings calculations and results and suggests the PUC count the reported total towards EDC compliance targets.
2. The SWE discovered an error in the calculation or disagrees with the assumptions used to estimate savings. If the magnitude of the error is greater than 1% at the portfolio level, EDCs refile their annual report to correct the error.
3. 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.

⁶⁶ 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.

4.9 Ad Hoc Tasks

4.9.1 Incremental Cost Database Update, Lighting

In the Final Order on the TRC Test for Phase III of Act 129 EE&C programs, the Commission determined that incremental measure costs would be defined for Phase III as they were for Phase II. EDCs have the flexibility to choose between the values in the SWE incremental cost database, adjusted values from the DEER database, or the values currently used for program planning and cost-effectiveness testing.⁶⁷ During PY8, the SWE completed a partial update of the incremental cost database focused on LED lighting in the residential and non-residential sectors. The LED incremental cost tables include “first cost” assumptions for LED lighting for measure two vintage categories:

- **Early Replacement and Retrofit** – Full cost of the LED equipment plus an estimate of the labor cost to install the LED lighting for non-residential equipment.
- **Replace on Burnout and New Construction** – Difference between LED first cost and first cost of comparable baseline lighting equipment. Labor costs are assumed to be the same for baseline and LED equipment and are excluded from the calculation.

In addition to these participant cost assumptions, the SWE developed estimates of the operation and maintenance (O&M) benefits associated with installation of LED lighting equipment. The SWE’s O&M calculations use the difference in rated lifetime between LED and baseline equipment and calculate a future cost savings to the program participant of not having to install another baseline lamp in several years when the original baseline lamp would have reached the end of its useful life. The net present of these future avoided replacement costs is calculated using EDC discount rate assumptions.

The SWE developed a high-level taxonomy of LED lighting equipment and organized the cost assumptions accordingly. The primary data sources for the update were as follows:

1. EDC program tracking data and supporting documentation
2. Scraping of cost data from the e-commerce websites of major lighting retailers

The Act 129 program provided information on the cost of LED equipment and the web-scraping data was used to develop cost estimates for baseline lighting equipment, which are not supported by EDC programs. The SWE analysis of LED prices revealed a significant drop in cost, even within PY8, while the cost of baseline equipment was relatively flat. For most major LED equipment categories, the values in the Incremental Cost Database update were lower than the planning values in EDC EE&C Plans, which improves the cost-effectiveness of efficient lighting program offerings.

4.9.2 Incremental Cost Database Update, Heat Pumps

During PY8, but for application in PY9 and beyond, the SWE also completed a partial update of the incremental cost database focused on Air-Source and Ductless Heat Pumps, affecting TRM

⁶⁷ The 2013 TRC Test Order for Phase II of Act 129 was issued on August 30, 2012. The 2016 TRC Test Order for Phase III of Act 129 was adopted by PUC Order at Docket No. M-2015-2468992 on June 11, 2015.

measures 2.2.1, 2.2.3, and 3.2.4. The newly developed incremental cost tables include assumptions for heat pump measures based on the following vintage:

- **Replace on Burnout and New Construction** – Difference between heat pump first cost and first cost of a comparable with the TRM-specified baseline efficiency. Labor costs are assumed to be the same for baseline and efficient heat pump equipment and are excluded from the calculation.

The updated incremental costs relied on three primary data sources:

1. PY8 project files
2. Scraping of cost data from at least five major online HVAC retailers
3. In-depth contractor interview results provided by two EDCs

The SWE analysis of the collected data resulted in an array of costs based on heat pump size and efficiency, which differs from the previous iteration of the incremental cost database for Ductless Mini-Splits, which only varied by efficiency rating and not tonnage. Overall, the updated costs are significantly lower than previous values, which improves the cost-effectiveness of these measures.

The heat pump incremental costs will be revisited in PY9, as more EDCs complete in-depth contractor interviews.

4.9.3 EISA 2020 Overview and Implications

During PY8, the SWE completed a memo summarizing two new rules issued by the DOE pertaining to EISA 2020.

While Phase II of the Energy Independence and Security Act (EISA) of 2007 is not set to take effect until January 1, 2020, in January of 2017, the Department of Energy (DOE) issued two rules that greatly expanded the scope of Phase II. Specifically, the DOE changed the definition of bulbs subject to EISA to include seven previously exempt bulb categories (most notably, reflectors, globes, and candelabras) and increased the upper end of the lumen range.

Though the recent changes in EISA rules do not affect section 2.1.1 (ENERGY STAR Lighting) of the 2016 Pennsylvania TRM, it is important to provide a brief overview of the implications of the two final rules issued by the DOE in January 2017 related to General Service Lamps (GSLs). In addition, the SWE will need to track the possible sell through (of non-compliant lighting), stockpiling, and other supply chain indicators to determine if the SWE recommends making any changes to the TRM baseline post 2020. The complete rules can be found in the federal register through the following links:

- <https://www.gpo.gov/fdsys/pkg/FR-2017-01-19/pdf/2016-32012.pdf>
- <https://www.gpo.gov/fdsys/pkg/FR-2017-01-19/pdf/2016-32013.pdf>

The first link is the final rule, which includes DOE's decision to amend the definition of GSLs. The most important takeaways from the amended definition are as follows:

- Efficiency standard of 45 lumens per watt

- The expansion of covered lumen range
- The elimination of seven exemptions

Based on the revised definition of GSL, the EISA Phase II backstop now covers the clear majority of residential lighting options. This means that very few bulbs will be exempt from EISA after January 1, 2020.

Efficiency Standard. The final rulemakings indicate that beginning January 1, 2020, GSLs will be subject to an efficiency standard of 45 lumens per watt – an efficiency standard that is higher than what current incandescent and halogen technologies can achieve. This efficiency standard suggests that post 2020, the baseline standard for covered lamps will effectively be CFLs. However, as the market is rapidly moving away from CFLs, it is possible that by 2020, the baseline for covered lamps will be LEDs.

Lumen Range Expansion. EISA Phase I covers GSLs between 310 to 2,600 lumens. The amended GSL lumen range, beginning January 1, 2020, will be 310 to 3,300 lumens. This means that EISA Phase II will apply to higher lumen-output lamps excluded from Phase I.

Elimination of Exemptions. As part of EISA Phase I, the DOE specifically identified 22 lamp types that were exempt (not covered) by the EISA efficiency standards. The final rules issued by the DOE in January 2017 discontinue exemptions for seven important categories beginning January 1, 2020.

- Reflector Lamps
- Rough Service Lamps
- Shatter-Resistant Lamps
- 3-Way Lamps
- Vibration Service Lamps
- T-Shape Lamps of 40 Watts or less or length of 10 inches or more
- B, BA, CA, F, G16-1/2, G25, G30, S, M-14 lamp of 40 W or less

Enforcement and Sell Through Period

The scope of Phase I of EISA only covered import and manufacture of lamps, and did not impose a sales ban – so if retailers obtained a lamp they were not precluded from selling that lamp.

The final EISA Phase II rulemakings prohibit **manufacture and sale** of covered lamps. However, the DOE further clarified in a footnote that it would likely allow a sell through period for non-compliant lamps after the backstop goes into effect (beyond 2020). In addition, the DOE has allowed for a possible delay (beyond 2020) in enforcement for at least some bulb categories. In addition, the SWE thinks it is unlikely that the DOE will receive funding to enforce the standards.

It is important to note that, in the final rules, the DOE has explicitly stated that they may not enforce the standards for all lamp types beginning in 2020 and may instead delay enforcement based on an ongoing dialog with lighting industry stakeholders.

Uncertainty

In the final rulemakings, the DOE indicated that they would issue specific enforcement guidelines closer to when the standards go into effect, but did not include a specific timeline. The DOE is currently engaged in discussions with lighting-industry stakeholders about the expected outcomes of the current rulemakings. In addition, in March 2017, the National Electrical Manufacturers Association (NEMA) filed a lawsuit against the DOE, challenging the EISA regulations.

These conversations and the lawsuit may mean additional changes or revisions to the rulemaking prior to January 1, 2020. This is an area that merits careful attention.

Section 5 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 PROGRAM DELIVERY

- The FirstEnergy companies incented approximately 600,000 non-ENERGY STAR lamps in PY8. Prior to the change in the ENERGY STAR specification on January 1, 2017, there was a program opportunity for the “value-line” bulbs, but after the softening of ENERGY STAR standards, EDCs should only support ENERGY STAR qualified lighting products. The SWE also notes that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning with lamps sold in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.⁶⁸
- PPL and the four FirstEnergy companies are ahead of projected energy savings totals despite spending less than projected. Duquesne Light’s PY8 spending and energy savings were both lower than planned. In PY8, PECO is the only EDC with a PY8 spending ratio that is higher (61%) than the PY8 energy savings ratio (53%). In addition, all EDCs except PECO delivered energy savings at a lower cost than projected in PY8. PECO’s actual PY8 acquisition cost was above EE&C plan projections for PY8. PECO and its ICSPs will need to deliver energy efficiency programs more efficiently in PY9 through PY12 to meet its compliance target.
- All seven EDCs are heavily reliant on the lighting measures, with over 60% of PY8 verified gross energy savings coming from the lighting end-use. Changing baselines in the residential sector are going to necessitate a significant shift in program focus in PY12. It will be important for EDCs to capitalize on the residential lighting program opportunity in PY9 through PY11.
- PPL’s Midstream Lighting program experienced 25% leakage, whereby 686 rebated lamps were ultimately installed in PECO territory. The SWE is considering this an outlier for PY8 and allowing the savings to be claimed. An update to the Evaluation Framework is forthcoming and will require the EDCs to study leakage within their programs annually, and to adjust in-service rates (ISR) based on their findings. In future program years, EDCs will not be allowed to claim leaked savings towards their savings targets.
- Non-residential project file reviews showed varying levels of evidence of appropriate selection of algorithms and assumptions for TRM-based and custom measures by the ICSPs of the seven EDCs. The SWE recommends all evaluation contractors perform more

⁶⁸ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to of lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8. For PY9Q2 and beyond, the eligibility requirements of the 2016 TRM will be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.

thorough audits of documentation for off-TRM assumptions. This would ensure that reported savings are not calculated in error due to minor oversights, and that evaluation contractors urge their corresponding ICSPs to supply unlocked versions of calculators to ensure transparency in the savings calculations performed.

- Project files are the supporting documentation maintained by EDC ICSPs and the basis for the values stored in tracking systems and ultimately presented as reported gross savings. Overall, PY8 residential project files responses were adequate and the supporting details were provided. In a limited number of cases, project files and project file details could not be matched to the tracking data. The SWE recommends that project files be organized by a unique identifier that is contained in the tracking data provided to the SWE so the two can be cross-referenced.

5.2 EVALUATION

The Pennsylvania EDCs and their evaluation contractors conducted a significant volume of verification and program design research in PY8. Some of the key findings and recommendations from their research – and the SWE audit activities – included the following:

- None of the EDC evaluation contractors quantified or monetized fossil fuel or water savings – although increased fossil fuel usage from fuel switching was included as a TRC cost. This asymmetric handling of fossil fuel impacts in the TRC Test leads to understated estimates of cost-effectiveness. Updating procedures to include calculated and monetize these benefits should be a top evaluation priority for PY9.
- FirstEnergy presented the results of a TRC sensitivity analysis on the assumed change in residential lighting baselines. This assumption, that once looked certain under the EISA 2020 backstop provisions, is increasingly unclear under the current administration. Assuming that EISA regulations will not be enforced in 2020 increases portfolio TRC ratios by 5-10%. The SWE will be examining this issue in detail in preparation for the Phase IV TRM update and market potential study.
- PECO's definition of a program is very broad and comprises many types of residential programs from Lighting Appliances & HVAC to Home Energy Reports. The SWE recommends that PECO include solution-level TRC calculations in the model to increase transparency of the inputs and calculations for individual solutions.
- PECO and FirstEnergy's evaluation contractors worked around the broad program definitions in the EDC EE&C plans and established alternative groupings measures for evaluation purposes. Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than the tariff-based program definitions.
- The SWE audit activities uncovered issues with the HER analysis for six of seven EDCs. The FirstEnergy companies submitted their analysis for review prior to the PY8 annual report filing date, so the corrections were reflected in the original filing. PECO will have to amend its PY8 filings.

- Peak demand savings were often evaluated with less rigor than energy savings, likely due to compliance being based solely on energy savings. The SWE recommends all evaluation contractors take greater care in the evaluation of peak demand savings, completing custom peak demand reduction calculations at the most granular level possible given the data available to accurately isolate the savings achieved during the TRM-prescribed peak window of 2:00 PM to 6:00 PM on summer weekdays.
- The SWE's review of verified savings for non-HER residential solutions found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused minor differences in savings – well under 1% of portfolio savings – which are detailed in the appendices along with recommendations for improvement.
- The SWE notes that in some cases, TRM defaults for open variables were used to calculate verified savings for Appliance Recycling Programs rather than the available customer-specific data. While this follows the 2016 TRM protocols, the 2016 TRM also encourages EDCs to apply the customer-specific or program-specific data that has been collected for as many open variables as possible to reflect the most accurate savings values.
- Commercial midstream program savings are expected to grow substantially in Phase III. The programs are currently focused on lighting, and account for 1.4% of the non-residential PY8 savings, but the EDCs are interested in expanding them to include non-lighting equipment such as Packaged Terminal Air Conditioning (PTAC) units, heat pumps and vending misers. Significant savings are expected to shift from downstream to midstream in the commercial sector. These programs offer customers more convenient access to rebates, but the program design creates difficulties for evaluation of savings. The SWE found higher leakage of bulbs into another EDC's service territory for one midstream program in PY8, and the EDC evaluator faced difficulties in identifying the locations of equipment sold through the program. The SWE recommends the EDCs improve the program design, and evaluation procedures to reduce leakage and improve the accuracy of savings generated by the midstream initiatives. The SWE will monitor the progress of midstream programs and update the Evaluation Framework to strengthen the savings verification procedures for these initiatives.
- Overall, the EDC evaluators estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, the SWE noted a few issues, generating recommendations for future efforts. First, EDC evaluators should make extra efforts to collect the data needed to estimate SO (as SO was excluded in one case due to incomplete data). Second, special effort should be made to generate a sample size that allows for robust NTG estimation and to avoid reporting NTG based on a single respondent. Third, when NTG values are not based on current estimation or earlier NTG values, but are assigned to complete cost-effective calculations, the reasons behind the assigned value should be explained.
- Two of the EDCs reported percentage satisfaction ratings and five (including the four FirstEnergy EDCs) reported mean satisfaction ratings. It will be more useful and insightful

to report the percentage of respondents selecting each point on the satisfaction scale. At minimum, this will provide a simple yet essential process evaluation metric – the percentage that are satisfied with the programs. In addition, the SWE would like all EDCs to report the percentage of responses for each point on a 5-point satisfaction scale. This will facilitate useful comparisons across programs and EDCs of the percentage that are satisfied with the programs.

- SWE inclusion in on-site inspections proved challenging for all evaluation contractors in PY8. Common deficiencies noted across all evaluation contractors included sampling that did not match the sampling plans submitted for each EDC; lack of timely notification for flagged sites of interest; and receipt of final reports past the deadline, which was too late to provide useful feedback for inclusion into evaluation contractors' annual reported savings. The SWE has developed a uniform and streamlined approach to coordinate ride-along visits and resolve challenges encountered during the PY8 effort, which was relayed to the evaluators in a guidance memo in October of 2017. Since the issuance of the memo, we have seen a marked improvement in evaluation contractors' processes for including the SWE in sites of interest throughout the first two quarters of PY9.

Appendix A Summary of EDC Progress Towards Portfolio Targets & Cross-Cutting Findings

A.1 EDC PROGRESS TOWARDS PORTFOLIO TARGETS

The following tables provide a summary of progress toward the individual EDC Phase III compliance targets and PY8 verified gross savings by customer segment.

Table 43: Summary of EDC PY8 Verified Savings and Phase III Portfolio Targets

EDC	Phase III Compliance Targets (MWh)			PY8 Verified Gross Savings (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	210,689	17,174	11,872
PPL	1,443,035	79,367	50,507	331,344	11,655	34,526
Duquesne	440,916	24,250	15,432	69,593	1,240	4,960
FE: Met-Ed	599,352	32,964	20,977	139,875	10,069	5,115
FE: Penelec	566,168	31,139	19,816	132,449	12,039	6,533
FE: Penn Power	157,371	8,655	5,508	37,130	3,190	2,257
FE: West Penn	540,986	29,754	18,935	131,330	10,344	10,237
Statewide	5,710,487	314,075	199,868	1,052,410	65,711	75,500

Table 44: Summary of EDC Phase II Carryover Savings

EDC	Phase III Compliance Targets (MWh)			Phase II Carryover (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	-	-	-
PPL	1,443,035	79,367	50,507	-	-	-
Duquesne	440,916	24,250	15,432	100,467	3,266	-
FE: Met-Ed	599,352	32,964	20,977	30,482	5,025	-
FE: Penelec	566,168	31,139	19,816	49,695	7,872	82
FE: Penn Power	157,371	8,655	5,508	13,866	1,805	7,316
FE: West Penn	540,986	29,754	18,935	20,540	3,354	-
Statewide	5,710,487	314,075	199,868	215,050	21,322	7,398

Table 45: Summary of EDC PY8 Verified Savings and Phase II Carryover

EDC	Phase III Compliance Targets (MWh)			PY8 Verified Gross Savings + CO (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	210,689	17,174	11,872
PPL	1,443,035	79,367	50,507	331,344	11,655	34,526
Duquesne	440,916	24,250	15,432	170,060	4,506	4,960
FE: Met-Ed	599,352	32,964	20,977	170,357	15,094	5,115
FE: Penelec	566,168	31,139	19,816	182,144	19,911	6,615
FE: Penn Power	157,371	8,655	5,508	50,996	4,995	9,573
FE: West Penn	540,986	29,754	18,935	151,870	13,698	10,237
Statewide	5,710,487	314,075	199,868	1,267,460	87,033	82,898

Table 46: Summary of EDC PY8 Verified Savings by Customer Segment

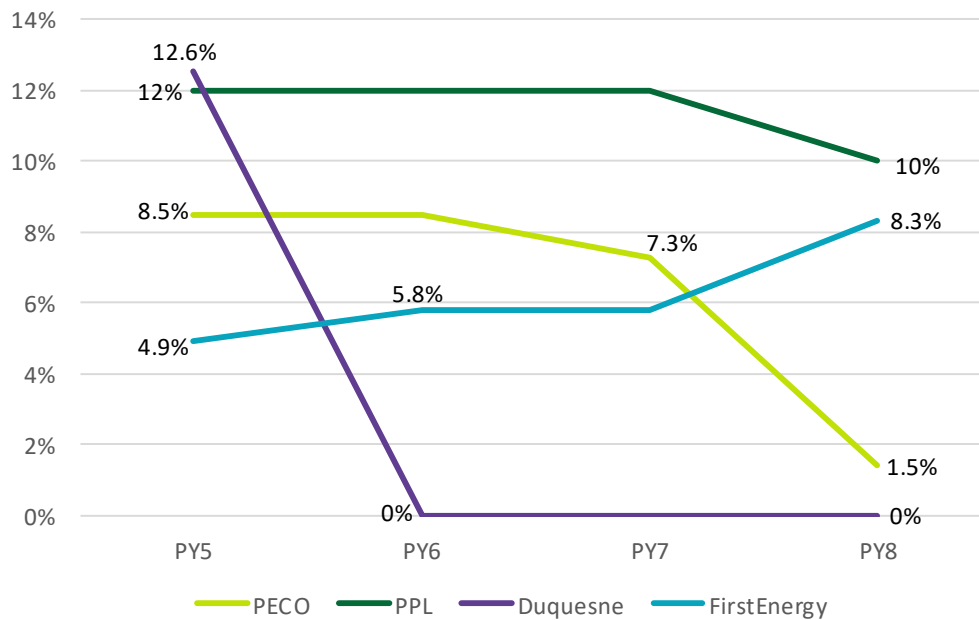
EDC	Residential (MWh)	Small C&I (MWh)	Large C&I (MWh)	GNI (MWh)	LI* (MWh)
PECO	146,622	19,327	15,694	11,872	17,174
PPL	169,199	68,870	47,094	34,526	11,655
Duquesne	45,429	8,382	9,613	4,960	1,208
FE: Met-Ed	84,402	14,075	26,178	5,115	10,105
FE: Penelec	82,862	18,750	11,945	6,533	12,359
FE: Penn Power	20,825	8,209	2,758	2,257	3,080
FE: West Penn	85,375	17,397	7,406	10,237	10,915
Statewide	634,714	155,011	120,688	75,500	66,496

*The verified savings for the FirstEnergy company low-income customer segment differs slightly from the LI compliance target because ADM confirms the income status of customers from a low-income school kit program for the compliance target (but considers all participants part of the low-income customer segment).

A.2 UPSTREAM LIGHTING – CROSS-SECTOR SALES

As noted in [Section 2](#), cross-sector sales rates represent the proportion of residential upstream program bulbs customers install in small commercial settings.

We report [Figure 27](#) again in this appendix to illustrate the difference in cross-sector sales rates across the EDCs from PY5 through PY8. As discussed below, the SWE suspects that at least some of the differences in cross-sector sales rates are due to research method.

Figure 27: Cross-Sector Sales Rates over Time

Different study methods have advantages and disadvantages and are susceptible to various types of bias. Store intercept surveys allow researchers to document the exact type and quantity of bulbs, and to discern program bulbs from non-program bulbs. However, it is often difficult to gain the cooperation of retailers, which can lead to unrepresentative pools of respondents from the subset of retailers willing to allow the intercepts. Additionally, store intercepts occur at specific dates and times, which may not fully capture purchases for small businesses. PECO and Duquesne relied on store intercept surveys to estimate cross-sector sales. Although both PECO and Duquesne had relatively high cross-sector sales rates in PY5 (8.5% and 12.6%, respectively), their cross-sector sales rates were the lowest among all EDCs in PY8 (1.5% and 0%, respectively).

Telephone surveys are less expensive than store intercepts, which allows them to be conducted over a longer period. However, customer recall of purchases made in the past can be unreliable, particularly for small-ticket items like light bulbs. In addition, residential telephone samples need to be very large to capture business purchasers. PPL and FirstEnergy relied on telephone surveys to estimate cross-sector sales, and their cross-sector sales rates were the highest among all EDCs in PY8 (10% and 8.3%, respectively). PPL ensured that business purchasers would be captured by specifically targeting small business customers in addition to residential customers.

The SWE suspects that at least some of the differences in cross-sector sales rates are due to research method. It is impossible to draw broad conclusions from [Figure 27](#) due to the variation in data collection and timing. However, considering the extremely low cross-sector sales rates of 0% and 1.5% based on store intercept surveys, and considering that the PPL PY5⁶⁹ and PY6 cross-sector sales rate point estimates were higher than 12%, [Figure 27](#) suggests that phone

⁶⁹ The PY5 PPL cross-sector sales rate was based on primary research conducted in PY4.

surveys may lead to higher cross-sector sales estimates, particularly if they target small business customers.

A.3 LOW-INCOME MEASURE PROPORTIONALITY ANALYSIS

As noted in the Executive Summary, the “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 low-income consumption relative to the total energy usage in the service territory. A low-income measure is defined as a measure that is targeted to low-income customers and is available at no cost to low-income customers. The SWE found that each EDC complied with the low-income proportionality requirement.

Table 47 reports the required minimum proportions and results of the SWE’s verification analysis.

Table 47: Low-Income Measure Proportionality Targets and SWE Verification Results

EDC	Proportionate Number of Measures Target	PY8 Proportionate Number of Measures, Reported	PY8 Proportionate Number of Measures, SWE Verified
PECO	8.80%	43.5%	26.3%
PPL	9.95%	22%	23.9%
Duquesne Light	8.40%	19.8%	23.1%
FE: Met-Ed	8.79%	37%	40.5%
FE: Penelec	10.23%	37%	40.5%
FE: Penn Power	10.64%	37%	40.5%
FE: West Penn	8.79%	37%	40.5%

A.3.1 Matching Measures to TRM Algorithms

EDCs reported compliance with the proportionate number of measures target in their individual PY8 Annual Reports and provided supporting lists of measures from their Phase III EE&C plans and classifications of measures to the SWE. However, upon analysis of the EDC measure classifications, the SWE found inconsistencies in how EDCs defined measures. The SWE advised EDCs to differentiate measures at the same granularity as algorithms in the Technical Reference Manual (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 compact fluorescent light 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.”⁷⁰

⁷⁰ Evaluation Framework.

The SWE matched measures as reported by the EDCs to TRM algorithm sections. Doing so identified when (1) multiple EDC-reported measures should be considered a single measure because they corresponded with a single algorithm section, or (2) a single EDC-reported measure could possibly be split into multiple measures because the name of the measure was general enough to encapsulate multiple algorithm sections.

A few challenges, described below, complicated the matching effort.

- Definition of “algorithm section”:** “Algorithm section” is not a clear-cut definition. Some subsections of the TRM have a single algorithm, which can easily be considered a single algorithm section. Other subsections have multiple algorithms split by text headings, but without any additional numbering. This occurs in *Section 2.2.1 Electric HVAC* of the TRM, which has different algorithms for different types of measures or actions (e.g., installing different types of efficient equipment, performing maintenance, or installing proper capacities). In these instances, each text heading was considered an individual algorithm section (e.g., *Section 2.2.1* has six algorithm sections). Still, other sections have multiple text headings, but the algorithms under each heading are functionally identical. This occurs in *Section 2.4.1 ENERGY STAR Refrigerators*, which has headings for “ENERGY STAR Refrigerator” and “ENERGY STAR Most Efficient Refrigerator.” The headings have identical equations except for different labeling for the variable representing the efficiency of the “new” refrigerator. Most EDCs combined these measures into a single measure and the SWE’s analysis does the same.
- Ambiguous measure names:** The EDCs provided comprehensive lists⁷¹ of their conservation measures and measure terminology varied across EDCs. Measure names had to be interpreted and matched to a TRM algorithm section by the SWE. Sometimes measures did not match exactly to an algorithm section of the TRM. This occurred when (1) measure names were too generalized, (2) measure names used wording that was not included in the TRM, but could be linked to a TRM section or algorithm (e.g., a multitude of measures can contribute to the “air sealing” measure in the TRM and could thus be matched to an algorithm even if the individual measure names were not present in the TRM), or (3) measure names were clear, but the measure was not discussed in the TRM (e.g., “clothes line installation”, “electric drying venting”, and “water heater timer”). When an EDC had unmatchable measure names, compliance was assessed by categorizing the measures into logical measure groups and including them as individual measures. The number of unmatchable measures ranged from 11% of an EDC’s reported measures to 40%. The specific counts of unmatchable measures are provided in each EDC’s result summary below.

When multiple EDC-reported measures were combined to match a single algorithm section in the TRM, the final measure was considered low-income if it included any EDC-reported, low-income qualified measures.

⁷¹ The measure lists from the FirstEnergy Companies were taken from Tables 8, 10, 12, and 14 of their Phase III EE&C plans. PECO, Duquesne Light, and PPL provided separate workbooks to the SWE.

A.3.2 Common Themes

There were some measure types that EDCs consistently characterized at different granularities than reflected in the TRM. Those measures are discussed below.

- Residential and Commercial Lighting:** The TRM includes a section each for residential (2.1.1) and commercial (3.1.1) efficient lamps and fixtures. The algorithm for both sections is “a straightforward algorithm that calculates the difference between baseline and new wattage,” regardless of bulb type and location. However, EDCs consistently split out measures by bulb type and location. The analysis used in this report combines these measures into one each for residential and commercial sectors to be consistent with the SWE recommendation.
- “Most Efficient” Appliances:** As discussed above, some TRM sections, such as 2.4.1 *ENERGY STAR Refrigerators*, include two different algorithms that are functionally the same. Both algorithms calculate the difference in efficiency between the old unit and the new unit. One EDC considered these as separate measures, and this would technically match the SWE recommendation. However, the other EDCs did not separate these measures and given that the algorithms are functionally the same. The SWE’s analysis groups them into a single measure as well.
- Air Sealing Methods:** The TRM has one algorithm section, 2.6.6, that addresses air sealing measures. The main inputs to the algorithm are overall air leakage measurements. The difference in the air leakage measurements is the combined effect of many different air leakage methods (e.g., weather stripping, caulking, etc.) that EDCs often report as separate measures, but that do not have their own savings algorithms. In the SWE’s analysis, these measures are deemed as part of the *Section 2.6.6* algorithm.
- Smart Power Strips:** The TRM has two algorithm sections for “Smart Strips” to accommodate two different tiers of smart strip technology. A few EDCs only include a single measure for smart strips. If the EDCs provide both Tier 1 and Tier 2 smart strips, then two measures should be counted. However, since this analysis could not confirm from the EDC-provided data which tiers of smart strips were provided by EDCs, only a single measure was counted.
- Refrigerator/Freezer Replacement and Recycling:** The TRM has one section (2.4.3) that encapsulates all refrigerator and freezer early replacement (replacing an inefficient, but functioning, appliance with a more efficient model) and recycling (removing an inefficient appliance and preventing it from being used again with or without replacing it). Some EDCs counted this as just a single measure, while others broke out the measure by freezer/refrigerator and early replacement/recycling. While the TRM does not have different algorithm sections with separate headings for freezers and refrigerators, the inputs for each are substantially different. Given these differences and that multiple EDCs reported refrigerators and freezers as separate measures, the SWE analysis treats them as separate measures. Additionally, the SWE analysis considers recycling and early replacement as separate measures. This matches some of the EDC reporting and reflects the difference in benefits generated from replacing an inefficient refrigerator (early replacement) and safely decommissioning an inefficient refrigerator (recycling).

- **Double Counting Measures:** The SWE guides the EDCs to count measures that are offered both as low-income (meaning the customer incurs none of the measure cost and is a low-income customer) and “non-low-income” (meaning the customer incurs some of the measure cost and/or is not a low-income customer) twice in the denominator of the compliance equation. Some EDCs followed this guidance and others did not. The SWE analysis sought to identify EDC-reported measures that should be double counted and incorporated the double counting into its overall measure counts for each EDC.

A.3.3 Results

Every EDC complied with low-income proportionality requirement. Matching EDC reported measures to the TRM algorithm resulted in higher levels of compliance than reported for six of the seven EDCs.

A.3.3.1 PECO

PECO reported that 43.5% of its 269 conservation measures qualified as low-income measures, which surpasses its 8.8% requirement. By the SWE’s analysis, when the EDC-reported measures are matched to TRM algorithm sections, 26.3% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 31.1% qualify as low-income. The reduction in compliance is partially attributable to PECO’s reported compliance not including measures offered both as low-income and “non-low-income” twice in the denominator of the compliance equation. The SWE analysis found 53 measures that should be counted twice in the denominator. Matching measures to the TRM and double counting the proper measures resulted in 209 individual measures, 45 of which do not match to individual TRM sections and algorithms.

A.3.3.2 PPL

PPL reported that 22.0% of its 82 conservation measures qualified as low-income measures, which surpasses its 9.95% requirement. By the SWE’s analysis, when the EDC-reported measures are matched to TRM algorithm sections, 23.9% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 25.0% qualify as low-income. Matching measures to the TRM resulted in 92 individual measures, 12 of which do not match to individual TRM sections and algorithms. The SWE analysis includes the double counting of measures offered to both low-income and non-low-income customers. The PPL reported compliance also properly double counted such measures.

A.3.3.3 Duquesne Light

Duquesne Light reported that 19.8% of its 101 conservation measures qualified as low-income measures, which surpasses its 8.4% requirement. By the SWE’s analysis, when the EDC-reported measures are matched to TRM algorithm sections, 23.1% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 26.3% qualify as low-income. Matching measures to the TRM resulted in 78 individual measures, nine of which do not match to individual TRM sections and algorithms. The SWE analysis counted twelve individual measures twice in the denominator of the compliance equation

because they were offered to both low-income and “non-low-income” customers. The Duquesne Light reported compliance had also double counted those measures.

A.3.3.4 FirstEnergy Companies

In their Phase III plans, the FirstEnergy Companies reported that 37% of their 158 conservation measures qualified as low-income measures, which surpasses every FirstEnergy EDC’s requirement. By the SWE’s analysis, when EDC-reported measures are matched to TRM algorithm sections, 40.5% of measures are low-income with measures unmatched to the TRM included. When unmatched measures are excluded, 31.6% of measures are low-income. Matching measures to the TRM resulted in 115 individual measures, 40 of which do not match individual TRM sections and algorithms. The SWE analysis counted 20 individual measures twice in the denominator of the compliance equation because they were offered to both low-income and “non-low-income” customers. The FirstEnergy EDCs had not double counted these measures.

A.3.4 Low-Income Measure Offerings

Table 48 shows a list of the individual measures provided by the EDCs to the low-income community. Since EDC-reported measure names were inconsistent between EDCs, measures are reported by TRM algorithm section. A check mark indicates that the corresponding EDC had at least one low-income EDC-reported measure that was matched to the TRM algorithm section. All the FirstEnergy EDCs (Met-Ed, Penelec, Penn Power, and West Penn) had identical low-income measures and are included as a single column: *FirstEnergy EDCs*.

The *TRM Algorithm Section* column shows the section number for each algorithm. As discussed above, some algorithms did not have unique section numbers. Letters were appended to such algorithm section numbers to create unique identifiers. Additional measures are not in the current TRM, but were matched to approved Interim Measure Protocols (IMPs). Those measures are labeled “IMPs”. Measures that could not be matched to a TRM algorithm section are labeled as “unmatched” and the measure name provided is the EDC-reported measure name.

Table 48: Summary of Low-Income Measures Provided by EDCs

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs ¹
N	85	55	22	18	47
ENERGY STAR Lighting	2.1.1	✓	✓	✓	✓
Residential Occupancy Sensors	2.1.2	✓			✓
Electroluminescent Nightlight	2.1.3	✓			
LED Nightlight	2.1.4	✓	✓	✓	✓
Electric HVAC CAC and ASHP	2.2.1a	✓			✓
Electric HVAC CAC and ASHP Maintenance	2.2.1c	✓			✓
Electric HVAC Furnace High Efficiency Fan	2.2.1f	✓			
Fuel Switch Electric Furnace to Fossil	2.2.2a	✓			
Fuel Switch Electric Baseboards to Fossil	2.2.2b	✓			
Ductless Mini-Split Heat Pumps	2.2.3				✓
ENERGY STAR Room Air Conditioner	2.2.4				✓
Room Air Conditioner Retirement	2.2.5	✓	✓		
Duct Sealing	2.2.6	✓		✓	✓
Furnace Whistle	2.2.7	✓	✓		✓
Programmable Thermostat	2.2.8	✓			✓
Heat Pump Water Heaters	2.3.1	✓	✓	✓	✓
Fuel Switch Electric Resistance to Fossil	2.3.3		✓		
Water Heater Tank Wrap	2.3.5	✓	✓	✓	
Water Heater Temperature Set Back	2.3.6	✓	✓		✓
Water Heater Pipe Insulation	2.3.7	✓	✓	✓	✓
Low Flow Faucet Aerators	2.3.8	✓	✓	✓	✓
Low Flow Showerheads	2.3.9	✓	✓	✓	✓
Thermostatic Shower Restriction Valve	2.3.10	✓	✓		
Refrigerator Recycling	2.4.3a	✓	✓		
Refrigerator Early Replacement	2.4.3b	✓	✓	✓	✓
Freezer Recycling	2.4.3c	✓	✓		
Freezer Late Replacement	2.4.3d	✓	✓		✓
ENERGY STAR Clothes Washers	2.4.4				✓
ENERGY STAR Electric Clothes Dryer	2.4.5				✓
ENERGY STAR Dehumidifier	2.4.8		✓		✓
Smart Strip Plug Outlets	2.5.3	✓	✓	✓	✓
Ceiling/Attic and Wall Insulation	2.6.1	✓		✓	✓
ENERGY STAR Windows	2.6.2	✓			✓
Residential Air Sealing	2.6.6	✓	✓	✓	✓
Crawl Space Wall Insulation	2.6.7	✓			
Rim Joist Insulation	2.6.8	✓		✓	

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs ¹
Lighting Improvements	3.1.1	✓			
New Construction Lighting	3.1.2	✓			
Traffic Lights	3.1.4	✓			
LED Exit Signs	3.1.5	✓			
LED Channel Signage	3.1.6	✓			
Electric Chillers	3.2.2	✓			
Controls: Economizer	3.2.9	✓			
Variable Frequency Drive Improvements	3.3.2	✓			
Variable Speed Refrigeration Compressor	3.5.8	✓			
Controls: Beverage Machine Controls	3.7.2	✓			
Controls: Snack Machine Controls	3.7.3	✓			
ENERGY STAR Refrigerated Beverage Machine	3.7.5	✓			
Smart Strip Plug Outlets	3.9.3	✓		✓	
ENERGY STAR Bathroom Ventilation in Commercial Applications	IMP	✓			
Floor Insulation	IMP	✓			
Furnace Maintenance	IMP	✓			✓
Permanent Fixture Removal	IMP	✓			
Permanent Lamp Removal	IMP	✓			
Residential Thermostats	IMP	✓	✓	✓	
Window Film	IMP	✓			
Window Repair	IMP	✓			
"Water Heater Timer"	Unmatched	✓			
"Water Cooled Heat Pump – Variable Refrigerant Flow"	Unmatched	✓			
"Retrocommissioning"	Unmatched	✓			
"HVAC Controls EMS"	Unmatched	✓			
"Energy Education"	Unmatched		✓		✓
"Setback Thermostat"	Unmatched		✓		
"Switch and Outlet Gasket Covers"	Unmatched			✓	
"Opower"	Unmatched			✓	
"Electric Heating Repair or Replacements"	Unmatched			✓	
"Appliance Timers"	Unmatched				✓
"Clothes Line Installation"	Unmatched				✓
"Electric Baseboard Heater Replacements"	Unmatched				✓
"Electric Dryer Venting Repair or Replacement"	Unmatched				✓
"Electrical Repairs"	Unmatched				✓

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs ¹
"Exhaust Fan Repair and Replacement"	Unmatched				✓
"Furnace Filter"	Unmatched				✓
"Gravity Film Exchange (DWHRS)"	Unmatched				✓
"Health and Safety Measures"	Unmatched				✓
"Heated Waterbed Mattress Replacement"	Unmatched				✓
"Plumbing Repairs"	Unmatched				✓
"Refrigerator/Freezer Thermometers"	Unmatched				✓
"Roof Coating"	Unmatched				✓
"Room Thermometer"	Unmatched				✓
"Sash Locks"	Unmatched				✓
"Vapor Barrier"	Unmatched				✓
"Vents (Roof, Gable, Soffit and Ridge)"	Unmatched				✓
"Water Heater Replacement"	Unmatched				✓
"Well Pump"	Unmatched				✓
"Window Quilt"	Unmatched				✓
"Window Tint"	Unmatched				✓

¹ All of the FirstEnergy EDCs (Met-Ed, Penelec, Penn Power, and West Penn) had identical low-income measures and are included as a single column: *FirstEnergy EDCs*.

A.4 NTG

Overall, the EDCs estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. The highest NTG ratios for residential programs were consistently reported for HER programs as they are based on an RCT design and the only difference between the treatment and control group are the reports themselves (and thus the analysis directly calculates net savings). The lowest estimated NTG ratios among residential programs were also consistent among EDCs: PECO, PPL, and Duquesne Light reported their lowest residential NTG values for the Appliance Turn-In Program and Met-Ed, Penelec, Penn Power, and West Penn estimated the lowest NTG for the Lighting component of the residential portfolio. There was less consistency across C&I NTG values across EDCs. Many C&I NTG values were taken from PY7 or PY6 values and are slated to be updated in PY9.

The EDCs made the NTG input data, NTG calculators, and NTG estimation syntax available to the SWE, allowing for a complete audit of the reported values. There have been some issues generating recommendations for future efforts, these include the following:

- Report when available data is not being utilized in the NTG estimation, an example being reporting why SO data was not useable.
- Special effort should be made to generate a sample size that allows for robust NTG estimation and avoids reporting NTG based on a single respondent.

- When NTG values are not based on current estimation or earlier NTG values, but are assigned to complete cost-effective calculations, the reasons behind the assigned value should be explained.

Appendix B PECO Audit Detail

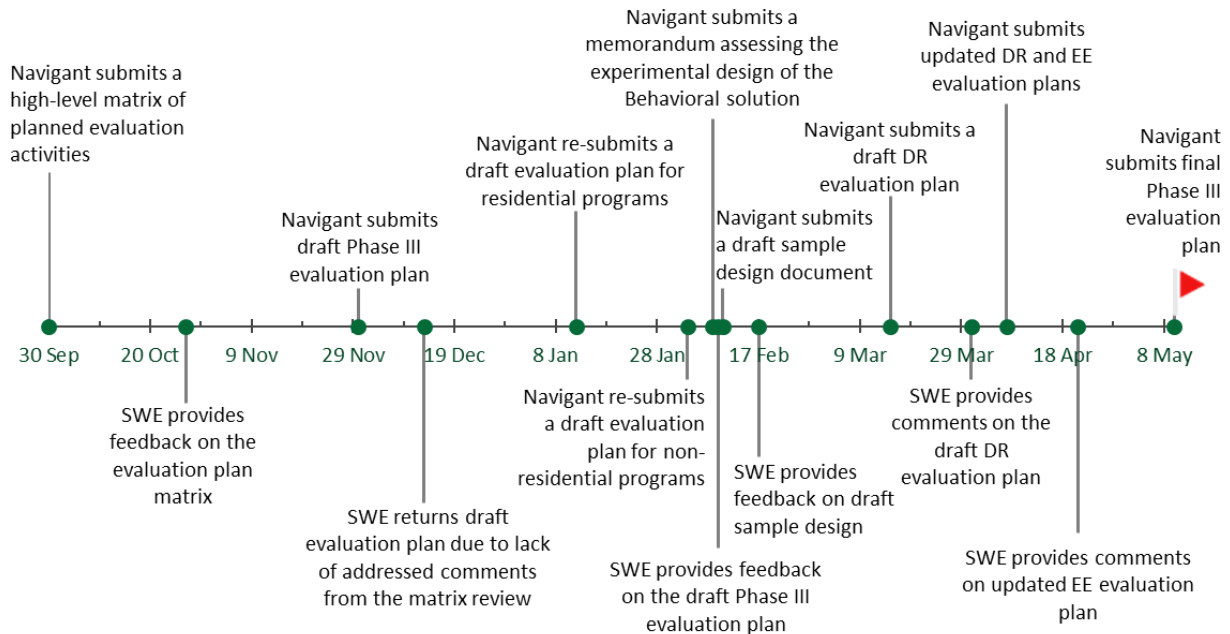
B.1 EM&V PLAN REVIEWS

The development and review of PECO's Phase III evaluation plan spanned the majority of PY8 and required significant discussions between the SWE and PECO's evaluation contractor (Navigant). PECO's Phase III EE&C plan is complex from an evaluation standpoint. While there are only five energy efficiency programs, those programs consist of several different 'solutions' with varying delivery mechanisms, efficient technologies, and implementation CSPs that need to be considered separately in the evaluation. In addition, some solutions span multiple EE&C Plan programs. Given these complexities, and the paradigm shift for Phase III that allowed impacts evaluations to be staggered across the phase, Navigant opted to begin the planning process by developing a high-level matrix of all planned evaluation activities.

Next, Navigant developed a full evaluation plan documenting the data collection methods and analysis approaches for the Phase III impact and process evaluation. The draft evaluation plan discussed the principles that would guide sampling activities, but did not provide the proposed sample design for any programs or solutions. A supplemental sample design document was developed later to supplement the evaluation plan and provide specific detail for each planned data collection activity. Once agreement was reached, the sample design was incorporated into the evaluation to create a single guiding document for Navigant's Phase III evaluation of PECO's portfolio.

Because demand response programs were not active in PY8, the evaluation planning process for PECO's DR programs lagged the energy efficiency planning. [Figure 28](#) documents the timing of the major milestones associated with finalizing the Phase III evaluation plan and sample design for PECO.

Figure 28: PECO Evaluation Plan Review Timeline, 2016-17



Key technical issues from the plan review process included the following items. Each of the issues were ultimately addressed satisfactorily prior to SWE's approval of the Phase III EM&V plan.

- Schedule and Organization of Impact Evaluations:** There were multiple discussions of how gross verified savings would be calculated and reported for program years when an impact evaluation was not conducted for solutions with two or three impact evaluations scheduled in Phase III.
- Sample Sizes:** Many of the impact evaluations were scheduled to happen two or three times during Phase III, but the reduced frequency was not balanced by an increase in depth.
- Vague Descriptions of Activities:** In draft plans, the descriptions of data collection techniques were frequently vague, or listed as "as needed." This made the proposed level of rigor impossible to determine, so the SWE requested more decisive planned activities.
- Sampling and Estimation of Non-Residential Sales in the Upstream Lighting Solution:** Navigant chose to use in-store intercept surveys with lighting purchasers at participating retailers to estimate cross-sector sales, or the proportion of lamps installed in non-residential sockets. The SWE had concerns with the calculation of sample sizes and with the proposed inferences about non-surveyed retailers from retailers where intercept surveys were conducted.
- Sampling and Estimation of Low-Income Sales in the Upstream Lighting Solution:** PECO's EE&C plan called for a large share of the low-income compliance target to be achieved through upstream lighting sales in stores located in predominantly low-income neighborhoods. The SWE requested clarification on the methodology used to tag stores

as low-income contributors and estimate the proportion of lamps sold in those stores that were purchased by low-income households.

- **Application of the Evaluation Framework DR Evaluation Protocol:** The baseline selection procedure for C&I participants and the implementation of matching versus within-subject regression for the Smart AC load control program were areas for the DR plan.
- **Changes to the Residential Lighting Baseline in PY12:** The draft evaluation plan misinterpreted the 2016 PA TRM implementation of the EISA provisions for residential lighting. The baseline for residential general service lighting effectively becomes a CFL in PY12, not in Phase IV.
- **Evaluation Details for the Behavioral Solution:** The SWE requested Navigant's review of the experimental design as part of the evaluation plan rather than the PY8 evaluation report so that any issues could be identified and addressed early on.

In addition to reviewing PECO's evaluation plans, the SWE reviewed seven residential survey instruments for the PY8 evaluation. These surveys addressed process, impact, and NTG topics.

B.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative." For 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 PECO and the FirstEnergy companies, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes because of program delivery method or technology supported. Navigant's evaluation activities for PECO were grouped by solution and samples were designed to meet the 85/15 sampling requirement for each solution.

Table 49 shows the relative precision at the 85% confidence level for a program/solution combination that used sampling in PY8. For the most part, the correlation between reported gross and verified gross savings was tighter than assumed in the sample size calculations. This led to relative precision values that were well below $\pm 15\%$ at the 85% confidence level.

Table 49: Relative Precision of Gross Verified Energy Savings Estimates by Program and Solution

Program	Solution	Relative Precision at 85% Confidence Level ($\pm$)
Residential EE Program	Lighting, Appliances, and HVAC	1%
Residential EE Program	Appliance Recycling	0%
Residential EE Program	New Construction	2%
Residential EE Program	Multifamily Targeted	1%
Low-Income EE Program	Whole Home	1%
Low-Income EE Program	Lighting	1%
Small C&I EE Program	Equipment and Systems	6%
Small C&I EE Program	New Construction	5%
Small C&I EE Program	Multifamily Targeted	21%
Small C&I EE Program	Whole Building	10%
Large C&I EE Program	Equipment and Systems	10%
Large C&I EE Program	New Construction	4%
Large C&I EE Program	Multifamily Targeted	5%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. The only value in [Table 49](#) that is above $\pm 15\%$ is the Multifamily Targeted solution within the Small C&I EE program. Navigant reported falling short of its planned sample size of 89 for this solution because of limited access at certain sites. The achieved PY8 sample size was 70. However, it is important to note that the Multifamily Targeted solution includes sample from the Residential EE, Small C&I EE, and Large C&I EE programs. Across the full sampling initiative, the sampling error was less than $\pm 15\%$ and met the requirements of the Evaluation Framework.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of Navigant's PY8 verification activities is discussed in detail in [Appendix B.4](#).

B.3 REPORTED GROSS SAVINGS AUDITS

B.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in PECO's PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program

- Incentive dollars for each program

The SWE leveraged PECO's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request. This creates some artificial challenges with replicating participation counts that the SWE will be working with PECO and Navigant to resolve in PY9.

B.3.1.1 Audit Findings

Table 50 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values in PECO's PY8 Annual Report and 'No' otherwise. Note that the tracking data supported PECO's reported MWh savings for each program.

Table 50: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Residential EE Program	147,919	147,919	Yes
Low-Income EE Program	19,865	19,865	Yes
Small C&I EE Program	17,783	17,783	Yes
Large C&I EE Program	25,965	25,965	Yes
CHP	0	0	Yes
Portfolio Total	211,532	211,532	Yes

Table 51 summarizes the SWE's findings regarding reported gross peak demand savings by program. The SWE's records match PECO's demand savings for each program.

Table 51: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Residential EE Program	11.7	11.7	Yes
Low-Income (LI) EE Program	2.2	2.2	Yes
Small C&I EE Program	2.9	2.9	Yes
Large C&I EE Program	3.9	3.9	Yes
CHP	0	0	Yes
Portfolio Total	20.8	20.8	Yes

Table 52 shows participation counts for each of PECO's programs. Although PECO's Annual Report is clear about how they define participation, the participant definitions vary from program to program. Within a single program, the participant definitions may vary from subprogram to subprogram. Within a single subprogram, participant definitions may vary from technology to technology (e.g., lighting to HVAC). As a result, the participation count for the portfolio – and even program totals – is a somewhat meaningless statistic.

The SWE was able to replicate participation for just one program – Small C&I EE. The participation count for Residential EE includes accounts that are part of PECO's Behavioral Solution (Home Energy Reports). Billing data for these accounts is not housed in the tracking data requested by the SWE, so the SWE did not expect to be able to use the tracking data to audit participation for that program. (Note that the SWE's audit results for the Behavioral Solution are presented in Appendix B.4.1.3 and we found no issues with their participation counts.) The SWE was able to replicate participation for one component of the Low-Income EE program (Lighting Solution), but not the other (Whole Home Solution). Participation for the LI Whole Home Solution relies partially on an audit number field that was not part of the tracking data extract provided to the SWE in PY8. The SWE will work with PECO and Navigant in PY9 to better understand the data elements required to replicate participation counts and make efforts to request them earlier in the audit process.

Table 52: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Residential EE Program	1,120,885	---	---
Low-Income EE Program	64,385	74,205	No
Small C&I EE Program	656	656	Yes
Large C&I EE Program	159	155	No
CHP	0	0	Yes
Portfolio Total	1,186,085	75,016	---

Finally, [Table 53](#) summarizes the SWE's findings regarding incentive dollars. For each program, the SWE was able to replicate the incentives shown in PECO's Annual Report. Note that there are no incentives for the behavioral component of the Residential EE program. This is why the SWE could replicate incentives for that program even though we were unable to replicate participation.

Table 53: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Residential EE Program	\$4,675	\$4,675	Yes
Low-Income EE Program	\$350	\$350	Yes
Small C&I EE Program	\$650	\$650	Yes
Large C&I EE Program	\$1,014	\$1,014	Yes
CHP	\$0	\$0	Yes
Portfolio Total	\$6,689	\$6,689	Yes

B.3.1.2 Action Items

For all programs represented in the tracking data, the SWE was able to replicate all energy savings values, all demand savings values, and all incentive values. For all programs except for Small C&I EE, the SWE was unable to replicate participation counts. This is in part since PECO uses values that are not housed in the SWE's tracking data extract to develop participation counts.

Thus, the SWE did not expect to be able to successfully audit participation counts for each program using the quarterly tracking data submissions.

B.3.2 Project File Reviews

B.3.2.1 Residential⁷²

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of PECO's residential project files for PY8 using the project file documentation provided by PECO and the evaluation contractor, Navigant, 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 project file packages included the majority of documentation requested, except for the New Construction solution. It should be noted that The New Construction solution was not evaluated in PY8, which may have contributed to the limited information available.

Table 54 presents an overview of the results of the SWE's residential project file reviews. As this was the first year of the Phase III project file reviews, the SWE is working with Navigant to clarify SWE data requests and data needs for future project file reviews, such as project IDs to match all project files to the tracking data.

⁷² The SWE also conducted a database review of PECO's quarterly tracking data to verify that PECO was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

Table 54: PECO PY8 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?
Residential Energy Efficiency Program	Upstream Lighting	8	✓	✓	✓	✓
Residential Energy Efficiency Program	Appliance and HVAC	17	✓	✓	✗	✓
Residential Energy Efficiency Program	Appliance Recycling	4	✓	✓	✓	✓
Residential Energy Efficiency Program	Whole Home	11	✓	✓	✗	✗
Residential Energy Efficiency Program	New Construction	10	✓	-	-	-
Residential Energy Efficiency Program	Multifamily Targeted Segment	9	✓	✓	✓	✓

As outlined above, an adequate number of project files and the supporting details were submitted for the residential program. Below is a summary of the project file reviews, including the few issues or discrepancies found between project files and tracking data.

The upstream lighting solution project files lacked enough details to verify product descriptions and quantities at times. The sampled invoices by Ecova did not contain enough detail to verify product descriptions and quantities, only the total incentive amounts. The sampled invoices by CMC Energy Services provided sufficient detail to verify product descriptions and quantities, which the majority matched the tracking database. However, a small number of CFLs (175 of 13,509) were not located in the tracking data.

The HVAC and Appliance project files matched the tracking data for the most part. However, three projects were unable to be verified in the tracking data. The discrepancy may be a result of rebate status of “approved” rather than “paid,” and therefore simply had not been entered into the tracking data at the time of the SWE’s review. All projects with a status of “paid” were matched to the tracking data.

The SWE located the Appliance Recycling Solution project files within the tracking database. The project file documentation had no discrepancies with the information in the tracking database.

The Whole Home Solution project file review discovered discrepancies with three of six sampled projects. One project’s heating system was inconsistently recorded in the project file (electric heat pump furnace) and the tracking database (electric furnace). Another project file has a rebate for fuel switching that could not be found in the tracking database. Lastly, the efficiency used in the savings calculation for a heat pump water heater does not match the listed AHRI efficiency nor the TRM default value. These findings are in addition to the findings the SWE discovered during the verified gross savings audit (see [Appendix B.4](#)).

Many of the New Construction Solution project files could not be matched to the tracking database, or did not include a unique ID variable or identifying information that could be used to locate the project within the tracking database. Only project files submitted from Q3 were in the tracking database, and no discrepancies were found in the SWE’s review.

While adequate numbers of project files were submitted for the residential solutions in PY8 and were generally accurate, the SWE notes that in a number of cases the project files could not be matched to the tracking database and in some cases, there were discrepancies between the project files and tracking data. The SWE makes the following recommendations for future project file submissions:

- Submitting project files and a matching sample of tracking data for each, including a unique identifier to easily match the tracking data to the files
- More thorough document review to ensure accurate transcription of Whole Home Solution project files

B.3.2.2 Non-residential

The SWE reviewed PECO’s C&I projects for PY8 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. All of the reviewed project file packages included all documentation requested and were well organized, allowing for a comprehensive review of the projects with only minimal deficiencies noted. Table 55 presents an overview of the results of the SWE's C&I project file reviews.

Table 55: PECO PY8 C&I Project File Review Summary

Project Number	Project Description	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for the SWE to follow?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
...1532845280	Lighting & Controls	✓	✓	✓	✓	✓	-
...1532845281	Lighting & Controls	✓	✓	✓	✓	✓	-
...1532846154	Lighting	✓	✓	✓	✓	✓	-
...1532924014	Lighting	✓	✓	✓	✓	✓	-
...1532973006	Lighting	✓	✓	✓	✓	✓	-
...1533949348	Refrigeration	✓	✓	✓	✓	✓	-
...1532863510	Lighting & HVAC	✓	✓	✓	✗	-	✗
...1532920608	Lighting & HVAC	✓	✗	✗	✓	-	✓
...1534068256	Lighting	✓	✓	✓	✓	✓	-

A review of the project files revealed only minimal issues that inhibited the SWE's understanding of the reported savings. The two specific issues observed are addressed individually by project below.

Calculations for measure number 13340 were not provided for project PECLPS1532863510. The measure was present in the tracking data, and equipment specifications were provided, but the project file lacked evidence or insight into how the savings were calculated. As such, the SWE cannot verify the reported savings.

Project PECLPS1532920608 presents a discrepancy in the reported savings between the tracking database (3497 kWh and 0.8782 kW) and the project file (2469.87 kWh and 0.02824 kW) for the air-cooled air-conditioner measure (measure number 14023).

The SWE annual reports from PY6 and PY7 submit that review of the PECO project files was seamless with only minimal inconsistencies. This trend continued through PY8, with project documentation being well organized and including all necessary documentation. The review process showed evidence of appropriate selection of algorithms and assumptions for both TRM-based and custom measures by PECO's implementers. Additionally, the SWE notes that the errors found were in projects that were not a part of Navigant's evaluation sample, and that similar errors were flagged by Navigant in a project within their evaluation sample. The SWE believes Navigant appropriately handles and reflects issues such as those noted above in their realization rates.

B.4 VERIFIED GROSS SAVINGS AUDITS

B.4.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings attributed to PECO's portfolio of residential programs. PECO's residential portfolio encompasses two umbrella programs, The Residential EE program and Low-Income EE Program, that are broken out into different solutions. The Residential EE Program solutions include the following: Lighting, Appliances, and HVAC (LAH); Appliance Recycling; Whole Home; New Construction; Multifamily Targeted Market Segment; and Behavioral. The Residential Low-Income EE Program includes a Whole Home Solution and a Lighting Solution. Note that the SWE reports the residential savings in the three following sections: upstream lighting, residential non-lighting, and behavior.

Overall, with the exception of Home Energy Reports, the verified savings followed proper TRM protocols and the verified savings are accurate. The SWE identified the evaluation activities that were used to verify savings for the residential programs. Table 56 provides a summary of the evaluation and M&V approaches used by PECO in their PY8 verified savings calculations. [Table 57](#) provides a summary of discrepancies that were discovered during the SWE audits of verified savings. This table provides a general summary of findings, for additional details please see the corresponding sections below. Note that, with the exception of Home Energy Reports, all of the

discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.⁷³

Table 56: Residential Program Evaluation Activities (by Solution) - PECO

Solution	Surveys	Site Visits	Desk Review ^a	Billing Analysis	PY7 Realization Rate
Lighting, Appliances, and HVAC	✓	--	✓	--	--
Appliance Recycling	✓	--	✓	--	--
Whole Homes ^b	--	--	--	--	--
New Construction	--	--	--	--	✓
Multifamily Targeted Market Segment	✓	--	✓	--	--
Behavior	--	--	--	✓	--
LI – Whole Homes	✓	--	✓	--	--
LI – Lighting	--	--	✓	--	--
^a The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.					
^b The savings associated with the Whole Home Solution did not undergo evaluation and did not claim any verified savings for PY8.					

⁷³ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

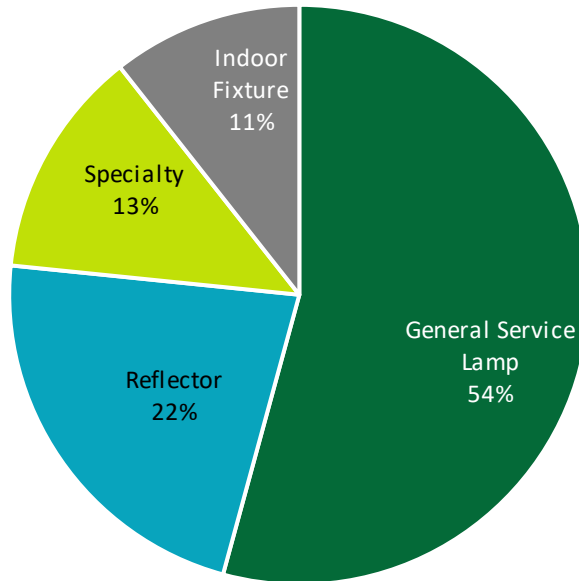
Table 57: PECO Residential Program Verified Savings Discrepancies - PECO

Solution	Sub-program/ Measure	Discrepancy	The SWE Recommendation
Appliance Recycling Solution	Refrigerator/ Freezer	Possible EDC gathered data issues; manufacturing ages reported in various ways	Consistent four-year data collection for appliance manufacturing age; adhere to TRM requirement for EDC data gathering
Appliance Recycling Solution	Room Air Conditioners	EDC gathered data vs. TRM Default; possible data collection issues	Include efficiency ratings in EDC data gathering. Apply EDC gathered inputs instead of TRM defaults
Whole Home Solutions	Various Measures	Incorrect application of TRM	Fix errors in TRM calculations before full evaluation and savings verification scheduled for PY9
Low-Income Whole Home Solutions	LED Lighting	Incorrect TRM Algorithm Applied	Apply correct TRM Algorithm
Low-Income Whole Home Solutions	CFL Lighting	Incorrect TRM Algorithm Applied	Apply correct TRM Algorithm
Low-Income Whole Home Solutions	Thermostatic Resistor Shower Valve	Incorrect TRM Default Applied	Apply correct TRM Default for Showers/day variable
Behavioral Solution	Home Energy Reports	Multiple Calculation Errors	Implement QA/QC procedures. Follow behavioral evaluation protocols from the Evaluation Framework*

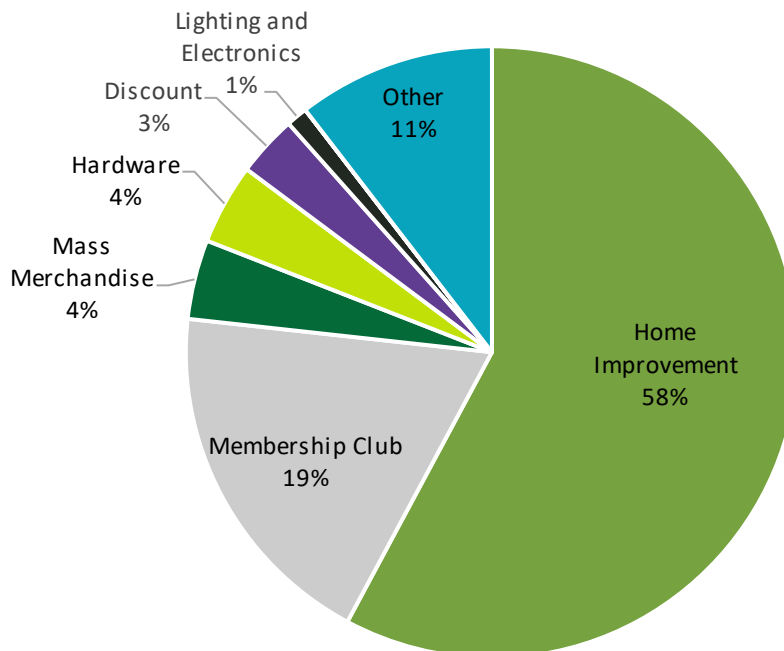
* The errors found by the SWE are detailed in [Section B.4.1.2](#) of this appendix.

B.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 1.6 million efficient light bulbs and fixtures through PECO's PY8 upstream lighting program. [Figure 29](#) displays the distribution of sales by product type. Over one-half (54%) of the products were general service lamps, while over one-fifth (22%) were reflectors.

Figure 29: PECO PY8 Upstream Lighting Sales by Product Type

Over three-quarters (77%) of PECO's PY8 upstream light bulbs and fixtures were sold through home improvement stores and membership clubs ([Figure 30](#)).

Figure 30: PECO PY8 Upstream Lighting Sales by Retail Channel

B.4.1.1.1 Audit Findings

The SWE reviewed the data in PECO's tracking system to verify that Navigant used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings.

Although the team identified some minor discrepancies (described in the review below), the SWE agrees with Navigant's verified gross savings for upstream lighting.

The SWE observed 709 unique lighting model numbers in the PY8 tracking system, and was able to locate 664 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. Possible reasons why the SWE was not able to cross-reference the remaining 45 models include deviations in the model number recorded in the tracking system versus the ENERGY STAR certified products lists (including private label products), the absence of ENERGY STAR product model numbers in the ENERGY STAR certified products lists, or the inclusion of non-ENERGY STAR products in the program. The 45 models the SWE was not able to verify as ENERGY STAR certified represent 4% of both bulbs sold and verified savings from upstream lighting.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for 24 of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system, or errors in the ENERGY STAR certified products lists.

The team confirmed that Navigant used the appropriate algorithms to calculate kWh and kW savings for upstream lighting. In addition, the SWE verified that Navigant used the correct interactive effects, ISR, residential HOU, and residential coincidence factor in the calculations. The SWE found that Navigant assigned baseline wattages in accordance with TRM protocol 2.1.1 for all but three models. The TRM instructs EDCs to use the manufacturer rated comparable wattage as the baseline wattage for bulbs with lumens outside of the lumen bins provided. However, for two reflector models with lumens outside of the lumen bins provided, a value other than the manufacturer rated comparable wattage was used as the baseline.⁷⁴ In addition, for one particular BR30 model, the baseline wattage for a type of reflector other than BR30 was applied. Combined, the impact of all discrepancies the SWE identified on initiative-level savings is negligible (less than one-tenth of 1%).

B.4.1.1.2 Cross-Sector Sales

Navigant estimated 0.73% cross-sector sales for standard LEDs and 2.0% cross-sector sales for specialty LEDs based on in-store intercept surveys conducted in PY8.⁷⁵ The majority of the surveys (70%) were conducted at Home Depot, the retailer accounting for 58% PECO's PY8 upstream lighting savings. The remainder of the surveys were conducted at hardware stores, a large retailer, a whole-sale club, and a secondhand retailer. Navigant applied the lower bound of the cross-sector sales point estimates for dollar stores and large retailers based on the assumption that they are less likely to have cross-sector sales. Similarly, Navigant assumed zero cross-sector sales for grocery and secondhand retailers.

⁷⁴ In one case, a value higher than the manufacturer rated comparable wattage was used, whereas in the other case a value lower than the manufacturer rated comparable wattage was used.

⁷⁵ Navigant did not estimate a PY8 cross-sector sales rate for CFLs because PECO stopped supporting CFLs during PY8. The PY7 cross-sector sales rate of 11% was applied to CFLs sold during PY8.

Navigant computed a weighted average HOU of 2,711 and coincidence factor of 0.47 by mapping survey respondents' business types to the building types listed in Table 3-5 of the TRM. Most of the respondents' business types map directly to the building types listed in Table 3-5; however, one business type (electrical contractor) does not. Navigant mapped electrical contractor to Industrial Manufacturing Shift 1, but the SWE thinks it would be more appropriate to map electrical contractor to Miscellaneous/Other.

B.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Review program offerings to ensure that all products are ENERGY STAR qualified.
 - The SWE was unable to verify a small portion (4%) of PY8 products as ENERGY STAR certified. While the team did not definitively determine that these were non-ENERGY STAR products, the SWE reminds all EDCs that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.
- Assign manufacturer rated comparable wattage as the baseline wattage for bulbs with lumens outside of the lumen bins provided in the TRM.
- For cross-sector sales, utilize the HOU and coincidence factor for Miscellaneous/Other building types for building types not listed in Table 3-5.

B.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting solutions found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

B.4.1.2.1 Lighting, Appliances & HVAC Solution

The Lighting, Appliance & HVAC (LAH) solution offers rebates on the residential customer purchase of qualified equipment, such as ENERGY STAR appliances, as well as upstream lighting incentives. The SWE audited each component of the LAH solution. Note that the SWE audit of lighting is reported in [Section B.4.1.1](#) of this appendix.

The SWE audit of the HVAC component of the LAH solution included air-source heat pumps, central A/C, ECM furnace fans, and GSHP desuperheaters (ductless mini-split heat pumps were excluded from verified savings due to a data collection error). The SWE determined that sample sizes were correct and savings were calculated in accordance with TRM protocols.

The SWE audit of the appliance component of the LAH solution involved review of a telephone verification survey. The telephone verification survey sample corresponded with the report and resulted in a realization rate of 1.00 for all appliances. The evaluators applied reported savings as verified savings. Auditors were unable to review if proper 2016 TRM protocols were applied to calculate appliance savings beyond the values reported in the EDC-provided data. The SWE

recommends including TRM calculations in the evaluation, or including the necessary variables for calculating TRM algorithms in the EDC-provided dataset.

B.4.1.2.2 Appliance Recycling Solution

The Appliance Recycling Solution (ARS) offers recycling options for refrigerators, freezers, and room air conditioners (RACs). The Low-income portion of the verified savings for appliance recycling solution is included in the low-income Whole Home Solutions savings ([Section B.4.1.2.6](#)). The SWE was unable to verify sample counts for refrigerator and freezer recycling portions of the program. Supporting documentation indicates 158 refrigerator surveys and 48 freezer phone surveys were completed, compared to reported counts of 164 and 47, respectively. In addition, the equipment ages provided in the EDC-provided data include instances in which a two-digit form of the year of manufacture was entered instead of a four-digit form. For example, a FV21M2WXFD Gibson Freezer, manufactured in 1992, was analyzed as if manufactured 92 years ago. In PY8 these errors increase the reported realization rate by less than 1%. The 2016 TRM outlines that refrigerator/freezer manufacture age is to be collected by the EDC. The SWE recommends standardizing the data collection process to account for possible data collection errors of this type.

The RACs were calculated correctly using the 2016 TRM default values. Auditors noticed that the RAC's cooling capacity and model numbers were included in EDC-provided data, but the TRM-default for capacity was used to calculate verified savings rather than EDC-data. While room ACs represent a very small share of the Appliance Recycling Solution savings, EDC collected model numbers could have been used to obtain actual efficiency ratings for the savings calculations rather than TRM defaults. If RACs become a larger part of the solution's savings, the SWE recommends using EDC-provided data and using the model numbers to obtain actual efficiency ratings.

B.4.1.2.3 Whole Home Solution

Per the EDC's evaluation plan, this program did not claim verified savings in PY8; however, the SWE noted the use of several incorrect default TRM values and missing data. For the TRM measure fuel switching: heat pump water heater to fossil fuel water heater, incorrect defaults were used for water temperature and ETDF variables. Incorrect default categories for overall household or unknown room for ENERGY STAR LEDs were also used. At present, the impact on savings calculations appears to be less than 1% (at the solution-level). The SWE recommends applying the correct TRM defaults and algorithms before the scheduled evaluation and verification of savings for this solution in PY9.

B.4.1.2.4 New Home Solution

In accordance with the program's evaluation plan, the PY7 realization rate was used in the calculation of verified savings for PY8. The SWE verified the PY8 reported savings using this approach. However, a deviation from the TRM algorithm was uncovered. The TRM specifies that the reported savings "of high-efficiency electric water heaters, lighting, and other appliances will be based on the algorithms presented for these measures ... [elsewhere in] this Manual," rather than those provided by the software used for building shell savings calculations. However, the

PYRTD figures used to determine PYVTD did not include these adjustments to lighting, water heating, and appliances. The SWE recommends following the TRM protocols correctly in PY9.

B.4.1.2.5 Multifamily Targeted Market Segment

The Multifamily Targeted Market Segment provided Low Flow Faucets, Low Flow Showerheads, ENERGY Star CFL light bulbs, and ENERGY Star LED bulbs to participating multifamily units. The SWE determined the sample sizes were correct, and verified savings were calculated using the correct 2016 TRM algorithms and defaults.

B.4.1.2.6 Low-Income Whole Home Solution

The Low-Income Whole Home Solution is comprised of multiple strata within the solution, which include Giveaways, Small Direct Install, Large Direct Install, Multifamily, Swaps, and LIURP. Various measures are offered in each stratum based on job type, which was tracked by the EDC and evaluation firm. Note that low-income appliance recycling customers use Residential EE - Appliance Recycling Solution, and the associated savings with low-income customers are compiled into the low-income Whole Home Solution. The verified savings for the entire solution were calculated using a sample population of measures, to obtain a realization rate that was in turn, applied to the entire reported savings population. The SWE audited all sampled measures using EDC-provided data.

The SWE discovered several minor errors in the calculations of the sampled population that was used to determine the realization rate for solution-level verified savings. The LED, CFL, and thermostatic restrictor shower valve measures all incorrectly applied the 2016 TRM algorithms, in some cases resulting in under-reporting savings (CFLs and LEDs) and in some cases over-reporting savings (thermostatic restrictor shower valves). The errors in the sample calculations affected the program-level savings by less than 1% (under-reported by 137 MWh). The SWE was unable to verify the sample sizes based on the EDC-provided data due to the inability to identify the stratum to which measures were associated. Auditors discovered that the reported LED and CFL baseline wattages provided in the full dataset included wattages that were not associated with typical residential or commercial wattages (approximately 2% of savings associated with lighting measures). The SWE recommends further vetting of EDC-gathered base wattages to confirm that the data are accurate, and to provide clear and organized data that indicates the stratum to which each record falls. The SWE also recommends using the correct application of 2016 TRM algorithms for calculating verified savings in PY9.

B.4.1.2.7 Low-Income Lighting Solution

The Low-Income Lighting Solution provides incentives for low-income customers to purchase ENERGY Star qualified LED light bulbs through retail stores serving lower income neighborhoods. The SWE found that the correct TRM-approved methods were followed and the verified savings were correct. The SWE reviewed Navigant's methods for determining the percentage of low-income households participating in the Lighting Solution and thinks it is a reasonable approach. But for PY9, the SWE would like more details on the model used to estimate household participation and review the model specifications.

B.4.1.3 Behavior

Approximately 30% of the PECO's PY8 verified gross energy savings came from Home Energy Reports issued to around 390,000 households. PECO was the most HER-reliant EDC for portfolio savings in PY8, but the only EDC who did not claim energy savings towards its low-income target from an HER offering. PECO's behavioral portfolio consists of the five different waves, or cohorts, of homes summarized in [Table 58](#).

Table 58: PECO HER Cohort Summary

Wave	First HER Mailing	Treatment Group Homes	Control Group Homes	Notes
Wave 1	August 2013	31,000	19,000	
Wave 2	March 2014	37,000	15,000	High usage homes
Wave 3	June 2015	64,000	19,000	
Wave 4	June 2016	216,000	19,000	
AC Saver	June 2016	40,000	0	All residential DR participants

The program ICSP Oracle (formerly Opower) implemented Waves 1-4 as a randomized control trial, where the eligible households were identified and then randomly assigned to either a treatment or control group. The AC Saver was not an RCT. This wave of homes consists of participants in PECO's residential DR program who were given HERs as a type of compensation for reduced incentives in the AC Saver program. Although there was no true experimental control group, Navigant created a quasi-control group using matching for the impact analysis.

The SWE performed a detailed audit of the RCT design, regression-based HER savings estimates, and recipient household counts using data provided by Navigant. Navigant's analysis methods included some departures from the behavioral evaluation protocol in the Evaluation Framework. In PY9 through PY12, the SWE expects the data management and analysis approaches for the behavioral solution to align with Evaluation Framework. The analysis also included three errors or oversights that require correction in PECO's cumulative Phase III performance totals.

1. The assumptions used to calculate average daily impacts and aggregate MWh savings for Wave 4 were misaligned. As a result, Wave 4 savings were approximately 2,000 MWh overstated.
2. A coding error in the AC Saver wave analysis caused matched control group homes to be duplicated in the analysis. As a result, the AC Saver wave savings were approximately 2,700 MWh overstated.
3. Navigant did not calculate peak demand savings for the behavioral solution. This omission understates the peak demand impacts by approximately 7.2 MW and the TRC benefits by approximately \$700,000.

Navigant was responsive to the SWE's audit findings and produced revised PY8 impact estimates that match the SWE's independent analysis. [Table 59](#) shows the original and corrected PY8 verified gross compliance savings for PECO's behavioral solution. The HER evaluation protocol

estimates net savings, so the changes to gross verified and net verified savings are identical. The sections that follow discuss each of the three issues in more detail.

Table 59: Original and Corrected PY8 HER Energy Savings

Wave	Original PY8 MWh	Corrected PY8 MWh	Difference (MWh)
1	7,528	7,528	0
2	14,280	14,280	0
3	19,022	19,022	0
4	23,065	21,062	-2,003
AC Saver	4,207	1,492	-2,715
Total	68,103	63,385	-4,718

Data Management

The approach Navigant used to ‘calendarize’ monthly billing data was inconsistent with the behavioral protocol of the Evaluation Framework. Instead of expanding the billing periods (which follow variable meter read schedules) to daily data and then collapsing to a common calendar basis, Navigant simply used the meter read date of each bill to assign the record to a month. If a home had a billing period that began on 5/2/2016 and ended 6/1/2016, that record was classified as “June 2016.” A billing period that began 5/30/2016 and ended 6/30/2016 would also be classified as “June 2016.” Because the same rules were used for the treatment and control groups, this approach does not directionally bias the estimate of the daily treatment effect, but it did contribute to the error observed with Wave 4.

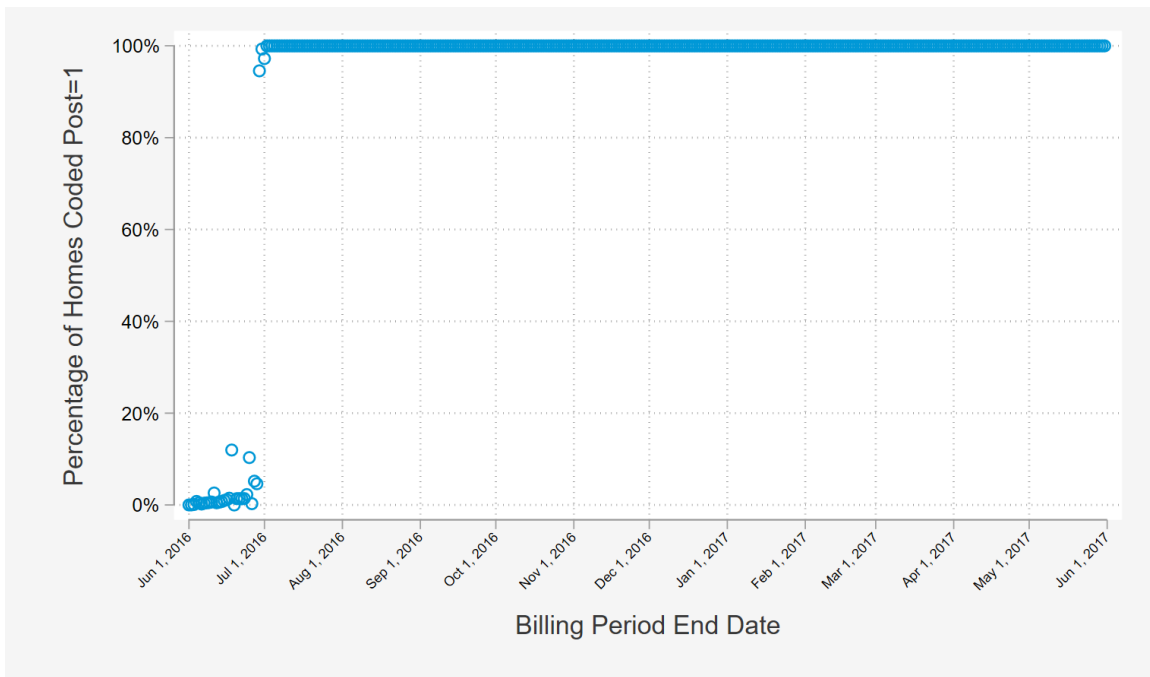
Navigant’s handling of estimated meter reads was also inconsistent with the guidance in the Evaluation Framework. Although estimated reads are infrequent for PECO (~ 1%), proper handling is straightforward and should be included in the calendarization process in the PY9 and beyond.

Wave 4 Aggregate Impacts

Wave 4 is the largest and newest HER wave in PECO’s behavioral solution. HER mailings to the treatment group homes began in June 2016. When coding the indicator variables for the regression model, Navigant initially applied the following logic:

- **Post-period** – the ‘post’ indicator variable is equal to 0 during the pre-treatment period and 1 after HER mailing began for both the treatment and control group. Navigant coded any billing period that began after June 1, 2016, as post = 1.
- **Program Year 8** – to estimate impacts specifically for PY8, the data set was restricted to months in PY8. The logic Navigant used for this restriction was billing periods that ended between June 1, 2016 and May 30, 2017.

Figure 31 shows the percentage of homes coded as post-treatment for each date in the PY8 definition. Notice that for the first month of the program year, most of the Wave 4 homes are coded as being in the pre-treatment period.

Figure 31: Wave 4 Transition from Pre-Period to Post-period

The regression model that Navigant utilized estimates the average daily savings during the post-treatment period. Unfortunately, this average daily savings value was multiplied by the total number of days in the program year – not the number of post-treatment days. Once the SWE identified the error, we suggested three potential remedies and calculated the revised savings using each one to confirm that the magnitude of the adjustment was the largely equivalent across methods.

1. Multiply the average daily savings value by the number of “post” days in PY8.
2. Recode the June bills as post = 1 and re-estimate the regression model.
3. Calendarize the data so the post-period and program year were on a clean monthly schedule.

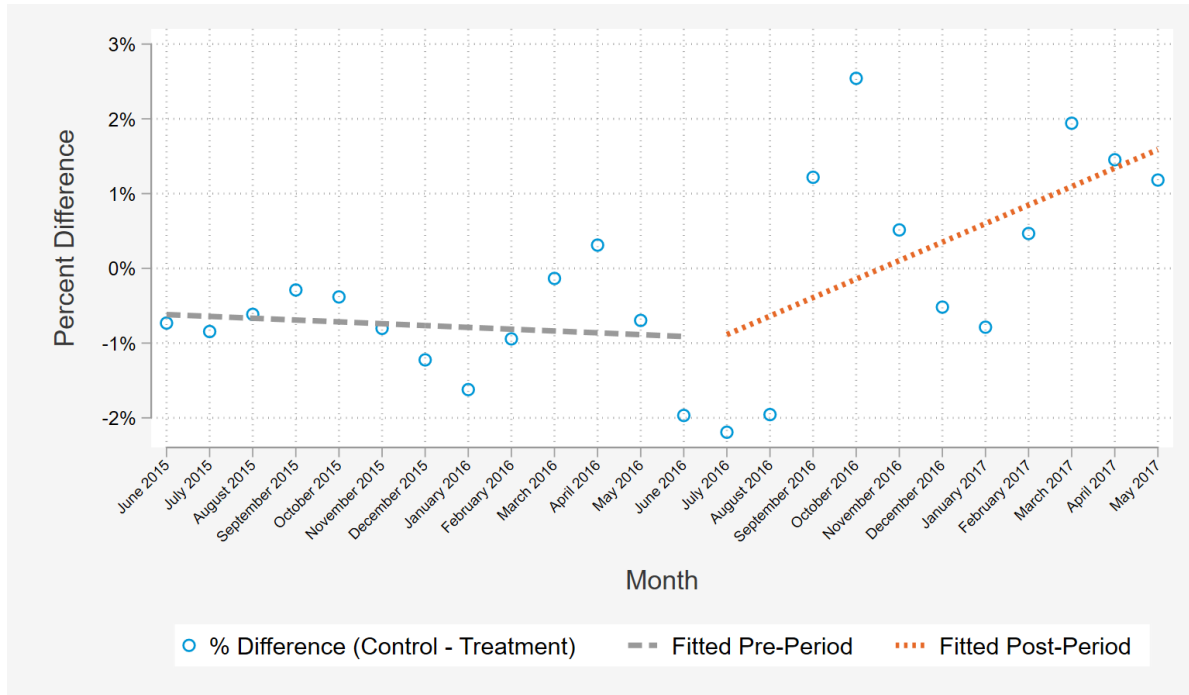
Navigant elected to implement correction #2 and their adjusted savings estimates matched the SWE’s corrected Wave 4 MWh totals. While this issue will not come up again in Phase III unless PECO creates a new wave, it shows a troubling lack of attention to detail or absence of QA/QC for a solution of this size that Navigant needs to correct in PY9.

AC Saver Matched Control Group

The AC Saver wave implementation was not an RCT with an experimental control group. This creates an evaluation challenge that is not present in Waves 1-4 because Navigant needed to create a control group via matching. Navigant handled the matching itself expertly. They used Euclidian distance matching with replacement to select the PECO residential account that most closely resembled the energy usage of each AC Saver participant from June 2016 through May 2017. The homes eligible for matching do not receive HERs from PECO. Matching “with replacement” means a control group home could match with more than one treatment group

household. If a control group home matches with more than one treatment group home, their consumption data is weighted more heavily in the model. Figure 32 shows the monthly difference in average kWh usage between the treatment and matched control group. The matches were good, with less than a 1% difference in average consumption for most months of the pre-period. The effect of HER exposure is also apparent in Figure 32. The orange line fits the trend in the post-period and shows that the treatment group homes are beginning to use less electricity than the matched control group.

Figure 32: AC Saver Wave Matching and Post-Treatment Period



The error in the AC Saver analysis was in the weighting of homes that matched to more than one treatment group home. Navigant used a technique called expansion to handle the weights. This means if a control group home was the best match for six treatment group homes, their billing data repeats six times in the analysis data set. Unfortunately, Navigant accidentally expanded the data twice. This means each home in the matched control group was included the square of the correct number of times.

The homes that matched more than once were typically lower usage households. For example, the account that matched the most times ($n=12$) was vacant and used zero kWh during the pre-treatment period. Correcting this coding error reduces the estimated savings for the AC Saver wave significantly. There are still statistically significant energy savings from this cohort for PY8, and the SWE expects the HER effect will increase over the course of Phase III as recipients internalize the HER messaging and modify their behavior.

Peak Demand Impacts

The behavioral protocol of the Evaluation Framework provided evaluation contractors several options for estimating peak demand savings for HER programs. Navigant did not attempt any of

the options and reported 0 kW of gross verified peak demand savings for the behavioral solution in PY8. The actions taken by HER recipients to save energy are difficult to understand without analyzing the hourly load data of the treatment and control groups. In absence of hourly load data, the most straightforward approach is to simply assume that the measured energy savings occur equally in each hour of the year – including the PJM peak demand period. Dividing the observed PY8 energy savings by the number of hours in year returns the following estimate of peak demand savings:

$$\text{Verified kW Savings} = \frac{63,385,000 \text{ kWh}}{8,760 \text{ hours}} = 7,236 \text{ kW}$$

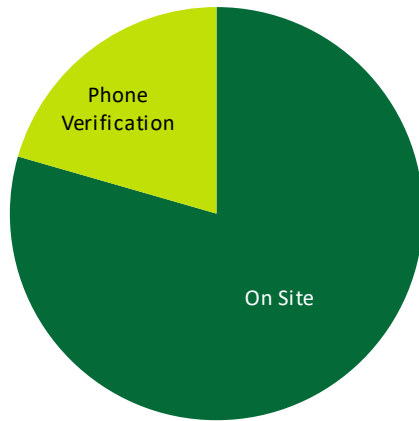
PECO's avoided cost of generation, transmission, and distribution capacity for PY8 is approximately \$93 per kW. Calculating the peak demand savings from HERs leads to an additional \$727,000 of TRC benefits. This increase is offset partially by an approximately \$187,000 reduction in avoided energy benefits from correcting the verified gross energy savings estimates. The result is a \$540,000 increase in the gross and net TRC benefits.

B.4.2 Non-Residential Audit Activities

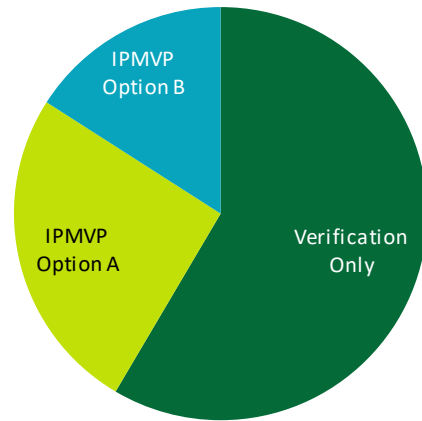
Figure 33 provides a summary of the evaluation activities and M&V approaches utilized by PECO's evaluation contractor in their PY8 verified savings calculations. Verification only was the preferred M&V approach both by energy savings contribution and project count. IPMVP Options A and B were reserved only for projects in the Large C&I Equipment and Systems Solution Program.

Figure 33: Summary of PECO's C&I Evaluation Activities

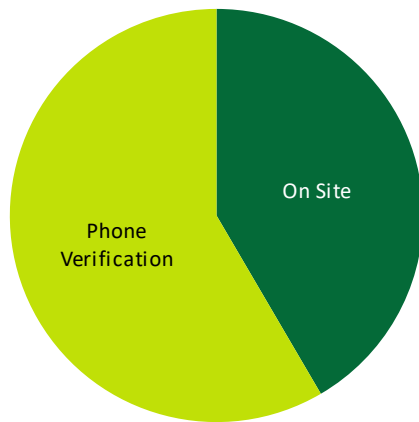
Evaluation Activity by kWh Contribution



M&V Approach by kWh Contribution



Evaluation Activity by Project Count



M&V Approach by Project Count

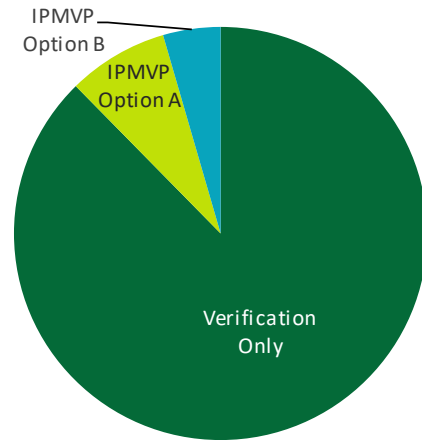
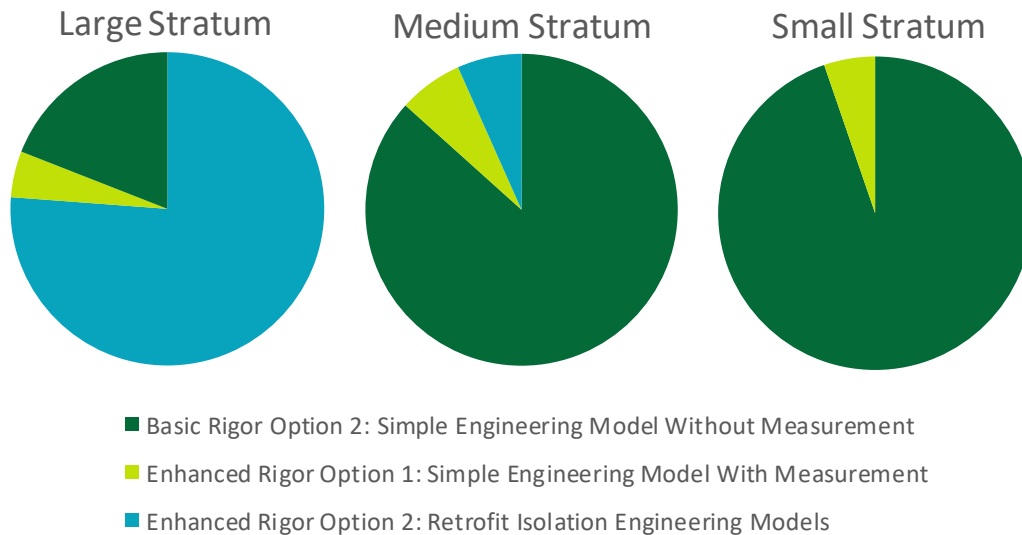


Figure 34 provides a summary of the evaluation activities and M&V approaches PECO's evaluation contractor used across strata. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 34: Summary of PECO's C&I Evaluation Activities Across Strata

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

B.4.2.1 Ride-Along Site Visits

Table 60 provides an overview of the SWE milestones for the audit of PECO's site inspection efforts.

Table 60: PECO Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
4	2,124,336	2	2	99%

The SWE encountered several setbacks in the planning and coordination of PY8 ride along audits with PECO's evaluation contractor. Specifically, the SWE found Navigant's processes deficient in the following areas:

- The SWE's involvement in sampled projects was impeded by basic housekeeping issues.
- The SWE was either not notified, or not notified within the designated two-week lead time, of flagged projects of interest.
- The evaluation contractor's SSMVPs were not submitted within the designated two-week lead time for many projects.

Navigant implemented a new tablet-based data collection and analysis tool to complete their PY8 site inspections. The SSMVPs and final reports submitted using this application were well organized; however, calculations were submitted as a "black box," where values were hardcoded

into cells of excel spreadsheets and formulae were not readily available. The evaluation contractor made traditional Microsoft Excel calculations available at the SWE's request.

Of the four audited projects, two projects contained lighting upgrades. Both projects were large C&I customers and involved on-site sampling due to the extent of the scopes of work. The SWE agreed with the methodology and calculations completed by PECO's evaluation contractors for lighting measures. On-site sampling strategies were completed in accordance with the Phase III Evaluation Framework, and calculations showed evidence that the TRM was followed appropriately.

The remaining two audited projects contained VFD upgrades; one of which raised several red flags in the evaluation contractor's calculations and processes, the most pressing of which was the suspected poor estimation of baseline energy consumption. PECLPS1533146026 was a VFD project accruing 301,596 kWh of energy savings, which was above the TRM threshold dictating at what size a VFD project requires baseline metering or appropriate modeling. Baseline logging was not able to be completed. At the post-retrofit inspection, the site contact detailed the baseline as inlet guide vanes, an alternate variable speed application. However, the evaluation contractor's calculations rely on the following assumption:

"Estimated pre-upgrade usage will be calculated using full speed motor power (HP x 0.746), derated by 5% to account for power variations produced by inlet guide vane (vortex damper) changes."

The SWE deemed this estimation technique an inappropriate modeling method as the calculations did not take into account motor efficiency, a reasonable load factor, and the variable speed operation created by inlet guide vanes. Furthermore, the 5% derate factor posed by the evaluation contractor appeared unsubstantiated. After multiple discussions with the evaluator, it was found that the SWE was not given complete project documentation prior to the site visit, which led to the SWE's lack of insight into the baseline.

Additionally, at the time the SWE presented their concerns to the evaluation contractor, the evaluation contractor had already submitted their final results and reports. The SWE and the evaluator continued discussing the project adjusting the savings many times. Once the revisions were final, the SWE and the evaluator reviewed the effects of the revisions to the project on the portfolio level savings and found it to be within less than 1% error at the portfolio level. As such, it was decided not to adjust the verified savings presented in the evaluator's final annual reporting.

The SWE's use of ride-along site inspections in place of independent site inspections was implemented in Phase II as a result of a high level of confidence in evaluation contractor practices. However, inclusion on flagged sites of interest proved to be challenging for all evaluation contractors in PY8. The SWE communicated the deficiencies in the site inspection process with the EDCs and their evaluation contractors via individualized phone conferences with all interested parties and through a guidance memo issued in October of 2017 detailing new tools implemented by the SWE to improve the process moving forward. The suggestions provided in the guidance memo were as follows:

- Navigant should submit samples in keeping with their EM&V plan to the SWE as they are drawn for SWE review. The SWE has created a template that should be followed for future

submissions to make sure all information needed to select an appropriate sample is included.

- Navigant should attempt to coordinate with the SWE in advance of scheduling flagged projects of interest to ensure SWE inclusion.
- Navigant should use the SWE's shared cloud-based calendar for scheduling and notification of upcoming site inspections.
- Navigant should submit excel calculations to the SWE along with their final report for projects evaluated using their new tablet-based data collection tool.
- Navigant should submit verified savings analyses to the SWE with enough lead time for changes to be properly incorporated into verified savings rollup exercises.

B.4.2.2 Verified Savings Desk Reviews

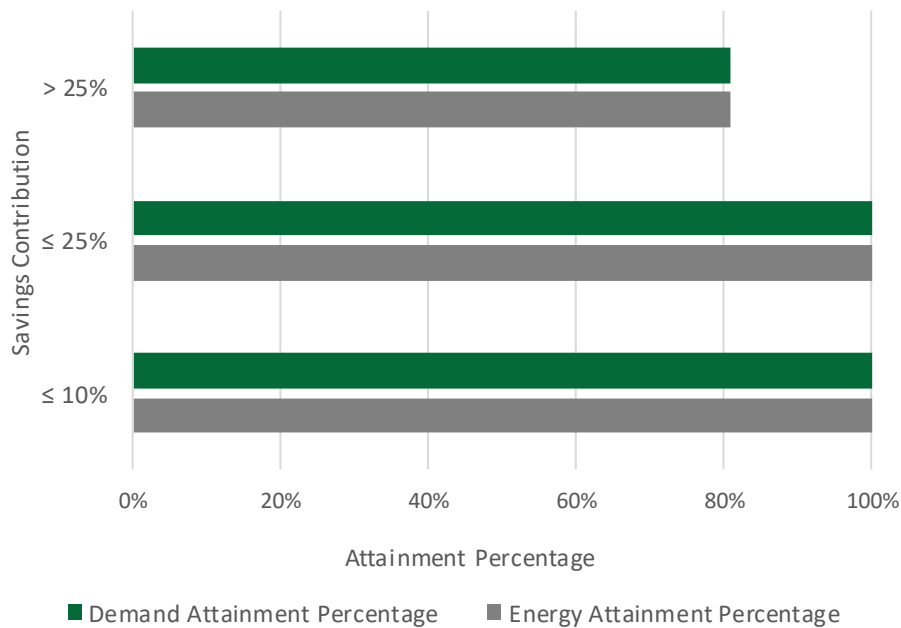
Table 61 provides an overview of the SWE milestones for the verified savings review of evaluated PECO projects.

Table 61: PECO Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
10	3,866,342	617	92%	94%

Overall, the SWE found that PECO's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. The SWE asserts that Navigant conducted appropriate M&V efforts, and that sufficient documentation supporting savings analyses was provided.

Of the ten projects reviewed, the SWE calculated adjusted energy and demand savings for only one project. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand savings attainment percentages of PECO's reviewed projects were 92% and 94%, respectively. The distribution of the attainment percentages by savings contribution is presented in Figure 35, and provides cause for concern regarding the level of scrutiny applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 35: PECO Verified Savings Attainment Percentage

Project PECLPS1532899267 achieved savings for the installation of 13 VFDs on various air handling system components. The verified savings calculations relied on trended fan speed data, which the evaluator used to calculate equivalent kW for each data point according to the following equation: $kW_{post} = Avg.kW_{base} \times \%Speed^{2.7}$. The evaluator's use of a static exponent of 2.7 appears unsubstantiated and is indicative of high parasitic losses by the VFD. However, the trend data shows that the average fan speed consistently exceeded 80%, at which speed the parasitic losses should be quite low according to the manufacturer's specification sheets. The SWE changed the exponent to be variable based on fan speed as derived by standard fan affinity laws. This revision resulted in decreased baseline consumption, and in turn, decreased energy and demand savings.

While having no effect on attainment percentages, the SWE found analysis files for PECLPS1532846027 to be deficient in that the verified savings calculation file submitted did not provide the formulae for the total savings. The SWE was able to reconcile the verified savings using the lighting calculator submitted for the reported savings calculations and found the formulae to be in agreement.

The review of PECO's verified savings calculations showed a high level of adherence to the TRM and Evaluation Framework. As a result, the SWE only recommends that Navigant provide analysis files with active calculations for verification by the SWE in future program years.

B.5 NTG

Overall, Navigant estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. However, for one solution, Navigant appeared to ignore evidence of

SO due to incomplete data to estimate SO. The SWE recommends that in future NTG evaluations Navigant make extra efforts to collect the data needed to estimate spillover.⁷⁶

B.5.1 Residential Programs

Navigant collected participant survey data by phone to inform the NTG for the Appliances and HVAC, Upstream Lighting, Appliance Recycling Solutions, and Multifamily Targeted Solutions. PY7 NTG were applied as the PY8 NTG for the Whole Home and New Construction Solutions, as was stated in the EMV plan, and will be estimated again in PY9. Navigant supplied survey data and a NTG calculator that allowed the SWE to fully audit the methods and findings.

Navigant weighted the Appliances and HVAC free-ridership values NTG inputs by individual participant energy savings, which were informed by the 2016 TRM. Spillover was estimated using PY7 consumer survey data and 2016 TRM for measure savings. The Appliances and HVAC NTG evaluation was estimated for the overall solution, as well as for five individual solution measures: Appliances, HVAC, Heat Pumps, Central Air Conditioners, and High Efficiency Furnace Fans.

Navigant employed in-store intercept surveys to gather data to calculate the PY8 NTG for upstream Lighting. They were able to use the instore intercept surveys to generate free-ridership, but a data collection error did not allow the data to inform spillover and spillover was assigned PY7 values. Navigant reported using the common method to develop the Lighting NTG.

Navigant conducted a participant survey that included the SWE battery of questions to determine net savings for refrigerators, freezers, and room AC components of the Appliance Recycling Solution. Navigant estimated four NTGs for the Appliance Recycling Solution: refrigerators, freezers, room air conditioners, and the solution total. In keeping with the UMP and 2016 TRM, spillover was not incorporated in the appliance recycling NTG.

Navigant surveyed landlords and tenants using the SWE approved questions to estimate net savings for the Multifamily Targeted Solution estimating both small and large residential NTG and inputs along with a Solution total NTG using the common estimation method.

Navigant assigned a NTG of one to the Behavioral Solution, in accordance with the Evaluation Framework.⁷⁷

⁷⁶ Navigant informed the SWE that the SO data was not useable in this case because the respondent did not provide answers to all of the questions needed to quantify spillover.

⁷⁷ As detailed in the Evaluation Framework, The RCT design eliminates the need for net-to-gross analysis because the control group does everything the treatment group “would have done.”

Table 62: Summary of NTG Estimates for PECO Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Lighting, Appliances & HVAC	0.56	0.04	0.48	1,023
Estimated	Appliance Recycling	0.63	0.0	0.37	221
Applied PY7 value	Whole Home	0.13	0.07	0.94	--
Applied PY7 value	New Construction	0.50	0.0	0.50	--
Estimated	Multifamily Targeted Market Segment	0.18	0.02	0.84	66
RCT	Behavioral	0	0	1.0	--

B.5.2 Residential Low-Income EE Programs

Navigant did not conduct NTG evaluations for any components of the PY8 Residential Low-income EE Program.

B.5.3 C&I EE Programs

The Small C&I EE Program used phone surveys to estimate NTG ratios, but only calculated NTG for the Multifamily Targeted Market Segment. PY7 NTG values were applied as the PY8 NTG ratios for the Equipment and Systems Solution, the C&I New Construction Solution, and the Whole Building Solution segments of the C&I EE Program. All Large C&I Program components were assigned PY7 NTG values. The Program components for which NTG was not estimated in PY8 will be estimated in PY9, as was agreed upon in the Phase III Sampling Plan. Navigant also reported the overall Small C&I and overall Large C&I program NTG, but did not indicate the method of calculation that incorporated the separate solution component NTG values into an overall NTG value. SWE recommends transparent language within the report on how the total segment NTG was produced.

The SWE determined that Navigant utilized the common method to generate the Multifamily Targeted Market Segment NTG. Navigant segmented the NTG analysis by measure to identify LEDs as a HIM and provide a LED specific NTG in addition to the overall program segment NTG. Navigant reported that there was no SO for the Multifamily Targeted Market Segment, though the data show evidence of a respondent installing additional showerheads due to their program participation. The SWE recommends that in future NTG evaluations Navigant make extra efforts to collect the data needed to estimate spillover.⁷⁸

⁷⁸ Navigant informed the SWE that the SO data was not useable in this case because the respondent did not provide answers to all of the questions needed to quantify spillover.

Table 63: Summary of NTG Estimates for PECO C&I EE Program

Approach	Solution or Program	Free-Ridership	Spillover	NTG	Sample Size
Applied PY7 value	Small C&I Equipment and Systems	0.23	0.02	0.79	--
Applied PY7 value	Small C&I New Construction	0.69	0.0	0.31	--
Applied PY7 value	Small C&I Whole Building	0.10	0.0	0.90	--
Estimated	Small C&I MF Targeted Market	0.35	0.0	0.65	7
Combination of Program component NTGs	Small C&I Program Total	0.27	0.01	0.75	7
Applied PY7 value	Large C&I Equipment and Systems	0.34	0.01	0.66	--
Applied PY7 value	Large C&I New Construction	0.48	0.0	0.52	--
Estimated	Large C&I MF Targeted Market	0.35	0.0	0.65	4
Combination of Program component NTGs	Large C&I Program Total	0.36	0.0	0.64	--

B.6 TRC

Table 64 summarizes the results from the Total Resource Cost (TRC) test for PECO's PY8 individual programs and portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY8 annual report.⁷⁹

⁷⁹ Verified savings were updated for the Residential EE Program based on an audit finding in [Appendix B.4.1.3](#). This resulted in a \$539,622 increase in gross and net TRC benefits, which improved the overall TRC ratio.

Table 64: Summary of PECO PY8 TRC Results

Program	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Residential EE ²	48,290	26,830	1.80	24,910	20,660	1.21
Low-Income EE	6,310	7,605	0.83	5,395	7,605	0.71
Small C&I EE	8,485	7,805	1.09	6,274	6,536	0.96
Large C&I EE	12,450	12,611	0.99	7,956	9,999	0.80
CHP	0	15	0.00	0	15	0.00
Portfolio Total¹	75,535	68,836	1.10	44,535	58,785	0.76

¹ Program costs will not sum to Portfolio Total, which includes costs from inactive Demand Response programs and cross-cutting portfolio costs.

² The TRC benefits and TRC ratios have been adjusted to correct for errors in PECO's Home Energy Report savings totals and TRC costs have been corrected for a minor reporting error in the PECO PY8 Annual Report. Navigant confirmed the accuracy of the TRC ratios, therefore, this table reports the values from the final TRC model rather than the PY8 Annual Report.

Of PECO's five energy efficiency programs, two were determined cost-effective and three were not, based on the TRC test using gross verified savings. When using net verified savings, one program was found to be cost-effective and four were non-cost-effective. The Small C&I EE Program was found cost-effective under gross verified savings, but non-cost-effective under net verified savings. PY8 TRC ratios are down slightly from previous Phase II of Act 129. PECO's definition of a *program* is very broad and comprises many types of individual program *solutions*, which makes it difficult to determine what components are reducing the TRC ratio. The break out of cost-effective and non-cost-effective energy efficiency programs are listed below.

Gross Verified Savings**Cost-Effective Programs (TRC > 1):**

- Residential Energy Efficiency (EE)
- Small C&I EE

Non-Cost-Effective Programs (TRC < 1):

- Low-Income EE
- Large C&I EE
- CHP

Net Verified Savings**Cost-Effective Programs (TRC > 1):**

- Residential EE

Non-Cost-Effective Programs (TRC < 1):

- Low-Income EE
- Small C&I EE
- Large C&I EE
- CHP

B.6.1 Assumptions and Inputs

The PY8 TRC model was developed by Navigant using the Analytica software. Below is a summary of the assumptions and inputs that were verified by the SWE.

- The PY8 TRC model used a discount rate of 7.6%, which matches PECO's Phase III EE&C plan.
- 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 2016 TRM.
- For the residential and commercial sectors, measure lives were reported at the measure-level. The SWE spot-checked some of the measure lives and found them to be consistent with the 2016 TRM.
- The PY8 TRC model was based on verified savings; however, program impacts were adjusted by an applicable realization rate prior to being imported into the model. The SWE confirmed that energy and demand savings were in-line with the verified gross savings outlined in PECO's PY8 Annual Report.
- 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 2016 TRC Order directive for Phase III. NTG ratios appear to be consistent with PECO's PY8 Annual Report.
- The PY8 TRC Model uses the Phase III approved avoided costs of energy and capacity. The SWE confirmed that the model selected the appropriate PY8 stream of avoided costs.
- The SWE confirmed that cost categories were handled correctly in the PY8 TRC model: incentives were not considered costs and administrative costs and incremental measure costs were incorporated as costs. However, incremental costs were assigned at the measure level and all other costs were assigned at the program level, which means there was no transparency into how costs were handled at the solution level. Therefore, the SWE was unable to determine if costs that relate to specific solutions were handled correctly. For example, the SWE was unable to determine if the incremental measure cost for lighting kits was not double counted as a program delivery cost.
- The PY8 TRC model assigned incremental costs at the measure level. The SWE spot-checked the incremental costs used in the TRC model and, while they seem reasonable, the basis for assigning incremental costs was poorly documented in the model.
- The SWE confirmed that a dual baseline was implemented with regards to CFL and LED installations. PECO implemented the dual baseline by adjusting down the EUL for both CFLs and LEDs, where applicable. For example, the LED measure life was reduced from 15 to 6.2 years for the Residential EE Program delivered through the Retail solution.

B.6.2 Conclusions and Recommendations

The SWE noted a few minor issues pertaining to the implementation of the TRC model, which are discussed below. None of the items are cause for concern about the material results of the TRC

model, and are noted here as recommendations for adjustments to be made in future Phase III reporting.

The PECO TRC model is performing all of the benefit-cost calculations in accordance with the 2016 TRC Order. The SWE review of the PECO model found no obvious calculation errors; however, not all of the background calculations and inputs were available to the SWE. In addition, PECO's definition of a *program* is very broad and comprises many types of residential programs from Lighting Appliances & HVAC to Home Energy Reports. The SWE recommends that PECO include solution-level TRC calculations in the model to increase transparency of the inputs and calculations for individual solutions.

Some inputs were poorly outlined in the model, including the basis for determining incremental costs. The SWE recommends that adequate documentation outlining the basis for assigning measure-level incremental cost and NTG factors be provided along with the model inputs file for PY9.

The PECO TRC model does not include any benefits from fossil fuel and/or water savings. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio.

B.6.3 Adjusted Home Energy Report Savings

The SWE made an adjustment to the verified MWh energy and demand savings for the HER Program. This resulted in a \$539,622 increase in gross and net TRC benefits, which improved the overall TRC ratio for the Residential EE Program. [Table 65](#) outlines the SWE's estimate of how this adjustment in savings affected the TRC ratio.

Table 65: Summary of Impact on PY8 TRC Results

Program	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Residential EE ¹	47,750	26,830	1.78	24,370	20,660	1.18
With adjusted HER savings	48,290	26,830	1.80	24,910	20,660	1.21

¹ The SWE notes that Residential EE gross benefits and costs reported in the PECO PY8 Annual Report do not match those found in the final TRC model. Navigant confirmed the accuracy of the TRC ratios, therefore, this table reports the values from the final TRC model rather than the PY8 Annual Report.

B.7 PROCESS

B.7.1 Residential Energy Efficiency Programs

Navigant reported on process evaluations for three residential program solutions: Lighting, Appliances & HVAC Solution, Appliance Recycling Solution, and Multifamily Targeted Market Segment Solution.⁸⁰

For the process evaluations of these program solutions, Navigant reviewed program documents and data, interviewed utility and implementation staff, and surveyed participants for a subset of solutions. The document and program data review informed identification of program goals; activities; updates; and, in some instances, identification of program trends and data-tracking errors. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) varied among solutions, but generally included the effectiveness of program administration, implementation, and delivery; customer program awareness, satisfaction, participation, and challenges; and recommendations.

Cross-cutting process evaluation findings were presented for the Residential EE Program overall.

1. As of the writing of this report and based on the PY8 impact evaluation results, it is clear that PECO and its CSPs needed time in PY8 to adjust to new requirements and implementation changes, and that some of the elements needed for success, such as supporting data and infrastructure, are still in progress.
2. Survey findings indicate that the EEMF's⁸¹ marketing initiatives, PECO's home energy audits, and the HERs sent via the Behavioral Solution are not yet top sources of information for customers. The EEMF's advertising efforts and PECO's main channeling programs, while important to the implementation plan, may not yet be as memorable to customers compared to tangible, direct-to-the-customer bill inserts or personal word of mouth marketing channels, such as landlords, personal contacts, and contractors.
3. In general, Residential EE Program participants are not learning about PECO's other offerings during the course of their experience within their respective solution, resulting in a missed opportunity to increase participation across the program.
4. Participants across the three Residential EE Program solutions included in the survey said they were either likely or extremely likely to recommend the solution to another person.

B.7.1.1 Lighting, Appliances and HVAC Solution

Summary of the Process Evaluation Findings

Navigant employed several data-collection methods to gather information for the process evaluation. For lighting measures, it reviewed program materials, interviewed program manager and implementation staff, and conducted an in-store intercept survey of 864 customers. For non-lighting measures, Navigant conducted 150 telephone surveys with HVAC and appliance rebate

⁸⁰ Navigant did not conduct a process evaluation for the New Construction Solution in PY8. For the Behavior Solution, Navigant is in the process of conducting a survey of participants and will provide those results in a follow-up memo.

⁸¹ Energy Efficiency Marketing Firm.

participants. Navigant also reviewed the participation tracking databases and other program materials. Based on these data, eight total key findings emerged (five for Lighting and three for Appliances & HVAC).

Lighting process key findings are as follows:

1. Customer preferences and experience with non-discounted models were the main reasons that customers purchased non-discounted LEDs over PECO-discounted bulbs.
2. The survey indicated that homeowners buy LEDs more frequently than renters, and that single-family residents buy LEDs more frequently than multifamily residents. Specifically, 83% of discounted bulb purchasers and 88% of non-discounted LED purchasers are homeowners, compared to 64% of standard efficiency purchasers. Additionally, 72% of LED purchasers have single-family homes, compared to 46% of standard efficiency purchasers.
3. The survey responses revealed that low-income customers are more likely to buy standard efficiency bulbs than program-discounted LEDs. Specifically, 5% of discounted LED purchasers were low-income customers, compared to 14% of standard efficiency purchasers that were low-income customers. This finding shows that the Residential Lighting Program is generally not reaching low-income customers with incentives for program-discounted LEDs.

Appliances & HVAC process key findings are as follows:

1. Navigant found a small portion (13%) of respondents who reported a neutral or dissatisfying experience with the program. The majority of this group (11% of the 13%) said their satisfaction was neutral. However, the remainder of respondents voiced frustration with Appliance and HVAC rebate delays and difficulties with filling out the rebate application.
2. The majority (78%) of respondents said they were extremely likely to recommend the Appliances and HVAC component to others.
3. The trade ally network of installation contractors is a key pathway for marketing PECO's portfolio of EE programs.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan, except for the program process and customer journey maps for the Appliances and HVAC component, which is still under development.

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. Navigant used a stratified random sampling approach for the participant phone survey, focusing on two strata: HVAC and appliances. Navigant achieved sample sizes that provided 85/15 confidence/precision per data-collection activity and/or stratum.

The SWE also determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with

a description of whether PECO was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations, except in one area. There were no references to the statistical test(s) used to evaluate the strength of differences reported between PY8 and prior program years. It would have been useful to know, for example, whether the proportion of respondents aware that PECO provided LED store discounts was statistically significantly different from PY7 to PY8. The reporting could have benefitted from this additional level of detail.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. Most recommendations were clear and actionable and were supported by the findings.

B.7.1.2 Appliance Recycling Solution

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY8 participation data and materials review, a telephone survey of 221 program participants, and in-depth interviews with the program and implementer staff. Based on these data, three key process findings emerged:

1. Satisfaction ratings for the Appliance Recycling Solution were overwhelmingly positive; however, 7% of respondents reported a neutral or dissatisfying experience with the solution. Reasons for a rating of 3 or below varied, but generally included a desire for faster rebates. The CSPs monthly reports to PECO include incentive check processing time as a key performance metric, but Navigant was unable to verify the claim that 100% of checks are processed within 15 business days.
2. An overwhelming majority (88%) of respondents said they were extremely likely to recommend the Appliance Recycling Solution to another person.
3. Induced replacements are up from the previous year. In PY7, Navigant found that 2% of refrigerator and 3% of freezer replacements were driven by customer participation in the program. In PY8, those numbers increased to 4% and 8%, respectively.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan, except for the program process and customer journey maps component, which is still under development.

For the data-collection task requiring sampling, the SWE determined that the sampling approach yielded an adequate sample and the report incorporated the required table showing the sampling strategy. Navigant used a stratified random sampling approach for the participant survey. Three strata focused on the measures (refrigerators, freezers, and room air conditioners). The sample provided 85/15 confidence/precision per stratum.

The SWE also determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a description of whether PECO was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.1.3 Whole Home Solution

No process evaluation was conducted in PY8. Navigant will conduct a process evaluation in PY9.

B.7.1.4 New Construction Solution

No process evaluation was conducted in PY8. Navigant will conduct a process evaluation in PY9.

B.7.1.5 Behavioral Solution

Summary of the Process Evaluation Findings

There are no process evaluation findings as of yet for the PY8 Behavioral Solution.

Summary of the Process Evaluation Audit

Navigant has not yet completed all the PY8 activities listed in the evaluation plan. Navigant is in the process of collecting process evaluation data through a phone survey of 700 participants in the Behavioral Solution. Navigant will provide information about these survey results in a follow-up memo once the data collection process has been completed.

B.7.1.6 Residential DR Program

No process evaluation was conducted in PY8. Navigant will conduct a process evaluation in PY9, including CSP interviews and customer surveys.

B.7.2 Multifamily Targeted Market Segment

The Multifamily Targeted Market Segment solution is a component of three PECO programs: Residential, Small C&I EE, and Large C&I EE. However, Navigant conducted and reported the process evaluation for the segment as a whole rather than separately within each program.

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY8 participation data and materials review, phone interviews with 16 property managers and one decision maker from a larger firm that owns multiple buildings, a phone survey of 66 participant tenants (with 35 completes from the Small stratum and 31 surveys from the Large stratum), and interviews of program managers and implementation staff. Based on these data, one key finding emerged:

1. Property managers and tenants are generally not aware of other PECO program and solution offerings. In addition, the measure mix in PY8 only included direct install lighting and water conservation measures.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan.

The SWE determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a

description of whether PECO was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.3 Low-Income EE Program

B.7.3.1 Whole Home Solution

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY8 participation data and materials review, a telephone survey of 213 program participants, and in-depth interviews with the program and implementer staff. Based on these data, three key findings emerged:

1. Free CFL activity participants are not aware of other PECO programs, including the Free Energy Check-Up activity. PECO could leverage the Free CFL activity, targeted to low-income communities through trusted community organizations, to encourage participation in complementary program activities. This is especially true given the high customer satisfaction reported by participants.
2. The Phase III customer marketing campaign has not generated the volume of incoming customer calls needed, and the call center has not prioritized outbound calls for this market. The CSP for this solution has continued to make outbound calls to CAP⁸² participants, leveraging their Phase II experience to generate projects. (The call center is delivering less than 25% of the needed appointments. The solution needs 50 Home Energy Check-Up appointments per day to meet its annual goals). The CSP reports that outbound calling is critical to engaging customers and overcoming barriers to participation. While the solution did not meet its PY8 goal, outbound phone calls conducted by the CSP have been instrumental to the program's PY8 results being as strong as they are.
3. Program staff have identified opportunities to collaborate with complementary programs and initiatives to increase participation. These efforts include the following:
 - a. Prioritize identification of older, second appliances eligible for recycling and referral to the Appliance Recycling program.
 - b. Collaboration with PGW and the Philadelphia Water Department on a pilot to provide a single home audit to customers delivering services for all three utilities.
 - c. Collaboration with the LIURP and the Energy Coordinating Agency (ECA) to deliver electric EE products to low-income households participating in these complementary programs.

⁸² Customer Assistance Program.

- d. PECO has provided energy kits to multifamily building tenants when their landlords have not completed a participation agreement. The kits provide a limited set of measures similar to direct install products.
- e. Marketing outreach targeted at low-income neighborhoods.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan.

For the data-collection task requiring sampling, the SWE determined that the sampling approach yielded an adequate sample and the report incorporated the required table showing the sampling strategy. Navigant used a stratified random sampling approach for the participant survey. PECO participants were surveyed to identify variances in customer experiences between the Free CFL and Free Home Energy Check-Up activities within the Whole Home Solution. Four strata were developed for the Free Home Energy Check-Up sample (very small single family, small single-family, large single-family, and multifamily). The sample provided 85/15 confidence/precision per stratum.

The SWE also determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a description of whether PECO was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.3.2 Lighting Solution

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY8 participation data and materials review, GIS analysis to assess customer income level, and in-depth interviews with the program and implementer staff. Based on these data, three key findings emerged:

1. The concentration of low-income households in PECO territory is not uniform, and not all retailer participants are well positioned geographically to deliver savings to qualifying households.
2. There are likely unidentified retailers that are not program participants, but are well positioned to reach low-income populations.
3. Some participating retailers are well positioned to deliver increased savings to low-income households.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan.

The SWE determined that the reporting followed the SWE guidelines. The annual report included descriptions of the methods, summary of findings, and a table of recommendations with a

description of whether PECO was implementing or considering those recommendations. The report included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.4 Small C&I EE Program

The Small C&I EE Program is made up of four solutions and two targeted market segments, shown with the solution below:

- Equipment and Systems Solution
- New Construction Solution
- Whole Building Solution
- Behavioral Solution (not implemented in PY8)
- Multifamily Targeted Market Segment
- Data Centers Targeted Market Segment (no participation in PY8)

As the Behavioral Solution was not implemented in PY8 and the Data Centers Targeted Market Segment had no participation in PY8, these program components did not provide a report on evaluation activities for the SWE to review. The SWE presents the review of the Multifamily Targeted Market Segment in its own section, given its cross-cutting nature.

The SWE presents brief overviews of the Equipment and Systems Solution, the New Construction Solution, and the Whole Building Solution in the following sections. To avoid redundancy, the Team then presents a summary of the process evaluation findings, as well as a summary of the process evaluation audit for these three solutions combined.

B.7.4.1 Equipment and Systems Solution, New Construction Solution, and Whole Building Solution

Summary of the Process Evaluation Findings

Data sources for the process evaluation of the Equipment and Systems Solution, the New Construction Solution, and the Whole Building Solution included PY8 participation data and materials review and in-depth interviews with the program and implementer staff. One key finding emerged:

1. As of the writing of this report and based on the PY8 impact evaluation results, it is clear that PECO and its CSPs needed time in PY8 to adjust to new requirements and implementation changes associated with the new phase and that some of the elements needed for success, such as supporting data and infrastructure, are still in progress. In short, the Small C&I EE Program did not meet its PY8 savings goals. Navigant's early feedback process evaluation research indicates that the savings shortfall is likely a result of several complex factors that are sometimes, but not always, solution specific. For

example, the length of the program application and time involved in applying for incentives, coupled with customer perception that incentives have decreased, caused Small C&I customers to forgo applying for incentives. These customers believe the incentive is not worth the effort. As a PY9 activity, Navigant will conduct a targeted process review of PECO's procedures and the documentation (i.e., lighting worksheet) required of customers to apply for incentives. In addition, per the PY9 Evaluation Plan, Navigant will survey Small C&I New Construction, Equipment and Systems, Data Centers, and Whole Building participants to measure program successes, identify improvements to design, and understand customer decision-making related to free-ridership and spillover.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan. The SWE determined that the reporting generally followed the SWE guidelines, with some exceptions. The annual report did not include the process findings in the table of recommendations along with the impact findings; it did, however, describe the process findings in the body of the report. The report generally included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was generally succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.4.2 Small C&I DR Program

No process evaluation was conducted in PY8. Navigant will conduct a process evaluation in PY9, including CSP interviews and customer surveys.

B.7.5 Large C&I EE Program

The Large C&I EE Program is made up of two solutions and two targeted market segments, shown with the solution below:

- Equipment and Systems Solution
- New Construction Solution
- Data Centers Targeted Market Segment (no participation in PY8)
- Multifamily Targeted Market Segment

The Data Centers Targeted Market Segment had no participation in PY8 and thus the PA SWE does not present a review of this program. The PA SWE presents the review of the Multifamily Targeted Market Segment in its own section, given its cross-cutting nature.

The PA SWE presents brief overviews of the Equipment and Systems Solution and the New Construction Solution in the following sections. To avoid redundancy, the Team then presents a summary of the process evaluation findings, as well as a summary of the process evaluation audit for both solutions combined.

B.7.5.1 Equipment and Systems Solution and New Construction Solution

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY8 participation data and materials review and in-depth interviews with the program and implementer staff for both the Equipment and Systems Solution and the New Construction Solution. One key finding emerged:

1. Similar to the Small C&I Program, not one Large Commercial EE Program solution met its PY8 savings goals. As discussed earlier, the Navigant early feedback process evaluation research indicates that the shortfall is likely a result of several complex factors that are sometimes, but not always, solution specific. For example, the length of the program application and the corresponding time involved in applying for incentives, coupled with customer perception the incentives have decreased, may be the reason Large C&I customers are not applying for incentives. These customers believe the incentive is not worth the effort. As a PY9 activity, Navigant will review PECO's new online application, as well as the processes, procedures, and documentation (i.e., lighting worksheet) required of customers to apply for incentives. In addition, per the PY9 Evaluation Plan, Navigant will survey Large C&I New Construction, Equipment and Systems, and Data Center customers to measure program successes, identify improvements to design, and understand customer decision-making related to free-ridership and spillover.

Summary of the Process Evaluation Audit

Navigant completed all the PY8 activities listed in the evaluation plan for both the Equipment and Systems Solution and the New Construction Solution, except for the participant process survey, which appears to have been deferred to PY9.

The SWE determined that the reporting generally followed the SWE guidelines, with some exceptions. The annual report did not include the process findings in the table of recommendations along with the impact findings; it did, however, describe the process findings in the body of the report. The report generally included sufficient detail for the SWE (and other readers) to assess the methods, findings, and recommendations.

Overall, the process evaluation discussion was generally succinct and highlighted findings that should be of value to the administrator and implementer. The recommendations were clear and actionable and were supported by the findings. Recommendations were drawn from key findings.

B.7.5.2 Large C&I DR Program

No process evaluation was conducted in PY8. Navigant will conduct a process evaluation in PY9, including CSP interviews and customer surveys.

B.7.6 Combined Heat and Power Program

No process evaluation was conducted in PY8. A process evaluation is scheduled for PY9.

Appendix C PPL Audit Detail

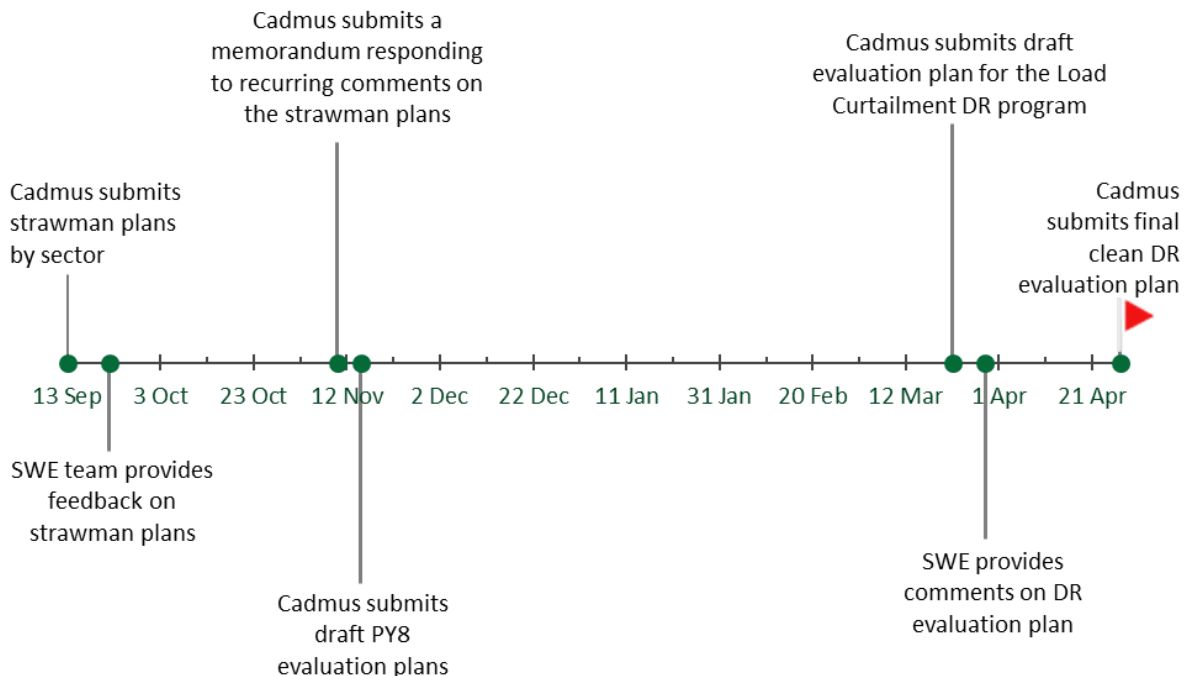
C.1 EM&V PLAN REVIEWS

PPL's evaluation contractor, Cadmus, first developed an overview of planned approaches for the residential, non-residential, and low-income sectors. Unlike several other EDCs, Cadmus opted to perform impact evaluations of each program annually. The SWE's review of these 'strawman' plans were largely focused on the nature of the data collection techniques (e.g., online vs. telephone surveys) and requesting additional detail be provided in the full evaluation plans.

Cadmus prepared separate evaluation plan documents for each program in PPL's Phase III EE&C plan. This allowed programs to follow different paths to review and approval. For example, the Home Energy Education program evaluation plan only required some minor discussions about the cohort characteristics and was finalized within a month of submission in draft form. At the other end of the spectrum, was the Distributor Discount program, which took almost six months to finalize. This 'midstream lighting' offering was a new offering for Phase III and the evaluation plan relied on finalization of an IMP.

Because demand response programs were not active in PY8, the evaluation planning process for PPL's DR programs lagged the energy efficiency planning. [Figure 36](#) documents the timing of the major milestones associated with the Phase III evaluation planning for the PPL/Cadmus team.

Figure 36: PPL Evaluation Plan Review Timeline, 2016-17



Key technical issues from the plan review process included the following:

- **Absence of Primary Data Collection in the Residential Sector:** The draft EM&V plans for residential programs called for almost exclusive reliance on the TRM for savings assumptions. No site visits were proposed for the residential sector programs and data collection was limited to simple verification. At the insistence of the SWE, Cadmus added site visits to the evaluation plan for the WRAP program and the residential new construction component of the Energy Efficient Home program.
- **Disregard of Equipment Specifications in the Appliance Recycling Program:** Although the ICSP collects the equipment characteristics for many of the open variables in the TRM algorithm (size, configuration, age), Cadmus proposed to rely on TRM defaults. The SWE viewed this approach as ‘cherry-picking’ because the historic default values in the TRM will produce systematically higher kWh savings values than the use of actual equipment characteristics. Ultimately, the use of TRM defaults was allowed.
- **Prospective Application of Billing Analysis Results:** The draft evaluation plans for the WRAP program called for billing analysis from previous years to be used to calculate gross verified savings. The intent was to allow savings to be reported in each annual report of the Phase despite insufficient post-retrofit data. The SWE requested that instead, Cadmus treat savings as unverified until sufficient participant billing data was available to calculate savings and limit the use of historic results to PY12 when compliance reporting necessitates it.
- **Verification of Baseline Equipment for Midstream Lighting:** The midstream lighting IMP provides assumed baseline equipment types and wattages for most types of LED lighting equipment. In some cases, the baseline is a code minimum lamp; in other cases, it is an assumed type of fixture being replaced (early replacement). The IMP requires evaluation contractors to perform site inspections to verify the actual types of equipment replaced and use the collected data to calculate gross verified savings accordingly using an Appendix C Lighting Calculator. There was substantial back-and-forth between Cadmus and the SWE to reach consensus on the specifics of these research tasks.
- **Additional Detail on Analysis of CHP Projects:** By definition, projects in the Custom program are unique, so it is difficult to prospectively describe the evaluation methods that will be utilized. However, planning documents showed CHP accounting for a large share of program savings. The SWE requested additional detail on how Cadmus planned to analyze the thermal side of CHP installations to support system efficiency requirements and TRC calculations.

In addition to reviewing PPL’s evaluation plans, the SWE reviewed 18 survey instruments and four interview guides. Sixteen of these instruments were for residential programs, five were for C&I programs, and one was for a low-income program. The surveys and interviews addressed process, impact, and NTG topics.

C.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

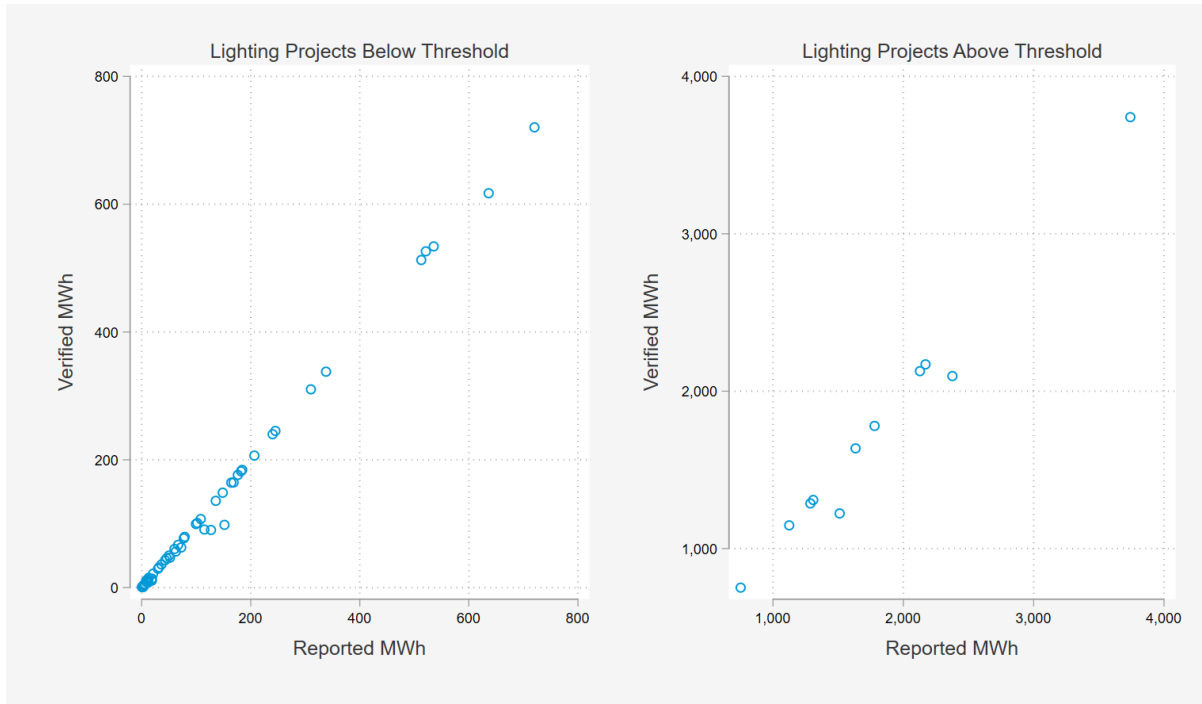
The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each “initiative.” For Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change did not guide sample design for Cadmus because PPL’s Phase III EE&C plan defines programs narrowly. The Cadmus evaluation activities for PPL were grouped by program and samples were designed to meet the 85/15 sampling requirement for each program. [Table 66](#) shows the results for energy.

Table 66: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Program

Program	Relative Precision at 85% Confidence Level ($\pm$)
Efficient Lighting	4.3%
Efficient Equipment	1.7%
Custom	5.3%
Energy Efficiency Kits and Education	1.4%
Appliance Recycling	0.0%
Energy Efficient Home	2.7%
Student Energy Efficient Education	1.2%
Weatherization Relief Assistance Program	6.3%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. The gross verified energy savings estimates for each program were well within the allowable levels of sampling error for PY8. This result is due to a combination of large evaluation sample sizes and a high degree of correlation between reported and verified savings at the project level.

[Figure 37](#) compares the reported gross and verified gross energy savings values for the 68 sampled projects in the Lighting stratum of the Efficient Equipment program. The figure separates projects above and below the TRM threshold of 750 MWh/yr for site-specific data collection. For most projects in both groupings, the reported and verified savings are identical.

Figure 37: PPL PY8 Non-Residential Lighting Sample Results

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of Cadmus' PY8 verification activities is discussed in detail in [Appendix C.4](#).

C.3 REPORTED GROSS SAVINGS AUDITS

C.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in PPL's PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation counts for each program
- Incentive dollars for each program

The SWE leveraged PPL's Q1-Q4 tracking data to audit these values. For PPL, the SWE receives both a full tracking data set, and an abridged extract tailored to our PY8 quarterly data request.

C.3.1.1 Audit Findings

Table 67 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the annual report and 'No' otherwise. Note that some program names from PPL Electric's Annual Report were not in the tracking data, and vice-versa. In future submissions, the programs in PPL Electric's reports and the tracking data should be the same, and they should be aligned with the approved Phase III EE&C plan. That said, the SWE was able to replicate the reported gross energy savings for all programs.

Table 67: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Recycling	12,035	12,035	Yes
Custom	71,332	71,332	Yes
Efficient Equipment	76,169	76,169	Yes
Efficient Lighting	150,376	150,376	Yes
Energy Efficiency Kits and Education	10,420	10,420	Yes
Energy Efficient Home	10,621	10,621	Yes
Home Energy Education	40,467	40,467	Yes
Low-Income WRAP	3,491	3,491	Yes
Student Energy Efficient Education	5,118	5,118	Yes
Portfolio Total	380,028	380,028	Yes

Table 68 summarizes the SWE's findings regarding reported gross peak demand savings by program. Like with energy savings, some program names from the annual report were not in the tracking data and vice-versa. Still, the SWE was able to replicate reported gross peak demand savings for each program.

Table 68: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Recycling	1.65	1.65	Yes
Custom	8.96	8.96	Yes
Efficient Equipment	10.16	10.16	Yes
Efficient Lighting	22.15	22.15	Yes
Energy Efficiency Kits and Education	0.75	0.75	Yes
Energy Efficient Home	1.95	1.95	Yes
Home Energy Education	54.39	54.39	Yes
Low-Income WRAP	0.34	0.34	Yes
Student Energy Efficient Education	0.46	0.46	Yes
Portfolio Total	100.81	100.81	Yes

Table 69 summarizes the SWE's findings regarding program participation. The SWE was able to duplicate participation counts for all programs.

Table 69: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Recycling	11,368	11,368	Yes
Custom	71	71	Yes
Efficient Equipment	1,751	1,751	Yes
Efficient Lighting	336,221	336,221	Yes
Energy Efficiency Kits and Education	12,117	12,117	Yes
Energy Efficient Home	11,401	11,401	Yes
Home Energy Education	184,257	184,257	Yes
Low-Income WRAP	2,718	2,718	Yes
Student Energy Efficient Education	24,145	24,145	Yes
Portfolio Total	584,049	584,049	Yes

Finally, [Table 70](#) summarizes the SWE's comparison of incentive dollars listed in program tracking data to the program totals in PPL's Annual Report. The SWE was unable to replicate incentive dollars for any of the five programs for which PPL Electric reported incentive dollars in their annual report. That said, note that the annual report incentives and tracking data incentives are directionally similar within any given program. This result is consistent with prior program years because the annual report values are pulled from a financial system of record as opposed to program tracking data. Because of the different source tables, the rebate amounts in the tracking data will generally be close, but never exactly equal to the incentive dollars in PPL's reports.

Table 70: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Recycling	\$341	\$367	No
Custom	\$4,325	\$4,197	No
Efficient Equipment	\$4,546	\$5,199	No
Efficient Lighting	\$11,513	\$11,494	No
Energy Efficient Home	\$1,734	\$1,612	No
Portfolio Total	\$22,459	\$22,869	No

C.3.1.2 Action Items

For all programs, the SWE was able to replicate reported MWh savings, reported MW savings, and participation counts with the quarterly tracking data. The only hurdle the SWE encountered was a matter of taxonomy – some program names that were in the tracking data were not in the annual report, and vice-versa. PPL Electric should take care to ensure that the program names used in the tracking data line up with the program names used in their reports.

C.3.2 Project File Reviews

C.3.2.1 Residential⁸³

As part of the reported savings (i.e., ex-ante) review, the SWE reviewed a sample of PPL's residential project files for PY8 using the project file documentation provided by PPL and the evaluation contractor, Cadmus, 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.

Table 71 presents an overview of the results of the SWE's residential project file reviews. As this was the first year of the Phase III project file reviews, the SWE is working with Cadmus to clarify SWE data requests and data needs for future project file reviews.

⁸³ The SWE also conducted a database review of PPL's quarterly tracking data to verify that PPL was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

Table 71: PPL PY8 Residential Project File Review Summary

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?
Appliance Recycling	n/a	6	✓	✓	✓	✓
Energy Efficient Homes	New Homes	4	✓	✓	✗*	✓
Energy Efficient Homes	Audits and Energy-Savings Kits	5	✓	✓	✓	✓
Energy Efficient Homes	Weatherization	5	✓	✓	✗*	✓
Energy Efficient Homes	Efficient Equipment	10	✓	✓	✓	✗
Energy Efficient Kits and Education**	n/a	10	✓	✓	✓	✓
Energy Efficient Lighting	n/a	9	✓	✓	✓	✓
Student Energy Efficient Education	n/a	1	✓	✓	-	-
Winter Relief Assistance	n/a	10	✓	✓	✓	✓

* Cadmus has addressed this issue and will begin including the CSP job number in PY9

** Project files for kits were not available from the CSP every quarter. A sample of records were provided to the SWE when available.

As outlined above, an adequate number of files and the supporting details were provided. Of the reviewed programs, the following issues or discrepancies were found between project files and tracking data.

The efficient equipment subprogram project files did not provide consistent information for capacity or efficiency. Three out of ten files reviewed provide proof of purchase, but no equipment specifications. One instance of a heat pump water heater was reported as 50 gallons in the tracking database, however the receipt indicates 80 gallons.

The Efficient Lighting project file documents matched the tracking database for nine of ten reviewed invoices. One file could not be verified due to the invoice being aggregated with other program measures.

Review of the Appliance Recycling program took longer than if a project ID had been provided, but a search of project names still allowed for verification. Cadmus has addressed this issue and will begin including the project ID going forward.

The New Homes subprogram and weatherization project files did not consistently include project IDs that could easily be matched to the tracking data. Cadmus has addressed this issue and will begin including the CSP job number going forward.

The PY8 review of residential project files found file packages were adequate and accurate. The SWE makes the following recommendations to improve the efficiency of the project file reviewing going forward:

- Submitting project files and a matching sample of tracking data for each, including a unique identifier to easily match data to the files.
- More clarity on how rebate amounts are calculated, specifically for New Homes and Weatherization projects.
- More thorough document review to ensure accurate transcription of appliance specifications.

C.3.2.2 Non-residential

The SWE reviewed PPL's C&I projects for PY8 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. All reviewed project file packages included all documentation requested and were well organized, allowing for a comprehensive review of the projects. [Table 72](#) presents an overview of the results of the SWE's C&I project file reviews.

Table 72: PPL PY8 C&I Project File Review Summary

Project Number	Project Description	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for the SWE to follow?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
PRJ-855368	Lighting	✓	✓	✓	✓	✓	-
PRJ-942429	Lighting	✓	✓	✓	✓	✓	-
PRJ-865250	Lighting	✓	✓	✓	✓	✓	-
PRJ-952998	Lighting	✓	✓	✓	✓	✓	-
PRJ-1000487	Lighting	✓	✓	✓	✓	✓	-
PRJ-1051651	Lighting	✓	✓	✓	✓	✓	-
PRJ-1067525	Lighting	✓	✓	✓	✓	✓	-
PRJ-1219794	Lighting	✓	✓	✓	✓	✓	-
PRJ-991421	Compressed Air	✓	✓	✓	✓	-	✓
PRJ-974194	Refrigerated case	✓	✓	✓	✓	-	✓
PRJ-909516	Lighting Controls	✓	✓	✓	✓	-	✓
PRJ-906683	HVAC	✓	✓	✓	✓	-	✓

A review of the project files revealed only minimal issues that affected the accuracy of PPL's reported savings. The two specific issues observed are addressed individually by project below.

Project PRJ-974194 achieved savings for the installation of five refrigerated cases. The baseline and efficient case kWh/ft/day values associated with two specific cases, MX1XG-12 and MX1XG-08, were transposed. Applying the appropriate values to the appropriate case lengths revealed the savings to be overestimated by 2%.

Project PRJ-974194 achieved savings for the installation of a ground-source heat pump. The savings calculations rely on the cooling efficiency of the unit, which was calculated as EER/12, where 12 is the conversion from Btu/hr to tons. Per the TRM, the correct formula for this equation is 12/EER. Correcting this error revealed the savings to be underestimated by 13.3%.

The SWE annual reports from PY6 and PY7 submit that review of PPL project files was seamless, with only minimal inconsistencies. This trend continued through PY8, with project documentation being well organized and including all necessary documentation. The review process showed evidence of appropriate selection of algorithms and assumptions for both TRM-based and custom measures by PPL's implementers.

C.4 VERIFIED GROSS SAVINGS AUDITS

C.4.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of PPL's portfolio of residential programs. PPL's portfolio of residential programs includes the following: Efficient Lighting Program, Efficient Equipment Program, Home Energy Education Program, Energy Efficiency Kits and Education Program, Appliance Recycling Program, Energy Efficient Home Program, Student Energy Efficient Education Program, and Weatherization Relief Assistance Program (WRAP). Note that the SWE reports the residential savings in the three following sections: upstream lighting, residential non-lighting, and behavior.

Table 73 provides a summary of the evaluation and M&V approaches used by Cadmus in their PY8 verified savings calculations. Table 74 provides a summary of discrepancies that were discovered during the SWE audits of verified savings. Note that all discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.⁸⁴

⁸⁴ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Table 73: Residential Program Impact Evaluation Activities - PPL

Program	Surveys	Site Visits**	Desk Review ^a	Billing Analysis	PY7 Realization Rate
Efficient Lighting Program	✓	--	✓	--	--
Home Energy Education Program	--	--	--	✓	--
Energy Efficiency Kits and Education Program	✓	--	✓	--	--
Appliance Recycling Program	--	--	✓	--	--
Energy Efficient Home Program	✓	✓	✓	--	--
Student Energy Efficient Education Program	✓	--	✓	--	--
Weatherization Relief Assistance Program	✓	✓	✓	--	--

* Site visits were completed by both Cadmus and the ICSP.

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

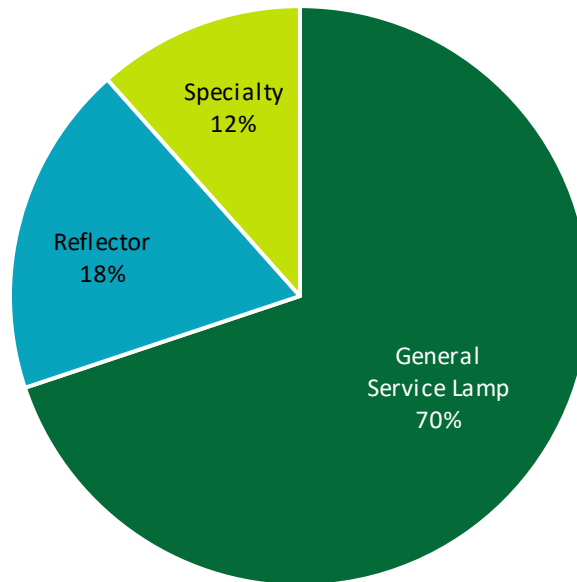
Table 74: Residential Program Verified Savings Discrepancies - PPL

Program	Sub-program/Measure	Discrepancy	The SWE Recommendation
Energy Efficiency Kits and Education	LED Lighting	Incorrect TRM Value	Apply Correct TRM Value for LED interactive effect variable for Demand Savings
Energy Efficiency Kits and Education	Smart Strips	Incorrect TRM Value	Apply correct TRM value for "unspecified" use for Demand Savings
Energy Efficient Home*	New Homes	Incorrect TRM Formula	Include Coincidence Factor to calculate Demand Savings
Energy Efficient Home	New Homes	Incorrect TRM Value	Apply correct TRM value for days in year
Efficient Lighting Program	Lighting, cross-sector sales	Incorrect TRM value	Utilize the HOU and coincidence factor listed in Table 3-5 for Miscellaneous/ Other building types for building types not listed in Table 3-5, or submit an IMP

C.4.1.1 Upstream Lighting & Cross-Sector Sales

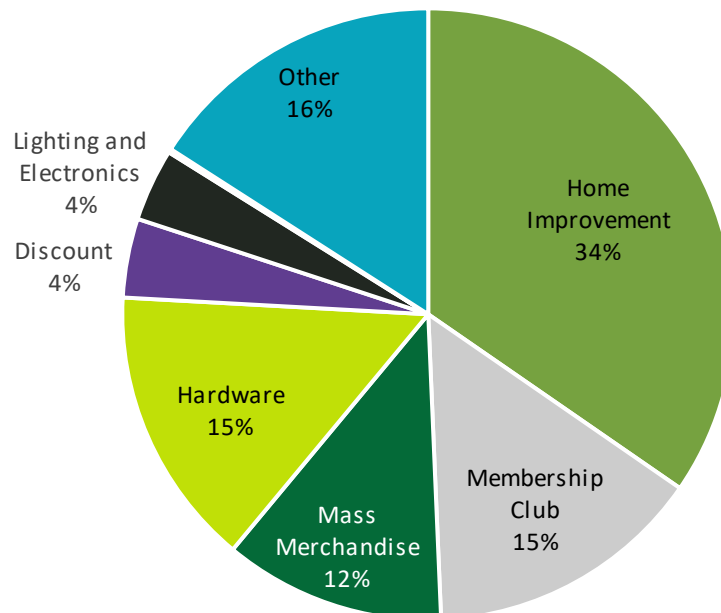
Customers purchased over 3.5 million efficient light bulbs through PPL's PY8 upstream lighting program. [Figure 38](#) displays the distribution of sales by product type. Over two-thirds (70%) of the bulbs were general service lamps.

Figure 38: PPL PY8 Upstream Lighting Sales by Product Type



Around one-third (34%) of PPL's PY8 upstream light bulbs were sold through home improvement stores. Nearly one-third (30%) were sold through hardware stores and membership clubs ([Figure 39](#)).

Figure 39: PPL PY8 Upstream Lighting Sales by Retail Channel



C.4.1.1.1 Audit Findings

The SWE reviewed the data in PPL's tracking system to verify that Cadmus used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with Cadmus' verified gross savings for upstream lighting.

The SWE observed 634 unique lighting model numbers in the PY8 tracking system and was able to locate 589 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. Possible reasons why the SWE was not able to cross-reference the remaining 45 models include deviations in the model number recorded in the tracking system versus the ENERGY STAR certified products lists (including private label products), the absence of ENERGY STAR product model numbers in the ENERGY STAR certified products lists, or the inclusion of non-ENERGY STAR products in the Efficient Lighting Program. The 45 models the SWE was not able to verify as ENERGY STAR certified represent 1% of both bulbs sold and verified savings from upstream lighting.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most models. The team observed minor discrepancies in efficient product wattage and/or lumens for 16 of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system, or errors in the ENERGY STAR certified products lists. The team confirmed that Cadmus used the appropriate algorithms to calculate kWh and kW savings for upstream lighting. In addition, the SWE verified that Cadmus used the correct baseline wattages, interactive effects, ISR, residential HOU, and residential coincidence factor in the calculations.

C.4.1.1.2 Cross-Sector Sales

Cadmus estimated 10% cross-sector sales for LEDs based on general population surveys of residential and small business customers. The residential and small business customer surveys provided estimates of the average number of bulbs purchased per residential and small business customer. Cadmus multiplied these two estimates by each surveyed population's total customer base and determined that the relative proportion of small business bulbs was 10%, while the relative proportion of residential bulbs was 90%.

Cadmus computed a weighted average HOU of 2,682 and demand coincidence factor of 0.47 by mapping survey respondents' building types to Table 3-5 in the TRM. One of the respondents' building types, agriculture, is not present in TRM Table 3-5. Rather than applying the HOU and coincidence factor listed in Table 3-5 for Miscellaneous/Other building types, Cadmus estimated the HOU and coincidence factor for agriculture by averaging the HOU and coincidence factor of four other building types listed in Table 3-5: Industrial Manufacturing Shift 1, Industrial Manufacturing Shift 2, Office, and Warehouse. While the SWE considers this to be a reasonable approach to estimating agriculture HOU and coincidence factor, it is not in accordance with the TRM protocol.

C.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Review program offerings to ensure that all products are ENERGY STAR qualified.
 - The SWE was unable to verify a small portion (one percent) of PY8 products as ENERGY STAR certified. While the team did not definitively determine that these were non-ENERGY STAR products, the SWE reminds all EDCs that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.
- For cross-sector sales, utilize the HOU and coincidence factor listed for Miscellaneous/Other building types for building types not listed in Table 3-5. Alternatively, PPL could submit an IMP to account for any building types not present in Table 3-5.

C.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting solutions found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

C.4.1.2.1 Energy Efficiency Kits and Education

PPL delivers energy education and kits with energy saving products to income-eligible customers through the Energy Efficiency Kits and Education program. In PY8, kits included LED bulbs, a night light, tier 2 advanced power strips, a furnace whistle, tips on energy efficiency behavior, and a paper survey. Kits for homes with electric domestic hot water also included a low-flow showerhead and a kitchen aerator. The SWE audited the paper and phone surveys, and records review conducted by the evaluator to verify realization rates and savings.

The SWE audit uncovered some minor errors in the application of TRM formulas used to verify savings. For peak demand savings, Cadmus incorrectly specified the LED interactive effect as negative 6% when it should have been positive 12%, whereas the smart strip energy savings calculations for unspecified use did not match the TRM formulas. We estimate the net impact of these minor errors to be approximately 0.06% of savings at the program level. The SWE recommends applying the correct TRM algorithm inputs in future years.

C.4.1.2.2 Appliance Recycling

PPL's Appliance Recycling Program offers a rebate for customers who turn in eligible inefficient refrigerators, freezers, and air-conditioning units, and provides free-pick up and recycling services for old appliances. The SWE audited the records review and estimated savings reported by Cadmus. Auditors determined that the correct TRM-approved methods were followed, and that sample sizes and verified savings were correct.

Cadmus applied TRM defaults outlined in their approved EM&V plan. The SWE notes the availability of EDC or evaluation-collected data, such as appliance age and percent of primary

usage, that may more accurately capture savings in future years.⁸⁵ For example, for refrigerators, the average age of a recycled unit was five years younger (24 years vs. 29 years for the TRM default), and a much smaller percentage of refrigerators served as the primary unit (10% compared to 65% for the TRM default).⁸⁶ There was a similar discrepancy in the age of recycled freezers. Overall, if EDC data was used, the SWE estimates that verified gross savings would have been reduced by approximately 1,600 MWh.

C.4.1.2.3 Energy Efficient Home

The SWE audited each component of the Energy Efficient Homes Program: New Homes, Audit - In home, Online Assessment Kit, Weatherization, and Efficient Equipment. The SWE audit consisted of reviewing EDC-provided data, REM/Rate models, and survey samples. The SWE determined that savings were calculated properly and in accordance with TRM savings and algorithms for most measures, although the evaluation uncovered several minor discrepancies.

The SWE audit identified several discrepancies in both sample size and the realization rate used to estimate savings for the New Homes subprogram. The reported site visit sample size for New Homes was 20; however, the subprogram realization rate included an additional four sites. Auditors determined from the EDC-provided data that the reported realization rate included four additional sites, which applied an LED Coefficient to account for LED lighting purchased through upstream-lighting channels. The Coefficient was based on builder surveys, and only applied to the four homes that the builders represented. The SWE audit uncovered the demand savings were calculated incorrectly, per the 2016 TRM. The peak demand error was a result of not applying the coincidence factor to the sample calculations, resulting in a realization rate of 60% (0.19 MW) for New Homes, opposed to the 89% (0.31 MW) stated in the report. At the program level, the error changes the peak demand realization rate of 92% indicated in the report to 87% (and reduces peak demand savings from 1.95 MW to 1.69 MW for the program). The SWE audit discovered a minor discrepancy in the algorithm used to calculate savings of heat pump water heaters, within the New Homes program. The error had almost no impact on the verified savings. The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

C.4.1.2.4 Student Energy Efficiency Education

The Student Energy Efficiency Education (SEEE) Program provides both classroom energy efficiency education and take-home energy-savings kits for students to install at home. The SWE conducted a review of Cadmus-provided data and the survey of all Home Energy Worksheets (HEWs) returned by students who received a kit. The SWE audit of Cadmus' data determined the correct algorithms, sample sizes, and inputs were implemented in calculating energy savings in accordance with their approved EM&V plan. A product recall on the electroluminescent nightlights provided in the kit were assigned a savings value of zero. The product recall did not affect the

⁸⁵ Reiterating section 1.2.2 of the 2016 TRM, EDCs are encouraged to continue with EDC data gathering rather than using default values provided in the TRM, and they are encouraged to apply the customer-specific or program-specific data that has been collected for as many open variables as possible to reflect the most accurate savings values.

⁸⁶ Cadmus informed the SWE that survey data are available for percentage of primary units, but are not used. If survey data were used it would result in a reduction of ~674 MWh. The SWE could not confirm these calculations because the survey data were not provided.

models that were provided in the kit; however, savings were not included as a precautionary measure. This precaution reduced the program realization rate compared to what would have been achieved without the product recall.

C.4.1.2.5 Low-Income Winter Relief Assistance Program (WRAP)

The Low-Income WRAP program provides a free energy audit for income-qualified customers and offers direct installation of a range of energy efficiency products and services based on a preapproved list of products and services and qualifying criteria. Products and services might include HVAC, lighting, weatherization, water saving/heating, appliances, appliance recycling, and home health and safety. The SWE audited savings and realizations rates for all measures included in the program. All measures applied the correct TRM-approved methods, sample sizes were correct, and the survey data was correctly incorporated into calculating realization rates and verified savings.

C.4.1.3 Behavior

Approximately 9% of PPL's verified gross energy savings for PY8 came from Home Energy Reports issued to around 183,000 residential and residential-LI households. The SWE reviewed Cadmus' methodology and agrees with their verified MWh and MW savings values for PPL's HER offering in PY8. By wave, [Table 75](#) shows average kWh savings and average percent savings per participant in PY8. Note that the two low-income waves were only active during the last month of PY8, so the summaries for those rows only reflect May 2017, not all of PY8.

Table 75: Average PY8 kWh Savings per Participant

Wave	Wave Start Date	Average Usage of Treatment Group (kWh)	Average PY8 Savings (kWh)	Average PY8 % Savings
Legacy Wave 1	April 2010	16,841	328	1.9%
Legacy Wave 2	June 2011	23,423	402	1.7%
Expansion Wave 1	October 2014	19,982	277	1.4%
Low-Income Wave 1	October 2014	654	10	1.6%
Low-Income Wave 2	June 2015	420	4	0.9%
Expansion Wave 2	June 2016	15,528	41	0.3%

The following sections highlight some of the SWE's auditing efforts. These efforts largely relied on calendarized billing data provided to the SWE by Cadmus, as well as HER program tracking data.

Group Equivalence

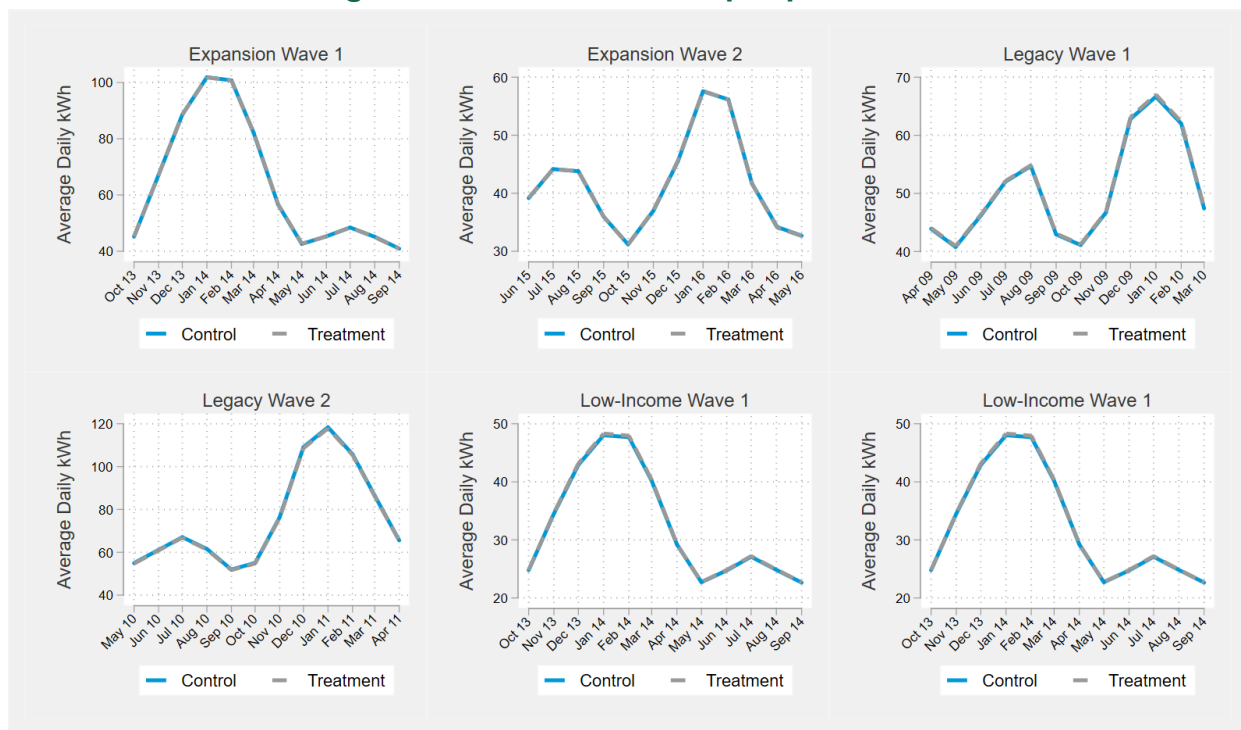
Each wave of PPL's HER offering employs a randomized control trial (RCT) design, where participants are randomly divided into control and treatment groups. With sufficiently large sample sizes and a sound randomization, the control and treatment groups should be essentially identical when it comes to energy consumption in the pre-period. If this proves to be the case, the HER

impact analysis is generally straightforward – the only plausible explanation for differences in energy consumption between the control and treatment groups in the post-period is HER exposure. For this reason, the SWE’s first step was to evaluate group equivalence in the pre-period.

For each of the six waves, [Figure 40](#) shows average daily pre-period consumption (kWh) for both of the experimental groups. In each individual chart, it may be tough to tell that there are two distinct lines. This is exactly what the SWE hoped to see, as it implies that the control and treatment groups were roughly equivalent in the pre-period when it comes to how much electricity they use.

In addition to looking at line plots, the SWE also ran t-tests comparing pre-period levels of average daily consumption (kWh) in the control and treatment groups for each wave. Each t-test yielded a p-value greater than 0.05, indicating that there are no statistically significant differences in pre-period average daily kWh consumption between the control and treatment groups. Combining this result with the trends in [Figure 40](#), the SWE is confident that the experimental groups for each wave were approximately identical in terms of energy consumption in the pre-period.

Figure 40: Pre-Period Group Equivalence



Data Checks

In creating valid HER impact estimates, one important factor is the coding of the post-period indicator variable. This variable should equal 1 for any billing records after the month in which HER exposure began, and 0 otherwise. [Table 76](#) shows when HER exposure began (as per page 112 of PPL’s Annual Report) and the first month of post-period data in the calendarized billing data set that Cadmus provided to the SWE. In checking the coding of the post indicator variable, the SWE noticed two items worthy of investigation:

1. For Legacy Wave 2, customers began receiving reports in June 2011, but the post-period in the billing data begins in May 2011. This discrepancy could be due to calendarization.
2. For three waves (Legacy Wave 1, Expansion Wave 1, and Low-Income Wave 1), PPL reports that HER exposure began in one of two months (e.g., “October or December”). Presumably, this means that some of the treatment group homes began receiving reports in October and others began receiving reports in December. This raises questions about how the post indicator variable should be coded – should all homes switch from the pre-period to the post-period at the same time, or should treatment group homes switch to the post-period only after their first HER delivery? If the latter option is chosen, then one has to make decisions regarding how the post indicator variable is coded for the control group (e.g., when do control group homes transition from pre-period to post-period if half of the treatment group homes transition in October and the other half transition in December?). Cadmus chose the former option (clean transition from pre-period to post-period for all homes), and the SWE does not take issue with this approach.

Table 76: When Does the Post-Period Begin?

Wave	When did customers begin receiving reports?	When is the first month of post data in the calendarized billing data?
Legacy Wave 1	April or May 2010	April 2010
Legacy Wave 2	June 2011	May 2011
Expansion Wave 1	October or December 2014	October 2014
Low-Income Wave 1	October or December 2014	October 2014
Low-Income Wave 2	June 2015	June 2015
Expansion Wave 2	June 2016	June 2016

The SWE also examined how the three lagged seasonal variables were calculated.⁸⁷ For the lagged winter variable, for example, Cadmus simply averaged pre-period consumption during the winter months (e.g., add average daily consumption for December, January, February, and March, then divide by four). The SWE suggests that Cadmus consider days-per-month when calculating the lagged seasonal variables in the future (i.e., December, January, and March should each have slightly greater weights than February). The difference between the two approaches is certainly minimal, but the SWE believes the second approach is better.

Impact Coefficients

The SWE had no issues replicating Cadmus’ PY8 impact coefficients (which are shown in [Table 77](#)). Our opinion is that the model Cadmus employed is slightly over specified. That said, the variables we feel are not needed in the model (CDD², CDD³, HDD², and HDD³) were found to be

⁸⁷ In calculating HER impacts, Cadmus employed the lagged seasonal (LS) model. The LS model is a post-only model that uses pre-period consumption as an explanatory variable. Three such variables are created: one that represents average daily consumption in the pre-period, one that represents average daily consumption during summer months in the pre-period, and one that represents average daily consumption during winter months in the pre-period.

statistically significant. The practical interpretation of the PY8 impact coefficient for Legacy Wave 1 is that average daily consumption in treatment group homes was 0.90 kWh less in PY8 than average daily consumption in control group homes, on average, after controlling for the effects of weather, time, and pre-period consumption patterns.

Table 77: PY8 Impact Coefficients

Wave	PY8 Impact Coefficient (kWh per Customer per Day)
Legacy Wave 1	-0.90
Legacy Wave 2	-1.10
Expansion Wave 1	-0.76
Low-Income Wave 1*	-0.34
Low-Income Wave 2*	-0.12
Expansion Wave 2	-0.11
*The treatment effect for low-income waves only includes May 2017.	

Annual Energy Savings

When it comes to calculating annual energy savings, there are three critical inputs: the impact coefficient, the number of participants in the treatment group, and the number of days each treatment group home received treatment (e.g., did they close their account before PY8 concluded?). Impact coefficients are shown in [Table 77](#), and the SWE used PPL's HER tracking data to calculate the other two inputs.

Regarding the number of participants, [Table 78](#) shows the SWE's audit finding. There are three distinct counts in this table:

- 'Unique PY8 Billing Data Accounts' represent the number of unique treatment group account numbers that had PY8 billing records in the billing data provided to the SWE.
- 'PY8 Tracking Data Accounts' represents the number of treatment group homes in Cadmus's HER tracking data who were active when PY8 treatment began. These counts are shown in Table C-5 of PPL's Annual Report, and the SWE was able to reproduce them using the program tracking data.
- 'Verified PY8 HER Recipients' represents the number of treatment group homes in Cadmus's HER tracking data for which Cadmus verified that the ICSP provided home energy reports in PY8. These counts are shown in Table C-5 of PPL's Annual Report, and the SWE was able to reproduce them using the program tracking data.

The counts that Cadmus used in developing their PY8 annual energy savings estimate are the 'Verified PY8 HER Recipients' counts. The SWE has no issue with this approach, though (1) the resulting savings estimate could be somewhat conservative and (2) it raises the question as to why the ICSP would not provide HERs to some of the treatment group homes who were active at the onset of PY8.

Table 78: PY8 Participation by Cohort

Wave	Unique PY8 Billing Data Accounts	PY8 Tracking Data Accounts	Verified PY8 HER Recipients
Legacy Wave 1	35,261	36,214	29,568
Legacy Wave 2	39,163	41,962	33,563
Expansion Wave 1	42,284	43,256	34,195
Low-Income Wave 1	51,422	52,326	45,597
Low-Income Wave 2	13,968	14,284	12,419
Expansion Wave 2	27,035	27,697	27,697
Total	209,133	215,739	183,039

Regarding the number of treated days, the SWE relied on a field called 'inactive_clean' in the HER program tracking data. For any customer lost due to attrition, the 'inactive_clean' field showed the date on which the customer became inactive. For customers who remained active in the program, the 'inactive_clean' field was empty. The SWE used this field to calculate the number of active days for each of the verified PY8 HER recipient accounts, then found the average number of active days for each wave. [Table 79](#) shows the results, as well as the other inputs needed to calculate PY8 annual energy savings.

Table 79: Annual MWh Savings by Cohort

Wave	Treated in PY8	Impact Estimate	Average Treated Days	PY8 Total Savings (MWh)
Legacy Wave 1	29,568	-0.90	364.76	9,705
Legacy Wave 2	33,563	-1.10	364.78	13,476
Expansion Wave 1	34,195	-0.76	364.64	9,480
Low-Income Wave 1	45,597	-0.34	30.81	476
Low-Income Wave 2	12,419	-0.12	30.74	47
Expansion Wave 2	27,697	-0.11	364.63	1,142
Total	183,039	---	---	34,326

Demand Savings

Cadmus' approach to estimating demand savings was relatively straightforward: convert PY8 annual savings (MWh) to PY8 savings per hour (MW), then multiply by 148%. These calculations are outlined in [Table 80](#). The 148% adjustment factor is largely informed by a PY4 ratio of peak demand reductions to average per-customer energy savings per hour. The SWE accepts Cadmus' estimate for HER demand savings (6.75 MW), but raises the following issues:

1. In converting annual savings to hourly savings, the SWE is not sure if Cadmus divided by 8,760 hours (or, in the case of the low-income waves, which were only active in May, 744

hours) or by the product of the average number of treated days and 24. Note that these two approaches will provide answers that only differ by about 0.01 MW.

2. Cadmus did not remove upstream and downstream savings uplift before converting energy savings to demand savings. For energy savings, Cadmus subtracted upstream and downstream savings uplift from PPL's portfolio total (not the HER program total) to avoid double-counting. Cadmus did not make similar adjustments from PPL's portfolio demand savings. The SWE feels an adjustment is warranted, but notes that the Evaluation Framework does not explicitly state that savings uplift should be removed before calculating demand savings. In future evaluations, this is something Cadmus should do.

Table 80: Demand Savings

Wave	PY8 Annual Savings (MWh)	PY8 Savings per Treated Hour (MW)	148%
Legacy Wave 1	9,705	1.11	1.64
Legacy Wave 2	13,476	1.54	2.28
Expansion Wave 1	9,480	1.08	1.60
Low-Income Wave 1	476	0.64	0.95
Low-Income Wave 2	47	0.06	0.09
Expansion Wave 2	1,142	0.13	0.19
Total	34,326	4.57	6.75

Downstream and Upstream Uplift

The SWE reviewed the methods Cadmus used in calculating downstream and upstream uplift savings and believes that their methods are sound. The Evaluation Framework states that upstream adjustments should be made after downstream adjustments have been made. Cadmus did this correctly, though Table 76 in PPL's Annual Report (which shows upstream uplift savings) makes it look like the downstream adjustments were not considered when creating the upstream adjustments. For each wave, [Table 81](#) shows the downstream and upstream uplift savings. In total, Cadmus calculated 2,415 MWh and 789 MWh in downstream and upstream uplift savings, respectively. Additionally, Cadmus included a 1,191 MWh adjustment for LEDs that were installed in PY7. Combined, these adjustments total up to 4,395 MWh. Note that Cadmus subtracted this value from PPL's portfolio total rather than subtracting it from the Home Energy Education program total.

Table 81: Downstream and Upstream Uplift

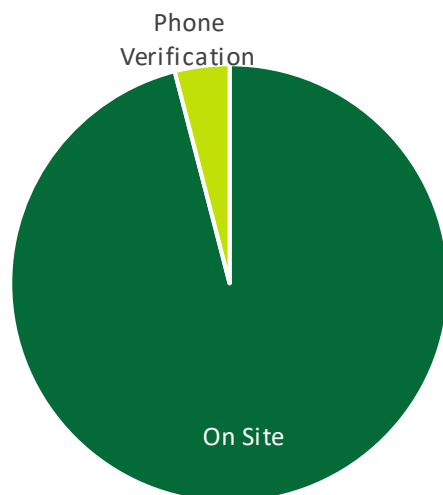
Wave	PY8 Annual Savings (MWh)	Downstream Uplift (MWh)	Adjusted Annual Savings	Upstream Adjustment Factor	Upstream Uplift (MWh)
Legacy Wave 1	9,705	1,025	8,680	3.00%	260
Legacy Wave 2	13,476	952	12,525	3.00%	376
Expansion Wave 1	9,480	301	9,179	1.50%	138
Low-Income Wave 1	476	42	434	1.50%	7
Low-Income Wave 2	47	-2	49	1.50%	1
Expansion Wave 2	1,142	97	1,045	0.75%	8
Total	34,326	2,415	31,912		789

C.4.2 Non-Residential Audit Activities

Figure 41 provides a summary of the evaluation activities and M&V approaches utilized by PPL's evaluation contractor in their PY8 verified savings calculations. PPL completed an exhaustive amount of site visits and relied heavily on verification only as their primary M&V approach, utilizing IPMVP methods only for those projects in their Custom Program.

Figure 41: Summary of PPL's C&I Evaluation Activities

Evaluation Activity by Project Count



M&V Approach by Project Count

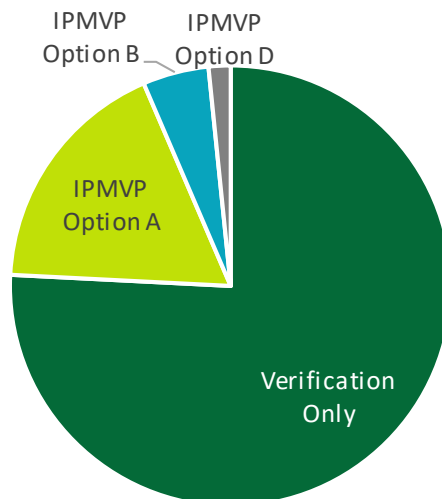
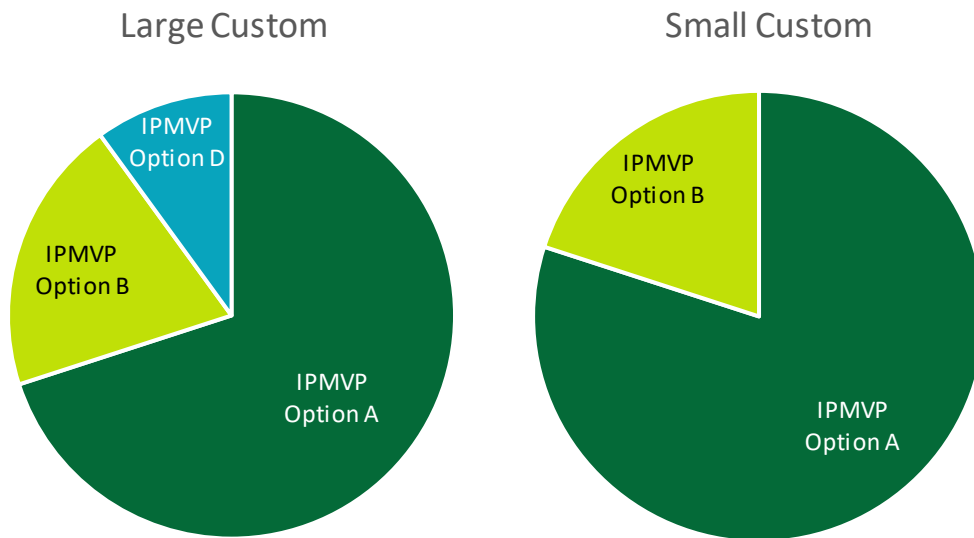


Figure 42 provides only a summary of the evaluation activities and M&V approaches PPL's evaluation contractor used across strata for all projects stratified by size⁸⁸. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 42: Summary of PPL's C&I Evaluation Activities Across Strata



The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

C.4.2.1 Ride-Along Site Visits

Table 82 provides an overview of the SWE milestones for the audit of PPL's site inspection efforts.

Table 82: PPL Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited [†] (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
10	5,142,381	2	3	100%

[†]Excludes 23,959,703 kWh attributed to a combined heat and power project which has not yet been commissioned and as such has been excluded from PPL's PY8 savings.

Overall, the SWE agreed with the methods of calculation employed by PPL's evaluation contractors. The calculations and accompanying reports were easy to follow and showed evidence that the TRM was being followed appropriately. The SWE agreed with all engineering decisions made by the evaluators, which included adjustments to reported savings where HOU

⁸⁸ Much of PPL's sampling plan is stratified by measure type with only the Custom Program and the Efficient Equipment – Lighting programs being stratified by project size. All other programs are excluded from Figure 42.

values were deemed inappropriate and adjustments to include interactive effects where they had been excluded in reported savings.

Recommendations were provided by the SWE for one site inspection in which the evaluator noted that interactive effects should have been included, but then failed to include them in the verified savings calculations. The SWE recalculated the savings and found the verified savings to be underestimated by 7%. For this project, the SWE recommended that greater care be taken to ensure all site findings are correctly translated into savings calculations. However, this was found to be an isolated incident and was not a theme throughout the site inspection process.

While the SWE was satisfied overall with the evaluator's final reports and verified savings calculations, the evaluator's processes for completing site inspections with SWE inclusion were cause for concern. Specifically, the SWE found Cadmus's processes deficient in the following areas:

- The SWE was either not notified, or not notified within the designated two-week lead time, of flagged projects of interest.
- The evaluation contractor's SSMVPs were not submitted within the designated two-week lead time for many projects.

The issues noted above were common to all seven EDCs and their teams of evaluation contractors. The SWE communicated the deficiencies in the site inspection process with the EDCs and their evaluation contractors via individualized phone conferences with all interested parties. A guidance memo was issued in October of 2017 detailing new tools implemented by the SWE to improve the process moving forward. Since the issuance of the memo, we have seen a marked improvement in PPL's processes for including the SWE in sites of interest throughout the first two quarters of PY9.

C.4.2.2 Verified Savings Desk Reviews

Table 83 provides an overview of the SWE milestones for the verified savings review of evaluated PPL projects.

Table 83: PPL Verified Savings Desk Review Milestones

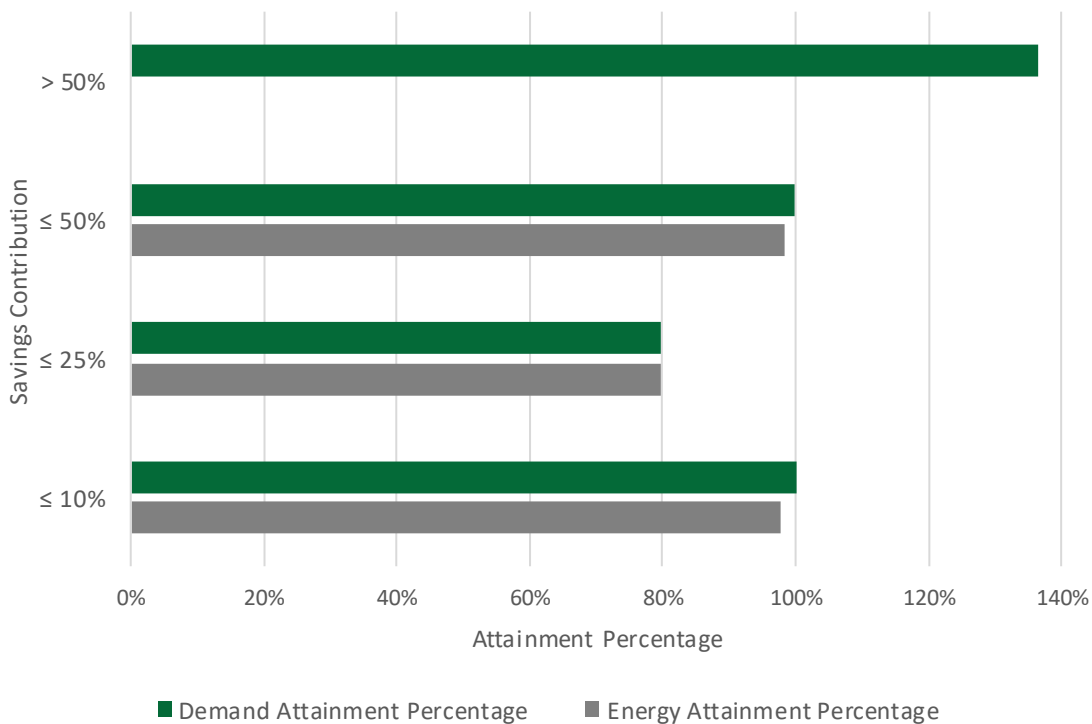
Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
13	15,619,222	1,546	96%	115%

Overall, the SWE found that PPL's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. Although submitted files were difficult to follow, the SWE asserts that Cadmus conducted appropriate M&V efforts.

Of the 13 projects reviewed, the SWE calculated adjusted energy and demand savings for three projects. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand

savings attainment percentages of PPL's reviewed projects were 96% and 115%, respectively. The distribution of the attainment percentages by savings contribution is presented in [Figure 43](#), and provides cause for concern regarding the level of scrutiny applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 43: PPL Verified Savings Attainment Percentage



Project RBT-1355424 achieved energy savings for the installation of a 1-MW combined heat and power (CHP) plant that operates in conjunction with an absorption chiller. The evaluator analyzed this project using a blend of IPMVP Options B and C. As pre- and post-installation data was included with the project file, the SWE tested the evaluator's regression model against raw data and found it overstated the consumption of the installed equipment. The SWE created an adjustment factor for each regression-dependent calculation and applied it to the verified savings. Additionally, the SWE found inconsistencies in the formulae used to calculate savings obtained using IPMVP Option B. The condenser water flow rate was a common input to several algorithms used, but varied across formulae between 2.4 gpm and 3.0 gpm. The SWE adjusted all calculations to use a common value of 3.0 gpm. In total, the SWE adjustments to the project resulted in increased demand savings, but decreased energy savings.

The SWE found an error in the calculations for Project RBT-799158, which achieved savings for the installation of a VFD on cooling tower fan. The evaluator's analysis included recreated lookup tables matching those in Section 3.3.1 of the TRM defining the run hours and coincidence factors for various fan types by location and building type. The evaluator's calculations incorrectly relied on a fan type input of "Supply Fan Motor" rather than "Cooling Tower Fan Motor." As all project

documentation detailed a cooling tower fan motor and did not provide any evidence to support off-TRM run hours, the SWE corrected the calculations, which reduced the energy savings significantly. The demand savings were unchanged as the coincidence factor is the same between the two inputs.

Project RBT-799135 achieved savings for a custom measure involving the replacement of injection molding machines and was evaluated using IPMVP Option C. As pre- and post-installation data was included with the project file, the SWE tested the evaluator's regression model against raw data and found it overstated the consumption of the baseline equipment. Upon closer inspection, the SWE determined this was the result of using averages where a median value was more appropriate. The SWE adjusted the dependent variable of the regression to be median values rather than averages; this resulted in a more accurate baseline when compared to the available trend data. In addition, the evaluator calculations relied on an assumed load factor of 5%, which was unsubstantiated. The SWE changed the load factor to 2% based on secondary sources. The adjustments made by the SWE resulted in a significant decrease to both the energy and demand savings.

To ensure the accuracy of verified savings in the upcoming program years, the SWE gives the following recommendations to PPL's evaluation contractor:

- Cadmus should provide analysis files with active calculations for verification by the SWE.
- Cadmus should more thoroughly check regression model performance against known actual data and make necessary adjustments or to regression-based annualized savings to prevent overstating savings.

C.5 NTG

Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.

C.5.1 Residential Programs

Cadmus estimated NTG for three residential programs: residential upstream Efficient Lighting, Appliance Recycling, and Energy Efficient Home Programs. Cadmus assigned a NTG value to the Energy Efficiency Kits and Education Program.

Cadmus utilized program tracking and marketing event records to estimate residential upstream Efficient Lighting NTG. Cadmus estimated a demand elasticity model that allowed for the calculation of free-ridership, but not spillover (as is permitted for upstream programs in the SWE Phase III Evaluation Plan), and assumed a spillover of zero. Cadmus then applied the modeled free-ridership and assumed spillover values as inputs into the common method of NTG calculation.

Cadmus estimated NTG for the Appliance Recycling Program using the 2016 TRM and online and telephone participant surveys. NTG was estimated for refrigerators, freezers, and program totals, excluding air conditioners with the recommended UMP appliance recycling protocol. Cadmus created a decision tree that depicts all the program's possible savings scenarios and

used the weighted average of the decision tree's values to inform NTG. The SWE was able to confirm the methodology and outcome using data files provided by Cadmus.

Cadmus used the common method to estimate NTG for the Energy Efficient Home Program, using builder self-reports for the New Home component of the program and online and telephone participant surveys for the audit and kit, weatherization, and efficient equipment program components. Free-ridership was weighted by verified program savings. Cadmus supplied data and NTG calculators that enabled the SWE to confirm the methods and results.

Cadmus assigned the Home Energy Education Program a NTG value of one, in accordance with the Evaluation Framework, citing the RCT design eliminating free-ridership and allowing negligible spillover.

Table 84: Summary of NTG Estimates for PPL Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated based on Demand Elasticity Model	Efficient Lighting	0.17	0.0	0.83	Program lighting sales records
Estimated	Appliance Recycling (refrigerator)	0.38	0.03	0.65	397
Estimated	Appliance Recycling (freezer)	0.37	0.05	0.68	152
Estimated	Appliance Recycling	--	--	0.66	558
Estimated	Energy Efficient Home	0.39	0.07	0.68	302
RCT	Home Energy Education	0.0	0.0	1	--

C.5.2 Low-Income Residential Programs

Cadmus did not conduct NTG research for any low-income program during PY8.

Cadmus assigned a NTG of one to the Energy Efficiency Kits and Education Program and the Weatherization Relief Assistance Program, citing the low-income status of the participants as the reason free-ridership would not be possible. This method is in keeping with Cadmus' approved EMV plan.

Cadmus assigns a NTG ratio of one to the Student Energy Efficient Education Program, reasoning that there is no free-ridership for this classroom-based program (and Cadmus did not estimate spillover. This method is in keeping with Cadmus' approved EMV plan.

C.5.3 C&I Programs

Cadmus utilized online and phone surveys to gather data for the Custom Program NTG analysis. Cadmus estimated free-ridership for small and large C&I, but only presented NTG for the total Custom Program. The large C&I strata was represented by a single respondent, the SWE

recommends a more targeted effort at stratified data gathering to ensure no strata specific estimates are based on a single participant. Cadmus utilized the common method to calculate NTG for the Custom Program.

The Efficient Equipment NTG evaluation was conducted across two strata, lighting and equipment using participant survey data. Cadmus did not estimate spillover for the program due to a lack of satisfactory data. An audit of the data and NTG calculators showed that Cadmus used the common method to estimate NTG.

Table 85: Summary of NTG Estimates for PPL C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Total Custom	0.21	0.0	0.79	15
Estimated	Equipment Efficient Equipment	0.22	0.0	0.78	7
Estimated	Equipment Efficient Equipment	0.23	0.0	0.77	62

C.6 TRC

Table 86 shows the high-level results of the PPL TRC calculation at the program level. The table shows benefits and costs, both gross and net, for each program in the PPL portfolio and overall, as well as the resultant TRC ratios.

Table 86: Summary of PPL's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Energy Efficiency Kits and Education	2,380	1,894	1.26	2,380	1,894	1.26
Home Energy Education	1,611	845	1.91	1,611	845	1.91
Low-Income WRAP	899	4,012	0.22	899	4,012	0.22
Student Energy Efficient Education	1,765	905	1.95	1,765	905	1.95
Appliance Recycling	4,032	1,945	2.07	2,645	1,945	1.36
Custom	25,904	26,245	0.99	20,464	21,369	0.96
Efficient Equipment	43,822	25,234	1.74	33,761	20,071	1.68
Efficient Lighting	73,711	14,787	4.98	61,180	13,162	4.65
Energy Efficient Home	6,176	12,316	0.50	4,073	9,126	0.45
Common Portfolio Costs		7,622			7,622	
Portfolio	160,299	95,804	1.67	128,778	80,950	1.59

Of PPL's nine programs, six are cost-effective by the TRC test and three are not. PY8 TRC ratios are down slightly from previous phases of Act 129.

Cost-Effective Programs (TRC > 1):

- Efficient Lighting
- Appliance Recycling
- Student Energy Efficient Educations
- Home Energy Education
- Efficient Equipment
- Energy Efficiency Kits and Education

Non-Cost-Effective Programs (TRC < 1):

- Low-Income WRAP
- Energy Efficient Home
- Custom

C.6.1 Notes from the Review of the TRC Model

Review of the TRC model finds that the EDC correctly applied the EE&C plan discount rate (7.63%) and line-loss factors (4.2% for industrial applications and 8.75% otherwise). NTG factors, including free-ridership and spillover, are applied appropriately. The SWE noted a handful of minor issues pertaining to the implementation of the TRC model, which are included here. None of the items listed below are cause for concern about the material results of the TRC model, and are noted here as recommendations for adjustments to be made in future PY reporting.

- The reported benefits of the Home Energy Education program include a potential double counting of a portion of those benefits, as noted in Table 8 and Section 7.5 of the PPL PY8 Annual report, but which nevertheless have been included in PPL's TRC calculation. The effect of the Home Energy Education Program Energy Savings Uplift would be to remove 4,395 MWh/year from that program. Adjusting the TRC model to remove that double counting yields an estimated⁸⁹ revised program TRC of 1.66, down from 1.91 (the NTG ratio for this program is 1, so gross and net TRC are the same for this program). This change does not change PPL's overall TRC ratio value beyond the margin of the rounding error in this reporting.
- The TRC model, as provided to the SWE, lacks documentation and transparency in the source data on which the calculations are based. The model, as provided, does not show the incremental cost basis for any measure. In an email, the contact for PPL states that the SWE incremental cost database was the primary source for per unit incremental costs, but there is no direct evidence of this in the TRC model provided.
- A change was recommended, and made, regarding the accounting of pre-EISA dual-baseline accounting in the TRC model. General service lamp pre-EISA savings were incorrectly included in the small C&I efficient lighting subprogram. An updated TRC model was provided, in which the pre-EISA general service lamp savings were correctly applied to the residential efficient lighting program. The change does not affect the efficient lighting TRC ratio nor the overall TRC ratio.
- Documentation could be improved to allow the SWE to better evaluate if avoided costs used in the TRC model are consistent with the EE&C plan approved costs. Average annual avoided costs as provided in the TRC model appendix are consistent with average annual avoided costs in the EE&C plan; however, the aggregation of hourly costs used to define the EE&C plan component costs for summer or winter, and on- or off-peak, are not clearly documented.
- Tables 13 and 15 in PPL's PY8 report contain a minor rounding error: TRC NPV Portfolio Total should be \$80,950 per the TRC model, not \$80,951. This does not have a substantive effect on the TRC ratio.

⁸⁹ This value is estimated by the SWE because the PPL PY8 document does not report the demand effect of this reduction in savings. To estimate the effect in the TRC model, SWE has used the ratio of reduction in savings (4,395MWh/34,326MWh) to reduce the annual deemed demand savings (6,752MW) for this program. $(6,725\text{MW} - (6,725\text{MW} \times (4,395/34,326))) = 5,887\text{MW}$.

- There are three lighting-related project lines that list “exit sign” in the descriptor, but which do not use a flat load shape when ascribing value to avoided energy costs, instead using a variable “Commercial Large Office Lighting” or “Commercial Small Office Lighting” load shape. Code dictates that exit sign lighting is constant, not variable, as are typical lighting projects. The effect of this change on the overall TRC ratio is miniscule.
- The SWE notes that the TRC model does not include any benefits from fossil fuel and/or water savings. For example, water savings are likely correlated with the avoided energy costs for items like showerheads and aerators. Costs from increased fossil fuel use from fuel-switching are, however, included. This asymmetric handling of fossil fuel costs and benefits understates the TRC ratio.

C.7 PROCESS

C.7.1 Residential Programs

Cadmus reported on PY8 process evaluations for four residential programs: The Appliance Recycling Program, The Energy Efficient Home Program, The Home Energy Education Program, the Student Energy Efficiency Education Program, and the Efficient Lighting Program.

For the process evaluations of the above programs, Cadmus reviewed program materials, interviewed PPL and implementation staff, and surveyed program participants and non-participants. The document and program data review helped to clarify program goals; activities; updates; and, in some instances, development of program theory and logic models. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) varied by program, but generally included the effectiveness of program administration, implementation, and delivery; customer and market actor program satisfaction, participation, and challenges; and recommendations.

Cadmus followed the evaluation plan for each program’s process evaluation for the most part, though there were some exceptions to this, mainly centered around sample size issues for various research activities. These will be covered in each program’s respective process evaluation audit summary below. In the case of deviations from the evaluation plan, Cadmus gave satisfactory explanations in most cases for why this happened, and, when possible, explained how the problem could be resolved in future evaluations.

The findings were clearly presented, and the conclusions were well supported by the findings overall. The conclusions were mostly concise and informative, and the recommendations followed from the conclusions.

C.7.1.1 Appliance Recycling Program

Summary of Process Evaluation Findings

In PY8, Cadmus conducted a process evaluation that included seven interviews split between PPL program managers (n=2), ICSP staff (n=3), and ICSP subcontractors (n=2). Other activities in the evaluation were online and telephone participant surveys, telephone surveys with non-

participants, a program database review, and a logic model review. The process evaluation findings for PY8 are summarized below:

- Demographic data from the participant surveys indicate that the program is reaching older generations, but not as many younger customers. As a comparison, 40% of Energy Efficient Home Program participants were born in 1970 or after, while only 17% of Appliance Recycling program participants were in this age group. Both programs are more likely to reach homeowners than renters.
 - Comparisons of respondents born earlier than 1970 with respondents born in 1970 or later found that older respondents were twice as likely to have heard of the program through a bill insert (46%) than younger respondents (22%). Younger respondents heard about the program through a greater variety of channels, most commonly through online sources (34%).

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan. All planned research activities for the process evaluation were performed and planned sample sizes for each research activity were achieved for all except the non-participant phone surveys. Non-participant surveys were fielded as part of a general population residential lighting survey; however, only nine participants in that survey indicated that they had recycled an eligible appliance outside of the program. The evaluation plan had targeted up to 70 respondents for this sample.

The methodology sections adequately explained the evaluation and included the required sampling and disposition information and tables. Analysis methods used to test for potential bias in the samples – such as significant differences in demographic characteristics between respondents to the different survey modes – were also discussed in the methodology, which the audit team found helpful. For the other research activity that required sampling – the online and phone surveys with participants – sampling was consistent with the numbers outlined in the evaluation plan. The target of 140 participant phone surveys was met. The goal was to complete as many online participant surveys as possible, with a final sample size of 409 being achieved. The participant phone survey sample sizes also achieved the desired 50/50 split between those recycling only refrigerators and those recycling freezers.⁹⁰

The program finding was clearly summarized and presented in tables and figures, and drew directly from the process evaluation activities. There was one recommendation that followed from the process evaluation. The report also included a table of with the recommendation, along with a description of whether PPL was implementing or considering that recommendation.

⁹⁰ Because freezers account for fewer units in the participant population, anyone who had recycled both measures could be included in the freezer sample, after which the refrigerator and freezer samples were cross checked to ensure no one was included in both.

C.7.1.2 Energy Efficient Home Program

Summary of Process Evaluation Findings

Cadmus conducted a process evaluation that included interviews with program staff and a wide range of implementation staff. This included builders and HVAC contractors, HVAC retailers, and energy auditors. In addition, online and telephone participant surveys were completed, along with a program database review and a logic model review. Not all targeted activities outlined in the research plan were achieved, these deviations will be detailed in the following section. The findings from the process evaluation are detailed below.

- HVAC contractors reported that the PPL rebates had little influence on customer demand for energy efficient heat pumps and central air conditioners. Also, of the 10 HVAC contractors interviewed, nine said the primary challenge of selling and promoting energy efficient HVAC equipment was the upfront cost of that equipment, particularly for higher efficiency models (18 SEER and above) because the rebate did not encourage customers to go beyond 16 SEER.
 - Most of the rebates for air source heat pumps and central air conditioners were for units 16 SEER to 18 SEER, the lowest equipment eligibility requirement, with a single rebate level. However, for ductless mini-split heat pumps, the program offered tiered rebates and purchases were more evenly distributed across the higher efficiencies.
- Of the five in-home energy auditors interviewed, four said the energy efficiency kits did not arrive before their visits, so they could not help customers install the products included in the kit. They suggested PPL change the kit ordering and delivery system to ensure timely arrival at the participant's home.
 - One contractor said kits were difficult to order.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan. In completing the process evaluation, all research activities outlined in the PY8 evaluation plan were completed; however, deviations occurred in the amount and type of participants included in some research tasks. Cadmus detailed each deviation from the evaluation plan for the process evaluation in the annual report, they are as follows:

- Cadmus did not field phone surveys with manufactured home participants or perform interviews with manufactured homes dealers because PPL temporarily discontinued this offer near the beginning of PY8.
- Online participant surveys for weatherization and efficient equipment participants were not fielded because Cadmus did not receive customer contact information in time to get the surveys completed and analyzed in time for the annual report. Cadmus plans to field the online survey for these participants in PY9.
- The in-home audit and kit participant phone/online surveys had a planned sample size of 70; however, the population of this component was only 88, which made reaching that

number not possible. Eight phone and three online surveys were completed for this sample.

- Cadmus added a lighting savings assessment to the process evaluation for the new homes solution. Builder interviews confirmed whether LEDs were purchased from retailers included in the PPL Efficient Lighting program to avoid double counting savings, and an LED adjustment coefficient was calculated.

Because online surveys are typically effective ways to reach a wider net of participant sample, the inability of the process evaluation to reach weatherization and efficient equipment participants via online survey stands out here. In PY9, a focus should be made by Cadmus and PPL to ensure that data requests, such as the participant contact information for these programs, are processed in a timely manner to ensure a sample that includes participants for all key program measures.

Aside from the deviations detailed above, the planned sample sizes for all research activities were met, including for all in-depth interviews with program and implementation staff. Tables included in the annual report also clarify the mode of the survey as it pertains to each sample size detailed in the table, which the SWE found helpful. The methodology sections adequately explained the evaluation and included the required sampling and disposition information and tables. The program findings were clearly summarized and presented in tables and figures, and while they drew from a mix of process and impact evaluation activities, the link to process evaluation activities was clear. There were four recommendations that followed from the process evaluation.

C.7.1.3 Home Energy Education Program

Summary of Process Evaluation Findings

Cadmus conducted a process evaluation of the Home Energy Education program that included interviews with program and implementation staff, the development and review of a logic model, and phone interviews with participants and non-participants. A second random sub-sample of the overall participant sample was generated as well, comprised of participants who had been removed from the program by the ICSP subcontractor and chose not to opt back in. This sample was given a separate, “low-propensity” survey to better understand why they did not re-engage with the program and gather data on attitudes and behavior regarding energy efficiency. All targeted samples were met, with the exception of the low-propensity sample within the treatment group – a screener question asking if the participant recalled seeing a notice letter to continue receiving home energy reports (which required an answer of “Yes”) – filtered out more than the anticipated number of respondents.

The results of the process evaluation are summarized below.

- The new home energy reports vendor used the low-propensity removal process to identify high-propensity customers who could contribute toward filling the Phase III expansion wave.
- Phase III treatment wave respondents – the wave that has seen only the new home energy reports – were the most satisfied. A significantly higher proportion of Phase III respondents (46%) said they were very satisfied with the report compared to Phase I (33%) and Phase II (34%) wave respondents.

- Phase III treatment wave respondents had a significantly lower proportion of program detractors (34%) than the Phase I (50%) and Phase II (57%) treatment wave respondents.
- Phase III treatment wave respondents gave a significantly higher mean agreement rating (7.2) compared to Phase I (5.3) and Phase II (5.8) treatment wave respondents for the statement, “I believe the like household comparison is accurate.”
- A significantly higher proportion of Phase III treatment wave respondents (69%) reported visiting the online portal than Phase III control wave respondents (51%).
- PPL said that after the new home energy reports vendor changed the reports to no longer use the term “neighbor,” the number of customer complaints to the program call center nearly ceased. In previous program years, the program call center commonly received complaints about the neighbor comparison.
- In the PY6 participant surveys, which covered the home energy reports sent by the previous vendor, treatment group respondents gave a mean agreement rating of 4.8 on a 10-point scale for the statement, “I believe the neighbor comparison is accurate.” In the PY8 participant surveys, which assessed the home energy reports from the new vendor, treatment group respondents gave a significantly higher mean agreement rating of 6.1 for the statement, “I believe the like household comparison is accurate.”
- Treatment group respondents most commonly suggested improving the accuracy of the home energy reports for the neighbor/like comparison and the personal usage data. The word “accurate” or “accuracy” appeared in 17% of the 126 suggestions submitted in the customer surveys.
- PY8 home energy reports were designed to increase the rate at which the treatment group completed the online home energy assessment, but led to only a minor increase in participation – only slightly higher than the control group.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan. In the one instance where the evaluation activity that required sampling did not reach its planned sample size, Cadmus gave a satisfactory explanation of the process and what factors led to the lower sample size. The low-propensity sample of participants, who did not opt back in to the program when given the chance later in PY8, were given a screener question asking if they remembered receiving a notice explaining the process of continuing to receive home energy reports. This answer required a yes, and screened out more participants than anticipated, dropping the sample size to 56 rather than the planned 70.

Aside from the deviation detailed above, the planned sample sizes for all research activities were met, including for in-depth interviews with program and implementation staff. Tables included in the annual report also clarify the mode of the survey as it pertains to each sample size detailed in the table. The methodology sections adequately explained the evaluation and included the required sampling and disposition information and tables.

The program findings were clearly summarized and presented in tables and figures, and, while they drew from a mix of process and impact evaluation activities, the link to process evaluation activities was clear. There were two recommendations that followed from the process evaluation.

C.7.1.4 Student Energy Efficient Education Program

Summary of Process Evaluation Findings

Process evaluation activities undertaken by Cadmus include analysis of the home energy worksheets (HEWs) returned from kit recipients, interviews with program staff and implementers, teacher interviews performed by the ICSP, and follow-up interviews with teachers performed by Cadmus. The findings of the process evaluation are summarized below.

- Similar to previous program years, in PY8, participants continued to use the plugged-in products (e.g., LED bulbs, smart power strips, and night lights) more than the water-saving products. ISRs for all kit products have decreased steadily since PY5. For showerheads, ISRs in two program cohorts have decreased from a high in PY5 of 31% and 34% to 25% and 27% in PY8. For faucet aerators, ISRs have dropped from 35% in PY5 to 29% in PY8. Despite low ISRs, and savings eligibility for electric water heat customers only, showerheads still generate a substantial portion of program savings.
 - Program stakeholders are looking for new ways to capture savings in the face of increased product saturation. In PY9, the ICSP is developing an augmented reality application, which it may pilot with the Take Action cohort to further engage students and their parents with the kit products at home.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan. In the case of the follow-up online survey fielded by Cadmus for teachers involved in the program, the achieved sample was more than double the sample target, after Cadmus opened the survey to all teachers rather than a subset.

Aside from this, planned sample sizes for all research activities were met, including for in-depth interviews with program and implementation staff. There were no planned sample sizes for the amount of HEWs or ICSP-fielded teacher surveys returned. The methodology sections adequately explained the evaluation and included the required sampling and disposition information and tables.

The program findings were clearly summarized and presented in tables and figures, and, while they drew from a mix of process and impact evaluation activities, the link to process evaluation activities was clear. There was one recommendation that followed from the process evaluation.

C.7.1.5 Efficient Lighting

Summary of Process Evaluation Results

The process evaluation for the Efficient Lighting Program included interviews with a PPL and an ICSP staff member, general population phone surveys with residential and small commercial lighting purchasers, a program database review, and a review of lighting manufacturer interviews performed by the ICSP. The findings of the process evaluation are summarized below.

- In PY8, the program exceeded planned sales and savings within the estimated budget. Promotional and merchandizing activities generated substantial sales lift and helped reduce free-ridership.
- Manufacturer interviews for the process evaluation indicated that they usually sell more LEDs in areas covered by utility-sponsored upstream lighting programs. They also reported selling 10% to 45% more LEDs in Pennsylvania than elsewhere in the country; they estimated LEDs represent roughly three quarters of national bulb sales. The interviewees believe that increased production of LEDs in the next few years would displace CFLs more than inefficient bulbs would. A small number of manufacturers also said, despite ENERGY STAR and EISA certifications, they would continue to sell uncertified LEDs to meet existing demand.
- Data from surveys show that LED purchases among residential customers is increasing, but some customers have never used them. Respondents who have used LEDs are more willing to pay than those who have not. LED users are more likely to have higher income and education levels than those who do not use them, and are more likely to live in single family homes.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan. Manufacturer interviews were not included in the process evaluation planning in the PY8 evaluation plan, but were added to the analysis. Aside from that, more surveys than planned were conducted with commercial customers, and there were not enough LED purchasers in the commercial sample that did not also install bulbs in residential spaces; therefore, the LED sample was not large enough to develop an ISR, and the PA TRM default was used. All process evaluation activities outlined in the evaluation plan were performed and included in the annual report. The tables included in the report contained sufficient detail, including the mode of the survey.

Evaluation findings were clearly summarized and presented in the text, and while they drew from a mix of process and impact evaluation activities, the link to process evaluation was clear. There were two recommendations that followed from the process evaluation.

C.7.2 Low-Income Programs

Cadmus reported on PY8 process evaluations for two low-income programs: The WRAP Program and The Energy Efficient Kits and Education Program. For the process evaluations of these programs, Cadmus reviewed program documents and data; interviewed utility and implementation staff, contractors, and end users; and surveyed program participants. The document and program data review informed identification of program goals, activities, and updates, and, in some instances, development of program theory and logic models. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) varied among programs, but generally included the effectiveness of program administration, implementation, and delivery; customer and market actor program satisfaction, participation, and challenges; and recommendations.

Cadmus followed the evaluation plan for each program's process evaluation for the most part, though there were some exceptions in the WRAP Program, mainly centered around sample size issues for various research activities. These will be covered in the program's process evaluation audit summary below. In the case of deviations from the evaluation plan, Cadmus gave satisfactory explanations in most cases for why this happened and, when possible, explained how the problem could be resolved in future evaluations.

The findings were clearly presented, and the conclusions were well supported by the findings overall. The conclusions were mostly concise and informative, the recommendations followed from the conclusions, and the recommendations were clear and actionable.

C.7.2.1 WRAP Program

Summary of Process Evaluation Findings

Cadmus conducted a process evaluation to generate findings on program delivery and participation, including the satisfaction of a variety of actors. Participant satisfaction was gauged through phone surveys, and program contractors and market actors (multifamily building property managers, manufactured home park property managers) were interviewed. There was also a logic model review and a process flow map review. The findings of the process evaluation are summarized below.

- Cadmus found that some WRAP participants and contractors had issues with some aspects of program communications. Some participants were confused about program benefits, eligibility requirements, energy education, and overall program implementation process. Some native Spanish speaking customers had difficulty communicating with program representatives. The ICSP subcontractor resolved this issue at the manufactured home park by sending Spanish speaking staff. However, the language barrier remained for some participants with other types of sites. WRAP contractors had some communication issues with the ICSP, indicating that job scheduling was not implemented optimally and created additional travel time. WRAP contractors also said they were not provided with instructions on who to reach at the ICSP, which caused confusion. After scheduling, some customers cancelled or failed to keep their appointment, inevitably leading to imperfect site visit schedules.
- All interviewed contractors had problems with the current tablet-based data management system because the interface does not allow contractors to review the data collected on site once entered into the tablet. This limits contractor's ability to run quality control checks on the field staff's work and requires contractors to keep separate records, adding time to the project.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan, but there were some deviations. Cadmus provided satisfactory explanations for the deviations, which included abandoning online participant surveys in favor of a phone only survey mode, and not completing phone surveys with participants in master-metered buildings due to a lack of contact information. The evaluation plan detail for the participant surveys included a contingency of increasing phone survey sample in the case of a low response rate to

the online survey. Given the uncertainty about the online survey mode during the planning stages, and the explanation provided by Cadmus in the annual report that the demographics of WRAP participants made satisfactory response rates unlikely, it might have been prudent for the evaluators to build a larger sample into the telephone surveys from the beginning. The final sample size of participant phone surveys (n=81) was only slightly higher than the planned sample size of 75 that was meant to be augmented by online survey responses.

Sample sizes in the final process evaluation matched the evaluation plan for interviews with EDC staff and market actors – Cadmus was actually able to interview all four participating contractors rather than the planned sample of three. Cadmus also included useful detail in the tables, breaking down sample sizes and research activities within the annual report, including the mode of the survey. All process evaluation research activities proposed in the evaluation plan for PY8 were performed as planned.

The program findings were clearly summarized and presented in tables and figures in the annual report. Findings drew from a mix of process and impact evaluation activities, but the link to process evaluation activities was clear. There were four recommendations that followed from the process evaluation. The SWE did observe that one recommendation, which described improving program communication in marketing materials and providing additional training to ICSP staff and contractors, would have been clearer and more actionable if broken into two recommendations.

C.7.2.2 Energy Efficiency Kits and Education Program

Summary of Process Evaluation Findings

The process evaluation performed by Cadmus in PY8 included interviews with PPL and ICSP program managers, as well as interviews with participating community-based organizations responsible for assisting the ICSP in recruiting participants and hosting the workshops that are part of the program. In addition, the paper surveys included in the kits provided to participants were analyzed, and telephone surveys were done with a sample of kit recipients who did not return the paper survey. The process evaluation findings are summarized below.

- Not all agencies feel fully equipped to train participants on the kits and how to install included products. One of the five interviewed agencies said some customers were confused by the two types of kits, and two of the five agencies wanted information on using Tier 2 advanced power strips and filter alarms. Two agencies said they often serve elderly clients who have trouble understanding the products in the kit; one agency said it received a lot of phone calls and repeat visits from elderly clients who asked how to install the products.
- One of the five interviewed agencies said that many of its clients take public transportation, walk, or bike to the location and have difficulty transporting the kit home. These customers sometimes leave the box and take the products home in a bag. Two agencies said they lose some customers who initially show interest at an event but do not come to the office to enroll and pick up the kit.
- Issues with the kit tracking system led to confusion throughout the program year. The ICSP and one agency said the current kit distribution tracking system made it difficult to

know to whom the kit was delivered or the type of kit the customer should receive. One high-volume agency decided to track its own kit distributions. Cadmus' review of program records in the PPL tracking database revealed issues with the ICSP data tracking and transfer system. Cadmus found that some customers received incorrect kit types and found errors in water heater configurations, laundry locations, home types, home cooling configurations, home heating fuel types, and survey responses between the two kit types.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan. There were two deviations from the process evaluation research tasks as originally outlined. One additional interview was done with implementation staff – both the ICSP and its subcontractor were interviewed rather than just the ICSP. The sample size of phone surveys with participants was also increased following an error by the contracted survey firm. Surveys for participants with non-electric water heating were sent to those with water saving measures in their kits, but Cadmus used the responses from those surveys that covered non-water products. In all, Cadmus met or exceeded planned sample sizes for all research activities, and were able to analyze 1,909 completed paper surveys returned by kit recipients.

Cadmus included useful detail in the tables, breaking down sample sizes and research activities within the annual report, including the mode of the survey.

The program findings were clearly summarized and presented in tables and figures, and while they drew from a mix of process and impact evaluation activities, the link to process evaluation data was clear. There were four recommendations that followed from the process evaluation.

C.7.3 Commercial and Industrial Programs

C.7.3.1 Efficient Equipment Program

Summary of Process Evaluation Results

Cadmus performed the process evaluation for the Efficient Equipment Program, which included interviews with PPL and ICSP program managers, a mix of phone and online participant surveys, interviews with participating contractors and design engineers, and a logic model review. The process evaluation was divided into two sections, one covering equipment and lighting products and another covering the distributor discount channel aspect of the program. The distributor discount channel is a midstream option, allowing contractors or end users to purchase discounted lighting at participating distributors, and so differs from the other, downstream channels used by the program. The results of the overall process evaluation are summarized below:

- Eight equipment and lighting survey respondents suggested that PPL provide more information about the program. Seven respondents requested information about available rebates, one had difficulty identifying which equipment was eligible, and another asked for guidance on preapproval requirements.
 - Additionally, one contractor suggested promoting tax credits. Fifty-five percent of survey respondents (86% of equipment respondents and 52% of lighting respondents) had visited PPL's website in the past six months.

- The EE&C Plan identified one potential program challenge may be that customers do not replace working equipment, even if that equipment is not efficient. However, 63% of respondents who replaced existing equipment said it was still in working condition with no problems, 35% said the replaced equipment had problems but was still working, and 2% said the equipment had failed or was not working.
 - The top two challenges for respondents involved not being able to make all desired energy efficiency improvements without a substantial investment (65%) and that making energy efficiency upgrades to facilities was cost-prohibitive (31%).
 - Additionally, five of nine contractors said the upfront cost was a challenge for customers.
- The most common way that participants learned about the program was from a contractor, vendor, or distributor (64%).
- The energy services company, contractor, vendor, or consultant who helped design the project had the most influence on a survey respondents' decisions about the project, with an average score of 4.37 out of 5, followed by the rebates from PPL with an average score of 3.91. Lighting respondents gave their contractor an average influence score of 4.39 out of 5, and equipment respondents gave their contractor an average influence score of 4.2 out of 5. Lighting respondents gave PPL rebates an average influence score of 3.98 and equipment respondents gave rebates an average influence score of 3.04 out of 5.
- Four contractors and design engineers said the program was very influential and five said the program was somewhat influential in a customer's choice to purchase more efficient equipment.
- The program is operating as designed, with distributors stocking efficient products and reaching customers as intended. The program met or exceeded the participating distributors' expectations and its success is grounded in its simplicity and instant rebate, which made it easier to sell discounted products to customers. The ICSP expects a much larger participation in PY9, with additional distributors and the currently active contractors who are now familiar with the discounted product offerings.
 - Most purchasers heard about the program from their distributor. Satisfaction with the program among distributors, purchasers, and end users is high. One suggestion from all distributors was to expand the qualified products list.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan. In the overall process evaluation, which was segmented into the equipment and lighting process evaluation and the distributor discount process evaluation, there were three exceptions to details in the evaluation plan. In each case, it was an issue surrounding sample size, and Cadmus highlighted the exception and provided an explanation for the discrepancy. Cadmus approached the combination of downstream and midstream delivery channels in the program as necessitating discussion in separate process evaluation sections,

which was handled well. The different research activities and sample groups applicable to each channel were broken down clearly in their respective sections.

Cadmus included useful detail in the tables, breaking down sample groups, sample sizes, and research activities within the annual report, including the mode of the survey. All process evaluation research activities included in the evaluation plan for PY8 were performed as planned.

The program findings were clearly summarized and presented in tables and figures, and, while they drew from a mix of process and impact evaluation activities, the link to process evaluation data was clear. There were four recommendations that followed from the process evaluation.

C.7.3.2 Custom Program

Summary of Process Evaluation Results

Cadmus performed the process evaluation for the Custom Program, which included interviews with PPL and ICSP program managers, a mix of phone and online participant surveys, interviews with participating contractors and design engineers, and a logic model review. The findings of the process evaluation are summarized below.

- PPL and the ICSP increased program awareness through outreach campaigns to explain how the Custom Program incentives could help reduce energy use, including sharing information with contractors or designers. The majority (60%) of survey respondents first learned about the program from their contractor, vendor, or distributor or through the PPL website (20%). Survey respondents said PPL's rebate was influential on their decision to complete a project, giving an average score of 3.73 out of 5, where 5 is extremely influential. Contractors and design engineers said the program was influential in a customer's decision to purchase more efficient equipment. Four contractors and design engineers said the program was somewhat influential and one said the program is very influential.
- One contractor and two of 15 participant survey respondents were not too satisfied with the rebate application process. Two participant survey respondents and one contractor recommended that PPL and the ICSP provide more information at the beginning about the application process and its requirements. One contractor recommended providing customers with a list of recommended contractors and 50% (n=16) of survey respondents had visited PPL's website within the past six months.

Summary of Process Evaluation Audit

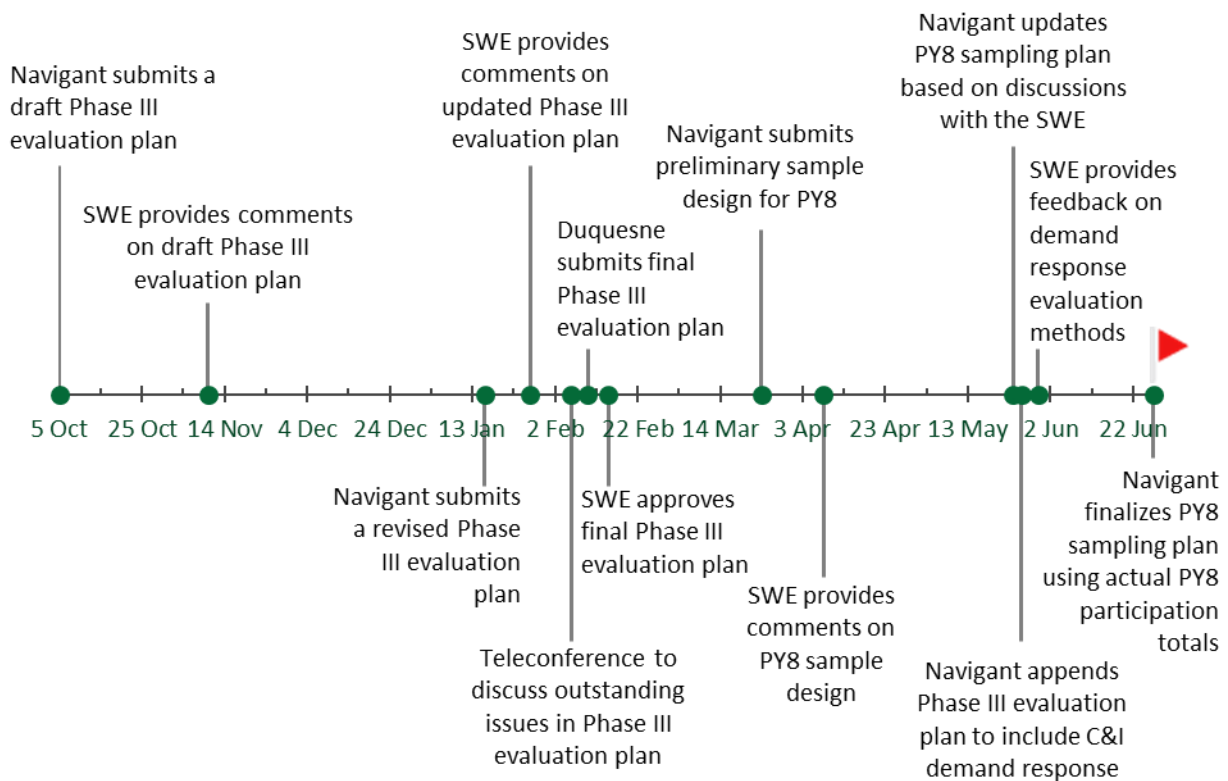
The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, including meeting sample size targets where targets were specified. Evaluation findings were clearly summarized and presented in tables and figures, and, while they drew from a mix of process and impact evaluation activities, the link to process evaluation activities was clear. There were two recommendations that followed from the process and impact evaluations, the SWE found the recommendations to be actionable, and found that they followed the conclusions, which were supported by ample evidence. There was one recommendation that followed from the process evaluation.

Appendix D Duquesne Audit Detail

D.1 EM&V PLAN REVIEWS

Duquesne Light's evaluation contractor elected to split the evaluation planning into two components: an overarching overview of the activities and methods for Phase III, and separate memorandum outlining the sample design for PY8 research activities. Figure 44 documents the timing of the major milestones associated with finalizing the Phase III evaluation plan and PY8 sample design for Duquesne Light.

Figure 44: Duquesne Light Evaluation Plan Review Timeline, 2016-17



Evaluation planning requires careful attention to budgets and resource allocation. At a high-level, more rigorous, or more frequent, data collection and analysis increases evaluation spending. The SWE worked carefully with Duquesne Light's evaluation contractor to understand the necessary tradeoffs when additional rigor was requested in certain areas, given fixed evaluation budgets. Key technical issues from the plan review process included the following:

- Schedule and Organization of Impact Evaluations:** except for the Upstream Lighting and Behavioral programs (which are evaluated all five years), Navigant proposed to evaluate programs either twice or three times in Phase III. There was substantial discussion on the expected increase in level of rigor associated with this decreased

frequency and how gross verified savings would be calculated for program years when an impact evaluation was not conducted.

- **Sample Sizes:** Assumptions about the coefficient of variation and program participation are primary drivers of sample size and the precision of the gross verified savings estimates. The SWE requested supporting detail for these assumptions, and, in some cases, requested Navigant utilize more conservative assumptions to ensure that minimum precision requirements would be met or exceeded.
- **Evaluation Details for the Behavioral Program:** The SWE requested the evaluation contractor validate the randomized control trial design, document the regression model specification, and revise the peak demand savings approach as part of the evaluation planning process. Additional clarity on the separation of Behavioral Program savings into residential and residential low-income (toward the LI carve-out) was also requested and provided.
- **Handling of Open Variables in the TRM:** For many parameters, the TRM allows for 'EDC Data Gathering,' but also provides a default value EDCs can use in the absence of primary data collection. The SWE provided comments to the plan centering on when to collect project-specific values and when to rely on TRM defaults.
- **Synthesis of Multiple Data Sources in the NTG and Process Evaluations:** The initial evaluation plan included data collection from multiple market actors (participants, non-participants, trade allies, etc.) to inform findings. The SWE requested additional detail on how these different data streams would be combined to develop results.

In addition to reviewing Duquesne's evaluation plans, the SWE reviewed one survey instrument and four interview guides. Two of these instruments were for residential programs while three were for C&I programs. The surveys and interviews addressed process and NTG topics.

D.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative." For Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. This change did not factor into the PY8 sample design for Navigant because Duquesne's Phase III EE&C plan already largely defines programs narrowly into logical initiatives. Navigant's evaluation activities for Duquesne Light were largely grouped by program and samples were designed to meet or exceed the 85/15 sampling requirement for each program. The Residential Energy Efficiency

Program included multiple initiatives (kits, rebates, and upstream lighting) that were sampled separately. [Table 87](#) shows the relative precision at the 85% confidence level of the PY8 energy savings for each program that received a gross impact evaluation.

Table 87: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Sampling Initiative

Program/Initiative	Relative Precision at 85% Confidence Level ($\pm$)
REEP Rebates	4.8%
Residential Appliance Recycling	2.0%
Commercial/Express Efficiency	1.7%
Midstream Lighting	12.1%
Small Commercial Direct Install	7.1%
Public Agency Partnership	4.8%
Community Education	2.0%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. All samples produced gross verified savings estimates with relative precision of less than $\pm 15\%$.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of Navigant's PY8 verification activities is discussed in detail in [Appendix D.4](#).

D.3 REPORTED GROSS SAVINGS AUDITS

D.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Duquesne Light's PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program
- Incentive dollars for each program

The SWE leveraged Duquesne Light's Q1-Q4 tracking data submissions to the SWE to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request.

D.3.1.1 Audit Findings

[Table 88](#) summarizes findings regarding reported gross energy savings. The Match column contains 'Yes' if the tracking data matches the annual report and 'No' otherwise. Note that the

Residential Appliance Recycling program is called 'RRP Refrigerator Recycling' in the tracking data. For all but two of Duquesne Light's programs, the SWE was able to replicate reported energy savings via the tracking data. The two programs for which we could not replicate reported energy savings with the tracking data are the Residential Behavioral Savings and Low-Income EE programs. However, note that the SWE does not expect to be able to reproduce savings for those two programs via the tracking data, as those two programs each have an HER component and HER data is not part of the tracking data. (The SWE's audit results for Duquesne Light's HER programs are presented in [Appendix D.4.1.3.](#)) Ignoring these two programs, the portfolio totals line up perfectly.

Table 88: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Residential Energy Efficiency	2,326	2,326	Yes
REEP: Upstream Lighting	34,358	34,358	Yes
Residential Appliance Recycling	1,261	1,261	Yes
Residential Behavioral Savings	6,536	---	---
Residential Whole House Retrofit	0	0	Yes
Low-Income Energy Efficiency	1,132	143	No
Express Efficiency	3,239	3,239	Yes
Small/Medium Midstream Lighting	1,025	1,025	Yes
Small Commercial Direct Install	3,626	3,626	Yes
Multifamily Housing Retrofit	159	159	Yes
Commercial Efficiency	3,642	3,642	Yes
Large Midstream Lighting	904	904	Yes
Industrial Efficiency	4,651	4,651	Yes
Public Agency Partnership	3,793	3,793	Yes
Community Education	1,084	1,084	Yes
Portfolio Total	67,737	60,068	---

Table 89 summarizes the SWE's findings regarding reported gross peak demand savings by program. As noted, the tracking data cannot be used to replicate savings for the Residential Behavioral Savings program or the HER contribution to Low-Income Energy Efficiency. For each other program, the tracking data support the reported gross peak demand savings values shown in Duquesne Light's Annual Report.

Table 89: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Residential Energy Efficiency	0.37	0.37	Yes
REEP: Upstream Lighting	3.48	3.48	Yes
Residential Appliance Recycling	0.14	0.14	Yes
Residential Behavioral Savings	3.52	---	---
Residential Whole House Retrofit	0.00	0.00	Yes
Low-Income Energy Efficiency	0.54	---	---
Express Efficiency	0.44	0.44	Yes
Small/Medium Midstream Lighting	0.16	0.16	Yes
Small Commercial Direct Install	0.36	0.36	Yes
Multifamily Housing Retrofit	0.02	0.02	Yes
Commercial Efficiency	0.26	0.26	Yes
Large Midstream Lighting	0.15	0.15	Yes
Industrial Efficiency	0.59	0.59	Yes
Public Agency Partnership	0.36	0.36	Yes
Community Education	0.23	0.23	Yes
Portfolio Total	10.62	6.57	---

Table 90 summarizes the SWE's findings regarding program participation. The SWE was able to replicate Duquesne Light's participation counts for all the programs we expected to be able to reproduce participation counts for. Like with energy and demand savings, the SWE did not expect to be able to audit participation counts for the Residential Behavioral Savings program or the Low-Income EE programs with the tracking data because of their HER components. Duquesne Light HER participation counts are audited as part of the HER audit (details shown in Section D.4.1).

Ignoring the two programs for which the SWE cannot attempt to count participation through our tracking data, the portfolio total is 6,441 in the annual report and 6,441 in the tracking data.

Table 90: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Residential Energy Efficiency	4,948	4,948	Yes
REEP: Upstream Lighting	N/A*	---	---
Residential Appliance Recycling	1,161	1,161	Yes
Residential Behavioral Savings	60,955	---	---
Residential Whole House Retrofit	0	0	Yes
Low-Income Energy Efficiency	19,206	---	---
Express Efficiency	94	94	Yes
Small/Medium Midstream Lighting	78	78	Yes
Small Commercial Direct Install	38	38	Yes
Multifamily Housing Retrofit	4	4	Yes
Commercial Efficiency	10	10	Yes
Large Midstream Lighting	43	43	Yes
Industrial Efficiency	11	11	Yes
Public Agency Partnership	41	41	Yes
Community Education	13	13	Yes
Portfolio Total	86,602	6,441	---
*Duquesne Light does not track individual participation for this program.			

Finally, [Table 91](#) summarizes the SWE's findings regarding incentive dollars. For the twelve programs in the tracking data, the SWE was able to replicate reported incentive dollars for eight.

For the remaining four programs, the incentives in the tracking data exceed the incentives in Duquesne's Annual Report. In total, the tracking data incentives exceed the annual report incentives by \$413,000. Note that a difference was expected because the annual report values are pulled from a financial system as opposed to program tracking data.

Table 91: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Residential Energy Efficiency	\$1,826	\$2,115	No
REEP: Upstream Lighting*	---	---	---
Residential Appliance Recycling	\$38	\$43	No
Residential Behavioral Savings	\$0	\$0	Yes
Residential Whole House Retrofit	\$0	\$0	Yes
Low-Income Energy Efficiency	\$0	\$0	Yes
Express Efficiency	\$139	\$182	No
Small/Medium Midstream Lighting	\$87	\$87	Yes
Small Commercial Direct Install	\$0	\$0	Yes
Multifamily Housing Retrofit	\$33	\$33	Yes
Commercial Efficiency	\$179	\$179	Yes
Large Midstream Lighting	\$109	\$109	Yes
Industrial Efficiency	\$156	\$156	Yes
Public Agency Partnership	\$149	\$226	No
Community Education	\$77	\$77	Yes
Portfolio Total	\$2,793	\$3,206	No
* Duquesne Light combines financials for REEP and REE.			

D.3.1.2 Action Items

The SWE was able to replicate energy savings, demand savings, incentives, and participation counts for all of Duquesne Light's programs except for the two programs with HER components (Residential Behavioral Savings and Low-Income EE), as HER data is not contained within the tracking data. Thus, the SWE did not expect to reproduce the savings or participation counts for those two programs via the tracking data.

Moving forward, the SWE has two recommendations:

1. The last tab in Duquesne Light's PY8 quarterly data submissions was typically a 'PY8 Cumulative' tab, which contained a cumulative participation dataset for PY8. Providing current, cumulative data is very helpful. However, instead of including this 'PY# Cumulative' tab, the SWE would prefer that Duquesne Light submits cumulative data in the other tabs. For example, '1.A.i. Res Programs' can contain a cumulative record of Duquesne Light's downstream residential program. In this case, it would not be necessary to include an additional column that contains information about which records were added or removed – simply remove/add the necessary rows. (Here, the SWE refers to the 'Update from Q3 Response?' column in the 'PY8 Cumulative' tab.) This would mean that Duquesne Light's fourth quarter submissions are significantly greater (in size) than their first quarter submissions, but this will help to automate procedures on the SWE's end.
2. Be sure to report measure life in years, not hours. For most records, Duquesne Light did indeed report measure life in years. However, in some cases (Res Upstream Details), measure life is instead reported as the rated life of the lamp (in hours).

D.3.2 Project File Reviews

D.3.2.1 Residential⁹¹

As part of the reported savings (i.e., ex-ante) review, the SWE reviewed a sample of Duquesne's residential project files for PY8 using the project documentation provided by Duquesne and the evaluation contractor, Navigant, 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. All project file packages included the documentation requested.

Project files were found to match most of the tracking data with few exceptions. [Table 92](#) presents an overview of the results of the SWE's residential project file reviews.

⁹¹ The SWE also conducted a database review of Duquesne Light's quarterly tracking data to verify that Duquesne Light was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

Table 92: Duquesne PY8 Residential Project File Review Summary

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?
Residential Energy Efficiency Program	Appliance Rebates	10	✓	✓	✓	✗
Residential Energy Efficiency Program	Efficiency Kits	4	✓	✓	✓	✓
Residential Energy Efficiency Program	Upstream Lighting	12	✓	✓	✓	✓
Residential Appliance Recycling	n/a	20	✓	✓	✓	✓

As outlined above, project files were found to be consistent with the tracking data with a few discrepancies, described below.

The appliance rebate subprogram had several inconsistencies between the project file documentation and the tracking data. The install date listed in the tracking database consistently lagged the installation date listed in the rebate application. In one instance, a furnace fan was recorded in the tracking data, but a central air conditioner was listed on the rebate application. In another instance, the efficiency of a central air conditioner was 17 SEER in the tracking database; however, the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certificate included in the project file documentation was 15 SEER.⁹²

The upstream lighting subprogram had some inconsistencies between watts reported in the tracking database and the watts associated with the lighting invoices, provided in the project file documentation. Most of the wattage discrepancies were one watt or less.⁹³ In one case, a model number for a light bulb in the tracking data did not match the model number listed in the invoices.

The Appliance Recycling project file review found one discrepancy of an application for a recycled refrigerator recorded as a freezer in the tracking database.

While the PY8 review of residential project files found project file packages to be typically well-organized and well-documented, the SWE found several instances of project files not matching the tracking data. The SWE makes the following recommendations:

- More thorough document review to ensure accurate transcription of appliance and HVAC equipment specifications.

D.3.2.2 Non-residential

The SWE reviewed Duquesne's C&I projects for PY8 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 projects. However, the SWE noted a handful of instances where the use off-TRM assumptions was unsubstantiated by additional documentation. [Table 93](#) presents an overview of the results of the SWE's C&I project file reviews.

⁹² The SWE notes that Navigant conducts an application file review and uses survey data to develop realization rates and calculate verified savings.

⁹³ The SWE notes that the model number of an LED bulb, listed in both an invoice and the tracking data, could not be matched to the ENERGY STAR lighting product list. However, the SWE and Navigant could match an abbreviated model number to the ENERGY STAR lighting product list. The matched bulb had a lower reported wattage, 11.5, than what is listed in the tracking data, 13. The tracking data is therefore potentially undercounting savings and Navigant took the conservative approach and used 13 W in the verified savings analysis. The SWE recommends that Navigant confirm the model number and wattage of the incentivized bulb going forward.

Table 93: Duquesne PY8 C&I Project File Review Summary

Project Number	Project Description	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for the SWE to follow?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
7944550093.57.02	Lighting	✓	✓	✓	✓	✓	-
2811500531.51.01	Lighting	✓	✓	✓	✓	✓	-
1241910380.51.01	Lighting	✓	✓	✓	✓	✓	-
4886120527.49.01	Lighting, Refrigeration, & Motors	✓	✓	✓	✓	✓	-
0477660474.49.01	Lighting, Refrigeration, & Motors	✓	✓	✓	✓	✓	-
0490399186.60.04	Lighting	✓	✓	✓	✓	✓	-
8193770211.60.01	Lighting	✓	✓	✓	✓	✓	-
6951830706.60.01	Lighting	✓	✓	✓	✓	✓	-
6292660155.53.01	Lighting Controls	✓	✓	✓	✓	✓	-
9827725356.53.01	Lighting	✓	✓	✓	✓	✓	-
5180200889.57.01	Lighting	✓	✓	✓	✓	✓	-
1352420880.53.01	Lighting Controls	✓	✓	✓	✓	✓	-

Project Number	Project Description	Are all files included?	Do values match program tracking data?	Does scope of work match between invoices and calculations?	Is there sufficient information for the SWE to follow?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
5487050888.58.01	Lighting	✓	✓	✓	✓	✓	-
9302910729.58.01	Lighting	✓	✓	✓	✓	✓	-
6951830706.60.01	Lighting	✓	✓	✓	✓	✓	-
2873420099.57.01	Lighting	✓	✓	✓	✓	✓	-
0531830581.60.01	Lighting	✓	✓	✓	✓	✗	-
0047850173.58.01	Lighting	✓	✗	✓	✓	✓	-
062920184.58.01	Lighting	✓	✓	✓	✓	✓	-

A review of the project files revealed only minimal issues affecting the SWE's ability to verify Duquesne's reported savings. The most prevalent issue identified was mismatching of key inputs across project documentation, which could generally be rectified through further discussion with the evaluation contractor. Specific issues encountered are addressed individually by project below.

Documentation for project 0531830581.60.01 includes an M&V report that presents a screen-shot of a completed lighting logger analysis. The HOU value on the screen-shot is 8,760, which is the value used for savings calculations. However, the sensor data analysis spreadsheet from which the screen-shot appears to have been taken states that the HOU are only 8,736. Further investigation into this matter found the difference to be related to the calculation of annual hours as a function of 52-weeks rather than 365-days.

Documentation for project 0047850173.58.01 presented a discrepancy in the reported savings between the EDC tracking data and the Appendix C calculators. The project included interior and exterior lighting retrofits, which were submitted on separate Appendix C calculators. The sum of the two calculators did not match the total reported savings for the project in Duquesne's PY8 project tracking data. The discrepancies are detailed in [Table 94](#).

Table 94: Discrepancies in Reported and Calculated Savings for 0047850173.58.01

Savings Source	Energy Savings (kWh)	Demand Savings (kW)
Tracking Database	34,608	6.82
Interior Lighting Appendix C	25,387	
Exterior Lighting Appendix C	9,996	
Sum of Appendix C Submittals	35,383	4.85

The SWE annual reports from PY6 and PY7 submit that the review of Duquesne project files was seamless, with only minimal inconsistencies. This trend continued through PY8; project documentation was generally well organized with necessary documentation provided in most cases. Omissions were easily rectified through follow up conversations with the evaluation contractor. Additionally, the SWE notes that the errors found were in projects that were not a part of Navigant's evaluation sample, and that similar errors were flagged by Navigant in project within their evaluation sample. The SWE believes Navigant appropriately handles and reflects issues such as those noted above in their realization rates.

D.4 VERIFIED GROSS SAVINGS AUDITS

D.4.1 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's portfolio of residential programs includes the following: Residential Energy Efficiency Program (REEP), Residential Appliance Recycling Program, Residential Behavioral Savings Program, and the Low-Income Energy Efficiency Program. Note that the SWE reports the residential savings in the three following sections: upstream lighting, residential non-lighting, and behavior.

Table 95 provides a summary of the evaluation and M&V approaches used by Duquesne Light in their PY8 verified savings calculations. Table 96 provides a summary of discrepancies that were discovered during the SWE audits of verified savings. Note that with the exception of Home Energy Reports, all of the discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.⁹⁴

Table 95: Residential Program Evaluation Activities

Program	Surveys	Site Visits	Desk Review ^a	Billing Analysis	PY7 Realization Rate
Residential Energy Efficiency Program	--	--	✓	--	✓
Residential Appliance Recycling Program	✓	--	✓	--	--
Residential Behavioral Savings Program	--	--	--	✓	--
Low-Income Energy Efficiency Program	--	--	--	--	✓

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

Table 96: Residential Program Verified Savings Discrepancies

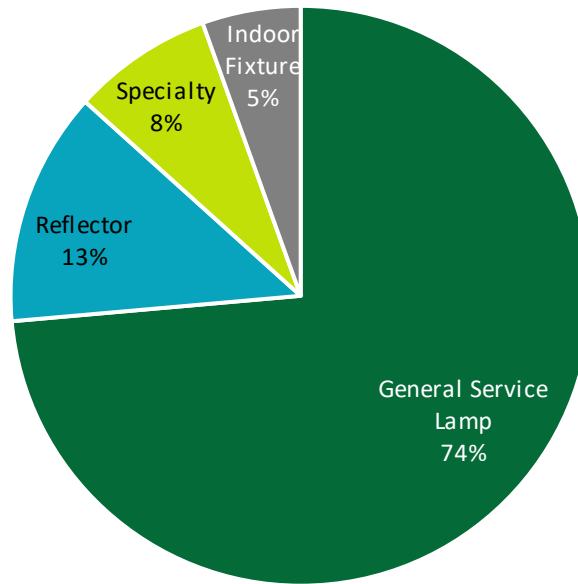
Program	Sub-program/ Measure	Discrepancy	The SWE Recommendation
Residential Energy Efficiency Program	Kits	Inconsistent kit-level savings; incorrect TRM default	Provide clearer kit component specifications; Tracking of counts of kits distributed at EDC give-away events; apply correct TRM baseline wattages and other TRM default values
Residential Behavioral Savings Program	HERs	Multiple Calculation Errors	Implement QA/QC procedures. Follow behavioral evaluation protocols from the Evaluation Framework*

*The SWE is recommending a correction to the peak demand savings estimate and an adjustment to the way average daily impacts get converted to program MWh savings totals

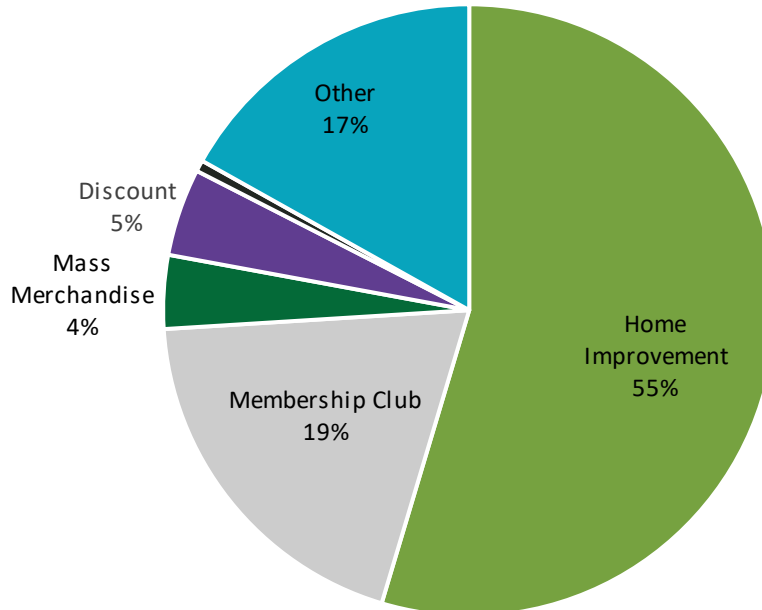
D.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 850 thousand efficient light bulbs and fixtures through Duquesne's upstream lighting program. Figure 45 displays the distribution of sales by product type. Nearly three-quarters (74%) of the products were general service lamps.

⁹⁴ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Figure 45: Duquesne PY8 Upstream Lighting Sales by Product Type

Nearly three-quarters (74%) of Duquesne's PY8 upstream light bulbs and fixtures were sold through home improvement stores and membership stores ([Figure 46](#)).

Figure 46: Duquesne PY8 Upstream Lighting Sales by Retail Channel

D.4.1.1.1 Audit Findings

The SWE reviewed the data in Duquesne's tracking system to verify that Navigant used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with Navigant's verified gross savings for upstream lighting.

The SWE observed 489 unique lighting model numbers in the PY8 tracking system and was able to locate 452 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. Possible reasons why the SWE was not able to cross-reference the remaining 37 models include deviations in the model number recorded in the tracking system versus the ENERGY STAR certified products lists (including private label products), the absence of ENERGY STAR product model numbers in the ENERGY STAR certified products lists, or the inclusion of non-ENERGY STAR products in the program. The 37 models the SWE was not able to verify as ENERGY STAR certified represent 5% of both bulbs sold and verified savings from upstream lighting.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most models. The team observed minor discrepancies in efficient product wattage and/or lumens for 33 of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system, or errors in the ENERGY STAR certified products lists.

The team confirmed that Navigant used the appropriate algorithms to calculate kWh and kW savings for REEP upstream lighting. In addition, the SWE verified that Navigant used the correct interactive effects, ISR, HOU, and coincidence factor in the calculations. The SWE found that Navigant correctly assigned baseline wattages in accordance with TRM protocol 2.1.1 for the majority of models. However, the team identified 19 decorative models and one globe model that are not exempt from EISA, but Navigant assigned the EISA exempt baseline wattage. The 19 decorative models in question had medium screw bases, but many were mischaracterized as candelabra base bulbs (which are exempt from EISA if they have less than 1,050 lumens) in the tracking data. Conversely, the team identified four models that are exempt from EISA because they are 3-way bulbs, but Navigant assigned the post-EISA 2007 baseline wattage. In addition, the team identified five R20 reflector models that were incorrectly coded as another type of reflector and were assigned an incorrect baseline wattage. Some of these errors overestimate savings, while others underestimate savings. Combined, the impact of all discrepancies the SWE identified on initiative-level savings is negligible (less than two-tenths of 1%).

D.4.1.1.2 Cross-Sector Sales

Navigant did not conduct any cross-sector sales research in PY8. Navigant applied the PY7 cross-sector sales rate of zero to Duquesne's PY8 sales.

D.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Review program offerings to ensure that all products are ENERGY STAR qualified.
 - The SWE was unable to verify a small portion (five percent) of PY8 products as ENERGY STAR certified. While the team did not definitively determine that these were non-ENERGY STAR products, the SWE reminds all EDCs that TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and

value line LEDs be assigned zero kWh savings because they are not eligible products.

- Review the tracking data and correct any errors regarding bulb or base types.

D.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting solutions found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

D.4.1.2.1 Residential Energy Efficiency Program (REEP)

The SWE audited both components of the Residential Energy Efficiency Program (REEP): Rebates and Kits. Note that the SWE's audit of the upstream lighting portion of REEP is reported in [Section D.4.1.1](#) of this appendix. The rebate component comprises several HVAC and ENERGY STAR appliance measures, including Air Source Heat Pumps, Central Air Conditioners, Dehumidifiers, Ductless Mini Splits, Room Air Conditioners, Freezers, Refrigerators, Heat Pump Water Heaters, Programmable Thermostats, and High Efficiency Heating Fans. The SWE determined the verified savings for rebated measures were correct and that Navigant had applied the 2016 TRM algorithms and PY7 realization rates appropriately.

The kit component of the REEP program includes two varieties of kits, one containing LED bulbs of various wattages and LED nightlights, and another containing CFLs, electroluminescent nightlights, and a smart power strip. In addition, some kits were distributed and tracked individually, while others were distributed en masse at giveaway events. The PY8 Evaluation Plan did not include a verified savings evaluation for the REEP kits. Instead, PY7 realization rates were applied to the reported savings values in PY8.

The SWE was unable to fully verify the savings calculations for kit giveaway events because the savings were provided as a single, aggregated savings value and did not include counts of the type(s) of kits or individual measures distributed at the giveaway events.

For kits that were tracked individually, the SWE was able to audit the verified savings and found several discrepancies in the values used to calculate savings for the REEP kits, as well as inconsistencies in reporting. The data provided by Duquesne Light recorded two different types of CFL kits, one labeled as "Phase II-III," with 277 kWh of reported savings and another labeled as "Phase III," with 288 kWh of reported savings. The difference in savings is due to replacing a 20-watt midrange CFL with an 18-watt variety in the Phase III kits. In examining the data and calculations used to generate reported savings, the SWE found that the Phase II-III CFL kits used two outdated TRM defaults in savings calculations – the efficient HOU and ISR – resulting in a slight over stating of savings. The Phase III CFL kit savings calculations also used incorrect TRM defaults for baseline wattages, for example 42.5 instead of 43 watts, which slightly understated savings. For these individually tracked kits, the SWE was able to use correct TRM defaults and found the savings difference to be under 1% of program savings and well below 1% of portfolio savings. While the impact on savings is small, this was only a subset of overall verified savings, and the multiple inconsistencies in applying TRM defaults is concerning and should be addressed in PY9 when savings are verified, and an updated realization rate is developed.

Finally, the Duquesne Light PY8 Annual Report only mentions a single CFL kit containing a 20-watt CFL and providing 288 kWh in savings. Based on data and calculations provided to the SWE, the kit containing the 20-watt CFL provided 277 kWh in savings, while the updated Phase III kit (with 20-watt bulb replaced by 18-watt variety) was associated with 288 kWh in savings. These discrepancies between the annual report and the program data in both the savings values and the exact measures offered in kits should be clarified in the PY9 report.

D.4.1.2.2 Residential Appliance Recycling Program

The Residential Appliance Recycling Program (RARP) provides rebates in exchange for removing inefficient refrigerators and freezers. The SWE audited the program savings by reviewing the EDC-provided data for both refrigerators and freezers. The SWE determined the verified savings followed the 2016 TRM protocols accurately. The SWE notes that Navigant used the TRM defaults rather than the appliance characteristics in the tracking data to calculate verified savings. The SWE notes that relying on TRM defaults appears to result in estimating higher savings for freezers, but **lower** savings for refrigerators. Overall, if EDC data was used, the SWE estimates that verified gross savings would have been reduced by approximately 8 MWh. The SWE was unable to verify the reported sample sizes and was unable to determine if this had an impact on verified savings. In addition, the SWE was unable to verify the reported RARP evaluation sample sizes. The RARP evaluation sample and program data were reported in multiple spreadsheets provided by Navigant, but the sample sizes varied slightly among the spreadsheets (ranging from 134 to 138 for refrigerators and 30 to 32 for freezers). The SWE recommends that Duquesne Light use EDC data to calculate verified savings in PY9 and clarify the evaluation sample in the data provided.⁹⁵

D.4.1.2.3 Low-Income Energy Efficiency Program

Duquesne Light also offers a low-income version of the kits. Similar to the REEP kits, there was not a full evaluation performed to verify savings in PY8, and PY7 realization rates were applied to the reported savings. The low-income kit savings were provided to the SWE as bulk savings values without quantities, and the structure of the data did allow the SWE to review and verify the number of kits distributed and verify that per-kit savings were calculated correctly.⁹⁶

In future program years, Duquesne Light should provide the SWE with tracking data on the number of kits distributed and the savings calculations for individual kits.

D.4.1.3 Behavior

Approximately 12% of Duquesne's verified gross energy savings for PY8 came from Home Energy Reports issued to around 80,000 residential and residential-LI households. While Duquesne was among the least HER-reliant EDCs for residential savings in PY8, close to 90% of

⁹⁵ The SWE calculated an overall RARP program realization rate of 94.4% using EDC collected data (the report indicates a 92% program realization rate). Reiterating section 1.2.2 of the 2016 TRM, EDCs are encouraged to continue with EDC data gathering rather than using default values provided in the TRM, and they are encouraged to apply the customer-specific or program-specific data that has been collected for as many open variables as possible to reflect the most accurate savings values.

⁹⁶ Updated tracking data was provided after the audits were completed, and the new data did include quantities for measures such as low-income kits. However, the new data was not provided in time to be verified as part of the SWE audits.

Duquesne's progress toward its low-income target in PY8 came from HERs. Duquesne's behavioral portfolio consists of the three different waves, or cohorts, of homes summarized in [Table 97](#).

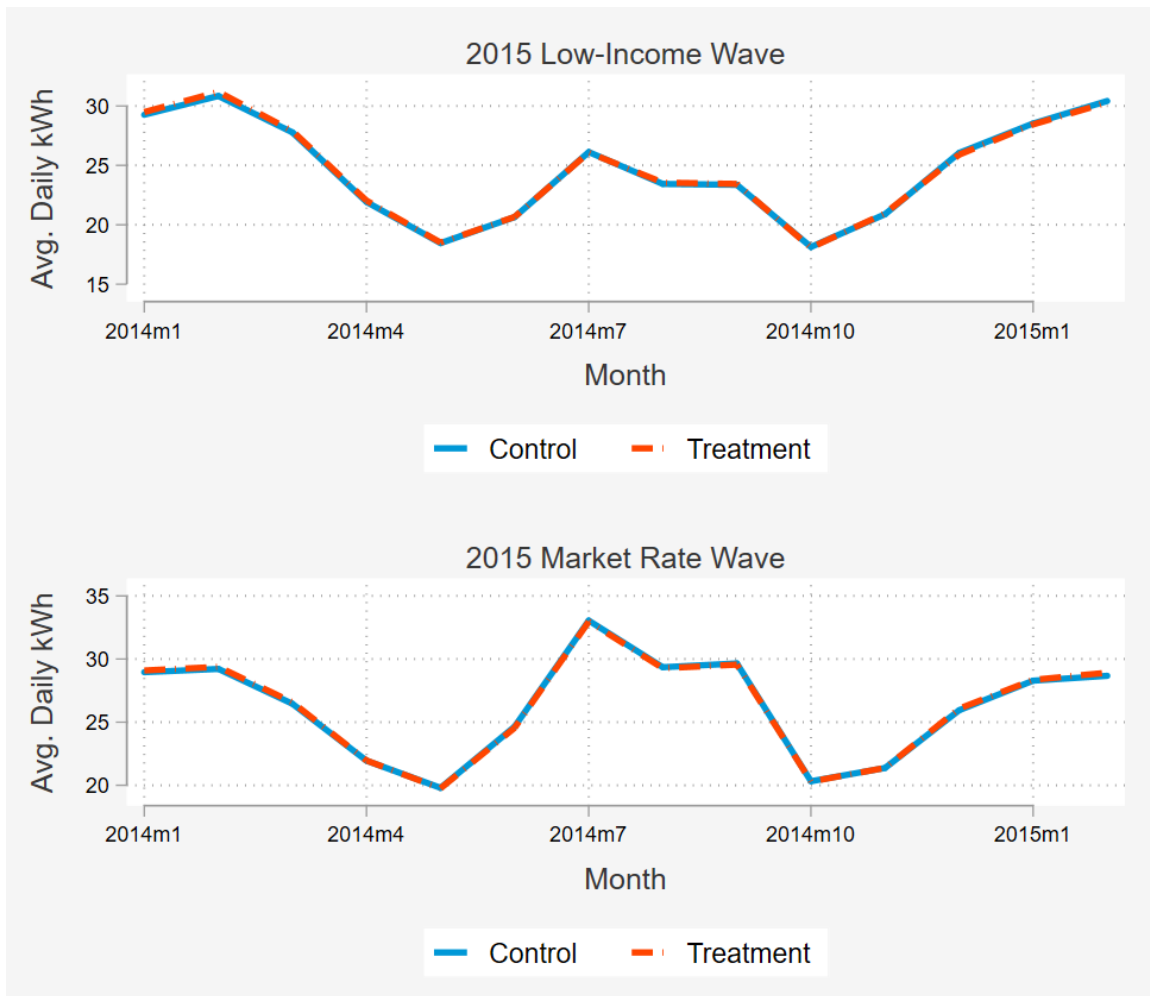
Table 97: Duquesne HER Cohort Summary

Wave	First HER Mailing	Treatment Group Homes	Control Group Homes
2012 Market Rate	July 2012 ⁹⁷	15,000	40,000
2015 Market Rate	March 2015	46,000	17,000
2015 Low-Income	March 2015	15,000	8,000

The SWE performed a detailed audit of the RCT design, regression-based HER savings estimates, and recipient household counts using data provided by Duquesne's evaluation contractor. Navigant's analysis included some departures from the behavioral evaluation protocol Evaluation Framework, which should be avoided in PY9. The SWE is also recommending a correction to the peak demand savings estimate and an adjustment to the way average daily impacts get converted to program MWh savings totals.

Each of the three Duquesne HER cohorts are delivered as an RCT. When group sizes are large and the randomization of homes to the treatment and control group is sound, there should be virtually no difference between the average energy usage of the groups in the pre-treatment period. [Figure 47](#) provides a visual comparison for the two 2015 waves. In each month of the pre-treatment period, the treatment and control group lines follow each other perfectly. In addition to visual comparisons, the SWE ran statistical tests of equivalence. These tests affirmed Navigant's assessment that the randomization was sound for each wave.

⁹⁷ The 2012 Market Rate cohort did not receive HERs from June 2013 to February 2015.

Figure 47: Comparison of Pre-Treatment Usage – 2015 Waves**Data Management**

The approach Navigant used to ‘calendarize’ monthly billing data was inconsistent with the behavioral protocol of the Evaluation Framework. Instead of expanding the billing periods (which follow variable meter read schedules) to daily data and then collapsing it to a common calendar basis, Navigant simply used the meter read date of each bill to assign the record to a month. If a home had a billing period that began on 5/2/2016 and ended 6/1/2016, that record was classified as “June 2016.” A billing period that began 5/30/2016 and ended 6/30/2016 would also be classified as “June 2016.” Because the same rules were used for the treatment and control groups, this approach does not directionally bias the results, but it does create some reporting issues. [Table 98](#) illustrates. Notice that the first ‘YearMonth’ period of the PY8 analysis period actually includes several weeks of Phase II consumption for most homes. Similarly, the last couple of weeks of PY8 are excluded for most homes.

Table 98: Average Start and End Date of Billing Periods in PY8 Analysis

YearMonth	Average Start Date	Average End Date
201606	5/16/2016	6/15/2016
201607	6/16/2016	7/16/2016
201608	7/18/2016	8/15/2016
201609	8/16/2016	9/15/2016
201610	9/15/2016	10/15/2016
201611	10/16/2016	11/15/2016
201612	11/14/2016	12/14/2016
201701	12/15/2016	1/15/2017
201702	1/16/2017	2/14/2017
201703	2/14/2017	3/14/2017
201704	3/16/2017	4/14/2017
201705	4/19/2017	5/18/2017

Navigant's handling of estimated meter reads was also inconsistent with the guidance in the Evaluation Framework. Although estimated reads are infrequent for Duquesne (~ 1%), proper handling is straightforward and should be included in the calendarization process in the PY9 and beyond.

Navigant's description of handling move-outs was also inconsistent with the Evaluation Framework behavioral protocol. In the PY8 Annual Report, Navigant describes a process where *"Participants and non-participants that moved out of Duquesne Light territory during the course of the program were omitted from the regression analysis to estimate program effects, but were included in the estimate of total program savings for the time prior to when they moved away. Navigant assumed that until a participant moves out, their program savings are equal to savings over the same period for participants that remain in the program for the balance of the program duration."* Excluding households that move more frequently (e.g., renters) from the analysis has the potential to bias the results and should be avoided in future program years. When the SWE investigated move-outs, it was clear that this passage in the report does not reflect how the data were actually analyzed (e.g., move-out homes were included in the analysis until they moved and stopped having data). Navigant should make sure that the description of impact evaluation methodology in future annual reports reflects the actual methods used.

To test the sensitivity of the PY8 verified gross savings values to these data management decisions, the SWE conducted an independent analysis following the data preparation procedures in the Evaluation Framework and the same regression model specification. [Table 99](#) compares the average PY8 kWh savings per household, by wave. Average savings per home are lower for the two residential waves, but larger for the low-income wave.

Table 99: Impact Comparison with Calendarized Data

Wave	Navigant Impact Coefficient	PY8 kWh Savings	SWE Impact Coefficient	PY8 kWh Savings
2012 Market Rate	-0.5017	183	-0.4739	173
2015 Market Rate	-0.2917	106	-0.2459	90
2015 Low-Income	-0.1478	54	-0.1905	70

While the differences in [Table 99](#) looks large, it is important to remember that these models are estimating a very small change relative to the total household consumption of 10,000 kWh per year. The SWE is not recommending Duquesne adopt the impact coefficients shown in [Table 99](#) in its PY8 verified savings totals. However, the data management procedures in the Evaluation Framework should be followed in PY9.

Regression Analysis

Duquesne's PY8 Annual Report describes use of a linear fixed-effects regression (LFER) model to estimate program impacts. However, this text was included in error because the evaluation used a lagged dependent variable (LDV) model. Both models are approved methods in the Evaluation Framework behavioral protocol, but the SWE required evaluation contractors to specify the model specification they would utilize in their EM&V plans. Navigant's EM&V plan for PY8 called for use of an LDV model; this is what was ultimately used, so the SWE has no issue with the model selection. However, Navigant should make sure that the description of impact evaluation methodology in future annual reports reflects the actual methods used.

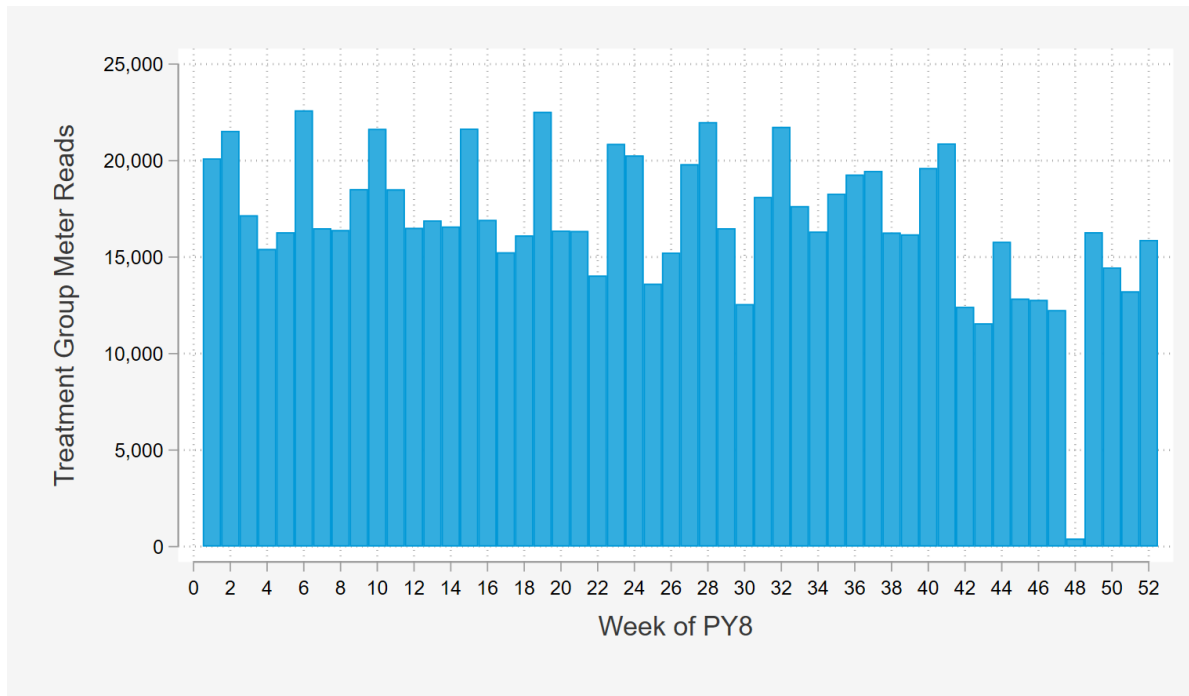
Participant Counts

The SWE also attempted to replicate the count of participating households reported by Navigant in the PY8 Annual Report. Participant counts are important because these are the totals used to convert the per-home savings estimates produced by the regression model to aggregate program impacts. Customers move and close their accounts with the EDC every month, so the number of active households in any given wave is always declining. The logic Navigant used to count active treatment group homes is unclear from the PY8 report or supporting documentation. The SWE used a standard approach, where the last available month of billing data is calculated for each account and the household is assumed to be active for all months prior. [Table 100](#) compares the results.

Table 100: Verification of Participant Counts

Year Month	2012 Market Rate		2015 Market Rate		2015 Low-Income	
	Navigant	SWE	Navigant	SWE	Navigant	SWE
2016m6	15,242	15,450	45,848	46,736	15,497	16,622
2016m7	15,242	15,450	45,848	46,735	15,375	16,383
2016m8	15,242	15,450	45,846	46,734	15,253	16,153
2016m9	15,242	15,449	45,846	46,733	15,134	15,917
2016m10	15,242	15,449	45,845	46,730	15,034	15,682
2016m11	15,241	15,445	45,839	46,698	14,913	15,439
2016m12	15,238	15,411	45,818	46,551	14,800	15,231
2017m1	15,229	15,361	45,764	46,328	14,712	15,050
2017m2	15,216	15,302	45,718	46,093	14,631	14,858
2017m3	15,210	15,249	45,675	45,849	14,551	14,679
2017m4	15,203	15,165	45,631	45,448	14,507	14,467
2017m5	15,154	14,416	45,308	42,420	14,348	13,818
Average	15,225	15,300	45,749	46,088	14,896	15,358

The SWE participant counts are consistently higher in each month until the end of PY8 – when they drop sharply. This abrupt drop led the SWE to investigate the raw billing data for any underlying issues. [Figure 48](#) shows the number of treatment group homes with meter read dates in each week of PY8. Weeks are defined as Sunday through Saturday. Notice that the program data has almost no records from week 48 (April 30 through May 6) and volume was lighter than average during the weeks prior.

Figure 48: HER Treatment Group Meter Reads by Week

This gap in the data is most likely a data transfer issue between Duquesne and the ICSP, rather than any actual gap in meter reading. The SWE compared the billing start and end dates through this period and found approximately 35,000 households in the treatment and control groups with a one-month gap between the end of one billing cycle and beginning of the next (e.g., a missing bill). This type of data quality issue should be uncovered by an evaluation contractor and addressed with the EDC and ICSP well before reporting gross verified program impacts.

The gap in billing data ultimately affects the estimates of aggregate program savings because of the approach Navigant used to convert average daily savings estimates to MWh impacts. Navigant multiplied the regression coefficients shown in [Table 99](#) by the sum of the number of days of PY8 billing data of the treatment group homes in each wave. For homes that are missing a bill, the number of days will be understated by approximately 30 days. The SWE implemented an alternative calculation where the number of days between the start of the first PY8 billing period and the end of the last PY8 billing period is used. Using this approach, the number of days in the missing bill are included in the total number of active days (unless the first or last bill of the program year is missing). [Table 101](#) compares the results.

Table 101: Billing Day Totals

Wave	Navigant Day Total	SWE Day Total	Ratio
2012 Market Rate	5,311,386	5,509,272	103.7%
2015 Market Rate	15,996,727	16,523,404	103.3%
2015 Low-Income	5,338,967	5,499,644	103.0%

Ideally, Navigant would collect the missing billing data from Duquesne Light and include it in the analysis. In absence of these billing records, the homes were still receiving HERs and presumably saving energy at a rate consistent with other non-missing months, so the missing period should be included in the PY8 savings totals. Accounting for the gaps using the SWE-proposed method increase the MWh savings of each wave between 3.0% and 3.7%. The SWE worked with Navigant to revise the calculation of MWh savings and produced revised PY8 energy savings estimates. Correcting this calculation increases Duquesne Light's PY8 verified gross savings total by 439 MWh, with 53 additional MWh towards the low-income compliance target.

Peak Demand Impacts

The behavioral protocol of the Evaluation Framework provided evaluation contractors several options for estimating peak demand savings for HER programs. Navigant attempted to align their methods with the protocol, but did a poor job executing the calculations. Page 68 of Duquesne's PY8 Annual Report states that *"Navigant calculated the demand savings by multiplying the verified savings by the percent energy savings during summer peak hours (14.1%) and dividing by the number of summer peak hours (262 hours). Percent energy savings during peak hours comes from EDC's cost effectiveness TRC calculator. Summer peak hours are defined as non-holiday weekday afternoons from 2:00 pm to 6:00 pm during June 1 to August 31."* There are two issues with this calculation.

1. The Summer on-peak energy share in Duquesne's PY8 TRC model is 18.0%, not 14.1% for Home Energy Reports (savings profile #14).
2. According to Duquesne's Phase III EE&C Plan⁹⁸, the allocation factors for energy are based on a broader definition of summer peak (8am to 8pm Monday to Friday, May through September). Instead of dividing the energy savings by 262 hours, Navigant should have divided the energy savings by approximately 1,300 hours.

Following discussions with Duquesne's evaluation contractor, it was decided that a simplified peak demand savings calculation where the energy savings estimate is divided by the number hours in a year (8,760) was a reasonable approach to revise the peak demand impact estimates. Correcting the errors using this approach reduces the PY8 verified gross and net demand savings from Home Energy Reports by over three MW. Table 102 shows the original and corrected energy and peak demand savings from the two programs that include HERs.

Table 102: Original and Corrected PY8 Program Impacts

Calculation	Program	Gross MWh	Gross MW	Net MWh	Net MW
Original	Residential Behavioral Savings	6,776	3.65	6,776	3.65
Corrected	Residential Behavioral Savings	7,162	0.82	7,162	0.82
Difference	Residential Behavioral Savings	386	-2.83	386	-2.83
Original	Low-Income Energy Efficiency	1,155	0.57	1,112	0.55
Corrected	Low-Income Energy Efficiency	1,208	0.14	1,165	0.14
Difference	Low-Income Energy Efficiency	53	-0.43	53	-0.42

These changes result in a reduction in TRC benefits of approximately \$208,000 and lower the gross TRC ratio for the portfolio from 2.10 to 2.09.

D.4.2 Non-Residential Audit Activities

Figure 49 provides a summary of the evaluation activities and M&V approaches utilized by Duquesne's evaluation contractor in their PY8 verified savings calculations. (Note that the figure excludes projects and savings associated with the Midstream Lighting Program.) Navigant utilized basic and enhanced rigor options equally by energy savings contributions.

⁹⁸ Duquesne Light Company. FINAL Duquesne Light Energy Efficiency and Conservation Plan Phase III. At page 105. Docket Number M-2015-2515375. (Duquesne Light Phase III EE&C Plan).

<http://www.puc.pa.gov/pcdocs/1397353.pdf>

Plan approved March 10, 2016

<http://www.puc.pa.gov/pcdocs/1422437.docx>

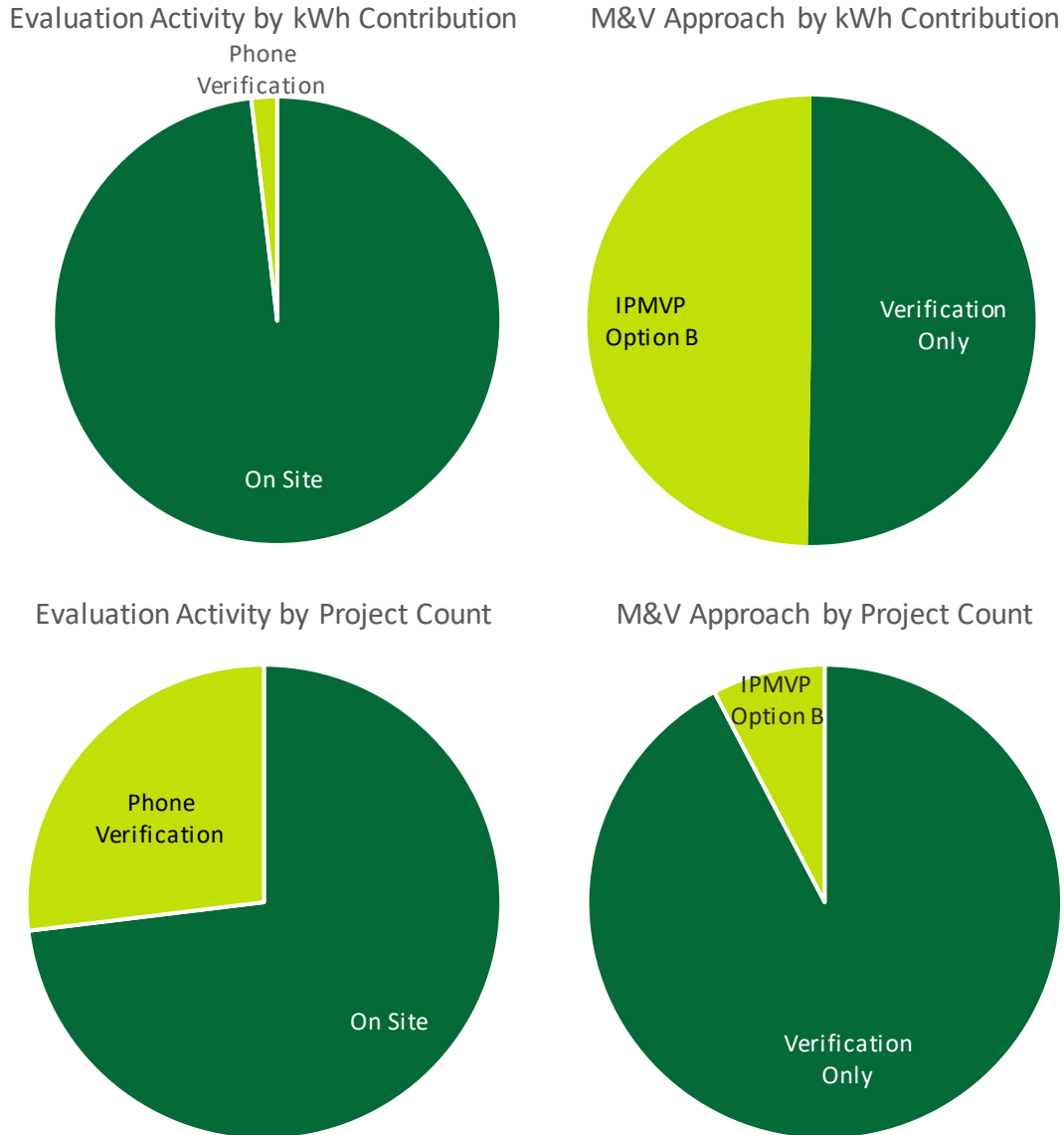
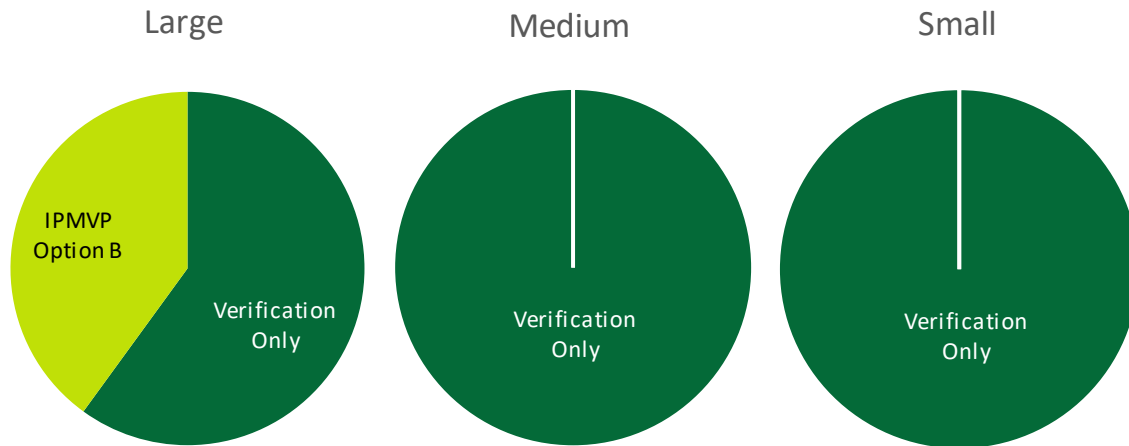
Figure 49: Summary of Duquesne's C&I Evaluation Activities

Figure 50 provides a summary of the evaluation activities and M&V approaches Duquesne's evaluation contractor used across strata. The distribution of rigor across sample strata shows that enhanced rigor methods were reserved for measure with the highest impact and/or level of uncertainty. However, the distribution of rigor fell short in the medium stratum where Table 3-2 of the Phase III Evaluation Framework dictates that projects of medium impact should have a 50/50 mix of basic and enhanced levels of rigor.

Figure 50: Summary of Duquesne's C&I Evaluation Activities Across Strata

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

D.4.2.1 Ride-Along Site Visits

[Table 103](#) provides an overview of the SWE milestones for the audit of Duquesne's site inspection efforts.

Table 103: Duquesne Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
16	2,557,761	4	4	100%

The SWE encountered several setbacks in the planning and coordination of PY8 ride-along audits with Duquesne's evaluation contractor. Specifically, the SWE found Navigant's processes deficient in the following areas:

- The SWE's involvement in sampled projects was impeded by basic housekeeping issues and simple miscommunications.
- The SWE was either not notified or not notified within the designated two-week lead time of flagged projects of interest.
- The evaluation contractor's SSMVPs were not submitted within the designated two-week lead time for many projects.

One example of the first bulleted concern (basic housekeeping issues) impeded the SWE from auditing a site visit reporting 2,159,015 kWh of savings. The project was included in the evaluation contractor's initial sample submittal and flagged for SWE inclusion. In the sample, the project was detailed as a VFD project under the name of "Pittsburgh CBD LLC." When alerted that all site inspections for PY8 had come to a close, the SWE inquired about the outstanding VFD project.

The scheduler forwarded a SWE declined invitation to a site inspection titled “One Oxford Centre Midstream Lighting.” The simple mismatching of project details between the sample and the calendar led to the SWE’s exclusion in verified savings auditing of this significant project.

Processes aside, the SWE agreed with the methodology and calculations submitted by Duquesne’s evaluation contractors overall. Minor issues were noted within four projects, leading to changes in verified savings of less than 1% per project. All the SWE’s suggested updates were incorporated into Duquesne’s final verified savings values by the evaluation contractor in time for their final reporting.

Navigant added a new subcontractor to the evaluation team in PY8. The SWE audited the new subcontractor at one facility comprising four individual projects. The SWE noted the new subcontractor did not appropriately achieve a relative precision of $\pm 20\%$ at the 90% confidence level when employing on-site sampling for two of the four projects. The SWE discussed the issue with Navigant and was assured it would be addressed immediately.

In general, the evaluation contractor’s submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. While minor mistakes were present in Navigant’s calculations, the evaluation contractor was readily available and amenable to discussing projects with the SWE and making updates as needed to ensure enhanced accuracy in verified savings values.

While the SWE was content with Navigant’s calculations and methodologies, the SWE makes the following process recommendations to improve site inspection practices thereby increasing confidence in resulting verified savings:

- Navigant should submit samples in keeping with their EM&V plan to the SWE as they are drawn for SWE review. The SWE has created a template that should be followed for future submissions to make sure all information needed to select an appropriate sample is included.
- Navigant should attempt to coordinate with the SWE in advance of scheduling flagged projects of interest to ensure SWE inclusion.
- Navigant should use the SWE’s shared cloud-based calendar for scheduling and notification of upcoming site inspections.

D.4.2.2 Verified Savings Desk Reviews

Table 104 provides an overview of the SWE milestones for the verified savings review of evaluated Duquesne projects.

Table 104: Duquesne Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
4	2,171,672	119	100%	100%

Due to the SWE's increased interest in Midstream Lighting projects in PY8, 16 Duquesne sites were selected for ride-along site inspections. As such, the SWE selected a smaller sample for desk reviews, only auditing four projects for a total of 20 verified savings verification analyses. Overall, the SWE found that Duquesne's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. The SWE asserts that Navigant conducted appropriate M&V efforts and that sufficient documentation supporting savings analyses was provided.

The SWE did not calculate adjusted energy or demand savings for any of the four projects reviewed. The review of Duquesne's verified savings calculations showed a high level of adherence to the TRM and Evaluation Framework.

D.5 NTG

D.5.1 Residential Programs

Navigant estimated NTG for the Residential Appliance Recycling Program for PY8 and applied PY7 NTG to the Residential Energy Efficiency Program. Navigant did not report a NTG for the Residential Whole House Retrofit program as there was no recorded program participation in PY8.

Navigant estimated NTG for the Appliance Recycling Program using the 2016 TRM and telephone participant surveys. NTG was estimated for refrigerators, freezers, and program totals with the recommended UMP appliance recycling protocol. Navigant created a decision tree that depicted all the program's possible savings scenarios and took the weighted average of the decision tree's values to inform NTG. Refrigerator NTG was calculated to comply with the HIM directives in the Phase III EMV Plan.

The Residential Home Energy Report Program claimed a NTG of one, in accordance with the Evaluation Framework, and was not informed by participant surveys, but assumes that the RCT design eliminates free-ridership and produces negligible spillover.

Table 105: Summary of NTG Estimates for Duquesne Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Residential Appliance Recycling	0.59	0.06	0.47	170
PY7	Residential Energy Efficiency	0.54	0.23	0.69	--
RCT	Home Energy Report	0.0	0.0	1.0	--

D.5.2 Low-Income Residential Programs

Navigant did not gather data during PY8 to estimate Low-Income Energy Efficiency Program.

Navigant reported the PY7 NTG as the PY8 NTG for the low-income kit portion of the LIEEP, though the SWE does not recommend NTG for low-income programs. The low-income home energy report was assigned a NTG of one, in accordance with the Evaluation Framework. The total LIEEP NTG was then calculated by combining the LI kit and LIHERS NTG, but it was not made clear what the method of calculation was. Navigant clarified to the SWE that a savings-weighted average was used to calculate the overall NTG. The SWE recommends more transparency in reporting when combining NTG ratios into a new NTG.

Table 106: Summary of NTG Estimates for Duquesne LIEEP

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY7	LIEEP Kits	0.47	0.04	0.57	--
RCT	LIEEP Home Energy Report	0.0	0.0	1	--
PY7 & RCT	LIEEP	--	--	0.93	--

D.5.3 C&I Programs

Navigant did not conduct NTG research in PY8 for the Commercial Efficiency Program, the Express Efficiency Program, Small Commercial Direct Install, Multifamily Housing Retrofit Program, Industrial Efficiency Program, Public Agency Partnership Program, and the Community Education Program. Navigant applied PY7 or PY6 NTG to the programs that did not conduct a PY8 NTG evaluation and will estimate NTG with new data in PY9. PY8 NTG was evaluated for the Midstream Lighting Program using participant survey data. Navigant used the common method excluding an estimation of spillover. The Phase III EMV plan indicated that NTG for the Midstream Lighting Program would not be estimated until PY9; the SWE recommends updating the Phase III EMV plan for consistency between plan and evaluation.

Table 107: Summary of NTG Estimates for Duquesne C&I Programs

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Large Midstream Lighting	0.09	0.0	0.91	4
Estimated	Medium Midstream Lighting	0.14	0.0	0.86	11
Estimated	Small Midstream Lighting	0.29	0.0	0.88	10
Estimated	Total Midstream Lighting	0.12	0	0.88	25
PY7	Commercial Efficiency/ Express Efficiency	0.44	0.0	0.56	--
PY6	Small Commercial Direct Install	0.07	0.07	0.99	--
PY7	Multifamily Housing Retrofit	0.29	0.0	0.71	--
PY7	Industrial Efficiency	0.32	0.0	0.68	--
PY7	Public Agency Partnership	0.20	0.0	0.80	--
PY7	Community Education	0.20	0.0	0.8	--

D.6 TRC

Table 108 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Duquesne's PY8 individual programs and overall portfolio. The SWE found inconsistencies in the verified kWh for the market rate and low-income home energy report measures, which impact the Residential Behavioral Savings and Low-Income Energy Efficiency Programs, respectively. The adjusted gross and net TRCs for the two updated programs, as well as the overall portfolio TRC, shown in bold, are lower than the values in the Duquesne Light PY8 Annual Report. However, these changes did not impact their status as cost-effective programs.

Table 108: Summary of Duquesne's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
REEP: Residential Energy Efficiency	19,885	7,717	2.58	13,665	6,171	2.21
Residential Appliance Recycling	364	228	1.60	170	228	0.74
Residential Behavioral Savings	358	143	2.50	358	143	2.50
Residential Whole House Retrofit	0	68	0.00	0	68	0.00
Low-Income Energy Efficiency	104	343	0.30	100	343	0.29
Express Efficiency	1,993	995	2.00	1,110	826	1.34
Small/Medium Midstream Lighting	908	153	5.95	803	147	5.48
Small Commercial Direct Install	1,824	983	1.86	1,811	983	1.84
Multifamily Housing Retrofit	32	310	0.10	23	290	0.08
Commercial Efficiency	1,839	1,428	1.29	1,024	1,068	0.96
Large Midstream Lighting	962	426	2.26	851	420	2.03
Industrial Efficiency	1,945	988	2.98	2,015	919	2.19
Public Agency Partnership	2,179	1,518	1.44	1,753	1,405	1.25
Community Education	916	633	1.46	745	541	1.38
Portfolio Total¹	34,319	16,418	2.09	24,636	14,037	1.74

¹ Program costs will not sum to Portfolio Total, which includes costs from inactive Direct Install programs.

Of Duquesne's 14 energy efficiency programs offered, 11 were found to be cost-effective and three were non-cost-effective when estimating the TRC using gross verified savings. Using net verified savings, ten programs were found to be cost-effective and four were non-cost-effective. The Residential Appliance Recycling Program was cost-effective under gross verified savings, but non-cost-effective under net verified savings. The following is a list of cost-effective and non-cost-effective programs.

Gross Verified Savings

Cost-Effective Programs (TRC > 1):

- REEP: Residential Energy Efficiency
- Residential Appliance Recycling
- Residential Behavioral Savings
- Express Efficiency
- Small/Medium Midstream Lighting
- Small Commercial Direct Install
- Commercial Efficiency

Net Verified Savings

Cost-Effective Programs (TRC > 1):

- REEP: Residential Energy Efficiency
- Residential Behavioral Savings
- Express Efficiency
- Small/Medium Midstream Lighting
- Small Commercial Direct Install
- Commercial Efficiency
- Large Midstream Lighting

- Large Midstream Lighting
- Industrial Efficiency
- Public Agency Partnership
- Community Education
- Industrial Efficiency
- Public Agency Partnership
- Community Education

Non-Cost-Effective Programs (TRC < 1): Non-Cost-Effective Programs (TRC < 1):

- Residential Whole House Retrofit
- Low-Income Energy Efficiency
- Multifamily Housing Retrofit
- Residential Appliance Recycling
- Low-Income Energy Efficiency
- Residential Whole House Retrofit
- Multifamily Housing Retrofit

D.6.1 Additional Notes from the TRC Model Review

- Duquesne used a discount rate of 6.9%, which is used to calculate the net present value of future program benefits. This is consistent with what is stated in their EE&C plan. Line loss adjustment factor was 1.0741.
- The incremental costs were derived from the PA SWE Database, the Database for Energy Efficiency Resources (DEER), contract cost, or identified measure cost studies. The SWE spot checked the incremental costs used in the TRC model and found them to be consistent with the PA SWE Database.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to recreate 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 TRC Order directive for Phase III.
- The SWE found that the cost categories were handled correctly: incentives were not considered costs, but administrative costs, incremental costs, and kits were incorporated as costs. The TRC model followed the protocol specified in the 2016 TRC Test Order pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- Duquesne did not offer space heating and water heating energy efficient measures that resulted in reduced fossil fuel consumption. The SWE recommends accounting for quantifiable water and fossil fuel avoided costs as stated in the 2016 TRM in future PY reporting should the relevant measures become available.
- The SWE verified the measure-specific EULs. The team found that the EULs were consistent with the 2016 TRM. Duquesne accounts for the dual baselines for residential (CFLs and LEDs) and nonresidential (LEDs) lighting by reducing the EULs to adjust lifetime savings. The bulbs' first year wattage (post-EISA 2007 Watts), as well as the years following, is used as the baseline until after 2020, when it is adjusted to Post-2020 Watts. The sum of the baseline wattages for the lifetime of the bulb is divided by the first-year wattage to get the adjusted EUL.

- The avoided costs of energy and capacity used in the PY8 TRC model are shown in Table 109. The TRC model avoided costs were updated from the avoided costs reported in Duquesne's Phase III EE&C Plan (left) that includes a 10% adder for the avoided costs of water. Duquesne did not have enough quantifiable support for the added avoided costs of water associated with delivered energy and removed the adder. The SWE agrees with the use of avoided costs without the adder.

Table 109: Duquesne Avoided Costs
EE&C Plan (left) and TRC Model (right)

	Energy \$/kWh				T&D \$/kW-year	Capacity \$/kW-year	Energy (\$/kWh)		
	S-On-Pk	S-Off-Pk	W-On-Pk	W-Off-Pk			S-Off-Peak	W-On-Peak	W-Off-Peak
2017	\$ 0.0496	\$ 0.0313	\$ 0.0543	\$ 0.0409	\$ 420379	\$ \$ 210421	\$ 0.0266	\$ 0.0462	\$ 0.0347
2018	\$ 0.0476	\$ 0.0308	\$ 0.0512	\$ 0.0394	\$ 420307	\$ \$ 440405	\$ 0.0262	\$ 0.0435	\$ 0.0334
2019	\$ 0.0462	\$ 0.0309	\$ 0.0496	\$ 0.0373	\$ 420556	\$ \$ 590293	\$ 0.0263	\$ 0.0421	\$ 0.0317
2020	\$ 0.0462	\$ 0.0310	\$ 0.0486	\$ 0.0316	\$ 420525	\$ \$ 600592	\$ 0.0264	\$ 0.0413	\$ 0.0268
2021	\$ 0.0611	\$ 0.0309	\$ 0.0639	\$ 0.0327	\$ 440507	\$ \$ 610519	\$ 0.0262	\$ 0.0543	\$ 0.0278
2022	\$ 0.0635	\$ 0.0323	\$ 0.0665	\$ 0.0342	\$ 470529	\$ \$ 630539	\$ 0.0274	\$ 0.0565	\$ 0.0291
2023	\$ 0.0658	\$ 0.0336	\$ 0.0689	\$ 0.0356	\$ 480533	\$ \$ 640539	\$ 0.0285	\$ 0.0585	\$ 0.0302
2024	\$ 0.0682	\$ 0.0349	\$ 0.0714	\$ 0.0370	\$ 490520	\$ \$ 660579	\$ 0.0297	\$ 0.0607	\$ 0.0315
2025	\$ 0.0704	\$ 0.0362	\$ 0.0738	\$ 0.0384	\$ 500500	\$ \$ 670598	\$ 0.0307	\$ 0.0627	\$ 0.0326
2026	\$ 0.0726	\$ 0.0374	\$ 0.0766	\$ 0.0400	\$ 510505	\$ \$ 680567	\$ 0.0318	\$ 0.0651	\$ 0.0340
2027	\$ 0.0989	\$ 0.0542	\$ 0.0989	\$ 0.0542	\$ 520520	\$ \$ 700540	\$ 0.0460	\$ 0.0840	\$ 0.0460
2028	\$ 0.0970	\$ 0.0527	\$ 0.0970	\$ 0.0527	\$ 520582	\$ \$ 710524	\$ 0.0448	\$ 0.0824	\$ 0.0448
2029	\$ 0.0953	\$ 0.0514	\$ 0.0953	\$ 0.0514	\$ 520539	\$ \$ 730539	\$ 0.0436	\$ 0.0809	\$ 0.0436
2030	\$ 0.0940	\$ 0.0503	\$ 0.0940	\$ 0.0503	\$ 520492	\$ \$ 750599	\$ 0.0428	\$ 0.0799	\$ 0.0428
2031	\$ 0.0939	\$ 0.0500	\$ 0.0939	\$ 0.0500	\$ 520590	\$ \$ 760797	\$ 0.0425	\$ 0.0797	\$ 0.0425
2032	\$ 0.1015	\$ 0.0547	\$ 0.1015	\$ 0.0547	\$ 520346	\$ \$ 780563	\$ 0.0465	\$ 0.0863	\$ 0.0465
2033	\$ 0.1100	\$ 0.0600	\$ 0.1100	\$ 0.0600	\$ 620229	\$ \$ 800985	\$ 0.0510	\$ 0.0935	\$ 0.0510
2034	\$ 0.1123	\$ 0.0613	\$ 0.1123	\$ 0.0613	\$ 620539	\$ \$ 810924	\$ 0.0520	\$ 0.0954	\$ 0.0520
2035	\$ 0.1147	\$ 0.0625	\$ 0.1147	\$ 0.0625	\$ 620374	\$ \$ 830974	\$ 0.0531	\$ 0.0974	\$ 0.0531

The SWE noted a minor issue pertaining to the implementation of the TRC model. Duquesne's EE&C Plan aggregated their annual hourly savings profiles into time-of-use periods based on the method described in the 2016 TRM. The SWE found inconsistencies in the classification of peak hours, resulting in more peak hours than what is consistent with the 2016 TRM, and therefore an overestimate of benefits. The SWE has recommended that Duquesne's load profile engine be updated to be consistent with the 2016 TRM in PY9 reporting.

D.7 PROCESS

The Duquesne Light PY8 evaluation plan noted that, "Duquesne Light's program effort is somewhat small, and consequently so are the resources earmarked for evaluation. The primary focus of evaluation efforts and resources will be on ensuring that all impact evaluation and compliance research is conducted properly and in a timely manner." This suggests a limited effort for the process evaluations and is reflected in the associated activities and the report for PY8.

D.7.1 Residential Programs

Duquesne Light operates five residential energy efficiency programs: The Residential Energy Efficiency Program (REEP), the Residential Appliance Recycling Program (RARP), the Whole

Home Energy Audits Program (WHEAP), the Home Energy Report Program, and the Low-Income Energy Efficiency Program (LIEEP).

For PY8, Navigant conducted process evaluation activities for two Duquesne Light residential programs: The Residential Energy Efficiency Program (REEP) and the Residential Appliance Recycling Program (RARP).⁹⁹

For the PY8 process evaluation of the above programs, Navigant conducted interviews with program managers and implementation contractors and reviewed program documentation and tracking databases. In addition, for the RARP program only, Navigant conducted surveys with program participants.

For each program, the SWE provides a summary of the process evaluation findings and the SWE's audit of those findings. In its review of the PY7 evaluation, the SWE commented that providing mean satisfaction ratings do not provide as much insight as showing the range of responses. This report did not do that and continued to report mean satisfaction ratings; the SWE reiterates that it will be more valuable and appropriate to report the percentage of respondents selecting each point on the satisfaction scale. At minimum, this will provide a simple yet essential process evaluation metric – the percentage that are satisfied (and dissatisfied) with the programs.

D.7.1.1 Residential Energy Efficiency Program (REEP)

Summary of Process Evaluation Findings

The Duquesne Light REEP program has three main components:

1. Rebates for energy efficient equipment
2. Upstream incentives for efficient lighting
3. Distribution of energy efficiency kits

Navigant's PY8 process evaluation activities for REEP addressed the Rebates and Upstream Lighting components. No process evaluation activities were conducted for the Energy Efficiency Kits component.

The evaluation of the Rebates program component included an application file review and an interview with the Duquesne Light Residential Coordinator. For the application file review, Navigant reviewed the Program Management and Reporting System (PMRS) data (customer information system) against a sample of REEP Rebate application files to confirm the fidelity of data tracking, processing, and reporting for that component of the program. The interview with the Duquesne Light Residential Coordinator was intended to assess REEP implementation and delivery. As the process evaluation did not include participant surveys, Navigant reported the following limited findings:

1. *Measure Mix*. Duquesne Light reduced the range of rebated measures in Phase III from the offerings of Phase II. For example, Duquesne Light no longer offers incentives for

⁹⁹ For PY8, Navigant did not conduct process evaluation activities for the Low-Income Energy Efficiency Program (LIEEP), the Whole Home Energy Audits Program (WHEAP), and the Home Energy Report program (both market rate and low-income components).

energy efficient dishwashers, televisions, whole house fans, faucet aerators, or CFLs. Navigant notes that these dropped measures either saw little savings activities in previous years or were susceptible to high free-ridership rates. For example, ENERGY STAR dishwashers and televisions had estimated market penetration rates in 2016 of 69% and 71%, respectively. The majority of the market offerings for these products are already efficient.

2. *Applications.* Navigant performed an in-depth application file review of 83 PY8 rebated measures and was able to confirm that the reported energy savings for most of that sample were accurate. These confirmations were made through a review of detailed materials provided by the utility that are part of the rebate application process. The team recalculated savings for 21 of the 83 measures based on its review of applications, receipts and invoices, and copies of utility bills, making slight changes to the reported savings values. Overall, Navigant calculated a realization rate of 99% for energy and 93% for demand. These activities confirmed that, for the large majority of rebates, Duquesne Light is capturing information and reporting savings at a sufficient level of accuracy within its tracking databases.
3. *Rounding.* Central air conditioner savings are based on SEER and capacity ratings, and the tracking database currently reports and uses rounded values to generate reported savings. Navigant notes that manufacturers report SEER values to one decimal. Also, capacity values in program tracking databases are rounded to whole ton numbers (i.e., where 1 ton equals 12,000 Btu/hr) when most manufacturers report capacity ratings at the single Btu/hr level. However, as indicated above, the use of these rounded numbers is generally yielding relatively accurate estimates.
4. The current HVAC rebate application does not collect information on heating capacity for ductless mini-split systems. Further, the space for reporting heating capacity for heat pumps is easily missed and the space for entering the information is cramped, sometimes leading to problems reading the reported values when they are included in the application.

For the PY8 process evaluation of the Upstream Lighting component, Navigant reviewed the lamp-level program details to confirm that Duquesne Light and its Upstream Lighting CSP are reporting savings details correctly and in accordance with the 2016 TRM for each lamp-specific entry. This review resulted in the following findings:

1. Overall, for PY8, Navigant found that data are tracked appropriately. Minor discrepancies resulted in realization rates of 103% for both energy and demand. Most often, these discrepancies could be traced to Navigant using different baseline wattage assignments than those of the CSP.
2. The first year of Phase III Upstream Lighting program component continued a multi-year shift toward LEDs and away from CFLs, with 71% of bulbs being LEDs and the remainder being CFLs.

Summary of Process Evaluation Audit

The process evaluation of REEP generally appears to have been consistent with the Phase III evaluation plan. For PY8, the evaluation planned for a documentation and database review,

program manager and implementer interviews, and an upstream lighting verification analysis. The report described results from corresponding process evaluation activities that included an application file review, an interview with the Duquesne Light Residential Coordinator, and a review of lamp-level details for the Upstream Lighting program component. Although the plan proposed to conduct implementer interviews, it appears that no such interviews were conducted.

D.7.1.2 Residential Appliance Recycling Program (RARP)

Summary of Process Evaluation Findings

Navigant's PY8 process evaluation activities for RARP included interviews with program staff and implementer, and a survey of 159 participants. Navigant reported the following findings:

RARP experienced a significant disruption when JACO's business operations ceased during PY7. This created substantial administrative issues for Duquesne Light. However, the program has rebounded well and continues to deliver an effective program at the outset of Phase III that drives high customer satisfaction among its participants. For PY8, RARP achieved 66% of its annual program goal.

1. *Net-to-Gross*. Free-ridership decreased from significantly high levels in PY7 (72%) to 59% in PY8. This year's free-ridership levels are more in line with previous estimates of 65 and 51% for PY5 and PY6, respectively. Similar to previous program years, Navigant found that when applying the SWE methodology for net savings, the majority of units fell into Scenario D: participants planned or indicated that units would have been disposed of anyway in the absence of the program.
 - a. Also, Scenario D is applied if units would have been provided to a retailer (presumably a retailer who replaces a recycled appliance) and the unit is over 10 years old. The SWE methodology assumes that units older than 10 years have no resale value and are therefore recycled when picked up by retailers. Recycled refrigerators and freezers in PY8 were 22 years and 27 years old on average, respectively.
2. *Program Awareness*. Similar to previous years, Navigant learned that the program continues to rely on friends and family word of mouth to spread awareness of the program. Survey respondents indicated most often that family or friends was their source for first hearing about the program. The second most often source mentioned was bill inserts. During PY7, television had been mentioned the second most often and represented nearly a quarter of all mentions of sources of awareness. That rate reduced to about 6% in PY8. Interestingly, Navigant notes that Duquesne Light does not advertise RARP on television. Rather, Duquesne Light customers viewed other EDC television promotions for their recycling programs, but customers did not differentiate between the EDCs. Online and website sources were mentioned 16% of the time in PY7; this increased to 23% in PY8.
3. *Satisfaction*. PY8 RARP survey respondents indicated high satisfaction with all aspects of the program. Respondents scored their overall experience with the program at a 9.5 and the time it took to receive the rebate at 9.1, both indicating high satisfaction. This is a significant improvement over PY7, when the time it took to receive the rebate scored a 3.6 out of 5 (previous surveys relied on a 5-point scale, where 5 meant "very satisfied"). This

lower score in PY7 was directly related to the disruption caused by the previous CSP's closure and discontinuation of implementation. The high score for PY8 shows that Duquesne Light, along with its new CSP, were capable of rebounding the program and reestablishing a positive experience for customers.

4. *Recycled Refrigerator HIM.* Navigant completed NTG research for recycled refrigerators and found a free-ridership rate of 63%, a spillover rate of 7%, and a NTG ratio of 44%. Navigant notes that the NTG ratio for RARP overall (i.e., when also considering freezers) in PY8 was 47%.
5. *Average Age.* The average age of all recycled refrigerators within the program for PY8 was 22 years, and the average age of freezers was 27 years. Duquesne Light's reported savings assumes that 56% of recycled refrigerators and 85% of freezers were manufactured before 1990. However, Navigant's review of the CSP's detailed tracking data found that that only 26% of refrigerators and 47% of freezers were manufactured before 1990.

Summary of Process Evaluation Audit

The process evaluation of RARP generally appears to have been consistent with the Phase III evaluation plan. For PY8, the evaluation planned for a documentation and database review, program theory/quality control review, program manager & implementer interviews, and participating customer surveys. The report provided a program logic model, but it is not clear from the report if the evaluation included the PY8 plan for documentation and database review and program theory/quality control review.¹⁰⁰

The report described results from process evaluation activities that included interviews with the Duquesne Light Residential Coordinator and the CSP, as well as a participant survey. The evaluation completed surveys with 159 participants, exceeding the 140 completed surveys targeted in the evaluation plan. Although the final sample size of 159 appears to be a large enough sample to yield acceptable confidence/precision levels, the Navigant report does not discuss how the sample was selected (e.g., random, quota, or convenience).

Also, for the PY8 evaluation, Navigant noted that it "redesigned its survey from a 5-point scale to a 10-point scale for Phase III to allow for more granularity in responses and to be consistent with other surveys Duquesne Light administers to its customers." This is inconsistent with the scale that is being used by the other EDCs, which continue to use a 5-point scale. The SWE recommends that Navigant consider reverting to a 5-point scale as this will facilitate development of comparative satisfaction levels across EDCs. Should Navigant choose to continue using a 10-point scale, future audit reports will show those satisfaction levels, but they will not be directly comparable to those reported by the other six EDCs.

¹⁰⁰ The evaluator indicated in subsequent communications that they conducted a database review, but as the program was unchanged from previous years, there was no need for the documentation and program theory/quality control reviews.

D.7.1.3 Low-Income Energy Efficiency Program (LIEEP)

Summary of Process Evaluation Audit

The Navigant report states up front that it “examined the program tracking data for additional programs and components including” the Low-Income Energy Efficiency Program (LIEEP) and particularly Low-Income kit handouts at specific low-income outreach events. However, the report does not describe any such activities or related results.¹⁰¹ The PY8 evaluation plan states only that “the low-income specific program component participants will comprise separate strata” in the evaluations of the Whole House Retrofit program and the Residential Behavioral Savings Program.

D.7.1.4 Home Energy Report Program

Summary of Process Evaluation Audit

The Navigant report states that they did not conduct process evaluation activities for the Home Energy Report program (both market rate and low-income components). However, the evaluation plan proposed program manager and implementer interviews in PY8. The report does not indicate if these interviews were conducted and does not provide any process-related results from them.

D.7.1.5 Home Energy Audits Program (WHEAP)

Summary of Process Evaluation Audit

The Navigant report states that they did not conduct process evaluation activities for the Whole Home Energy Audits Program (WHEAP). It further states that “Duquesne Light did not report any savings for the Whole House Energy Audit Program (WHEAP) during PY8. Navigant notes that the program is active, but savings have not been posted as the program activities ramp up for the new Phase. Navigant plans to evaluate this program during PY9 and when savings are reported.”

While it is understandable that no process evaluation would be conducted for this program, it is worth noting that the evaluation plan had proposed the following activities for PY8:

- Program Theory/Quality Control Review
- Program Manager & Implementer Interviews
- Participating Customer Surveys for Verification rate, NTGR, and selected process issues
- Audit Contractor Interviews

D.7.2 C&I Programs

Duquesne Light operated eight C&I energy efficiency programs in PY8:¹⁰²

- The Express Efficiency Program (EXP)
- The Commercial Efficiency Program (CEP)

¹⁰¹ The evaluator indicated in subsequent communications that there were no noteworthy findings.

¹⁰² An additional C&I Act 129 program, the Large Curtailable Load program, began its ramp up in late PY8, but was not offered to customers until the summer 2017 (PY9).

- The Small Commercial Direct Install Program (SCDI)
- The Nonresidential Midstream Lighting Program (ML)
- The Multifamily Housing Retrofit Program (MFHR)
- The Industrial Efficiency Program (IEP)
- The Public Agency Partnership Program (PAPP)
- The Community Education Efficiency Program (CEEPP)

The PY8 process evaluation effort focused on the Midstream Lighting program. Navigant had planned to conduct an in-depth process evaluation of the Community Education Efficiency program in PY8. As part of this, PY8 process evaluation related activities performed in PY8 included program documentation review, interviews with the program manager and implementation contractor, and development of a program logic model. However, the program ramped up more slowly than expected in Phase III and, as a result, the full process evaluation was deferred to PY9.¹⁰³

Navigant conducted program manager and implementation contractor interviews and program documentation reviews for all the other C&I programs. The evaluator also had planned to conduct Trade Ally interviews for PY8 for all the commercial and industrial efficiency programs. However, participation in the programs took longer to ramp up than expected with new CSPs and these interviews were deferred to the PY9 evaluation.

D.7.2.1 Midstream Lighting Program

Summary of Process Evaluation Findings

The process evaluation of the Midstream Lighting program¹⁰⁴ was based on interviews with the program manager and implementation contractors, interviews with active and non-active lighting distributors, program documentation review, and a survey of program participants. Navigant completed phone interviews with 11 registered active and two registered non-active distributors enrolled in the program during PY8.¹⁰⁵ The program had a total of 102 unique participants, and Navigant attempted to complete a census survey of those participants and was able complete surveys with 25 of them. The evaluator reported the following key findings for the Midstream Lighting program:¹⁰⁶

¹⁰³ Results from the evaluation are not provided in the PY8 report and the SWE therefore assumes that they will be included in the PY9 report when the full process evaluation will be conducted. Note that to ensure updated information and results, the evaluation activities performed in PY8 will likely need to be repeated or revisited for the PY9 evaluation.

¹⁰⁴ *The Midstream Lighting program officially is actually two programs – the Small Nonresidential Upstream Lighting program and the Large Nonresidential Upstream Lighting program. However, the evaluation report refers to this combined program as the Midstream Lighting program as it is targeted at distributors rather than manufacturers or customers.

¹⁰⁵ Active distributors are those who registered for the program and documented sales of eligible program bulbs during the PY8 period (January to May 31, 2017) and registered non-active distributors enrolled in the program, but did not submit any invoices of bulbs sales.

¹⁰⁶ The first two findings typically would be considered impact evaluation findings. However, they are shown here because they were listed as findings in the process evaluation report.

1. The realization rate for energy savings for this program was 156%. Reasons for a realization rate other than 100% included the following:
 - a. For the largest project, Navigant used customer-specific hours of use for several usage groups, while the CSP used the TRM building type default hours of use (the only choice they had, given that this was a midstream program). The use of the building type default hours of use grossly under-estimated the hours of use in this situation, resulting in a 240% realization rate. Because this project accounted for 64% of the savings for the PY8 program, this was the main driver behind the 156% realization rate for the program. Excluding this project, the program realization rate would have been much lower.
 - b. *Bulb counts (ISR)*. With respect to bulb counts verified, 2,649 out of a total of 2,991 bulbs reported as installed by sampled participants could be verified (89%). This is close to the CSP's assumed 85% ISR, though not so close to the current IMP ISR assumption of 98%. For one participant, 80 of 320 bulbs were not installed because the new LEDs made the space bright enough without them. For almost all the other participants having less than 100% ISR, bulbs were in storage or count differences were only slight.
 - c. *Building type (Hours of Use)*. The reported building type was accurate for 15 of the 22 sites visited. For the other seven sites, the incorrect reported building type served to understate the hours of use and therefore savings (i.e., was "conservative").
 - d. *Bulb type (Hours of Use)*. For two projects, pin-base lamps were used, but the CSP used the TRM hours of use associated with screw-in bulbs, which is lower, resulting in an understatement of savings (i.e., was "conservative").
 - e. *Baseline wattage*. Baseline wattages were generally correct, except for bulb types requiring the use of the IMP's formula (certain PAR and MR16 bulbs). For these, the CSP chose to use the manufacturer's or the ENERGY STAR Qualified Products List's baseline wattage. However, the IMP states that the IMP formula should be used if possible. Not using the formula in these cases resulted, again, in understating the project savings (i.e., was "conservative").
2. Program participation slowly ramped up in PY8, and the PY8 evaluation findings may not predict what will happen in PY9. However, thus far, except for the current 98% ISR in the program's IMP, the key IMP factors – baseline wattage and building type – do not appear to have resulted in overstated savings. Rather, they have resulted in savings being understated. It is not clear whether the use of the baseline bulb wattage formula for PAR and MR bulbs produces a more accurate baseline wattage than that of either the manufacturer's projected baseline wattage or the baseline wattage provided in the ENERGY STAR Qualified Products List (QPL). For the few sites requiring the use of the formula, the formula yielded a much higher baseline wattage (and therefore higher savings) relative to these other sources.
3. Respondents have reported high satisfaction with all program aspects.

4. Respondents reported that lack of awareness was the largest barrier to participation.
5. Overall, distributors view the Duquesne Light Midstream Lighting program in a positive light and are generally satisfied with the program. The program can be integrated into a variety of business models and its discounts can influence sales of LEDs that otherwise would not have happened, which is beneficial for both the distributor and its customers.
6. For distributors who currently do not have large volumes of LED sales, the program can also be effective in helping them increase market share in this area.
7. An area that the program could improve is with the online portal. Distributors would like the process for submitting invoices to be more streamlined, with less troubleshooting required. Ecova has acknowledged this issue and is working on improving the portal.
8. Overall, registered distributors were looking forward to program participation, but had not yet completed the onboarding process and were still setting up a local office to enable participation.
9. Distributors recommended adding LED flat panels, pin-based bulbs, medium-base bulbs, and fixtures to the program-eligible product list. This recommendation was made by both active and inactive distributors.

Summary of Process Evaluation Audit

Midstream Lighting Program

With a few exceptions, the process evaluation of the C&I Midstream Lighting program appears to have been mostly consistent with the Phase III evaluation plan. For PY8, the EM&V plan called for at least the following activities:

- Program participation database and documentation review
- Review/develop logic model and program flow documentation
- Surveys with end users (sample size depends on total number)
- Interviews with purchasing contractors/customers (up to six) and non-participating contractors (up to six)
- Interviews with participating and non-participating distributors (up to 12)
- Review of whatever industry sales or shipment data or information that may become available

The report described results from process evaluation activities that included program documentation review, development of a program logic model, a program manager interview, an implementation contractor (CSP) interview, interviews with registered active and non-active lighting distributors, interviews with non-registered distributors, and a survey of program participants. Although the plan proposed to conduct “interviews with purchasing contractors/customers (up to six) and non-participating contractors (up to six),” it appears that no

such interviews were conducted.¹⁰⁷ The EM&V plan also listed numerous key and important process evaluation issues. Most of these issues are not addressed in the report.

The EM&V plan noted that this “is a new program and so will receive additional attention.” The report also notes that, “this program launched in January 2017 with the goal of providing customers with easy access to efficient lighting. The results of the first program year will inform future program development.” Typically, however, a process evaluation of a new program such as this would include providing the program administrator with early feedback to facilitate its working out any hiccups in initial program delivery. Despite the recognition in the plan of the need for “additional attention” for a new program such as this, the evaluation does not appear to have either planned or provided any early feedback. The evaluator remarked in subsequent communications that “the program began in the middle of the third quarter of the program year. Early process work to provide early feedback was not possible.” However, the SWE sees no reason why early feedback should not be possible, regardless of when the program began.

Finally, the evaluation switched from a 5-point satisfaction scale for the participant survey to a 10-point satisfaction scale for the distributor interviews. As noted previously, the SWE recommends that Navigant consider using a consistent a 5-point scale as this will facilitate development of comparative satisfaction levels across EDCs. Should Navigant choose to continue using a 10-point scale, future audit reports will show those satisfaction levels, but they will not be directly comparable to those reported by the other six EDCs. Additionally, in Figure 5, the graphic on satisfaction levels shows only the bar lengths, but not the actual values. Since the bars are very similar in length, it is not possible to determine if there are any differences in satisfaction levels for the different areas. Regardless, as also noted previously, the SWE recommends that future evaluation reports provide the percentage distribution of responses for each point on the satisfaction scale.

¹⁰⁷ In subsequent communications, the evaluator indicated that these interviews were not needed because the “participant survey indicated that very few (<10%) of respondents heard about the program or obtained their bulbs through contractors. Distributors sold the overwhelming portion of the bulbs.”

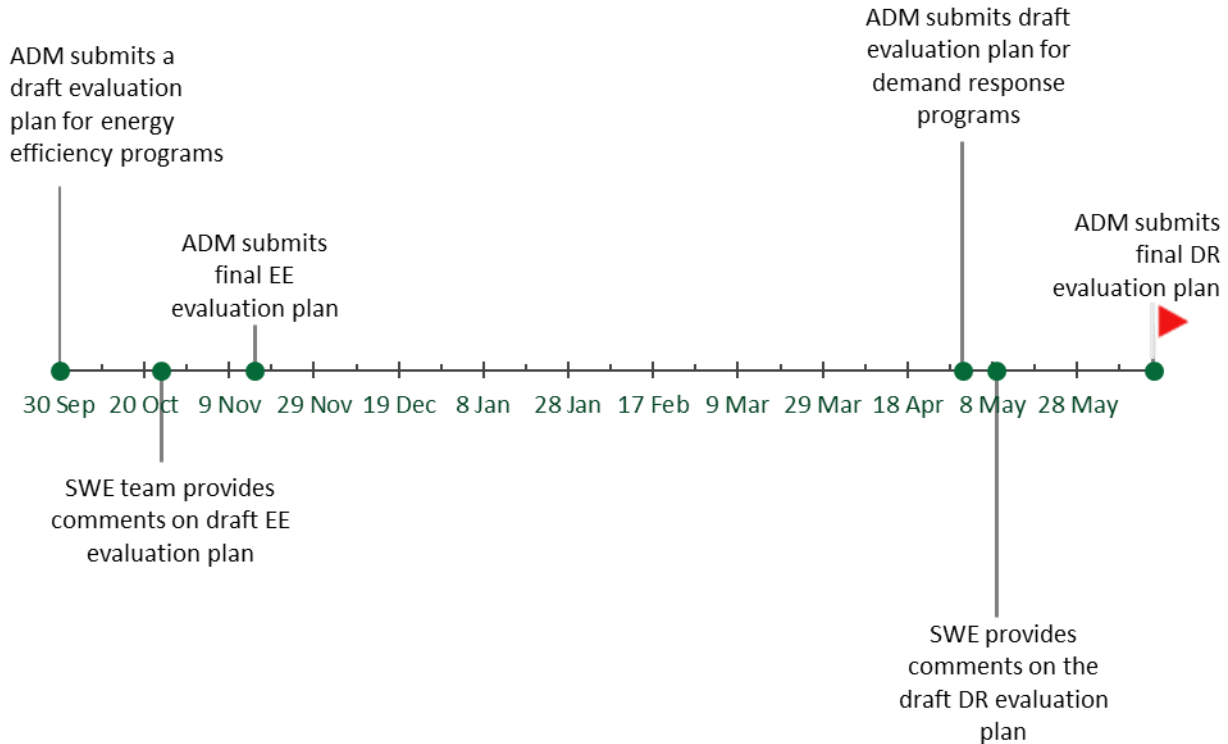
Appendix E Met-Ed Audit Detail

E.1 EM&V PLAN REVIEWS

The four FirstEnergy companies offer a similar portfolio of programs for Phase III of Act 129. Program offerings, measures offered, incentive levels, tracking system, and ICSPs are all determined company wide. Given the similarities across EDCs, FirstEnergy's evaluation contractor, ADM Associates, prepared a single evaluation plan for the four EDCs. EDC-specific considerations were addressed as needed throughout the plan. Met-Ed's EE&C plan programs are organized by sector, with separate programs for Small C&I, Large C&I, and Government and Institutional rate classes. The separation between these three programs is dictated by tariffs, but, in practice, the same offerings are available to all non-residential customers regardless of rate code. For evaluation purposes, ADM chose to organize non-residential energy efficiency projects into initiatives by equipment type (Lighting, HVAC, Custom, etc.). The SWE supported this decision to organize non-residential research by equipment category.

ADM's Phase III evaluation plan called for an impact evaluation of each initiative annually. This approach avoids the frequency versus rigor decisions that made up a large part of the plan review process for Duquesne Light and PECO. The FirstEnergy companies' evaluation plan review process was the most efficient in the state because the draft plan submitted to the SWE was detailed, included adequate sample sizes, and was consistent with the major expectations of the Evaluation Framework.

Phase III demand response performance goals begin in PY9, so the evaluation planning process for Met-Ed's DR programs lagged the energy efficiency planning. [Figure 51](#) documents the timing of the major milestones associated with finalizing the Phase III evaluation plan for Met-Ed.

Figure 51: Met-Ed Evaluation Plan Review Timeline, 2016-17

- Model Selection for Home Energy Reports:** FirstEnergy reduced the number of homes receiving HERs in PY8 compared to Phase II totals. When the equivalence of the new treatment and control groups were assessed in the evaluation plan, some statistically significant differences in consumption during the pre-treatment period were identified. The SWE and ADM worked together on several simulation exercises to determine which regression model specification was best equipped to net out these differences and produce unbiased estimates of HER impacts.
- Treatment of DR Participants That Shave 5CP Loads:** Capacity costs are allocated to customers via a methodology that looks at metered load during the ‘5 coincident peak’ hours of a year. Some large customers attempt to forecast and reduce loads during likely hours to reduce their cost obligation. ADM and the SWE ultimately agreed on an approach where this behavior is ignored and all weekdays that are not PJM or Act 129 DR events are eligible for inclusion in the DR baseline calculation.
- Synthesis of Multiple Methods for NTG and Process:** Several of the key research questions for the NTG and process evaluations had multiple methods proposed. This approach is recommended in the Evaluation Framework, but the SWE requested additional detail on how results would be combined to arrive at conclusions.
- Low-Income Considerations:** Some offerings are delivered to both residential and residential low-income customers. The SWE requested clarification in several places on how savings from low-income participants would be separated from the residential class.

- **Mechanics of the Non-Residential Certainty Stratum:** For the largest C&I projects, ADM works alongside the ICSP to integrate M&V into the program delivery. In these cases, there is no reported savings estimate – ADM just calculates the gross verified savings. Because of the alternate process, the projects must be quarantined in the extrapolation of program savings from the evaluation sample. Certainty project results do not factor into the realization rate calculation for smaller strata where sampling is used.

In addition to reviewing FirstEnergy's evaluation plan, the SWE reviewed eleven survey instruments and one interview guide. Nine of these instruments were for residential programs while three were for C&I programs. The surveys and interviews addressed process, impact, and NTG topics.

E.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative." For 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 because of program delivery method or technology supported.

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. For example, projects from the three non-residential energy programs (C&I Energy Solutions for Business – Small, C&I Energy Solutions for Business – Large, and Government & Institutional Tariff) were assigned to one of five solutions.

- C&I Lighting
- C&I Custom
- C&I Prescriptive
- C&I Appliance Turn-In
- C&I Direct Install (minimal savings in PY8 – no evaluation sample)

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than the tariff-based program definitions, which each include the same mix of measures. It is also a more efficient sample design because lighting projects are more likely to

share similar characteristics across the Small C&I, Large C&I, and Government programs than a heterogeneous mixture of measures from a single program definition.

Table 110 lists evaluation initiatives, along with the relative precision of the PY8 gross verified savings estimate at the 85% confidence level.

Table 110: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level (±)
Appliance Turn-In (ATI)	7.5%
Low-Income ATI	9.5%
Kits	4.9%
Low-Income Kits	10.7%
C&I Lighting	6.4%
C&I Custom	2.6%
C&I Prescriptive	10.5%
Upstream Lighting	10.2%
C&I ATI	8.9%
Residential HVAC	7.4%
Residential Appliances	9.4%
Low-Income Appliances	11.5%
Residential Direct Install	11.5%
Low-Income Direct Install	9.8%
Residential New Construction	12.0%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. Each of the 15 sampling initiatives shown in Table 110 produces verified gross savings estimates of better than ±15% precision at the 85% confidence level.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of ADM's PY8 verification activities is discussed in detail in Appendix E.4.

E.3 REPORTED GROSS SAVINGS AUDITS

E.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Met-Ed's PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program
- Incentive dollars for each program

The SWE leveraged Met-Ed's PY8 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request.

E.3.1.1 Audit Findings

Table 111 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Met-Ed's PY8 Annual Report and 'No' otherwise. For every program, the SWE's records agree with the energy savings values reported in the annual report.

Table 111: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	4,009	4,009	Yes
Energy Efficient Homes	48,126	48,126	Yes
Energy Efficient Products	25,460	25,460	Yes
Low-Income Energy Efficiency	9,107	9,107	Yes
C&I Energy Solutions for Business – Small	12,526	12,526	Yes
C&I Energy Solutions for Business – Large	30,919	30,919	Yes
Governmental & Institutional Tariff	274	274	Yes
Portfolio Total	130,422	130,422	Yes

Table 112 summarizes the SWE's findings regarding reported gross peak demand savings by program. The SWE's records matched Met-Ed's reported peak demand savings for each of the seven programs.

Table 112: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.56	0.56	Yes
Energy Efficient Homes	6.55	6.55	Ye
Energy Efficient Products	3.18	3.18	Yes
Low-Income Energy Efficiency	1.15	1.15	Yes
C&I Energy Solutions for Business – Small	1.92	1.92	Yes
C&I Energy Solutions for Business – Large	4.11	4.11	Yes
Governmental & Institutional Tariff	0.01	0.01	Yes
Portfolio Total	17.47	17.47	Yes

Table 113 summarizes the SWE's findings regarding program participation. The SWE was able to replicate participation counts for all programs except one – Low-Income Energy Efficiency. For this program, the participation counts differed by fewer than 30 participants (which is roughly 0.005% of the portfolio total). The SWE is not concerned about this difference.

Table 113: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	3,974	3,974	Yes
Energy Efficient Homes	202,956	202,956	Yes
Energy Efficient Products	315,681	315,681	Yes
Low-Income Energy Efficiency	26,955	26,982	No
C&I Energy Solutions for Business – Small	348	348	Yes
C&I Energy Solutions for Business – Large	116	116	Yes
Governmental & Institutional Tariff	32	32	Yes
Portfolio Total	550,062	550,089	No

Finally, [Table 114](#) summarizes the SWE’s findings regarding incentive dollars. The SWE was able to replicate incentive dollars for three of the seven programs for which Met-Ed reported non-zero incentives (Governmental & Institutional Tariff Program, Appliance Turn-in, and LIEE).

For the EE Products, Small C&I Energy Solutions, and Large C&I Energy Solutions programs, the incentive dollars in the tracking data are directionally similar to the incentive dollars from Met-Ed’s Annual Report. In sum, the incentives for these three programs are approximately equal between the two data sources (\$3,692,000 in the annual report, \$3,715,000 in the tracking data). The difference is explained a product of upstream lighting cross-sector sales findings. FirstEnergy moves money between EE Products and Small C&I Energy to avoid cross subsidization between residential and commercial sectors, so we are not concerned about the differences in financials for these programs. It is a necessary change to ensure equitable cost recovery across rate classes.

For the EE Homes program, incentives from the tracking data are vastly different from the incentives shown in the annual report. This is likely due to the fact that incentive dollars in the annual report include direct install equipment costs and costs for EE&C kits. Kit costs are not housed in the tracking data. The difference between the two values (\$2,458,000) is roughly equal to the incentive amount that Met-Ed has earmarked for kits in their PY8 EE&C plan (\$2,649,000). Therefore, the SWE is not concerned about this difference. Ignoring this program, the incentives from the tracking data and annual report are very similar (\$4,013,000 and \$3,993,000 respectively).

Table 114: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	\$228	\$227	Yes
Energy Efficient Homes	\$2,634	\$176	---
Energy Efficient Products	\$1,426	\$1,514	No
Low-Income Energy Efficiency	\$58	\$57	Yes
C&I Energy Solutions for Business – Small	\$724	\$637	No
C&I Energy Solutions for Business – Large	\$1,542	\$1,564	No
Governmental & Institutional Tariff	\$14	\$14	Yes
Portfolio Total	\$6,627	\$4,189	---

E.3.1.2 Action Items

For each of Met-Ed's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. For all programs but one (LIEE), the SWE was able to replicate participation counts with the quarterly tracking data. Regarding participation, the portfolio totals in the annual report and the tracking data only differ slightly and the SWE is not concerned about the difference. For six of the seven programs for which Met-Ed reported non-zero incentive dollars, the SWE was able to calculate directionally similar incentive dollars via the tracking data. For these six programs, the portfolio totals line up almost perfectly.

The SWE's only concern at this point is being able to replicate incentive dollars for the Energy Efficient Homes program. The SWE acknowledges that the difference is due to the costs of the EE kits being correctly treated as incentives, and we do not view this as a tracking data issue.

E.3.2 Project File Reviews

E.3.2.1 Residential¹⁰⁸

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 projects for PY8 using the project documentation provided by the evaluation contractor, ADM, in response to the SWE's standing quarterly data request. The

¹⁰⁸ The SWE also conducted a database review of Met-Ed's quarterly tracking data to verify that Met-Ed was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

project file packages included savings calculation worksheets, rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages included all documentation requested.

The project file documentation for all residential programs were generally well organized and provided the data needed for the review, but occasionally revealed inconsistencies with the tracking data. [Table 115](#) presents an overview of the results of the SWE's residential project file reviews. Note that [Table 115](#) includes project file reviews for all FirstEnergy EDCs.

Table 115: Met-Ed PY8 Residential Project File Review Summary

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?
Appliance Turn In	ATI	12	✓	✓	✓	✓
Energy Efficient Homes	New Homes	8	✓	✓	✓	✓
Energy Efficient Products	Appliances	8	✓	✓	✓	✓
Energy Efficient Products	Lighting	16	✓	✓	✓	✗
Energy Efficient Products	HVAC	8	✓	✓	✓	✓
Low-Income EE Program	New Homes	1	✓	✗	✓	✓
Low-Income EE Program	Appliances	8	✓	✓	✓	✓
Low-Income EE Program	ATI	4	✓	✓	✓	✓
Low-Income EE Program	Weatherization	8	✓	✓	✓	✓

As outlined above, an adequate number of project files and the supporting details were submitted for the residential program. Below is a summary of the project file reviews, including the few issues or discrepancies found between project files and tracking data.

For residential lighting, there were discrepancies in the wattage of lamps between the project files and tracking data. While discrepancies were found in most sampled projects, typically they differed by only one watt, or less. The SWE notes that a portion of the wattage discrepancies (smaller than one watt) may be due to rounding the wattages into the tracking database. However, there were a few cases where the discrepancy was several watts.

For the New Homes Program, the project files were easily found within the tracking data; however, there was insufficient information to verify the rebated amount. The SWE could not determine whether the rebate was based on HERS Score, percent of savings over UDRH, or kWh saved.

There were minor issues found within the Low-Income Weatherization program. The SWE matched the project files with the tracking data for the following measures: lighting, faucet aerators, low flow showerheads, and smart power strips. However, for insulation, air sealing, and appliance replacement measures, the SWE could not match the project files to the tracking data and therefore could not verify the accuracy of the tracking database for these measures.

The following issue applies generally to the residential project files, but it is specifically noted in the review of the Appliance Turn-In and HVAC programs. The Account IDs listed in the project files were not listed accurately in the tracking data, which made it difficult to match the projects to the data. It appeared that, at times, the fields in the tracking data containing the IDs had been rounded and were no longer able to be identified with the project file ID. The SWE was ultimately able to locate the project within the tracking data by using other information found in the project files, such as name and address. However, this is a time-consuming process.¹⁰⁹

While the PY8 review of residential project files found project file packages to be typically well-organized, the SWE found several instances of missing or inaccurate data. To ensure the accuracy of reported savings in upcoming program years, the SWE makes the following recommendations:

- Submitting project files and a matching sample of tracking data for each program, including a unique identifier to easily match data to the files.
- More clarity on how rebate amounts are calculated, specifically for the New Homes program.
- More thorough document review to ensure accurate transcription of lighting wattages, including the eliminating the practice of rounding of wattages in the tracking database.

E.3.2.2 Non-residential

The SWE reviewed Met-Ed's C&I projects for PY8 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,

¹⁰⁹ ADM is working with CSPs to use an alternative matching key, such as rebate number, for PY9 and beyond.

equipment specification sheets, and post-inspection forms. Most of the project file packages included all documentation requested, with the exception of lighting projects, which consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Met-Ed's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. The evaluator, however, has implemented a process for PY9 through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes.

Project files were generally well organized, but oftentimes revealed deviations from the TRM-specified calculation methodologies and assumptions. [Table 116](#) presents an overview of the results of the SWE's C&I project file reviews.

Table 116: Met-Ed PY8 C&I Project File Review Summary

Project Number	Project Description	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?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
FESPPS1534043553	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043563	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043631	Street lighting	✗	✓	✓	✓	✓	-
FESPPS1534074081	Street lighting	✗	✓	✓	✓	✓	-
FESPPS1534095820	High Efficiency Evaporator Fans	✓	✓	✓	✓	✓	-
FESPPS1534189445	Motors (ECM)	✓	✓	✓	✗	✗	-
FESPPS1534209097	HVAC	✓	✓	✓	✓	✗	-
FESPPS1534263998	HVAC	✓	✓	✓	✓	✗	-
FESPPS1534363730	VFD	✓	✓	✓	✓	-	✓

A review of the project files revealed several instances of deviations from the TRM for calculation of savings associated with deemed measures. Specific issues aside from the missing Appendix C calculators are addressed individually by project below.

Projects FESPPS1534263998 and FESPP1534209097 achieved savings for installation of new packaged/split AC units. Energy savings calculations provided by the implementer relied on $IEER_{ee}$ and $EER_{baseline}$ values. This is a departure from the TRM algorithm specified in Section 3.2.1, which recommends that $IEER_{ee}$ and $IEER_{baseline}$ values be used to calculate kWh savings.

Project FESPPS1534189445 achieved savings for the installation of a new walk-in refrigeration system utilizing electronically commutated motors (ECMs) consistent with measure 3.5.3 of the 2016 TRM. The measure covers energy and demand savings associated with the replacement of existing shaded-pole (SP) or permanent-split capacitor (PSC) evaporator fan motors in walk-in refrigeration cases. The reported savings were calculated using TRM-default values for the replacement of an SP motor with an ECM. Review of the product literature,¹¹⁰ however, revealed that the newly installed evaporator can only be made with either PSC or ECM fans. As the incremental cost of the measure represents the cost difference between a PSC motor and an ECM, the implementer assumption of SP motors is not an appropriate baseline. This resulted in overestimated savings.

The SWE annual reports from PY6 and PY7 submit that review of the Met-Ed project files was seamless, with only minimal inconsistencies. While the PY8 review of C&I project files found project file packages to be well-organized, the SWE found several instances of deviations from TRM-specified methodologies and assumptions. To ensure the accuracy of reported savings in upcoming program years, the SWE makes the following recommendations:

- More thorough audits of documentation for off-TRM assumptions should be performed to ensure that savings are not calculated in error due to minor oversights.
- Use of unlocked calculators, particularly noted for HVAC projects, will be helpful for the SWE to understand the algorithms and inputs used by the implementer and approved by the evaluator.

E.4 VERIFIED GROSS SAVINGS AUDITS

E.4.1 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 portfolio of Residential programs includes the following: The Appliance Turn-In Initiative, The Energy Efficient Homes Initiative, The Energy Efficient Products Initiative, and the Low-Income Energy Efficiency Initiative. Each program contains various subprograms, which are addressed separately below in tables and text as needed (if evaluation details differ or where the SWE audits determined that certain subprograms showed

¹¹⁰ Technical bulletin for the equipment is available at:
<http://www.heatcrafterpd.com/PDF/Bohn%20Tech%20Bulletins%20Folder/BN-TB-CU-AIRCOOLED-HAD-.5-6.pdf>

discrepancies not shared by others in a program). Note that the SWE reports the residential savings into the three following sections: upstream lighting, residential non-lighting, and behavior. Overall, the verified savings followed proper TRM protocols and the verified savings are accurate. The SWE identified the evaluation activities that were used to verify savings for the residential programs. [Table 117](#) provides a summary of the evaluation and M&V approaches used by Met-Ed in their PY8 verified savings calculations. [Table 118](#) provides a summary of discrepancies that were discovered during the SWE audits of verified savings. Note that all of the discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.¹¹¹

Table 117: Residential Program Evaluation Activities – Met-Ed

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied PY7 RR
Appliance Turn-In (LI & Non-LI)	✓	--	✓	--	--
EE Kits (LI & Non-LI)	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	✓	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting	✓	--	✓	--	--
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Low-Income WARM	--	✓	✓	✓	--

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

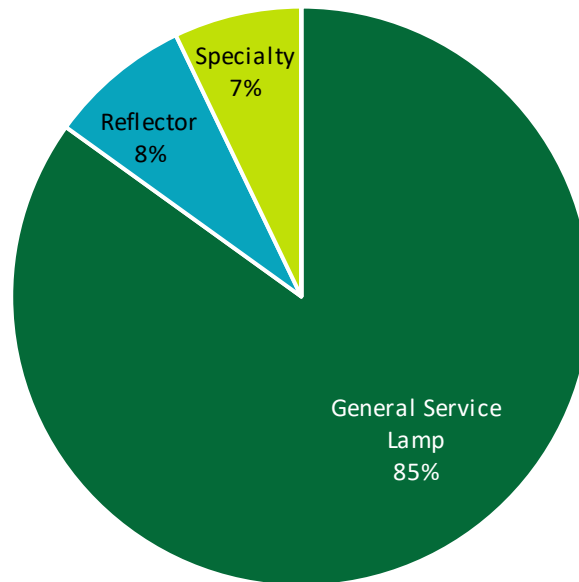
¹¹¹ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Table 118: Residential Program Verified Savings Discrepancies – Met-Ed

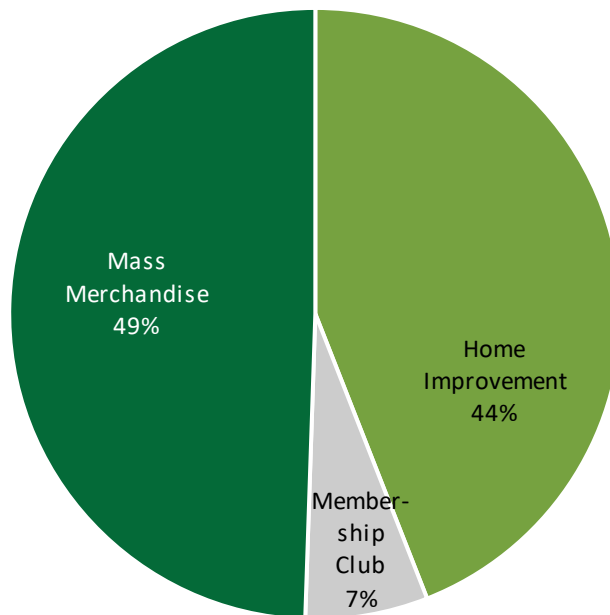
Program/ Subprogram	Measure	Discrepancy	The SWE Recommendation
Appliance Turn-In (LI & Non-LI)	Dehumidifiers	Possible EDC gathered data quality issues, not used for savings calculations	Review data collection process for measure, incorporate gathered values in future PYs
Residential New Construction	ENERGY STAR Clothes Washer	Incorrect TRM savings applied	Use correct/up-to-date TRM values
Appliances	ENERGY STAR Clothes Washers	Outdated TRM default applied	Use correct/up-to-date TRM values

E.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 800 thousand efficient light bulbs and fixtures through Met-Ed's PY8 upstream lighting program. [Figure 52](#) displays the distribution of sales by product type. Over four-fifths (85%) of the products were general service lamps.

Figure 52: Met-Ed PY8 Upstream Lighting Sales by Product Type

Most (93%) of Met-Ed's PY8 upstream light bulbs and fixtures were sold through home improvement and mass merchandise stores ([Figure 53](#)).

Figure 53: Met-Ed PY8 Upstream Lighting Sales by Retail Channel**E.4.1.1.1 Audit Findings**

The SWE reviewed the data in Met-Ed's tracking system to verify that ADM used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with ADM's verified gross savings for the Upstream Lighting Initiative.

The SWE observed 449 unique lighting model numbers in the PY8 tracking system, and was able to locate 349 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The 100 models the SWE was not able to verify as ENERGY STAR certified represent 23% of upstream bulbs sold and 22% of verified savings from upstream lighting. FirstEnergy had included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. However, TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. The SWE sent FirstEnergy a memo in October of 2017, recommending that beginning in PY9, the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products. According to FirstEnergy, its companies stopped rebating non-ENERGY STAR LEDs in PY9.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most ENERGY STAR models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for three of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system or errors in the ENERGY STAR certified products lists. The team confirmed that ADM used the appropriate algorithms, interactive effects, ISR, residential HOU, and residential coincidence factor to calculate kWh and kW savings. The team found that ADM assigned baseline wattages in accordance with TRM protocol 2.1.1 for all but three decorative models, which were mistakenly classified as EISA exempt. Combined, the impact of

all discrepancies the SWE identified on initiative-level savings is negligible (less than two-tenths of 1%).

E.4.1.1.2 Cross-Sector Sales

ADM estimated 8.3% cross-sector sales for the combined FirstEnergy companies based on a general population survey. Survey respondents were asked how many bulbs they purchased and if they installed them in a residence, business, or both. Unfortunately, the survey was not designed to capture the proportion of residential versus commercial installations for the subset of respondents who reported installing bulbs in both a residence and a business (6% of respondents), necessitating a follow-up call to gather this information. ADM computed a weighted average HOU of 1,821 and coincident factor of 0.32 by mapping survey respondents' business types to the building types listed in Table 3-5 of the TRM.

E.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Ensure that all products are ENERGY STAR qualified.
 - FirstEnergy included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.¹¹²
- Edit the general population survey so that in future program years, the proportion of bulbs installed in residences and businesses for respondents who claimed to install bulbs in both locations can be gathered during the survey without the need for a follow-up call.

E.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

E.4.1.2.1 Energy Efficient Homes Program

The SWE audited each of the four components of the Energy Efficient Homes Program: Energy Efficiency Kits (EE Kits), HERs (reported in [Section E.4.1.3](#) of this appendix), Residential Direct Install, and New Homes by using the gross impact data submitted by FirstEnergy. Overall, the SWE audits concluded that the correct TRM algorithms were applied and verified savings were correct for all program kits and direct install measures. The SWE noted a minor discrepancy between the survey sample size reported in the annual report and the survey sample size identified in the raw data provided by FirstEnergy for all program kits. ADM clarified the

¹¹² The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8.

discrepancy, noting that they applied a 200-day cut-off, removing survey responses that were completed more than 200 days after the kit receipt date. In addition, respondents within the 200-day cut-off who could not remember receiving a kit were also removed from the reported survey sample.

The SWE audited the New Home sample that was used to determine a realization rate for the sub-program. The audit included a review of REM/Rate models and, as specified in the 2016 TRM, application of 2016 TRM savings to ENERGY Star lighting and appliance measures used to verify savings. The audit found that the new home sub-program was incorrectly applying 2016 TRM savings for ENERGY Star clothes washers and undercounting savings. This resulted in a conservative realization rate of 88.2% that was applied to the new homes program, while the SWE calculated a realization rate of 89.3% (however, this represents a very small portion of program level savings – 0.02% or 11 MW). The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

E.4.1.2.2 Energy Efficient Products Program

Each component of the Energy Efficient Products (EEP) Program was audited by the SWE, including appliances, HVAC equipment, and consumer electronics. Note that the SWE's audit of the upstream lighting portion of the Energy Efficient Products Program is reported in [Section E.4.1.1](#) of this appendix.

The SWE audits of the consumer electronics portions of the program verified that correct TRM algorithms were used and the verified savings were correct.

The SWE audits of the HVAC and appliance measures included in the program found that nearly all the verified savings were correct. However, minor discrepancies were found for ground source heat pumps (GSHPs) and ENERGY Star Clothes washers regarding adherence to correct TRM algorithms.

In the case of GSHPs, the audit concluded that one system was of commercial capacity based on cooling capacity, but the savings calculations did not follow the commercial GSHP algorithm in the TRM; data for two variables requiring EDC collection, necessary for TRM-based calculations, were missing from the FirstEnergy data. This situation is a grey area as the commercial GSHP measure in the TRM is for non-residential settings. In discussions with the SWE, ADM proposes a potential baseline of two residential ASHPs in cases moving forward. The SWE agrees this is likely a reasonable approach and recommends working with ADM to develop an IMP if this becomes a more popular measure in residential settings.

The SWE audit also discovered an incorrect application 2016 TRM deemed value for ENERGY Star Clothes Washers. The savings calculation used for verified savings was using an outdated cycle per year value. The SWE notes that the GSHP and ES Clothes Washer error accounted for less than 1% of measure level savings and had a negligible impact on program and portfolio level savings. The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

E.4.1.2.3 Low-Income WARM Program

The Low-Income WARM Program is a low-income direct install initiative offering similar measures across three sub-programs: WARM-Plus, WARM-Extra Measure, and WARM-Multifamily. The WARM program includes LED lighting, smart power strips, domestic hot water measures, HVAC heating and cooling measures, refrigerator and freezer replacement and recycling, insulation, air sealing, and duct sealing. The SWE audited all measures included in the program using the full downstream dataset and the survey sample subset provided by FirstEnergy. The SWE found that the correct TRM-approved methods were followed, survey sample sizes were correct and survey data correctly incorporated into the verified savings calculations, and the verified savings were correct.

E.4.1.2.4 Appliance Turn-In Program (Low-Income and Non-Low-Income)

The Appliance Turn-In Program is divided into low-income and non-low-income stratum, each offering turn-in options for refrigerators, freezers, room air conditioners, and dehumidifiers. The SWE audited EDC-provided data for each measure offered by the non-low-income and low-income strata of the program. Dehumidifiers were a newer addition to the turn-in program and used an approved IMP for savings calculations, while refrigerator, freezer, and room air conditioner turn-ins utilized TRM algorithms to determine savings. Auditors determined that the verified savings for all measures were correct, and that, in almost all cases, calculations correctly followed the relevant TRM and IMP algorithms and guidelines, and correctly incorporated the participant survey data into the verified savings calculations.

For dehumidifier turn-ins, auditors noticed that an outdated IMP default value for the Wilkes-Barre area was applied to Williamstown and Scranton, though this did not affect savings in an appreciable way. Also regarding dehumidifiers, auditors noticed that 68% of dehumidifiers in the sample were recorded in the EDC data collection process as having 10 pints of capacity, which stuck out as a possible data collection error. The SWE agrees with ADM's decision to use default IMP values for all dehumidifiers when calculating savings rather than using what is likely to be faulty data, while allowed by the IMP. The SWE recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.

E.4.1.3 Behavior

Approximately 26% of Met-Ed's verified gross energy savings for PY8 came from Home Energy Reports issued to around 156,000 residential and residential-LI households. The SWE reviewed ADM's methodology and accepts their verified MWh and MW savings values for Met-Ed's HER offering in PY8. By cohort, [Table 119](#) shows average kWh savings and average percent savings per participant in PY8. Note that the 'Average Number of Participants' column shows the average number of participants per month during PY8.

Table 119: Average PY8 kWh Savings per Participant

Sector	Cohort Start Date	Average Number of Participants	Average PY8 kWh Savings	Average PY8 % Savings
Low-income	July 2012	11,265	295	2.06%
Residential	July 2012	78,376	276	1.99%
Low-income	January 2014	2,605	275	1.68%
Residential	January 2014	52,541	146	1.08%
Residential	January 2015	12,545	231	1.73%

The following sections highlight some of the more important audit findings: errors in the coding of “pre” and “post” indicator variables, the calculation of lag terms, missing eligibility filters, and duplicating participant counts.

“Pre” and “Post” Coding Errors

In reviewing the HER billing data, the first item that the SWE checked was the coding of the pre- and post-indicator variables. For a given cohort, all months prior to the billing cycle in which the randomized controlled trial (RCT) starts should be coded as pre = 1 and post = 0, and all months after the billing cycle in which the RCT starts should be coded as pre = 0 and post = 1. When reviewing the distribution of the pre- and post-indicator variables, the SWE noticed two issues:

1. For both 2012 cohorts (residential and low-income), there was an error in the coding of the post indicator variable. In December of 2013 and January of 2014, the post indicator variable was set equal to 0, though it should have been 1. (Note that the pre-indicator variable was coded correctly for these cohorts.) Because the lagged seasonal (LS) model is a post-only model, these records were being left out of the regression.
2. For the January 2015 cohort (residential), there was an error in the coding of the pre-indicator variable. Once again in December of 2013 and January of 2014, the pre-indicator variable was set equal to 0 instead of 1. This means that these months were not factoring into the calculation of the lagged terms used in the LS model.

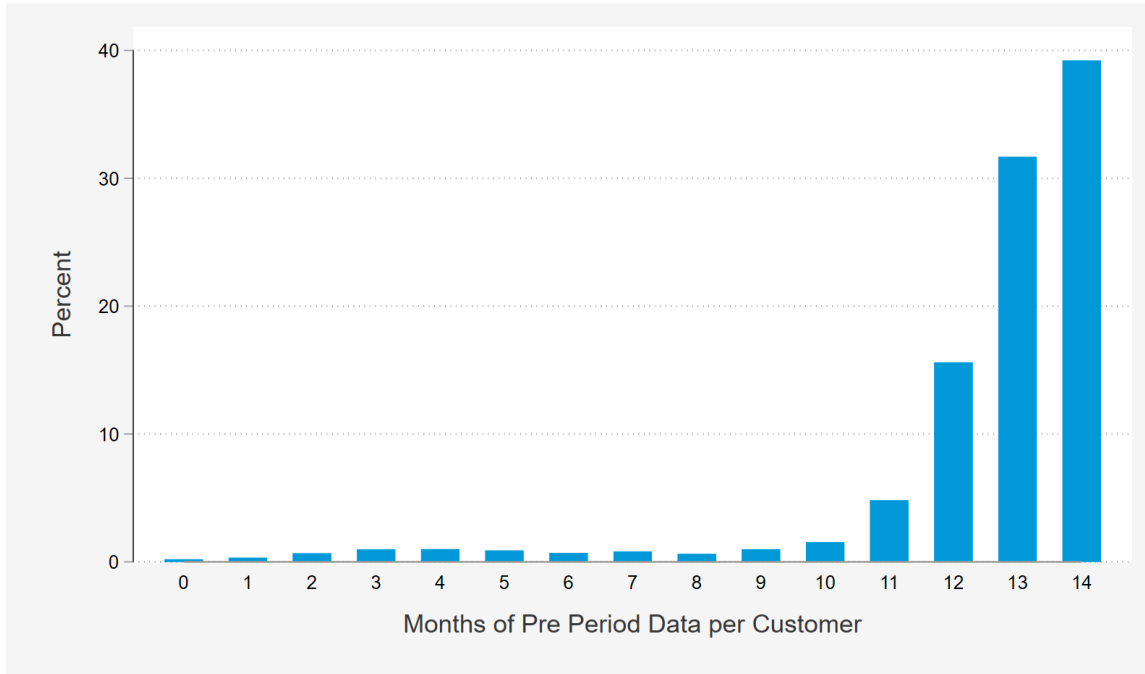
The SWE informed ADM about these issues, and ADM was able to update the numbers in their PY8 annual report before the report was submitted to the PUC. After fixing the coding issues, verified savings for Met-Ed increased by 104 MWh – 25 MWh for low-income cohorts and 79 MWh for residential cohorts. This was only possible because ADM submitted their data well in advance of the annual data request deadline.

Calculating Lag Terms

The LS regression model is a post-only model – only records from the post period are used in the regression. That said, some of the explanatory variables in the model are calculated based on pre-period data: (1) average daily consumption in the pre-period, (2) average daily consumption during the summer in the pre-period, and (3) average daily consumption during the winter in the pre-period. For some homes, there was not enough pre-period data to calculate these lag terms. [Figure 54](#) shows the distribution of the number of months of pre-period data per customer. Across

all Met-Ed cohorts, 13.5% of homes had less than twelve months of pre-period data, 4.8% of homes had less than seven months of pre-period data, and 0.5% of homes had less than two months of pre-period data.

Figure 54: Number of Pre-Period Months per Customer



The limited amount of pre-period data for some homes raises two issues:

1. An eligibility screen should have filtered these homes out of the RCT. The number of homes with less than seven months of pre-period data is not insignificant. Some homes even had zero months of pre-period data. Sufficient pre-period data is a key component of an unbiased impact evaluation.
2. How should the lag terms be calculated? As an example, suppose the only months of “pre” data for a customer are April, May, and June. (This was the case for several participants.) The average winter usage in the pre-period for this customer is not known; thus, this customer should have fallen out of the regression model. Instead, Oracle used average daily usage for April through June as the lagged winter variable (average daily consumption during the winter in the pre-period). As another example, some customers had just one month of pre-period data – November. The average pre-period summer usage for these customers is not known, but Oracle used average daily usage in November as the lagged summer variable (average daily usage during the summer in the pre-period).

The SWE performed savings calculations using two approaches. First, to replicate ADM’s savings values, we used Oracle’s lag terms. After replicating ADM’s savings values, the SWE dropped any participant without at least twelve months of pre-period data and re-ran the LS model for each cohort. Regression estimates were then used to calculate savings in the same manner that ADM calculated savings (i.e., identical participant counts and adjustments were used). [Table 120](#)

shows the results. On aggregate, the SWE estimate was approximately 1,078 MWh greater than the ADM estimate. The biggest differences were for the 2014 residential cohorts – a gain of nearly 1,000 MWh. As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework provided no guidance on how to handle the calculation of lag terms when there is insufficient pre-period data.

Table 120: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	3,324	3,302	-23
Residential	July 2012	21,658	21,613	-45
Low-income	January 2014	717	892	176
Residential	January 2014	7,650	8,224	574
Residential	January 2015	2,903	3,300	396
Total		36,253	37,3301	1,078

The issue described in this section is more of a program design issue than an evaluation issue. Homes with insufficient pre-period data should have been filtered out when homes were being selected for the RCT. If such a filter had been applied, then calculating the lag terms would be a straightforward process. For PY9, the SWE recommends Met-Ed investigate homes with less than twelve months of pre-period data to see if additional billing records are available in FirstEnergy's billing system. If additional billing records are available, they can be included in the impact analysis. If additional billing records are not available, the SWE recommends dropping any homes without at least twelve months of "pre" data from the LS model. The monthly impact estimates derived from the model can then be applied to the homes with insufficient pre-period data. (Note that the underlying assumption here is that homes without sufficient pre-period data do not systematically differ from homes with sufficient pre-period data. The SWE believes this is a reasonable assumption.)

Participation Counts

Participant counts are important because these are the totals used to convert the per-home savings estimates produced by the regression model to aggregate program impacts. The SWE's participation count audit began with the calendarized billing data provided by ADM. For any given month/cohort combination, we counted the number of unique Oracle IDs in the billing data. Presumably, the number of unique IDs for the given month/cohort combination would equal the number of participants for that combination. However, this was not the case. For every month/cohort combination, reported participation exceeded the number of unique IDs. For residential cohorts, the reported participation count typically exceeded the number of unique IDs by more than 100. For low-income cohorts, the differences were less pronounced.

At this point, the SWE turned to the raw, un-calendarized billing data. Because billing cycles can exceed 31 days in length, the SWE took a different approach to calculating participants. Rather than calculate the number of unique IDs within a given cohort/month combination, we calculated

the number of unique IDs beyond a certain date. As an illustrative example, suppose we wanted to compute the number of participants in Met-Ed's 2012 LI cohort for March of 2017 (11,086). We removed any records with a billing end date prior to 3/1/2017, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that tied up with the reported counts.

Demand Savings

As with energy savings, the SWE calculated demand savings using two approaches – mimic ADM's approach, then re-run the LS model without any homes with less than twelve months of pre-period data. The results, which mirrored the results for energy savings, are shown in [Table 121](#). On aggregate, the SWE method returned an additional 0.119 MW in demand savings. The SWE approves the PY8 verified demand savings and recommends that ADM runs the LS model without homes that have less than twelve months of pre-period data in the future.

Table 121: Demand Savings Comparison

Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.37	0.36	-0.00
Residential	July 2012	2.39	2.38	-0.01
Low-income	January 2014	0.08	0.10	0.02
Residential	January 2014	0.84	0.91	0.07
Residential	January 2015	0.32	0.36	0.04
Total		3.99	4.11	0.12

In reviewing ADM's methodology, only one issue arose. Step 3 of ADM's demand savings methodology lists a regression equation with terms for three different end uses – heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not use the 'flat' end use. That said, the results from using just the heat pump and interior lighting end-uses are close to what they would be if flat was the only end-use included.

E.4.2 Non-Residential Audit Activities

[Figure 55](#) provides a summary of the evaluation activities and M&V approaches utilized by Met-Ed's evaluation contractor in their PY8 verified savings calculations. ADM completed site visits for 95% of the evaluation sample; the sites that did not receive site visits were evaluated via billing analysis, which is considered an enhanced rigor method. Basic Rigor was the preferred M&V approach both by energy savings contribution and project count. IPMVP Options A through D were reserved only for projects in the Custom strata.

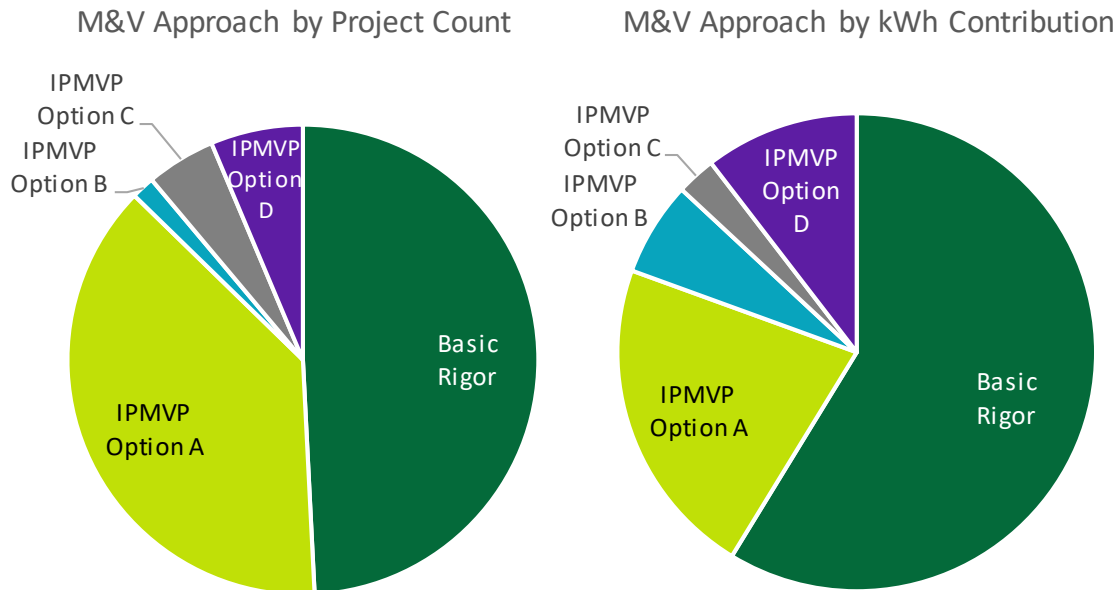
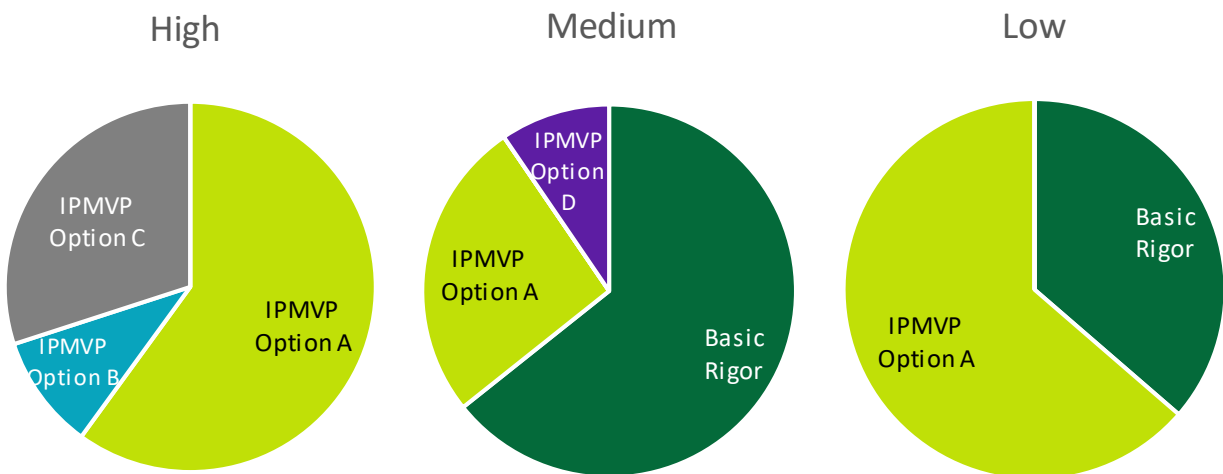
Figure 55: Summary of Met-Ed's C&I Evaluation Activities

Figure 56 provides a summary of the evaluation activities and M&V approaches Met-Ed's evaluation contractor used across strata. Met-Ed's sampling plan consisted of 11 strata, which the SWE binned for the purposes of this comparison. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 56: Summary of Met-Ed's C&I Evaluation Activities Across Strata

Note: The SWE binned Met-Ed's 11 sample strata for the purposes of this comparison.

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

E.4.2.1 Ride-Along Site Visits

Table 122 provides an overview of the SWE milestones for the audit of Met-Ed's site inspection efforts.

Table 122: Met-Ed Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
0	0	0	0	N/A

FirstEnergy was given permission by the SWE to pull a sample across all FirstEnergy Companies without EDC-specific targets for the SWE audit activities. As such, only one site was included in FirstEnergy's sample for the Met-Ed territory. The SWE requested to be included on the site inspection, but was only given 12 hours' notice of the scheduled appointment. The SWE was not able to ride along with the evaluator on such short notice. In PY9, FirstEnergy will be required to adhere to EDC-specific targets for their SWE audit sampling, which should alleviate the chances of this happening in future program years.

E.4.2.2 Verified Savings Desk Reviews

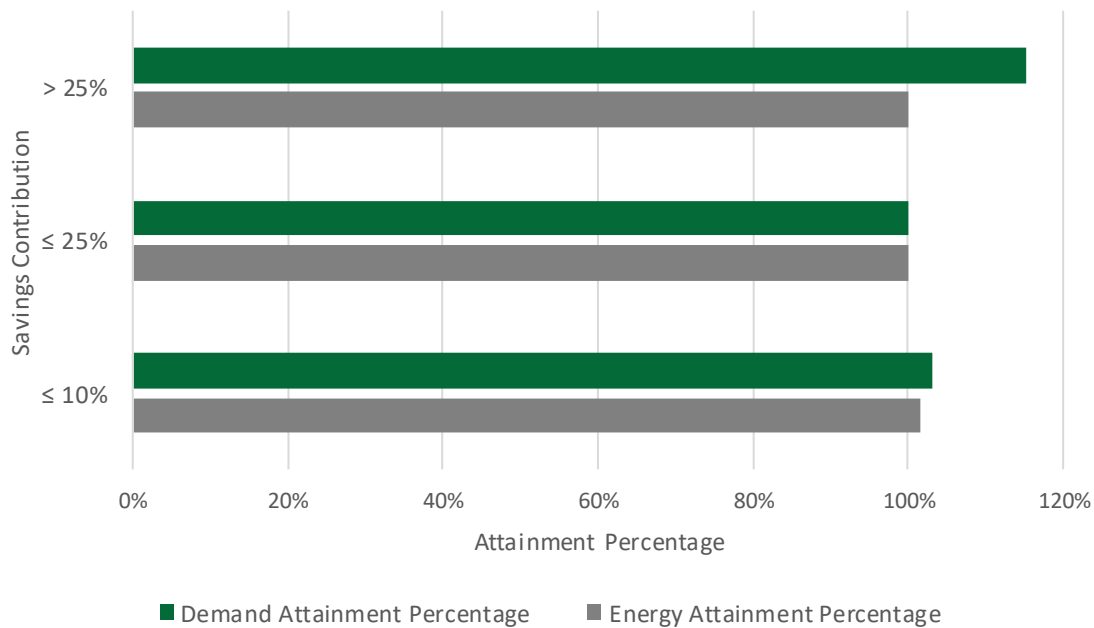
Table 123 provides an overview of the SWE milestones for the verified savings review of evaluated Met-Ed projects.

Table 123: Met-Ed Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
16	16,813,078	2,443	100%	107%

Overall, the SWE found that Met-Ed's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures, but oftentimes used incorrect inputs into TRM-algorithms. Custom projects generally employed sound engineering methods with respect to energy savings, but oftentimes exhibited errors in translating change in demand to peak load reductions.

Of the sixteen projects reviewed, the SWE calculated adjusted energy and/or demand savings for eight projects. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand savings attainment percentages of Met-Ed's reviewed projects were 100% and 107%, respectively, with large variances ranging from 81% to 333% per project. The distribution of the attainment percentages by savings contribution is presented in Figure 57. This distribution provides cause for concern regarding the level of scrutiny applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 57: Met-Ed Verified Savings Attainment Percentage

In general, lighting projects consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Met-Ed's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. The evaluator, however, has implemented a process for PY9 through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes. The omission of Appendix C calculators had no effect on the attainment percentages and has already been addressed by the evaluator.

Project PRJ-1731-F achieved energy savings through the installation of an ENERGY STAR commercial hot food holding cabinet. ADM's calculations assumed the equipment operated for 17 hours every day of the week. However, the posted operating hours verified on site show that the equipment operated for 16 hours for five days of the week, and for 17 hours for two days of the week. The SWE adjusted the calculations to use the average daily hours across all weekdays based on this schedule. These changes resulted in a slight reduction in estimated savings.

Project PRJ-1865-F achieved energy savings through the installation of anti-sweat heater controls, an ENERGY STAR commercial fryer, and two ENERGY STAR ice makers. Savings for the ice makers were calculated according the algorithm given in Section 3.7.1 of the TRM for "Remote-Condensing with Remote Compressor" type ice makers, which includes a term for ice harvest rate (pounds of ice per day). ADM's calculations used the harvest rates as shown in the units' manufacturers' literature (1,425 lbs/day and 1,580 lbs/day). However, the ENERGY STAR listings for the installed units showed lower harvest rates (1,200 lbs/day and 1,284 lbs/day). The SWE adjusted the calculations to use the harvest rates listed in the ENERGY STAR QPL, resulting in a slight reduction in estimated savings and demand reduction. No adjustments were made to the savings calculated for the anti-sweat heater controls or the commercial fryer.

Project PRJ-1721-C achieved energy savings through the installation of high-efficiency evaporator fan motors in reach-in and walk-in refrigerated cases. ADM's calculations for the fans in reach-in cases assumed that all 45 fans were installed in reach-in coolers. However, at the site visit, it was confirmed that seven of these fans were installed in reach-in freezers (in the seven-door seafood freezer). The SWE adjusted the savings calculations to be based on 38 fan motors in reach-in coolers and 7 fan motors in reach-in freezers, using the algorithm terms for freezers as prescribed by Section 3.5.2 of the TRM. This resulted in an increase in estimated savings and demand reduction, as the TRM assumes a lower COP for freezers than for coolers, augmenting the interactive effect of installing efficient evaporator fan motors. No adjustments were made to the savings calculated for the fans in the walk-in cooler.

Project PRJ-1846-C achieved energy savings through the installation of various ENERGY STAR equipment: (4) refrigerators, (2) reach-in coolers, (1) reach-in freezer, (35) ice makers, (108) printers, (249) computers, and (1) computer monitor. Several errors were found in ADM's selection inputs, which had implications on the associated deemed and calculated savings. The errors found were all results of either of the following issues:

- ADM selected inappropriate equipment types when TRM-deemed savings are presented as a function of the equipment type selection.
- ADM utilized inputs for open variables from specification sheets rather than qualified product lists.

An overview of the errors noted is presented in [Table 124](#). The net impact of all these changes was an increase in both energy and demand savings for the overall project. Additionally, the freezer volume could not be verified on the ENERGY STAR QPL, as a screenshot of the QPL was not provided and the model is no longer listed on the ENERGY STAR QPL. No adjustments were made to the freezer calculations.

Table 124: Errors Noted in PRJ-1846-C

Equipment	TRM Assumptions Used	Actual Equipment Type	Input per Spec Sheet	Input per QPL
Refrigerators	Built-in refrigerator-freezer – automatic defrost with top-mounted freezer without an automatic icemaker	Refrigerator-freezers – automatic defrost with top-mounted freezer without an automatic icemaker		
Reach-In Refrigerator/Freezer			Internal Volume: 24.2 c.f. and 51.6 c.f.	Internal Volume: 23.43 c.f. and 50.53 c.f.
Ice Makers	Remote head	Self-Contained	Harvest Rate: 425 lbs/day	Harvest Rate: 322 lbs/day, 327 lbs/day
Printer	41-50 ppm	31-20 ppm		

Project PRJ-9005-C achieved savings through industrial process improvements. The SWE noted that the verified savings did not include a coincidence factor in the peak kW demand reduction calculation. The exclusion of a coincidence factor implies that average production is sustained throughout the peak period. This may be the case; however, no justification was provided to support this claim. The SWE has not calculated adjusted savings, but recommends that justification be provided for all custom CF calculations in the future.

Project PRJ-1788-C achieved savings through the installation of high-efficiency welders. ADMs calculations included an operating factor meant to represent the number of working hours that the welder was actively being used. This factor was correctly applied in the energy savings calculation, but was erroneously applied to the demand savings calculation. As the demand savings are only based on peak conditions, an operating factor should not be applied. The SWE removed this operating factor from the demand savings calculations. ADM applied a coincidence factor of 0.33 to the demand savings; however, they did not provide any justification for this value. The SWE checked the savings against other sources and found them to be reasonable, so the coincidence factor of 0.33 was deemed acceptable. However, care should be taken to justify custom coincidence factors used in savings calculations.

Project PRJ-1927-C also achieved savings through the installation of high-efficiency welders. As described for project PRJ-1788-C, the SWE removed the operating factor for the demand savings calculation. For this project, ADM used a coincidence factor of 1.00 without any justification for this value. The SWE changed the coincidence factor to 0.33, based on the assessment that the values used for PRJ-1788-C were in line with expectations.

Project PRJ-9004-C achieved savings through the installation of a new hot and chilled glycol system, new air handling units, and modified HVAC system operational parameters. ADM calculated savings for this project using IPMVP Option C. To calculate demand savings, ADM assessed the average daily kW demand of the project across all weekdays in June, July, and August. This type of calculation assumes that the load shape is consistent across each hour of each day, which the SWE feels is unlikely. The SWE modified this calculation to focus on the peak hours of 2:00 PM to 6:00 PM by determining a ratio of average baseline kW during peak hours to average baseline kW during all summer weekday hours, and applying this ratio to the calculated average summer weekday kW reduction.

Project PRJ-1855-C achieved energy savings by replacing two compressors (one constant-speed and one variable-speed) with one variable-speed compressor. The M&V report stated that in the baseline system, the constant-speed compressor was used for baseload, and the variable-speed compressor was used for trim. ADM's baseline calculations prioritized the variable-speed compressor, only adding the constant-speed compressor energy use at times when the variable-speed compressor alone could not meet the required load. The SWE expects that this system setup would actually prioritize the constant-speed compressor, using the variable-speed compressor to meet any remaining load. The SWE adjusted the baseline calculations to reflect this expected operating scheme. This change resulted in an increase in energy and demand savings estimates.

To ensure the accuracy of verified savings in the upcoming program years, the SWE gives the following recommendations to Met-Ed's evaluation contractor:

- ADM should take greater care in ensuring that equipment is being properly classified when selecting from multiple equipment options and related algorithms in the TRM.
- ADM should source key TRM algorithm term values from QPLs instead of from manufacturer literature when available.
- The implementer should request that project participants provide copies/screenshots of relevant QPL listings at the time of application, as products may be removed by QPLs during the lag between application and evaluation.
- ADM should provide justification for the custom calculation of all off-TRM assumptions, such as coincidence factor and hours of use, and should complete custom peak demand reduction calculations at the most granular level possible given the data available.

E.5 NTG

E.5.1 Residential Programs

ADM/Tetra Tech estimated a PY8 NTG for several programs: the Appliance Turn-in Program, the Energy Efficiency Kit component of the Energy Efficient Homes Program, and the Residential Energy Efficient Products Program.

For the Appliance Turn-In Program, ADM/Tetra Tech used primary data collection (participant surveys) to estimate NTG for all appliances in the program, though the SWE recommends

estimating NTG by measure. NTG was estimated with the recommended UMP appliance recycling protocol. ADM/Tetra Tech created a decision tree that depicted all the program's possible savings scenarios and took the weighted average of the decision tree's values to inform NTG.

For the Energy Efficient Homes Program, ADM/Tetra Tech calculated NTG for the Energy Efficiency Kits component of the program; the kit component of the program was a high-impact measure (HIM). The Energy Efficiency Kits NTG was calculated using data from participant surveys and the common method. FirstEnergy provided Excel workbooks with the raw data from their NTG research and the SPSS syntax files used to calculate the NTGRs from the raw data, which allowed the SWE to confirm methodology.

ADM/Tetra Tech assigned the HERs component of the program a NTG of 1, in accordance with the Evaluation Framework, and was not informed by participant surveys, but assumes that the RCT design eliminates free-ridership and produces negligible spillover.

A NTG of 0.5 was applied to the Direct Install and New Homes components of the Program. The SWE could not determine the reason for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.

For the Residential Energy Efficient Products Program, ADM/Tetra Tech applied the NTG from Phase II to the upstream Electronics component of the program. The upstream Lighting component NTG was estimated in PY8 and was informed by retailer and customer surveys. ADM/Tetra Tech provided data and syntax, allowing the NTG and method to be verified by the SWE. The SWE notes that the lighting NTG did not include all of the data collection, analysis and reporting included in the ADM / Tetra Tech evaluation plan, including reporting on market progress indicators (MPIs), a Delphi Panel, shelf stocking or sales data analysis. ADM/Tetra Tech noted that the missing NTG estimation methods have not been completed nor data collected. The SWE recommends vigilance in acquiring pricing data, shelf stocking data, and completing the Delphi panel to avoid further delays that would hinder a more rigorous upstream lighting NTG.

The downstream components of the Program (Residential HVAC initiative and Residential Appliances) were based on customer survey data. NTG was weighted by measure energy savings and were confirmed by the SWE to be calculated with the common method. ADM/Tetra Tech estimated HVAC NTG using self-report data from program participants using the common method recommended in the Evaluation Framework, which was verified by the SWE audit.

Table 125: Summary of NTG Estimates for Met-Ed Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.50	0.0	0.50	184
Estimated	Upstream Lighting	0.63	0.0	0.37	176 (customers) 12 (retailers)
Estimated	EE Kits	0.21	0.03	0.82	136
RCT	Home Energy Reports	0	0	1	--
Applied*	Direct Install and New Homes	--	--	0.50	--
Estimated	HVAC	0.55	0.0	0.45	74

E.5.2 Low-Income Residential Programs

ADM/Tetra Tech assigned LIEEP a NTG of 1, in keeping with the PY8 Evaluation Plan and SWE Phase III Evaluation Framework.

E.5.3 C&I Programs

ADM/Tetra Tech conducted NTG research in PY8 for the Business Lighting, Business Custom, and Business Prescriptive components of the C&I ES for Business Program for both small and large C&I. ADM/Tetra Tech utilized PY7 NTG ratios for the Business Appliance Turn-in and Business Direct Install components of the ES Program, and has stated in the Phase III EMV plan that new NTG research will be conducted in PY9.

ADM/Tetra Tech utilized participant customer and vendor surveys to gather data for the ES Business Lighting component; the sample was stratified by participant MWh usage to capture the impacts of a small number of program participants who represent a large portion of the program savings. The data was then used to estimate NTG for the MWh strata and the overall program NTG. The data and method were reviewed by the SWE and found to be in keeping with the Phase III Evaluation Framework using the common method for estimation. ADM/Tetra Tech employed the same data gathering method utilized in the Lighting component with the Custom component to represent the small group of participants who contributed a large percentage of the overall program component savings. ADM/Tetra Tech had limited success recruiting the largest participants in their research and, to avoid this issue in the future, have proposed including NTG research as part of the rebate application package to ensure greater participation rates and higher levels of confidence. NTG was estimated by usage strata and total program component, and the data and method were in keeping with the Framework and the common method of estimation. The SWE recommends presenting multiple years of Lighting NTG to observe the differences between previous methods and methods including the additional participants. The NTG methodology for the Prescriptive component was identical to the Custom component methodology and found to be compatible with the Phase III guidelines and the common method. The SWE

recommends that ADM/Tetra Tech describe their method of incorporating Program components NTG values to estimate total program NTG for the sake of transparency.

Table 126: Summary of NTG Estimates for Met-Ed C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Small Energy Solutions for Business Lighting	0.36	0.02	0.66	63
Estimated	Small Energy Solutions for Business Custom	0.63	0.0	0.37	40
Estimated	Small Energy Solutions for Business Prescriptive	0.59	0.0	0.41	15
PY7	Small Energy Solutions for Business Appliance Turn-In	--	--	0.50	--
PY7	Small Energy Solutions for Business Direct Install	--	--	0.50	--
Estimated	Small Energy Solutions for Business Total	--	--	0.65	--
Estimated	Large Energy Solutions for Business Lighting	0.36	0.02	0.66	63
Estimated	Large Energy Solutions for Business Custom	0.63	0.0	0.37	40
Estimated	Large Energy Solutions for Business Prescriptive	0.59	0.0	0.41	15
Estimated	Large Energy Solutions for Business Total	--	--	0.55	--

E.6 TRC

Table 127 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Met-Ed's PY8 individual energy efficiency programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY8 annual report.

Table 127: Summary of Met-Ed's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefit s (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Appliance Turn-in	1,513	652	2.32	756	652	1.16
Energy Efficient Homes	10,004	7,154	1.4	8,257	6,608	1.25
Energy Efficient Products	13,647	7,070	1.93	5,166	3,498	1.48
Low-Income Energy Efficiency	2,563	3,409	0.75	2,563	3,409	0.75
C&I Energy Solutions for Business - Small	5,872	4,136	1.42	3,814	2,984	1.28
C&I Energy Solutions for Business - Large	15,060	10,778	1.40	8,037	6,202	1.30
Governmental & Institutional Tariff	96	115	1.84	64	91	0.7
Portfolio Total ¹	48,755	33,712	1.45	28,656	23,845	1.2

¹ Program costs will not sum to Portfolio Total which includes costs from inactive Direct Install programs.

Of Met-Ed's seven energy efficiency programs offered, six were found to be cost-effective and one was non-cost-effective when estimating the TRC using gross verified savings. Using net verified savings, five programs were found to be cost-effective and two were non-cost-effective. The Governmental & Institutional Tariff Program was cost-effective under gross verified savings, but non-cost-effective under net verified savings. The following is a list of cost-effective and non-cost-effective programs.

Gross Verified Savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business – Small
- C&I Energy Solutions for Business – Large
- Governmental & Institutional Tariff

Non-Cost-Effective Programs (TRC < 1):

- Low-Income Energy Efficiency

Net Verified Savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business – Small
- C&I Energy Solutions for Business – Large

Non-Cost-Effective Programs (TRC < 1):

- Low-Income Energy Efficiency
- Governmental & Institutional Tariff

E.6.1 Additional Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- Met-Ed used a discount rate of 6.63%, used to calculate the net present value of future program benefits, is consistent with their EE&C plan. Line loss adjustment factors varied by Residential (1.0945), Small C&I (1.072) and Large C&I (1.072) sectors.
- The incremental costs were derived from the SWE Incremental Cost Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumption, and evaluations. The SWE spot checked the incremental costs used in the TRC model and found them to be consistent with Met-Ed's EE&C plan.
- Realization rates for energy and demand impacts were applied to the program impacts in the TRC model, which were based on ex ante annual savings values, to calculate ex post 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 TRC Order directive for Phase III.
- The SWE found that the cost categories were handled correctly: participant incentives were not considered TRC costs, but administrative costs, incremental costs, and kits were incorporated as costs. The TRC model followed the protocol specified in the 2016 TRC Test Order pertaining to the treatment of free rider participant costs; free-ridership participant costs are not included in net program costs.
- The TRC model reports the cost from increased heating usage due to lighting interactive effects from more efficient lighting as a negative Total NPV Lifetime Non-Electric Benefit. The SWE agrees that the cost should be accounted for as a non-electric benefit rather than a fossil fuel switching program cost.
- The Met-ED TRC model accounts for the dual baselines for residential lighting by reducing the EULs to adjust lifetime savings. FirstEnergy notes in their report that their 2016 TRM-compliant TRCs are conservative due to the growing uncertainty of the likelihood of DOE enforcement of EISA 2020 standards, and presents gross and net TRCs with and without the dual baseline for comparison. [Table 128](#) shows that without the dual baseline included in the TRC model, the gross and net TRCs are higher than when the dual baselines are included.

Table 128: Met-Ed Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.45	1.20
Without Dual Baseline	1.56	1.26

The SWE noted a handful of minor issues pertaining to the implementation of the TRC model, which are included here. None of the items listed below are cause for concern about the material results of the TRC model, and are noted here as recommendations for adjustments to be made in future PY reporting.

- The PY8 TRC models used the avoided costs of energy and capacity estimated using the method approved in the Phase III EE&C. While the avoided costs in the TRC model appeared to be within reasonable ranges, the SWE was unable to directly compare the costs since the costs were not provided in the Phase III EE&C plan like it had been in prior program years. The SWE recommends an avoided costs table be included in future EE&C plans.
- The SWE verified the measure-specific EULs. The team found that the EULs were mostly consistent with the 2016 TRM. The EUL for Programmable Thermostats are 11 in the 2016 TRM and Met-Ed's EE&C Plan but are 15 in the TRC model. The SWE recommends updating the Programmable Thermostat EUL in future PY reporting.
- The TRC model ignores decreased fossil fuel consumption from energy efficient measures that saved space heating and water heating fuel, underestimating the benefits. The SWE recommends accounting for quantifiable water and fossil fuel avoided costs as stated in the 2016 TRM in future PY reporting.
- Met-Ed's EE&C Plan states that the avoided cost data is based on the methodology prescribed in the 2016 TRC Order and savings values based on the protocols stated in the 2016 TRM. Annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broad peak definition, which are unlike Act 129 peak hours defined in the 2016 TRM. The result are higher on-peak fractions than would otherwise be under the 2016 TRM with energy savings based on seasons. Despite this difference, the avoided costs and load profiles share common definitions. The SWE is convinced the results are sound.

E.7 PROCESS

Four EDCs – Met-Ed, Penn Power, Penelec, and West Penn – operate an identical set of nine energy efficiency programs. 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. Therefore, the SWE's audit summary described in this section pertains to all four FirstEnergy utilities.

In summary, process evaluation reporting was very sparse and uninformative. For almost all the programs, the report provided only participant survey sample sizes and key findings and recommendations. While noting that these process evaluations also included interviews with

program staff and the Implementation Conservation Service Provider (ICSP), the report did not provide any further information on these interviews or associated findings.¹¹³

The report also showed only means for satisfaction ratings for surveyed participants; it will be more valuable and appropriate to report the percentage of respondents selecting each point on the satisfaction scale.¹¹⁴ At minimum, this will provide a simple yet essential process evaluation metric – the percentage that are satisfied (and dissatisfied) with the programs.

E.7.1 Residential Programs

The four FirstEnergy EDCs operate the following four residential energy efficiency programs:

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- Low-Income Energy Efficiency

The ADM/Tetra Tech team reported on process evaluations for all four residential programs: the Residential Appliance Turn-In, Residential Energy Efficient Products, Residential Home Performance, and Residential Low-Income programs.

As noted previously, the description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff interviewed. The report also did not provide any details on the results of the participant survey or the findings from the staff interviews.

Additionally, ADM/Tetra Tech reported combined results for the Low-Income and non-Low-Income components for the Appliance Rebate, Behavioral, and Kits sub-programs of the Energy Efficient Products and Energy Efficient Homes programs. The report notes that the findings and recommendations for those program components were reported in those sections. However, aside from a couple of mentions of low-income participant survey responses in findings for the Behavioral component of the Energy Efficient Homes program, the relevant report sections for the Energy Efficient Products and Energy Efficient Homes programs did not provide any indication or evidence that they had evaluated the applicable low-income program components. Additionally, the descriptions of the participant survey sample sizes for those programs do not mention whether they included a low-income sample. Therefore, it was not possible to assess if the sample sizes for any of the Residential Programs satisfied the needed levels of confidence/precision.¹¹⁵

¹¹³ The evaluator provided the following comment in subsequent communications: “We provided what was available at the time in the report. We will provide significantly more detail in the PY9 annual report, however we wanted to show progress made by the PY8 annual report.”

¹¹⁴ The evaluator indicated in subsequent communications that they will provide this additional information.

¹¹⁵ The evaluator indicated in subsequent communications that they will provide additional detail in the PY9 annual report,

E.7.1.1 Appliance Turn-In Program

Summary of Process Evaluation Findings

Tetra Tech interviewed an unspecified number of program and implementer staff and surveyed 184 Met-Ed program participants, 197 Penelec, 152 Penn Power program participants, and 173 WPP program participants. ADM/Tetra Tech reported the following key findings:

1. Bill inserts continue to be the most common source of program information.
2. Program satisfaction remains high. The lowest satisfaction was with the wait time before pick-up, which was still over 4.0 on a 5-point scale.

Summary of Process Evaluation Audit

While the process evaluation of the Appliance Turn-in Program appears to have been consistent with the Phase III evaluation plan, the reporting on the process evaluation findings was very sparse, providing only the participant survey sample size and key findings and recommendations. While noting that the process evaluation also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), it did not provide any further information on these interviews or associated findings.¹¹³

The description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff interviewed. The process evaluation memorandum states that the surveys were conducted “through a combination of web and phone,” but it does not explain what that means. Presumably, the survey collected some responses by phone and some by web. However, other interpretations are possible, such as that the evaluator called respondents to recruit them to a web survey. Assuming that the participant survey sample consisted of a phone stratum and a web stratum, a discussion of the possible method effects (including an empirical assessment) would have been valuable.

The report also did not provide any detail on the results of the participant survey or the findings from the staff interviews. It would be useful to be able review the responses to the questions in those interviews, particularly the level of overall participant satisfaction with the program.

E.7.1.2 Energy Efficient Homes Program

Summary of Process Evaluation Findings

In PY8, ADM/Tetra Tech conducted process evaluations for two of four program components: Energy Efficiency Kits (EE Kits) and Home Energy Reports.¹¹⁶

For the Energy Efficiency Kits program component, ADM/Tetra Tech surveyed 136 Met-Ed program participants, 132 Penelec program participants, 143 Penn Power program participants, and 154 WPP program participants. The evaluators reported the following key findings:

¹¹⁶ The EE Kits component includes two subcomponents: Energy Efficiency Kits distributed by PowerDirect, and School Education Kits distributed by AM Conservation Group (AMCG). The program components for which process evaluation were not conducted in PY8 are: Residential Direct Install, and New Homes.

1. FirstEnergy customers participating across all of the Kits subprograms report high levels of satisfaction (> 4 on a 5-pt scale) with all surveyed program components.
2. Nearly half (48%) of Kits participants name e-mail as their preferred communication channel with their utility.

For the Home Energy Reports program component, ADM/Tetra Tech surveyed 195 Met-Ed program participants, 201 Penelec program participants, 202 Penn Power program participants, and 203 WPP program participants. The evaluators reported the following key findings:

1. Program participants express high levels of satisfaction with the overall quality of service provided by their utility.
2. Customer engagement with the Home Energy Reports is high. A majority of households read the reports and say they have read all or almost all of the reports they have been sent. Readership is somewhat higher among low-income households.
3. Program participants engage in energy-saving behaviors and about 30 to 40% report doing these things more now than in previous years. Low-income participants are somewhat more likely to engage in the energy-saving actions that were measured by the survey.
4. The main barriers to doing more to save energy are the cost of doing things and finding the time to do things. Knowing what to do, or how to prioritize their actions, is also a significant barrier as participants report they need more detailed tips or itemization of the main energy consuming equipment in their homes.
5. Participants generally rate the HERs positively, but they express concerns about the accuracy of the neighbor comparison, and feel the tips can be too general or repetitive. Some suggestions for improvement are available from the program (e.g., electronic access) or through other FirstEnergy programs (e.g., home energy audits).

Summary of Process Evaluation Audit

In general, the reporting on the process evaluation findings was very sparse, providing only the participant survey sample size and key findings and recommendations. While noting that the process evaluation also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), it did not provide any further information on these interviews or associated findings.¹¹³

The description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff interviewed. The process evaluation memorandum states that the surveys were conducted “through a combination of web and phone,” but it does not explain what that means. Presumably, the survey collected some responses by phone and some by web. However, other interpretations are possible, such as that the evaluator called respondents to recruit them to a web survey. Assuming that the participant survey sample consisted of a phone stratum and a web stratum, a discussion of the possible method effects (including an empirical assessment) would have been valuable.

The report also did not provide any detail on the results of the participant survey or the findings from the staff interviews. It would be useful to be able review the responses to the questions in those interviews, particularly the level of overall participant satisfaction with the program.

Energy Efficiency Kits. It was not possible from the evaluation report to fully assess the extent to which the process evaluation of the Energy Efficiency Kits (EE Kits) component of the Program followed the Phase III process evaluation plan. The process evaluation plan identified a wide range of researchable questions and data collection activities to support answering them; it goes on to note that these “issues will be refined to address individual sub-programs through interviews with FirstEnergy implementation and ICSP staff.” However, the report does not include any description of which questions were addressed and what data collection was performed to answer them.

With regard to participant surveys, the sampling plan for the gross impact evaluation called for surveys of an average of 150 participants across each EDC. The sampling plan further provides quotas by the type of kit (School Education, Online Audit - Electric Kits, Online Audit - Non-Electric Kits, Direct Distribution - Electric Kits, Direct Distribution - Non-Electric Kits). Although the plan for the process evaluation identifies participant surveys as a data collection activity, it does not specify sample sizes. Therefore, we assume that the process evaluation relied on the sampling plan described for the gross impact evaluation. Although the reported final sample sizes appear to be within the general ballpark of the planned average of 150 participants per EDC, in its discussion of the Low-Income program (see below), the report states that the process evaluation of the Energy Efficiency Kits component of that program will be conducted with the process evaluation of the corresponding component of the Energy Efficient Homes program. But the sample sizes for completed participant surveys do not indicate if any of those included surveys of participants from the Low-Income program. Therefore, it is not possible to assess if the sample sizes adhered to the original plan and satisfied the needed levels of confidence/precision.¹¹⁵ Also, unlike in the evaluation plan, the report does not provide any breakdown of surveys completed by the type of kit.

Home Energy Reports. It was not possible from the evaluation report to assess the extent to which the process evaluation of the Home Energy Reports component of the Program followed the Phase III process evaluation plan. The process evaluation plan identified a wide range of researchable questions and data collection activities to support answering them; it goes on to note that these “issues will be refined to address individual sub-programs through interviews with FirstEnergy implementation and ICSP staff.” However, the report does not include any description of which questions were addressed and what data collection was performed to answer them. Although the evaluation plan did not specify sample sizes for participant surveys, the sample sizes reported appear to be sufficiently large to achieve 85%/15% confidence/precision. That said, as noted above for the Energy Efficiency Kits program component, in its discussion of the Low-Income program (see below), the report states that the process evaluation of the Behavioral component of that program will be conducted with the process evaluation of the corresponding component of the Energy Efficient Homes program. However, the sample sizes for completed participant surveys do not indicate if any of those included surveys of participants from the Low-Income program. Therefore, it is not possible to assess if the sample sizes adhered to the original plan and satisfied the needed levels of confidence/precision.¹¹⁵ The sole indication that the

evaluation of this program component did, in fact, include a Low-Income survey sample are mentions of low-income participant responses in Findings 2 and 3, above.

E.7.1.3 Energy Efficient Products Program

Summary of Process Evaluation Findings

In PY8, ADM/Tetra Tech conducted process evaluations for three of four program components: Appliances, HVAC, and Lighting.¹¹⁷ The process evaluation for the Appliances and HVAC program components was combined since both take a downstream delivery approach. The Upstream Electronics program component did not receive a process evaluation.

For the Appliances and HVAC program components, ADM/Tetra Tech surveyed 150 Met-Ed program participants, 144 Penelec program participants, 117 Penn Power program participants, and 146 WPP program participants. The evaluators reported the following key findings:

1. Some customers feel rebates take too long to process. Approximately 10% of respondents recalled the rebate took longer than 90 days to process, which is the time frame communicated by the application. This led to lowered satisfaction with the program.
2. Some participants in the Appliance Rebate sub-program reported their income in a range that would qualify for the low-income Appliance Rebate sub-program.
3. While overall program satisfaction was high, Appliance participants rated their satisfaction with the amount of the rebate lower than other program aspects.
4. Contractors were by far the most common source of program information for HVAC participants. Satisfaction with HVAC contractors was particularly high, averaging 4.7 out of 5.

For the Upstream Lighting program component, ADM/Tetra Tech surveyed 176 Met-Ed program participants, 169 Penelec program participants, 183 Penn Power program participants, and 143 WPP program participants. The evaluators reported the following key findings:

1. Awareness of energy efficient lighting products is high and has increased since Phase II. Almost all customers are at least "somewhat familiar" with CFLs, and three-quarters report equal familiarity with LEDs. In contrast, only 55% of customers expressed this level of familiarity with LEDs in response to similar survey questions at Phase II. More than one-half understand that LEDs are more energy efficient than CFLs.
2. Usage of energy efficient lighting products is high. Over 80% of customers have ever used CFLs in their homes and two-thirds have used LEDs.
3. Customers express a preference for, and greater satisfaction with, LEDs over CFLs. Among customers familiar with both CFLs and LEDs, more than 60% prefer LEDs. The quality of lighting from LEDs and greater energy efficiency are most often cited as the reasons for this preference. Two-thirds are "very satisfied" with LEDs, while less than 30% express similar satisfaction with CFLs.

¹¹⁷ A process evaluation was not conducted for Upstream Electronics.

4. Lighting purchases over the past 12 months are predominantly LEDs (57%). However, more than one-third of purchases still included incandescent bulbs. About two-thirds of purchases are made to replace an incandescent bulb, usually because the existing bulb is burned out.
5. Customers consider a wide range of factors when shopping for lighting products. Although price is most often the most important consideration, it is not the overwhelming deciding factor. Almost one in five cite the brightness of the bulb and 15% point to bulb life as most important.
6. Customers who have not used LEDs show declining reluctance to use these products since Phase II. Although 35% are “not at all” or “somewhat unlikely” to install an LED in the next 12 months, this is down from over one-half at Phase II. Almost one in five are “very” or “extremely likely” to install LED bulbs in the next year.
7. Using the Van Westendorp Price Sensitivity Meter, LED bulbs are a “bargain” at \$2.00 to \$2.76 (median, mean, respectively) and “starting to get expensive” at \$4.00 and \$5.04 (median, mean) for those who have not previously used LEDs. However, most customers are not aware of market prices: 60% of customers “don’t know” if the price of LEDs is higher, lower, or about the same as last year.
8. Awareness of program-sponsored price discounts is low. Only one in ten customers who purchased a program-eligible lighting product was aware that the price of the bulbs they purchased had been discounted.
9. Evidence from customer self-reports suggest that most will purchase energy efficient lighting products regardless of the program-sponsored discount.
10. Regular interaction with the program implementer is relatively rare among the surveyed retailers. Those who have met with the representative are satisfied with the help they receive, but a request for more contact was among the most frequent suggestion for program improvements.
11. Retailers are very satisfied with the program. Suggestions for ways it could be even more useful to their stores included more contact with program representatives, more and better signage (larger, bolder), and activities by the program representative that could reinforce the store’s education efforts (e.g., displays, in-person interactions with customers).

Summary of Process Evaluation Audit

In general, the reporting on the process evaluation findings was very sparse, providing only the participant survey sample sizes, researchable issues, and key findings and recommendations. While noting that the process evaluation also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), it did not provide any further information on these interviews or associated findings.¹¹³

The description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff interviewed. The process evaluation memorandum states that the appliances and HVAC survey was conducted “through a combination of web and phone,” but it

does not explain what that means. Presumably, the survey collected some responses by phone and some by web. However, other interpretations are possible, such as that the evaluator called respondents to recruit them to a web survey. Assuming that the participant survey sample consisted of a phone stratum and a web stratum, a discussion of the possible method effects (including an empirical assessment) would have been valuable.

The report also did not provide any detail on the results of the participant survey or the findings from the staff interviews. It would be useful to be able review the responses to the questions in those interviews, particularly the level of overall participant satisfaction with the program.

Appliances and HVAC. For the Appliances and HVAC program components, ADM/Tetra Tech surveyed 150 Met-Ed program participants, 144 Penelec program participants, 117 Penn Power program participants, and 146 WPP program participants. Although these sample sizes exceed the 70 completed surveys per EDC that were outlined in the evaluation plan, in its discussion of the Low-Income program (see below), the report states that the process evaluation of the Appliance Rebate component of that program will be conducted with the process evaluation of the corresponding component of the Energy Efficient Homes program. But the sample sizes for completed participant surveys do not indicate if any of those included surveys of participants from the Low-Income program. Therefore, it is not possible to assess if the sample sizes adhered to the original plan and satisfied the needed levels of confidence/precision.¹¹⁵

It also was not possible from the evaluation report to fully assess the extent to which the process evaluation of the Appliances and HVAC program components followed the Phase III process evaluation plan. The process evaluation plan identified a wide range of researchable questions and data collection activities to support answering them; it goes on to note that these “issues will be refined to address individual sub-programs through interviews with FirstEnergy implementation and ICSP staff.” However, the report does not include any description of which questions were addressed and what data collection was performed to answer them.

Upstream Lighting. For the Upstream Lighting program component, ADM/Tetra Tech surveyed 176 Met-Ed program participants, 169 Penelec program participants, 183 Penn Power program participants, and 143 WPP program participants. These sample sizes exceed the 70 completed surveys per EDC that were outlined in the evaluation plan.

It was not possible from the evaluation report to fully assess the extent to which the process evaluation of the Upstream Lighting program component followed the Phase III process evaluation plan. The process evaluation plan identified a wide range of researchable questions and data collection activities to support answering them; it goes on to note that these “issues will be refined to address individual sub-programs through interviews with FirstEnergy implementation and ICSP staff.” However, the report does not include any description of which questions were addressed and what data collection was performed to answer them. Further, net impact evaluation plan discussion mentions retailer surveys and market progress indicators (MPIs), such as awareness and satisfaction. None of these results are detailed in the process evaluation report.¹¹³

Upstream Electronics. The evaluation plan for the NTG evaluation of the Upstream Electronics program component described the following: “Tetra Tech will conduct up to ten interviews with market actors such as participating store personnel and relevant procurement teams. These

interviews may be combined with Upstream Lighting retailer interviews in cases where retailers participate in both programs. A general population study will be conducted primarily to research upstream lighting market progress indicators (MPIs), but a set of questions will be included to address consumer electronics as well. Similarly, a Delphi panel will be conducted with a focus on lighting, but also including questions regarding consumer electronics.” Further, the process evaluation plan gave no indication that any of the program components would be excluded for PY8. Based on this, the expectation was that the evaluation activities planned for the NTG evaluation would include process questions. This did not happen and a process evaluation was not conducted for the Upstream Electronics program component. That said, Upstream Electronics accounted for a very small percentage of the overall Energy Efficient Products program savings, ranging by EDC from 0.6% to 2.5%. Therefore, not conducting a process evaluation of the Upstream Electronics program component will likely be marginal value to overall program delivery and performance.

E.7.1.4 Low-Income Program

Summary of Process Evaluation Findings

For PY8, ADM/Tetra Tech conducted the process evaluations for the Appliance Rebate, Behavioral, and Kits sub-programs with the similar Non-Low-Income programs in the Energy Efficient Products and Energy Efficient Homes programs. The report notes that the findings and recommendations for those program components were reported in those sections.

The report implies but does not clearly state that for the Low-Income program specifically, a separate process evaluation was conducted for the Direct Install program component. The report also includes a table that provides population sizes and sample sizes for a survey of participants. However, instead of showing the population sizes, this table ([Table 89](#), reproduced below) shows the Gross Verified MWh as reported in the preceding [Table 87](#).

Table 129: LIP Program Process Evaluation Sample Design (*Reported*)

EDC	Population Size	Achieved Sample Size	Response Rate
Met-Ed	1,551	80	30.0%
Penn Power	2,433	85	38.0%
Penelec	842	73	36.0%
WPP	1,954	101	35.0%

The correct population sizes were reported in an excel file (Master Input Spreadsheet 111017) provided by ADM/Tetra Tech and are shown in the table below.

Table 130: LIP Program Process Evaluation Sample Design (*Actual*)

EDC	Population Size	Achieved Sample Size	Response Rate
Met-Ed	1,467	80	30.0%
Penn Power	2,259	85	38.0%
Penelec	726	73	36.0%
WPP	1,121	101	35.0%

ADM/Tetra Tech reported key findings, but did not specify if these were specifically for the Direct Install component of the Low-Income program and left it to the reader to infer that to be the case. These key findings are provided below.

1. Contractors are required to enter information in the FirstEnergy tracking system and a state-run website.
2. While nearly all direct install measures are installed by the contractor, participants still report some are left behind for the homeowner to install. This may result in the measures never being installed and may impact the realization rate. This has improved since Phase II, but participants still report 4% of measures are left uninstalled.

Summary of Process Evaluation Audit

As noted previously, the ADM/Tetra Tech report indicated that it conducted the process evaluations for the Appliance Rebate, Behavioral, and Kits sub-programs with the similar Non-Low-Income programs in the Energy Efficient Products and Energy Efficient Homes programs. However, aside from a couple of mentions of low-income participant survey responses in findings for the Behavioral component of the Energy Efficient Homes program, the relevant report sections for the Energy Efficient Products and Energy Efficient Homes programs did not provide any indication or evidence that they had evaluated the applicable low-income program components. Additionally, the descriptions of the participant survey sample sizes for those programs do not mention whether they included a low-income sample. Therefore, it is not possible to assess if the sample sizes satisfied the needed levels of confidence/precision.¹¹⁵

While the process evaluation of the Direct Install program component appears to have been consistent with the Phase III evaluation plan, the reporting on the process evaluation findings was very sparse, providing only the participant survey sample size and key findings and recommendations. While noting that the process evaluation also included interviews with program staff and contractors, it did not provide any further information on these interviews or associated findings.¹¹³

The description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff interviewed. The process evaluation memorandum states that the surveys were conducted “through a combination of web and phone,” but it does not explain what that means. Presumably, the survey collected some responses by phone and some by web. However, other interpretations are possible, such as that the evaluator called respondents to

recruit them to a web survey. Assuming that the participant survey sample consisted of a phone stratum and a web stratum, a discussion of the possible method effects (including an empirical assessment) would have been valuable.

The report also did not provide any detail on the results of the participant survey or the findings from the staff interviews. It would be useful to be able review the responses to the questions in those interviews, particularly the level of overall participant satisfaction with the program.

E.7.2 C&I Programs

The four FirstEnergy EDCs operate the following five C&I energy efficiency programs:

- C&I Energy Solutions for Business - Small
- C&I Demand Response - Small
- C&I Energy Solutions for Business - Large
- C&I Demand Response - Large
- Governmental & Institutional Tariff

For PY8, The ADM/Tetra Tech team reported on process evaluations for three C&I programs: the Energy Solutions for Business-Small, Energy Solutions for Business-Large, and Government and Institutional programs.

As noted earlier, the description of the research activities conducted provided a very general outline of what the evaluator did. Although the reports provided sample sizes for the participant surveys, they did not identify the number of staff or contractors interviewed. The report also did not provide any detail on the results of the participant survey or the findings from the staff and contractor interviews.¹¹⁸ Further detail on this process evaluation is provided below.

E.7.2.1 Energy Solutions for Business – Small, Energy Solutions for Business – Large, Government and Institutional

Summary of Process Evaluation Findings

In PY8, ADM/Tetra Tech conducted combined process evaluations for the Large C&I, Small C&I, and Government and Institutional programs. The survey sample was stratified into three project types: Custom, Lighting, and Other. The Other category included prescriptive downstream measures, but excluded Appliance Turn-In. Across all of these project types and EDCs, the program had a total of 2,473 participants in PY8. From this population of participants, ADM/Tetra Tech drew a sample of 802 participants and completed phone surveys with a total of 343 of them.

For the Lighting program component, ADM/Tetra Tech completed phone surveys with 63 Met-Ed program participants, 103 Penelec program participants, 45 Penn Power program participants, and 70 WPP program participants.

¹¹⁸ The evaluator provided the following comment in subsequent communications: “We provided what was available at the time in the report. We will provide significantly more detail in the PY9 annual report, however we wanted to show progress made by the PY8 annual report.”

For the Custom program component, ADM/Tetra Tech completed phone surveys with 17 Met-Ed program participants, 18 Penelec program participants, seven Penn Power program participants, and 14 WPP program participants.

As noted above, the Other category included prescriptive downstream measures, but excluded Appliance Turn-In. For the Other program components, ADM/Tetra Tech completed phone surveys with two Met-Ed program participants, two Penelec program participants, seven Penn Power program participants, and one WPP program participant.

Across all project types and strata, the evaluators reported the following key findings:

1. Participating customer and trade ally satisfaction remains high. Average customer and trade ally satisfaction ratings across all aspects of the program met or exceeded 4.0 on a 1 to 5 scale, with 1 being “not at all satisfied” and 5 being “very satisfied”. Nearly two-thirds of participant customer respondents (64%) reported that they have recommended FirstEnergy’s business programs to others and 84% said they are “very likely” to participate in FirstEnergy’s programs again in the future, suggesting a strong pipeline for future participation.
2. Trade allies continue to be the primary driver of customer awareness and participation in Phase III. While the program has been successful in generating repeat participants through the trade ally relationships, views on the level of general customer awareness of FirstEnergy’s business programs is mixed. Participants report preferring to receive information about FirstEnergy’s programs through email or electronic newsletters, direct mail, and utility bill inserts.
3. Impressions of the transition to a new ICSP are largely positive, though feedback suggests there may be opportunities to further support to trade allies. Most trade allies interviewed felt well supported by the program and report being in regular communication with their ICSP representative. At the same time, some trade allies noted the loss of some established working relationships and longer response times to requests or questions than observed under the previous ICSP.
4. While recent efforts to provide additional application support have been recognized, further streamlining the application process remains among the most common recommendations provided by customers and trade allies. Participating trade allies and customers often described the application process as time-consuming and/or cumbersome. Additionally, several trade allies mentioned not pursuing program incentives for certain projects due to the perceived administrative burden or combination of the required paperwork not being worth the incentives available through the program.

Summary of Process Evaluation Audit

In general, the reporting on the process evaluation findings was very sparse, providing only the participant survey sample sizes, a cursory description of the researchable issues, and key findings and recommendations. While noting that the process evaluation also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), it did not provide any further information on these interviews or associated findings.¹¹⁸

The data collection activities described in the ADM/FirstEnergy report were limited to interviews with FirstEnergy and ICSP staff, a participant survey, and contractor interviews. However, the PY8 evaluation plan also proposed to collect data from numerous additional data sources:

- Review of data tracking systems
- Program data/documentation review
- Trade ally interviews: participant, non-participant, and wait-listed trade allies. It is not clear from the report if the contractor interviews discussed in it included any of these trade ally groups.
- Wait-listed customer interviews
- Benchmarking study
- Audit review

The report does not mention having conducted any of these data collection activities that were described in the PY8 evaluation plan.

The research activities described in the report provided a very general outline of what the evaluator did. The report did not identify the number of staff interviewed. It provided sample sizes for the participant surveys, but did not indicate the confidence/precision levels of the final samples.¹¹⁹ The report also did not provide any detail on the results of the participant survey or the findings from the staff interviews. It would be useful to be able review the responses to the questions in those interviews, particularly the level of overall participant satisfaction with the program.

E.7.2.2 C&I Demand Response Program – Small, C&I Demand Response Program—Large

For both the small and large C&I Demand Response programs, the ADM/Tetra Tech report states that a “process evaluation was not conducted in PY8.”

¹¹⁹ The evaluator indicated in subsequent communications that they will provide additional detail in the PY9 annual report,

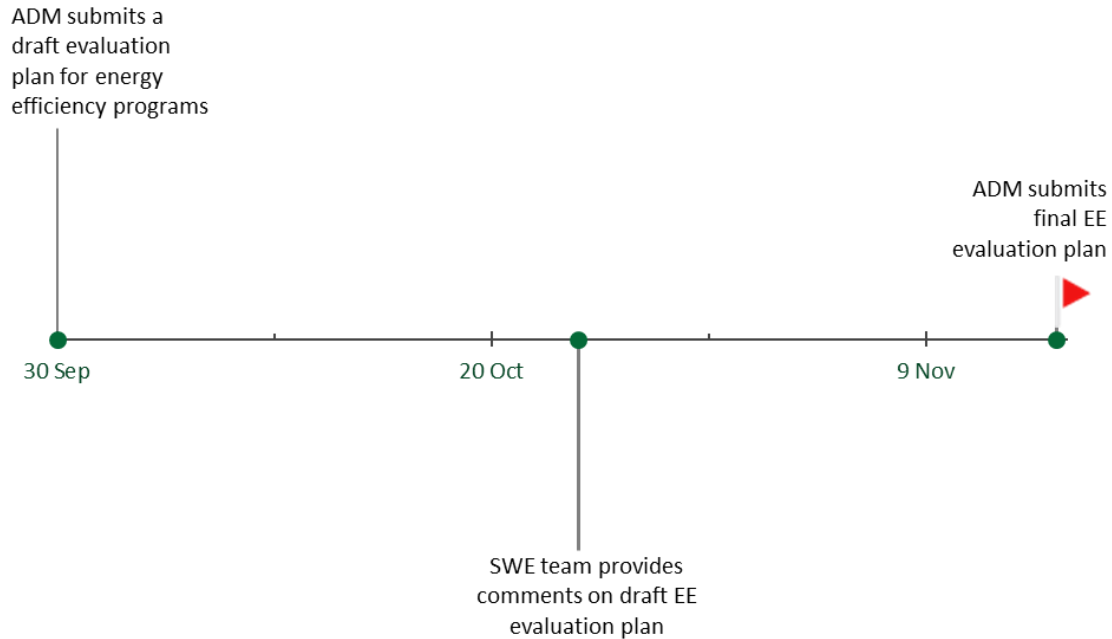
Appendix F Penelec Audit Detail

F.1 EM&V PLAN REVIEWS

The four FirstEnergy companies offer a similar portfolio of programs for Phase III of Act 129. Program offerings, measures offered, incentive levels, tracking system, and ICSPs are all determined company wide. Given the similarities across EDCs, FirstEnergy's evaluation contractor, ADM Associates, prepared a single evaluation plan for the four EDCs. EDC-specific considerations were addressed as needed throughout the plan. Penelec's EE&C plan programs are organized by sector with separate programs for Small C&I, Large C&I, and Government and Institutional rate classes. The separation between these three programs is dictated by tariffs, but in practice, the same offerings are available to all non-residential customers regardless of rate code. For evaluation purposes, ADM chose to organize non-residential energy efficiency projects into initiatives by equipment type (Lighting, HVAC, Custom, etc.). The SWE supported this decision to organize non-residential research by equipment category.

ADM's Phase III evaluation plan called for an impact evaluation of each initiative annually. This approach avoids the frequency versus rigor decisions that made up a large part of the plan review process for Duquesne Light and PECO. The FirstEnergy companies' evaluation plan review process was the most efficient in the state because the draft plan submitted to the SWE was detailed, included adequate sample sizes, and was consistent with the major expectations of the Evaluation Framework.

Penelec was not assigned a demand response target for Phase III and FirstEnergy elected not to run any voluntary programs. [Figure 58](#) documents the timing of the major milestones associated with finalizing the Phase III evaluation plan for Penelec.

Figure 58: Penelec Evaluation Plan Review Timeline, 2016

- Model Selection for Home Energy Reports:** FirstEnergy reduced the number of homes receiving HERs in PY8 compared to Phase II totals. When the equivalence of the new treatment and control groups were assessed in the evaluation plan, some statistically significant differences in consumption during the pre-treatment period were identified. The SWE and ADM worked together on several simulation exercises to determine which regression model specification was best equipped to net out these differences and produce unbiased estimates of HER impacts.
- Synthesis of Multiple Methods for NTG and Process:** Several of the key research questions for the NTG and process evaluations had multiple methods proposed. This approach is recommended in the Evaluation Framework, but the SWE requested additional detail on how results would be combined to arrive at conclusions.
- Low-Income Considerations:** Some offerings are delivered to both residential and residential low-income customers. The SWE requested clarification in several places on how savings from low-income participants would be separated from the residential class.
- Mechanics of the Non-Residential Certainty Stratum:** For the largest C&I projects, ADM works alongside the ICSP to integrate M&V into the program delivery. In these cases, there is no reported savings estimate – ADM just calculates the gross verified savings. Because of the alternate process, the projects must be quarantined in the extrapolation of program savings from the evaluation sample. Certainty project results do not factor into the realization rate calculation for smaller strata where sampling is used

In addition to reviewing FirstEnergy's evaluation plan, the SWE reviewed eleven survey instruments and one interview guide. Nine of these instruments were for residential programs while three were for C&I programs. The surveys and interviews addressed process, impact, and NTG topics.

F.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative." For 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 because of program delivery method or technology supported.

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. For example, projects from the three non-residential energy programs (C&I Energy Solutions for Business – Small, C&I Energy Solutions for Business – Large, and Government & Institutional Tariff) were assigned to one of five solutions:

- C&I Lighting
- C&I Custom
- C&I Prescriptive
- C&I Appliance Turn-In
- C&I Direct Install (minimal savings in PY8 – no evaluation sample)

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than the tariff-based program definitions, which each include the same mix of measures. It is also a more efficient sample design because lighting projects are more likely to share similar characteristics across the Small C&I, Large C&I, and Government programs than a heterogeneous mixture of measures from a single program definition.

Table 131 lists evaluation initiatives along with the relative precision of the PY8 gross verified savings estimate at the 85% confidence level.

Table 131: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level ($\pm$)
Appliance Turn-In	6.1%
Low-Income ATI	10.2%
Kits	5.2%
Low-Income Kits	9.8%
C&I Lighting	9.9%
C&I Custom	5.1%
C&I Prescriptive	10.6%
Upstream Lighting	10.2%
C&I ATI	9.2%
Residential HVAC	10.2%
Residential Appliances	8.4%
Low-Income Appliances	10.8%
Residential Direct Install	7.8%
Low-Income Direct Install	9.7%
Residential New Construction	14.0%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. Each of the 15 sampling initiatives shown in [Table 131](#) produces verified gross savings estimates of better than $\pm 15\%$ precision at the 85% confidence level.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of ADM's PY8 verification activities is discussed in detail in [Appendix F.4](#).

F.3 REPORTED GROSS SAVINGS AUDITS

F.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penelec's PY8 Annual Report. Specifically, the values we examined are:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program
- Incentive dollars for each program

The SWE leveraged Penelec's PY8 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request.

F.3.1.1 Audit Findings

Table 132 summarizes the SWE's findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Penelec's PY8 Annual Report and 'No' otherwise. The SWE was able to replicate energy savings for each of the programs.

Table 132: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	3,826	3,826	Yes
Energy Efficient Homes	38,523	38,523	Yes
Energy Efficient Products	33,501	33,501	Yes
Low-Income Energy Efficiency	10,950	10,950	Yes
C&I Energy Solutions for Business – Small	18,071	18,071	Yes
C&I Energy Solutions for Business – Large	15,811	15,811	Yes
Governmental & Institutional Tariff	852	852	Yes
Portfolio Total	121,534	121,534	Yes

Table 133 summarizes the SWE's findings regarding reported gross peak demand savings by program. The SWE's records match Penelec's reported gross peak demand savings for each of the seven programs.

Table 133: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.50	0.50	Yes
Energy Efficient Homes	4.96	4.96	Yes
Energy Efficient Products	3.60	3.60	Yes
Low-Income Energy Efficiency	1.30	1.30	Yes
C&I Energy Solutions for Business – Small	2.99	2.99	Yes
C&I Energy Solutions for Business – Large	1.86	1.86	Yes
Governmental & Institutional Tariff	0.01	0.01	Yes
Portfolio Total	15.23	15.23	Yes

Table 134 summarizes the SWE's findings regarding program participation. For each of Penelec's seven programs, the SWE was able to exactly replicate (or nearly replicate) the participation counts shown in Penelec's Annual Report. For the LIEE program, the two data sources disagree by two participants. The SWE is not concerned about this difference.

Table 134: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	3,483	3,483	Yes
Energy Efficient Homes	209,088	209,088	Yes
Energy Efficient Products	372,475	372,475	Yes
Low-Income Energy Efficiency	37,329	37,331	Yes
C&I Energy Solutions for Business – Small	608	608	Yes
C&I Energy Solutions for Business – Large	110	110	Yes
Governmental & Institutional Tariff	233	233	Yes
Portfolio Total	623,326	623,328	Yes

Finally, [Table 135](#) summarizes the SWE’s findings regarding incentive dollars. Of the seven programs for which Penelec reported non-zero incentive dollars in their annual report, the SWE was able to replicate (or nearly replicate) the incentives for four programs: Appliance Turn-in, LIEE, Large C&I Business Solutions, and the Governmental & Institutional Tariff Program. For two other programs (EE Products and Small C&I Business Solutions), the incentive dollars in the tracking data were directionally similar to the incentive dollars in the annual report. For these two programs, note that the sum of incentives in the annual report (\$2,657,000) and the sum of incentives in the tracking data (\$2,658,000) are very similar. The difference is explained a product of upstream lighting cross-sector sales findings. FirstEnergy moves money between EE Products and Small C&I Energy to avoid cross subsidization between residential and commercial sectors, so we are not concerned about the differences in financials for these programs. It is a necessary change to ensure equitable cost recovery across rate classes.

For the remaining program – Energy Efficient Homes – incentives from the tracking data are vastly different from the incentives shown in the annual report. The SWE understands the discrepancy between incentives in the quarterly tracking data and incentives in the annual report for these two programs is largely attributable to EE kits. Indeed, in their annual report, Penelec notes that incentive dollars include direct install equipment costs and costs for EE&C kits. The discrepancy between data sources (\$2,485,000) is similar to the incentive amount that Penelec had earmarked for kits in their PY8 EE&C plan (\$2,740,000). Disregarding this program, Penelec’s portfolio total in the annual report is \$3,721,000. The corresponding total in the tracking data is \$3,723,000.

Table 135: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	\$197	\$197	Yes
Energy Efficient Homes	\$2,515	\$30	--
Energy Efficient Products	\$1,494	\$1,605	No
Low-Income Energy Efficiency	\$79	\$80	Yes
C&I Energy Solutions for Business – Small	\$1,163	\$1,053	No
C&I Energy Solutions for Business – Large	\$744	\$745	Yes
Governmental & Institutional Tariff	\$43	\$43	Yes
Portfolio Total	\$6,236	\$3,753	---

F.3.1.2 Action Items

For all Penelec's programs, the SWE was able to replicate reported MWh savings, reported MW savings, and participation counts with the tracking data. For six of the seven programs which Penelec reported non-zero incentive dollars, the SWE was able to calculate directionally similar (though not exactly the same) incentive dollars via the tracking data. The portfolio totals for these six programs line up almost exactly.

The SWE's only concern at this point is being able to replicate incentive dollars for the Energy Efficient Homes program. The SWE acknowledges that the discrepancy is due to the costs of the EE kits being correctly treated as incentives, and we do not view this as a major issue.

F.3.2 Project File Reviews

F.3.2.1 Residential¹²⁰

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of Penelec's residential projects for PY8 using the project documentation provided by the evaluation contractor, ADM, in response to the SWE's standing quarterly data request. The project file packages included savings calculation worksheets, rebate applications, equipment

¹²⁰ The SWE also conducted a database review of Penelec's quarterly tracking data to verify that Penelec was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages included all documentation requested.

Project file documentation for all residential programs were generally well organized and provided the data needed for the review, but occasionally revealed inconsistencies with the tracking data. [Table 136](#) presents an overview of the results of the SWE's residential project file reviews. Note that [Table 136](#) includes project file reviews for all FirstEnergy EDCs.

Table 136: Penelec PY8 Residential Project File Review Summary

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?
Appliance Turn In	ATI	12	✓	✓	✓	✓
Energy Efficient Homes	New Homes	8	✓	✓	✓	✓
Energy Efficient Products	Appliances	8	✓	✓	✓	✓
Energy Efficient Products	Lighting	16	✓	✓	✓	✗
Energy Efficient Products	HVAC	8	✓	✓	✓	✓
Low-Income EE Program	New Homes	1	✓	✗	✓	✓
Low-Income EE Program	Appliances	8	✓	✓	✓	✓
Low-Income EE Program	ATI	4	✓	✓	✓	✓
Low-Income EE Program	Weatherization	8	✓	✓	✓	✓

As outlined above, an adequate number of project files and the supporting details were submitted for the residential program. Below is a summary of the project file reviews, including the few issues or discrepancies found between project files and tracking data.

For the New Homes Program, the project files were easily found within the tracking data; however, there was insufficient information to verify the rebated amount. The SWE could not determine whether the rebate was based on HERS Score, percent of savings over UDRH, or kWh saved.

There were minor issues found within the Low-Income Weatherization program. The SWE matched the project files with the tracking data for the following measures: lighting, faucet aerators, low flow showerheads, and smart power strips. However, for insulation, air sealing, and appliance replacement measures, the SWE could not match the project files to the tracking data and therefore could not verify the accuracy of the tracking database for these measures.

The following issue applies generally to the residential project files, but it is specifically noted in the review of the Appliance Turn-In and HVAC programs. The Account IDs listed in the project files were not listed accurately in the tracking data, which made it difficult to match the projects to the data. It appeared that, at times, the fields in the tracking data containing the IDs had been rounded and were no longer able to be identified with the project file ID. The SWE was ultimately able to locate the project within the tracking data by using other information found in the project files, such as name and address. However, this is a time- consuming process.¹²¹

While the PY8 review of residential project files found project file packages to be typically well-organized, the SWE found several instances of missing or inaccurate data. To ensure the accuracy of reported savings in upcoming program years, the SWE makes the following recommendations:

- Submitting project files and a matching sample of tracking data for each program, including a unique identifier to easily match data to the files.
- More clarity on how rebate amounts are calculated, specifically for the New Homes program.

F.3.2.2 Non-Residential

The SWE reviewed Penelec's C&I projects for PY8 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 project file packages included all documentation requested, with the exception of lighting projects, which consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Penelec's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. However, the evaluator has implemented a process for PY9 through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes.

¹²¹ ADM is working with CSPs to use an alternative matching key, such as rebate number, for PY9 and beyond.

Project files were generally well organized, with minimal deviations from the TRM-specified calculation methodologies and assumptions. [Table 137](#) presents an overview of the results of the SWE's C&I project file reviews.

Table 137: Penelec PY8 C&I Project File Review Summary

Project Number	Project Description	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?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
FESPPS1534043535	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043570	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043581	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043589	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043627	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534074117	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534095851	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534209051	HVAC	✓	✓	✓	✗	✗	-
FESPPS1534073998	VFD, Economizer	✓	✓	✓	✓	-	✓
FESPPS1534074152	Ice machines & ASH controls	✓	✓	✓	✓	✓	-
FESPPS1534074043	Motors	✓	✓	✓	✓	-	✓

A review of the project files revealed only one instance of deviations from the TRM for calculation of savings associated with deemed measures. Project FESPPS1534209051 achieved savings for installation of new packaged/split AC units. Energy savings calculations provided by the implementer relied on $IEER_{ee}$ and $EER_{baseline}$ values. This is a departure from the TRM algorithm specified in Section 3.2.1, which recommends that $IEER_{ee}$ and $IEER_{baseline}$ values be used to calculate kWh savings.

The SWE annual reports from PY6 and PY7 submit that review of the Penelec project files was seamless, with only minimal inconsistencies. This trend continued through PY8, with project documentation being well organized and showing a high degree of consistency with the TRM. To ensure the accuracy of reported savings in upcoming program years, the SWE only recommends the use of unlocked calculators for transparency in the evaluation process.

F.4 VERIFIED GROSS SAVINGS AUDITS

F.4.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the Pennsylvania Electric portfolio of residential programs. Pennsylvania Electric's portfolio of Residential programs includes the following: The Appliance Turn-In Initiative, The Energy Efficient Homes Initiative, The Energy Efficient Products Initiative, and the Low-Income Energy Efficiency Initiative. Each program contains various subprograms, which are addressed separately below in tables and text as needed. Note that the SWE reports the residential savings into the following sections: upstream lighting, residential non-lighting, and behavior.

Overall, the verified savings followed proper TRM protocols and the verified savings are accurate. The SWE identified the evaluation activities that were used to verify savings for the residential programs. [Table 138](#) provides a summary of the evaluation and M&V approaches used by Penelec in their PY8 verified savings calculations. [Table 139](#) provides a summary of discrepancies that were discovered during the SWE audits of verified savings. Note that all discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.¹²²

¹²² The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Table 138: Residential Program Evaluation Activities - Penelec

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied PY7 RR
Appliance Turn-In (LI & Non-LI)	✓	--	✓	--	--
EE Kits (LI & Non-LI)	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	--	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting	✓	--	✓	--	--
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓		✓		
Low-Income WARM	--	✓	✓	✓	--

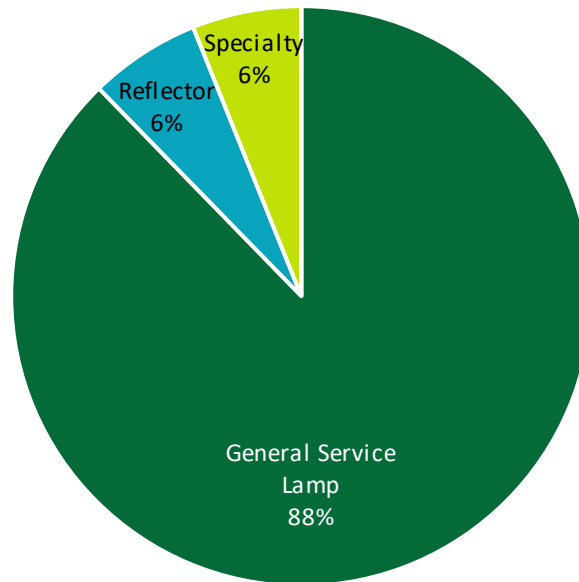
Table 139: Residential Program Verified Savings Discrepancies – Penelec

Program/ Subprogram	Measure	Discrepancy	The SWE Recommendation
Appliance Turn-In (LI & Non-LI)	Dehumidifiers	Possible EDC gathered data quality issues, not used for savings calculations	Review data collection process for measure, incorporate gathered values in future PYs
HVAC	Packaged Terminal ACs	No equipment-specific data used in savings calculations	Use individual equipment specs in future, rather than applying “market average” values for savings
Appliances	ENERGY STAR Clothes Washers	Outdated TRM default applied	Use correct/up-to-date TRM values

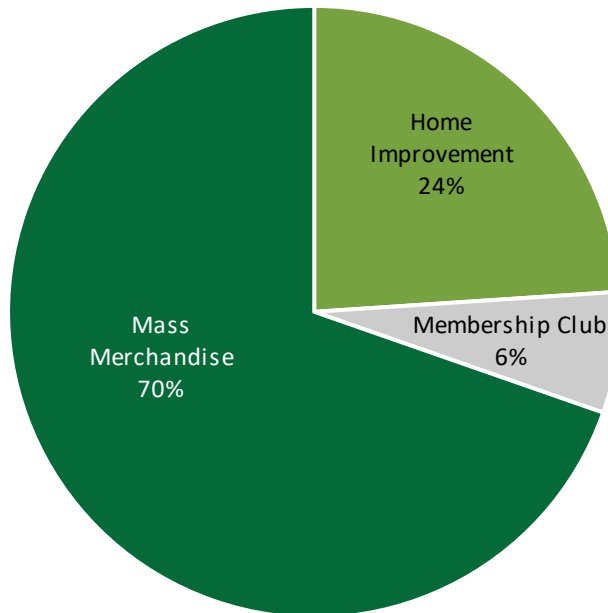
F.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased just under one million efficient light bulbs and fixtures through Penelec's upstream lighting program. [Figure 59](#) displays the distribution of sales by product type. Most (88%) of the products were general service lamps.

Figure 59: Penelec PY8 Upstream Lighting Sales by Product Type



Over two-thirds (70%) of Penelec's PY8 upstream light bulbs and fixtures were sold through mass merchandise stores ([Figure 60](#)), while nearly one-quarter (24%) were sold through home improvement stores.

Figure 60: Penelec PY8 Upstream Lighting Sales by Retail Channel**F.4.1.1.1 Audit Findings**

The SWE reviewed the data in Penelec's tracking system to verify that ADM used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with ADM's verified gross savings for the Upstream Lighting Initiative.

The SWE observed 449 unique lighting model numbers in the PY8 tracking system, and was able to locate 349 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The 100 models the SWE was not able to verify as ENERGY STAR certified represent 18% of both bulbs sold and verified savings from upstream lighting. FirstEnergy included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. However, TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. The SWE sent FirstEnergy a memo in October of 2017 recommending that beginning in PY9, the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products. According to FirstEnergy, its companies stopped rebating non-ENERGY STAR LEDs in PY9.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for three of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system, or errors in the ENERGY STAR certified products lists. The team confirmed that ADM used the appropriate algorithms, interactive effects, ISR, residential HOU, and residential coincidence factor to calculate kWh and kW savings. The team found that ADM assigned baseline wattages in accordance with TRM protocol 2.1.1 for all but three decorative models, which were mistakenly classified as EISA exempt. Combined, the impact of all

discrepancies the SWE identified on initiative-level savings is negligible (less than one-half of 1%).

F.4.1.1.2 Cross-Sector Sales

ADM estimated 8.3% cross-sector sales for the combined FirstEnergy companies based on a general population survey. Survey respondents were asked how many bulbs they purchased and if they installed them in a residence, business, or both. Unfortunately, the survey was not designed to capture the proportion of residential versus commercial installations for the subset of respondents who reported installing bulbs in both a residence and a business (6% of respondents), necessitating a follow-up call to gather this information. ADM computed a weighted average HOU of 1,821 and coincident factor of 0.32 by mapping survey respondents' business types to the building types listed in Table 3-5 of the TRM.

F.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Ensure that all products are ENERGY STAR qualified.
 - FirstEnergy included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.¹²³
- Edit the general population survey so that in future program years, the proportion of bulbs installed in residences and businesses for respondents who claimed to install bulbs in both locations can be gathered during the survey without the need for a follow-up call.

F.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

F.4.1.2.1 Energy Efficient Homes Program

The SWE audited each of the four components of the Energy Efficient Homes Program: Energy Efficiency Kits (EE Kits), HERs, Residential Direct Install, and New homes using the gross impact data submitted by FirstEnergy. The team audited the new home sample that was used to determine the realization rate for the sub-program. The audit included a review of REM/Rate models and, as specified in the 2016 TRM, application of 2016 TRM savings to ENERGY Star lighting and appliance measures used to verify savings. Note that the SWE's audit of the HERs is reported in [Section F.4.1.3](#) of this appendix.

¹²³ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8.

Overall the SWE audits concluded that the correct TRM algorithms were applied and verified savings were correct for all program EE kits, Residential Direct Install measures, and New Homes. The SWE noted a minor discrepancy between the survey sample size reported in the annual report and the survey sample size identified in the raw data provided by FirstEnergy for all program kits. ADM clarified the discrepancy, noting that they applied a 200-day cut-off, removing survey responses that were completed more than 200 days after the kit receipt date. In addition, respondents within the 200-day cut-off who could not remember receiving a kit were also removed from the reported survey sample.

F.4.1.2.2 Energy Efficient Products Program

The SWE audited Penelec's Energy Efficient Products Program. This program consists of the following non-lighting components: appliances, HVAC equipment, and consumer electronics.

The SWE determined that the consumer electronics and HVAC portions of the program savings were correctly calculated using the TRM protocols. The SWE notes that the HVAC component of the program of the program savings had a minor discrepancy in the PTAC calculations, but not enough to warrant any changes in the overall program savings. Savings for PTAC systems were reported in the data with no corresponding calculations to support the values. The SWE requested clarification from ADM, who reported that the parameters in the TRM algorithm were based on a market average for PTAC systems. The SWE recommends calculating savings based on individual PTAC system specifications in future program years. The SWE audit also discovered an incorrect application 2016 TRM deemed value for ENERGY Star Clothes Washers. The savings calculation used for verified savings was using an outdated cycle per year value. The SWE notes that the PTAC systems and ES Clothes Washer error accounted for less than 1% of measure level savings, and had a negligible impact on program and portfolio level savings. The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

F.4.1.2.3 Low-Income WARM Program

The Low-Income WARM Program is a low-income direct install initiative that consists of three sub-programs: WARM-Plus, WARM-Extra Measure, and WARM-Multifamily. The WARM Program includes the following measures: LED lighting, smart power strips, domestic hot water, HVAC heating and cooling, refrigerator and freezer replacement and recycling, insulation, air sealing, and duct sealing. The SWE audited all measures using the full downstream dataset and survey sample subset provided by FirstEnergy. The SWE found that the exact TRM calculations were used to determine the savings, survey sample sizes were correct, and the reported savings were accurate.

F.4.1.2.4 Appliance Turn-In Program (Low-Income and Non-Low-Income)

The Appliance Turn-In Program consists of low-income and non-low-income stratum. The Turn-In Program offers options for refrigerators, freezers, room air conditions, and dehumidifiers. The SWE audited EDC-provided data for each measure offered by the non-low-income and low-income strata of the program. Auditors determined that the verified savings for refrigerators, freezers, and room air conditioner turn-ins were correct and followed the relevant TRM algorithms

and guidelines (including correctly incorporating the participant survey data into the verified savings calculations).

The SWE did notice a minor discrepancy for dehumidifier turn-ins. Dehumidifiers were a newer addition to the turn-in program and used an approved IMP for savings calculations. An outdated IMP default value for the Wilkes-Barre area was applied to Williamstown and Scranton, though this discrepancy did not change the overall savings. Also regarding dehumidifiers, auditors noticed that 68% of dehumidifiers in the sample were recorded in the EDC data collection process as having 10 pints of capacity, which stuck out as a possible data collection error. The SWE agrees with ADM's decision to use default IMP values for all dehumidifiers when calculating savings rather than using what is likely to be faulty data, while allowed by the IMP. The SWE recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.

F.4.1.3 Behavior

Approximately 19% of Penelec's verified gross energy savings for PY8 came from Home Energy Reports issued to around 165,000 residential and residential-LI households. The SWE reviewed ADM's methodology and accepts their verified MWh and MW savings values for Penelec's HER offering in PY8. By cohort, [Table 140](#) shows average kWh savings and average percent savings per participant in PY8. Note that the 'Number of Participants' column shows the average number of participants during PY8.

Table 140: Average PY8 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY8 kWh Savings	Average PY8 % Savings
Low-income	July 2012	7,024	219	1.72%
Residential	July 2012	50,250	204	1.63%
Low-income	January 2014	1,863	354	2.64%
Residential	January 2014	67,208	115	1.27%
Low-income	December 2014	10,338	201	2.50%
Residential	December 2014	30,056	100	1.37%

The following sections highlight some of the more important audit findings: errors in the coding of "pre" and "post" indicator variables, the calculation of lag terms, missing eligibility filters, and duplicating participant counts.

"Pre" and "Post" Coding Errors

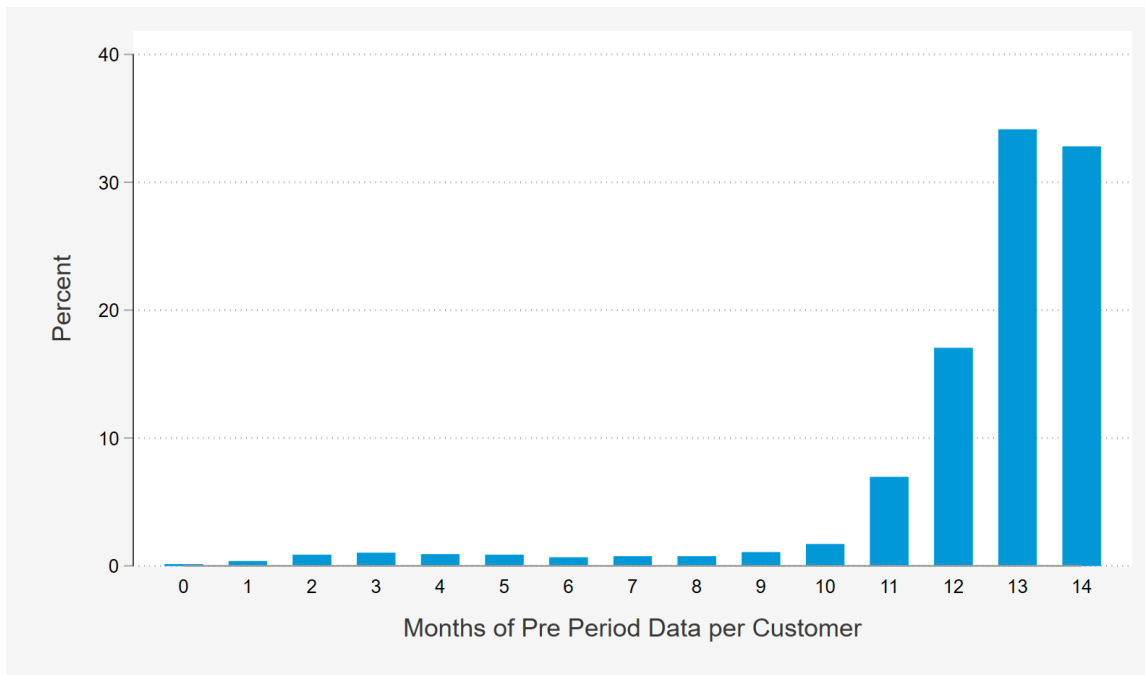
In reviewing the HER billing data, the first item that the SWE checked was the coding of the pre- and post-indicator variables. For a given cohort, all months prior to the billing cycle in which the randomized controlled trial (RCT) starts should be coded as pre = 1 and post = 0, and all months after the billing cycle in which the RCT starts should be coded as pre = 0 and post = 1. When reviewing the distribution of the pre- and post-indicator variables, the SWE noticed two issues:

1. For both 2012 cohorts (residential and low-income), there was an error in the coding of the post indicator variable. In December of 2013 and January of 2014, the post indicator variable was set equal to 0, though it should have been 1. (Note that the pre-indicator variable was coded correctly for these cohorts.) Because the lagged seasonal (LS) model is a post-only model, these records were being left out of the regression.
2. For both of the December 2014 cohorts (residential and low-income), there was an error in the coding of the pre-indicator variable. Once again in December of 2013 and January of 2014, the pre-indicator variable was set equal to 0 instead of 1. This means that these months were not factoring into the calculation of the lagged terms used in the LS model.

The SWE informed ADM about these issues, and ADM was able to update the numbers in their PY8 annual report before the report was submitted to the PUC. After fixing the coding issues, verified savings for Penelec increased by 257 MWh – 154 MWh for low-income cohorts and 103 MWh for residential cohorts. This was only possible because ADM submitted their data well in advance of the data request deadline.

Calculating Lag Terms

As noted, the LS regression model is a post-only model – only records from the post period are used in the regression. That said, some of the explanatory variables in the model are calculated based on pre-period data: (1) average daily consumption in the pre-period, (2) average daily consumption during the summer in the pre-period, and (3) average daily consumption during the winter in the pre-period. For some homes, there was not enough pre-period data to calculate these lag terms. [Figure 61](#) shows the distribution of the number of months of pre-period data per customer. Across all Penelec cohorts, 16.0% of homes had less than twelve months of pre-period data, 4.8% of homes had less than seven months of pre-period data, and 0.5% of homes had less than two months of pre-period data.

Figure 61: Number of Pre-Period Months per Customer

The limited amount of pre-period data for some homes raises two issues:

1. An eligibility screen should have filtered these homes out of the RCT. The number of homes with no more than six months of pre-period data is not insignificant. Some homes even had zero months of pre-period data. Sufficient pre-period data is a key component of an unbiased impact evaluation.
2. How should the lag terms be calculated? As an example, suppose the only months of pre-data for a customer are April, May, and June. (This was the case for several participants.) The average winter usage in the pre-period for this customer is not known, thus this customer should have fallen out of the regression model. Instead, Oracle used average daily usage for April-June as the lagged winter variable (average daily consumption during the winter in the Pre-period). As another example, some customers had just one month of pre-period data – November. The average pre-period summer usage for these customers is not known, but Oracle used average daily usage in November as the lagged summer variable (average daily usage during the summer in the pre-period).

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we used Oracle's lag terms. After replicating ADM's savings values, the SWE dropped any participant without at least twelve months of pre-period data and re-ran the LS model for each cohort. Regression estimates were then used to calculate savings in exactly the same manner that ADM calculated savings (i.e., identical participant counts and adjustments were used). [Table 141](#) shows the results. On aggregate, the SWE estimate was approximately 415 MWh less than the ADM estimate. One cohort (residential, January 2014) saw an increase in savings of 665 MWh, but all others saw a decrease. These decreases ranged from 15 MWh up to 427 MWh. As noted, the SWE approves of ADM's MWh and MW savings estimates as the

behavioral protocol of the Evaluation Framework provided no guidance on how to handle the calculation of lag terms when there is insufficient pre-period data.

Table 141: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	1,539	1,500	-39
Residential	July 2012	10,267	10,051	-216
Low-income	January 2014	660	645	-15
Residential	January 2014	7,737	8,401	665
Low-income	December 2014	2,074	1,647	-427
Residential	December 2014	3,017	2,633	-383
Total		25,293	24,878	-415

The issue described in this section is more of a program design issue than an evaluation issue. Homes with insufficient pre-period data should have been filtered out when homes were being selected for the RCT. If such a filter had been applied, then calculating the lag terms would be a straightforward process. For PY9, the SWE recommends Penelec investigate homes with less than twelve months of pre-period data to see if additional billing records are available in FirstEnergy's billing system. If additional billing records are available, they can be included in the impact analysis. If additional billing records are not available, the SWE recommends dropping any homes without at least twelve months of pre-data from the LS model. The monthly impact estimates derived from the model can then be applied to the homes with insufficient pre-period data. (Note that the underlying assumption here is that homes without sufficient pre-period data do not systematically differ from homes with sufficient pre-period data. The SWE believes this is a reasonable assumption.)

Participation Counts

Participant counts are important because these are the totals used to convert the per-home savings estimates produced by the regression model to aggregate program impacts. The SWE's participation count audit began with the calendarized billing data provided by ADM. For any given month/cohort combination, we counted the number of unique Oracle IDs in the billing data. Presumably, the number of unique IDs for the given month/cohort combination would equal the number of participants for that combination. However, this was never the case – the number of unique IDs was less than the reported participation count for each month/cohort combination.

At this point, the SWE turned to the raw, un-calendarized billing data. Because billing cycles can exceed 31 days in length, the SWE took a different approach to calculating participants. Rather than calculate the number of unique IDs within a given cohort/month combination, we calculated the number of unique IDs beyond a certain date. As an illustrative example, suppose we wanted to compute the number of participants in Penelec's 2012 LI cohort for March of 2017 (6,897). We removed any records with a billing end date prior to 3/1/2017, then counted the number of unique

IDs in the remaining records. Using this method, we calculated participant counts that tied up with the reported counts.

Demand Savings

As with energy savings, the SWE calculated demand savings using two approaches – mimic ADM’s approach, then re-run the LS model without any homes with less than twelve months of pre-period data. The results, which mirrored the results for energy savings, are shown in [Table 142](#). On aggregate, the SWE method returned 0.046 MW less in demand savings. The SWE approves the PY8 verified demand savings and recommends ADM runs the LS model without homes that have less than twelve months of pre-period data in the future.

Table 142: Demand Savings Comparison

Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.17	0.17	-0.00
Residential	July 2012	1.13	1.11	-0.02
Low-income	January 2014	0.07	0.07	-0.00
Residential	January 2014	0.85	0.93	0.07
Low-income	December 2014	0.23	0.18	-0.05
Residential	December 2014	0.33	0.29	-0.04
Total		2.79	2.74	-0.05

In reviewing ADM’s methodology, only one issue arose. Step 3 of ADM’s demand savings calculation calls for a regression equation with terms for three different end uses – heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not use the ‘flat’ end use. That said, the results from using just the heat pump and interior lighting end uses are close to what they would be if flat was the only end use included.

F.4.2 Non-Residential Audit Activities

[Figure 62](#) provides a summary of the evaluation activities and M&V approaches utilized by Penelec’s evaluation contractor in their PY8 verified savings calculations. ADM completed site visits for 96% of the evaluation sample; the sites that did not receive site visits were evaluated via billing analysis, which is considered an enhanced rigor method. Basic Rigor was the preferred M&V approach both by energy savings contribution and project count. IPMVP Options A through D were reserved only for projects in the Custom strata.

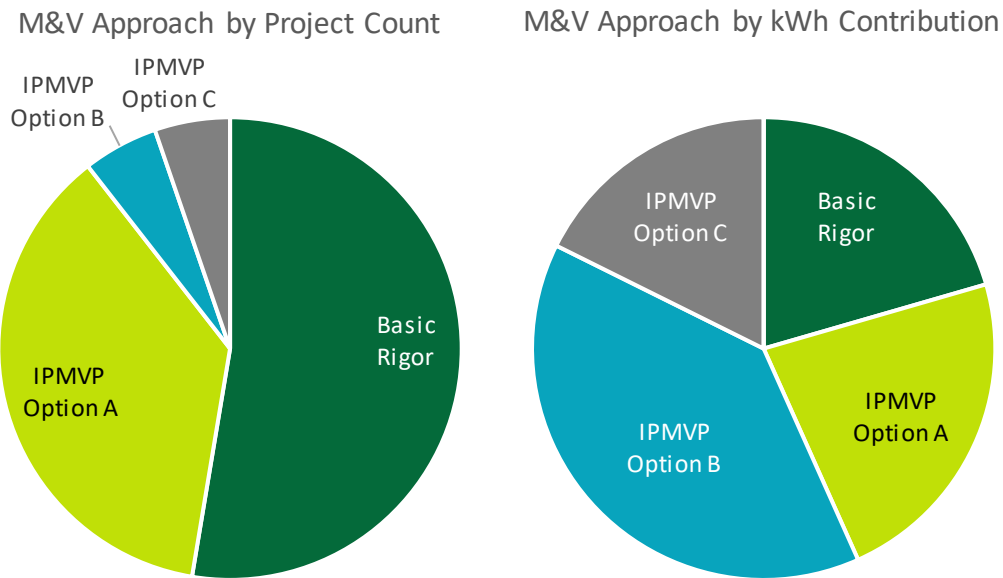
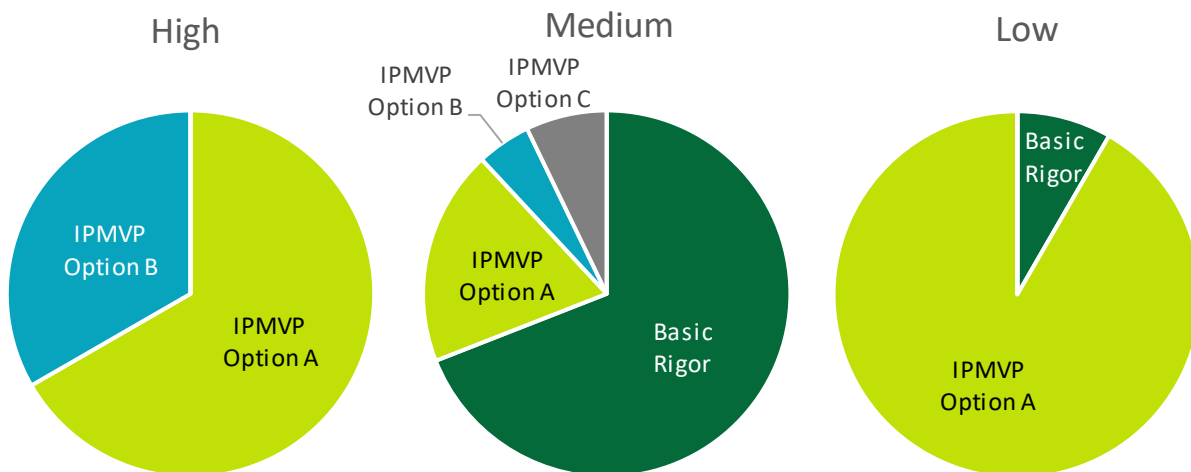
Figure 62: Summary of Penelec's C&I Evaluation Activities

Figure 63 provides a summary of the evaluation activities and M&V approaches Penelec's evaluation contractor used across strata. Penelec's sampling plan consisted of 11 strata, which the SWE binned for the purposes of this comparison. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 63: Summary of Penelec's C&I Evaluation Activities Across Strata

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

F.4.2.1 Ride-Along Site Visits

Table 143 provides an overview of the SWE milestones for the audit of Penelec's site inspection efforts.

Table 143: Penelec Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
9	727,219	2	4	100%

Overall, the SWE agreed with the methodology and calculations completed by Penelec's evaluation contractors. Custom calculation files were sometimes difficult to follow; however, the evaluation contractor was readily available to discuss and update calculations whenever needed. The evaluation contractor's submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. The SWE agreed with all engineering decisions made by the evaluators, which included adjustments to reported savings where HOU values were deemed inappropriate, and adjustments to include interactive effects where they had been excluded in reported savings. Additionally, the SWE commends the evaluation contractor on employing additional evaluation strategies to corroborate verified savings when traditional methods elicit a high degree of uncertainty. Some minor errors were found in a handful of sites, which were all appropriately addressed by the evaluator. More details on the errors found are provided in the following paragraphs.

The SWE provided recommendations for PRJ-1620-L, in which the evaluator noted that the heating fuel was unknown, but used deemed interactive effects allocated to non-electric heating. The SWE recalculated the savings and found the verified savings to be overestimated by 3%. This was found to be an isolated incident and was not a theme throughout the site inspection process.

The SWE and evaluator corresponded heavily on PRJ-1673-L, a project with a high degree of uncertainty in lighting operation schedule. As many values needed to complete an Appendix C calculator were unclear or under contention, the evaluation contractor performed a billing analysis to help stabilize the results from the traditional calculation. Many iterations were performed until both the SWE and evaluator were satisfied with the accuracy of the results. The SWE appreciates the evaluation contractor's collaborative approach to this project. However, it was noted that the site inspector did not discuss possible contributions to a billing analysis that may be irrelevant to the lighting project (e.g., have they changed their thermostat setbacks? Have facility operating hours changed?) with the site contact. Understanding possible contributions to changes in monthly and annual utility bills is crucial to performing a billing analysis. While the billing analysis was not the intended evaluation methodology, the SWE recommends the evaluation contractor ask these questions on-site if there is a possibility a billing analysis will be completed. Additionally, the evaluation contractor could also follow up with a brief phone call to discuss this possibility once the decision to complete a billing analysis has been made.

While the SWE was satisfied overall with the evaluator's final reports and verified savings calculations, SWE inclusion on flagged sites of interest proved to be challenging for ADM, and all evaluation contractors, in PY8. The SWE communicated the deficiencies in the site inspection process with the EDCs and their evaluation contractors via individualized phone conferences with all interested parties and through a guidance memo issued in October of 2017 detailing new tools implemented by the SWE to improve the process moving forward. The suggestions provided in the guidance memo were as follows:

- ADM should submit samples in keeping with their EM&V plan to the SWE as they are drawn for SWE review. The SWE has created a template that should be followed for future submissions to make sure all information needed to select an appropriate sample is included.
- ADM should attempt to coordinate with the SWE in advance of scheduling flagged projects of interest to ensure SWE inclusion.
- ADM should use the SWE's shared cloud-based calendar for scheduling and notification of upcoming site inspections.

F.4.2.2 Verified Savings Desk Reviews

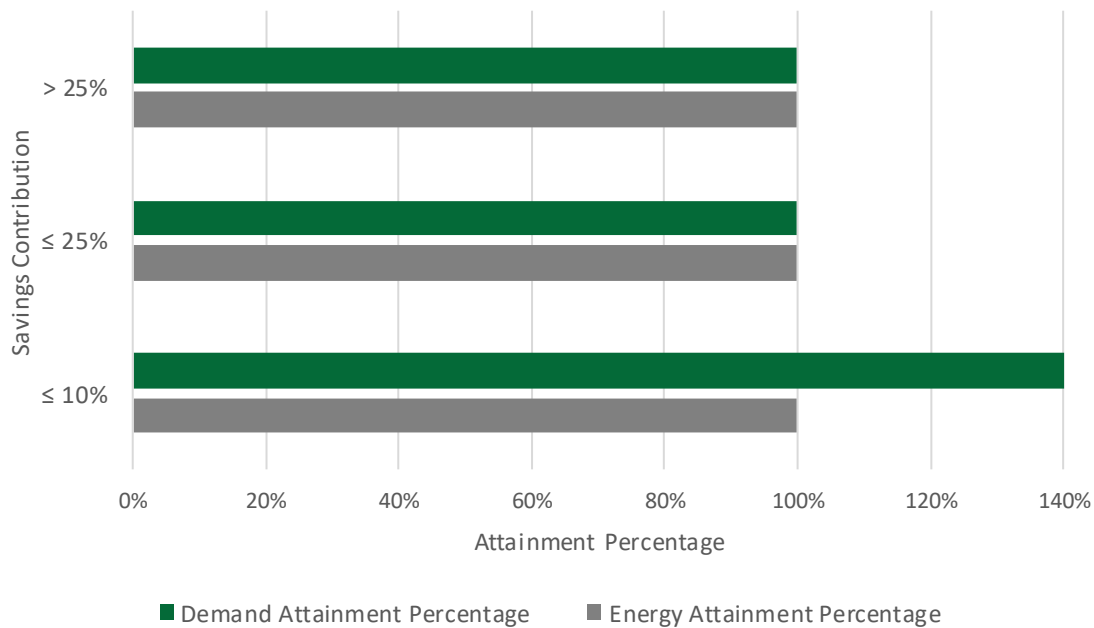
Table 144 provides an overview of the SWE milestones for the verified savings review of evaluated Penelec projects.

Table 144: Penelec Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
8	1,021,504	110	100%	102%

Overall, the SWE found that Penelec's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. The SWE asserts that ADM conducted appropriate M&V efforts, and that sufficient documentation supporting savings analyses was provided.

Of the eight projects reviewed, the SWE calculated adjusted demand savings for only one project, and did not adjust any energy savings. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand savings attainment percentages of Penelec's reviewed projects were 100% and 102%, respectively. The distribution of the attainment percentages by savings contribution is presented in Figure 64, and provides proof that greater scrutiny was applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 64: Penelec Verified Savings Attainment Percentage

In general, lighting projects consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Penelec's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. However, the evaluator has implemented a process for PY9, through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes. The omission of Appendix C calculators had no effect on the attainment percentages, and has already been addressed by the evaluator.

The analysis workbook for project PRJ-1743-A listed appliance model numbers different than those shown in the site visit pictures. However, as the relevant savings algorithm inputs matched between the listed and photographed units, no calculation adjustments were necessary.

The SWE found an error in the calculations for project PRJ-1741-C. This project achieved savings for the installation of Air-Source Heat Pumps (ASHP) and was evaluated using IPMVP Option C. The evaluator ran regression analyses based on cooling degree day (CDD), heating degree day (HDD), and dry-bulb temperature (DBT). The final results were based on all the constituents in a way that provided a non-weather-dependent load shape (i.e., the resulting savings are identical in each month of the year). Note that Table 3-1 of the Evaluation Framework asserts that enhanced rigor consists of "a regression analysis (IPMVP Option C) of consumption information from utility bills with adjustments for weather and overall time period reported." The evaluator then calculated a coincidence factor from the results to account for peak demand savings by comparing the average CDD of the peak period to the max CDD of the peak period. In general, a coincidence factor is used to determine the likelihood that the known change in load of a system will occur within the peak window of 2:00 PM to 6:00 PM, and should be divorced from hours of use and other factors contributing to kWh savings. As the regression analysis resulted in a non-weather-dependent load shape, the values used in the evaluator's analysis are not simple changes in

consumption and, as such, the application of a coincidence factor is inappropriate. Performing a weather-dependent billing analysis would allow for easier calculation of peak coincident demand savings. However, to use the regression model already completed, the SWE adjusted the demand savings based on the calculated energy-to-demand-factor (ETDF). ETDF is a ratio used in several weather-dependent measures within the TRM, and is calculated as follows:

$$\text{ETDF} = \frac{\text{Average Demand}_{\text{Summer WD 2-6 PM}}}{\text{Annual Energy Usage}}$$

For a constant and consistent load, an ETDF will be 8,760; an ETDF higher than 8,760 infers that the load peaks outside of the TRM-defined peak window, while an ETDF lower than 8,760 infers that the load peaks coincidentally with the TRM-defined peak window. An ASHP measure is a cooling measure, and should peak in the summer, causing an ETDF less than 8,760. The evaluator's savings resulted in an ETDF of 40,689. The reported savings were calculated based off of TRM algorithms and resulted in an ETDF of 7,490, which is a more appropriate value for a cooling measure. The SWE adjusted the evaluator's energy savings by the reported ETDF value to recalculate the adjusted demand reduction.

Project PRJ-1957-C was also evaluated using IPMVP Option C. The regression created for this project was better correlated with annual weather data as expected. The verified demand savings were calculated through a regression analysis using an Excel statistical calculator add-on, which reports the results as hard-coded values. It is unclear to the SWE whether the demand savings are reflective of peak demand or change in connected load.

While the review of Penelec's verified savings calculations showed appropriate use of rigor across projects, the SWE makes the following recommendations to ensure the accuracy of project-level verified savings in the upcoming program years:

- ADM should provide more enhanced quality controls to ensure all calculations are sound. Ratios should have like terms in the numerator and denominator; unit analysis should confirm the correct units are obtained for all calculated values; energy and demand savings should fall within expected ranges for the measure of interest.

F.5 NTG

F.5.1 Residential Programs

ADM/Tetra Tech estimated a PY8 NTG for several programs: the Appliance Turn-in Program, the Energy Efficiency Kit component of the Energy Efficient Homes Program, and the Residential Energy Efficient Products Program.

For the Appliance Turn-In Program, ADM/Tetra Tech used primary data collection (participant surveys) to estimate NTG for all appliances in the program though the SWE recommends estimating NTG by measure. NTG was estimated with the recommended UMP appliance recycling protocol. ADM/Tetra Tech created a decision tree that depicted all the program's possible savings scenarios and took the weighted average of the decision tree's values to inform NTG.

For the Energy Efficient Homes Program, ADM/Tetra Tech calculated NTG for the Energy Efficiency Kits component of the program; the kit component of the program was a high-impact measure (HIM). The Energy Efficiency Kits NTG was calculated using data from participant surveys and the common method. FirstEnergy provided Excel workbooks with the raw data from their NTG research and the SPSS syntax files used to calculate the NTGRs from the raw data that allowed the SWE to confirm methodology.

ADM/Tetra Tech assigned the HERs component of the program a NTG of 1, in accordance with the Evaluation Framework, and was not informed by participant surveys, but assumes that the RCT design eliminates free-ridership and produces negligible spillover. A NTG of 0.5 was applied to the Direct Install and New Homes components of the Program. The SWE could not determine the source of the New Homes and Direct Install NTG, and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.

For the Residential Energy Efficient Products Program, ADM/Tetra Tech applied the NTG from Phase II to the upstream Electronics component of the program. The upstream Lighting component NTG was estimated in PY8 and was informed by retailer and customer surveys. ADM/Tetra Tech provided retailer and customer syntax and data allowing NTG and method to be verified by the SWE. The Lighting NTG did not include Delphi panel NTG (as was the preferred method noted in the PY8 Evaluation Plan) or shelf stocking and or sales data analysis. ADM/Tetra Tech noted that the missing NTG estimation methods have not been completed or collected. The SWE recommends vigilance in acquiring pricing data, shelf stocking data, and completing the Delphi panel to avoid further delays that would hinder a more rigorous upstream lighting NTG.

The downstream components of the Program (Residential HVAC initiative and Residential Appliances) were based on customer survey data. NTG was weighted by measure energy savings and were confirmed by the SWE to be calculated with the common method. ADM/Tetra Tech estimated HVAC NTG using self-report data from program participants using the common method recommended in the Evaluation Framework, which was verified by the SWE audit.

Table 145: Summary of NTG Estimates for Penelec Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.57	0.0	0.43	197
Estimated	Upstream Lighting	0.66	0.0	0.34	169 (customers) 16 (retailers)
Estimated	EE Kits	0.20	0.03	0.83	132
RCT	Home Energy Reports	0	0	1	--
Applied	Direct Install and New Homes	--	--	0.50	--
HVAC	Estimated	0.49	0.01	0.52	72

F.5.2 Low-income Residential Programs

ADM/Tetra Tech assigned LIEEP a NTG of one, in keeping with the PY8 Evaluation Plan and SWE Phase III Evaluation Framework.

F.5.3 C&I Programs

ADM/Tetra Tech conducted NTG research in PY8 for the Business Lighting, Business Custom, and Business Prescriptive components of the C&I ES for Business Program for both small and large C&I. ADM/Tetra Tech utilized PY7 NTG ratios for the Business Appliance Turn-in and Business Direct Install components of the ES Program and has stated in the Phase III EMV plan that new NTG research will be conducted in PY9.

ADM/Tetra Tech utilized participant customer and vendor surveys to gather data for the ES Business Lighting component. The sample was stratified by participant MWh usage to capture the impacts of a small number of program participants who represent a large portion of the program savings. The data was then used to estimate NTG for the MWh strata and the overall program NTG. The data and method were reviewed by the SWE and found to be in keeping with the Phase III Evaluation Framework using the common method for estimation. ADM/Tetra Tech employed the same data gathering method utilized in the Lighting component with the Custom component to represent the small group of participants who contributed a large percentage of the overall program component savings. ADM/Tetra Tech had limited success recruiting the largest participants in their research and, to avoid this issue in the future, have proposed including NTG research as part of the rebate application package to ensure greater participation rates and higher levels of confidence. NTG was estimated by usage strata and total program component, and the data and method were in keeping with the Framework and the common method of estimation. The SWE recommends presenting multiple years of Lighting NTG to observe the differences between previous methods and methods including the additional participants. The NTG methodology for the Prescriptive component was identical to the Custom component methodology, and found to be compatible with the Phase III guidelines and the common method. The SWE recommends that ADM/Tetra Tech describe their method of incorporating Program components NTG values to estimate total program NTG for the sake of transparency.

Table 146: Summary of NTG Estimates for Penelec C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Small Energy Solutions for Business Lighting	0.20	0.05	0.85	103
Estimated	Small Energy Solutions for Business Custom	0.44	0.0	0.56	13
Estimated	Small Energy Solutions for Business Prescriptive	--	--	0.43	22
PY7	Small Energy Solutions for Business Appliance Turn-In	--	--	0.43	--
PY7	Small Energy Solutions for Business Direct Install	--	--	0.50	--
Estimated	Small Energy Solutions for Business Total	--	--	0.82	--
Estimated	Large Energy Solutions for Business Lighting	0.20	0.05	0.85	103
Estimated	Large Energy Solutions for Business Custom	0.44	0.0	0.56	13
Estimated	Large Energy Solutions for Business Prescriptive	--	--	0.43	22
Estimated	Large Energy Solutions for Business Total			0.76	

F.6 TRC

Table 147 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penelec's PY8 individual energy efficiency programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY8 annual report.

Table 147: Summary of Penelec's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Appliance Turn-in	1,156	648	1.78	497	648	0.77
Energy Efficient Homes	9,626	6,126	1.57	8,135	5,999	1.36
Energy Efficient Products	1,6916	6,565	2.58	5,853	3,119	1.88
Low-Income Energy Efficiency	3,048	3,504	0.87	3,048	3,504	0.87
C&I Energy Solutions for Business - Small	8,449	6,291	1.34	6,981	5,296	1.32
C&I Energy Solutions for Business - Large	6,485	6,571	0.99	4,986	4,898	1.02
Governmental & Institutional Tariff	283	336	0.84	239	301	0.79
Portfolio Total ¹	45,964	30,041	1.53	29,740	23,765	1.25

¹ Program costs will not sum to Portfolio Total which includes costs from inactive Demand Response programs.

Of Penelec's seven energy efficiency programs offered, four were found to be cost-effective and three were non-cost-effective. Program cost-effectiveness varied by whether gross or net verified savings were used. The Appliance Turn-in program was cost-effective when the TRC was estimated using gross verified savings, but was not when using net verified savings. C&I Energy Solutions for Business – Large Program was cost effective under net verified savings, but non-cost-effective under gross verified savings. The following is a list of cost-effective and non-cost-effective programs.

Gross Verified Savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business – Small

Net Verified Savings

Cost-Effective Programs (TRC > 1):

- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business – Small
- C&I Energy Solutions for Business - Large

Non-Cost-Effective Programs (TRC < 1):

- Low-income Energy Efficiency
- Governmental & Institutional Tariff
- C&I Energy Solutions for Business - Large

Non-Cost-Effective Programs (TRC < 1):

- Appliance Turn-in
- Low-income Energy Efficiency
- Governmental & Institutional Tariff

F.6.1 Additional 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 incremental costs were derived from the PA SWE Database, historic actuals, the Database for Energy Efficiency Resources (DEER), and company assumption and evaluations. The SWE spot checked the incremental costs used in the TRC model and found them to be consistent with Penelec's EE&C plan.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to recreate 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 TRC Order directive for Phase III.
- The SWE found that the cost categories were handled correctly: incentives were not considered TRC costs but administrative costs, incremental costs, and kits were incorporated as costs. The TRC model followed the protocol specified in the 2016 Test Order pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The TRC model reports the cost from increase heating usage due to lighting interactive effects from more efficient lighting as a negative Total NPV Lifetime Non-Electric Benefit. The SWE agrees that the cost should be accounted for as a non-electric benefit rather than a fossil fuel switching program cost.
- The Penelec TRC model accounts for the dual baselines for residential lighting by reducing the EULs to adjust lifetime savings. FirstEnergy notes in their report that their 2016 TRM-compliant TRCs are conservative due to the growing uncertainty of the likelihood of DOE enforcement of EISA 2020 standards and presents gross and net TRCs with and without the dual baseline for comparison. [Table 148](#) shows that without the dual baseline included in the TRC model, the gross and net TRCs are higher than when the dual baselines are included.

Table 148: Penelec Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.53	1.25
Without Dual Baseline	1.69	1.32

The SWE noted a handful of minor issues pertaining to the implementation of the TRC model which are included here. None of the items listed below are cause for concern about the material results of the TRC model, and are noted here as recommendations for adjustments to be made in future PY reporting.

- The PY8 TRC models used the avoided costs of energy and capacity estimated using the method approved in the Phase III EE&C. While the avoided costs in the TRC model appeared to be within reasonable ranges, the SWE was unable to directly compare the costs since the costs were not provided in the Phase III EE&C plan like it had been in prior program years. The SWE recommends an avoided costs table be included in future EE&C plans.
- The SWE verified the measure-specific EULs. The team found that the EULs were mostly consistent with the 2016 TRM. The EUL for Programmable Thermostats are 11 in the 2016 TRM and Penelec's EE&C Plan, but are 15 in the TRC model. The SWE recommends updating the Programmable Thermostat EUL in future PY reporting.
- The TRC model ignores decreased fossil fuel consumption from energy efficient measures that saved space heating and water heating fuel, underestimating the benefits. The SWE recommends accounting for quantifiable water and fossil fuel avoided costs as stated in the 2016 TRM in future PY reporting.
- Penelec used a discount rate of 6.77%, used to calculate the net present value of future program benefits, is slightly lower than the 6.89% that is stated in their EE&C plan. A lower discount rate would result in a higher net present value. Line loss adjustment factors varied by Residential (1.0945), Small C&I (1.072), and Large C&I (1.072) sectors.
- Penelec's EE&C Plan states that the avoided cost data is based on the methodology prescribed in the 2016 TRC and savings values based on the protocols stated in the 2016 TRM. Annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broad peak definition, which are unlike Act 129 peak hours defined in the 2016 TRM. The results are higher on-peak fractions than would otherwise be under the 2016 TRM with energy savings based on seasons. Despite this difference, the avoided costs and load profiles share common definitions. The SWE is convinced the results are sound.

F.7 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including Penelec, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit review described for Met-Ed previously pertains to all four FirstEnergy utilities, including Penelec.

Appendix G Penn Power Audit Detail

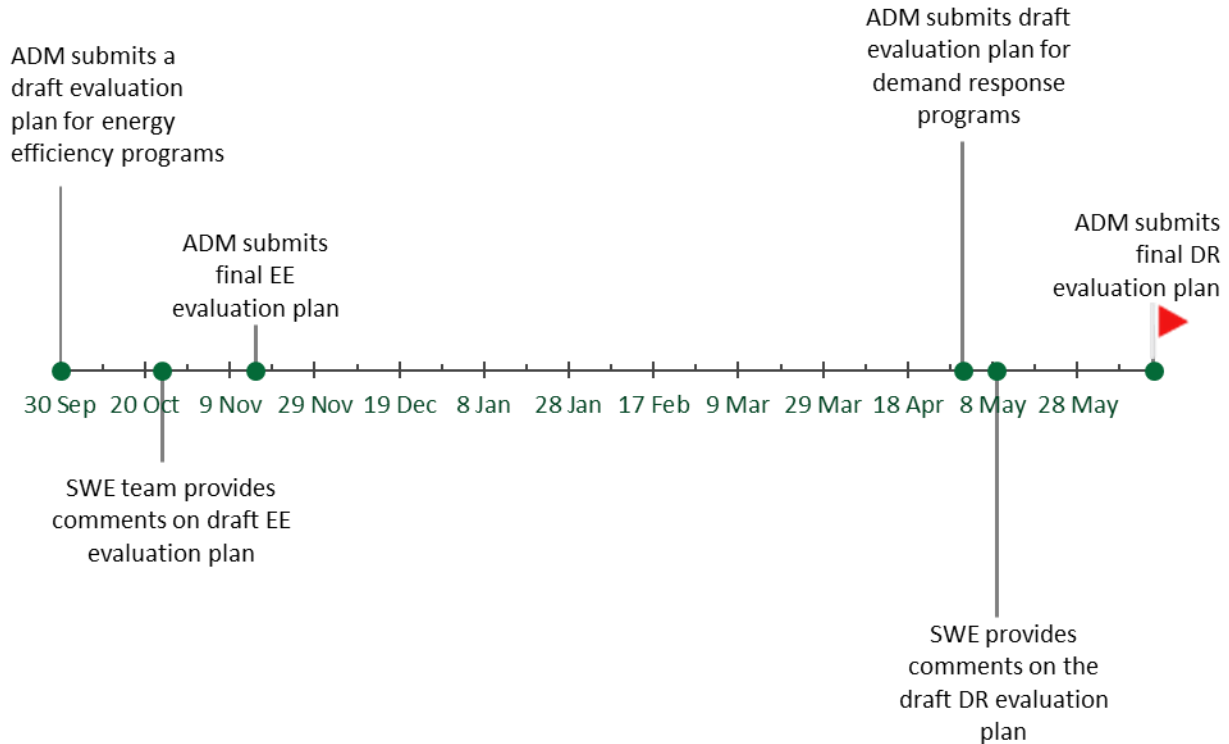
G.1 EM&V PLAN REVIEWS

The four FirstEnergy companies offer a similar portfolio of programs for Phase III of Act 129. Program offerings, measures offered, incentive levels, tracking system, and ICSPs are all determined company wide. Given the similarities across EDCs, FirstEnergy's evaluation contractor, ADM Associates, prepared a single evaluation plan for the four EDCs. EDC-specific considerations were addressed as needed throughout the plan. Penn Power is the smallest EDC subject to Act 129 and this had implications on several areas of the evaluation plan. The most notable difference between Penn Power and the other FirstEnergy companies is in sample sizes. The participation totals are lower in Penn Power service territory and this allows statistical precision targets to be reached with small sample sizes.

Penn Power's EE&C plan programs are organized by sector with separate programs for Small C&I, Large C&I, and Government and Institutional rate classes. The separation between these three programs is dictated by tariffs, but, in practice, the same offerings are available to all non-residential customers regardless of rate code. For evaluation purposes, ADM chose to organize non-residential energy efficiency projects into initiatives by equipment type (Lighting, HVAC, Custom, etc.). The SWE supported this decision to organize non-residential research by equipment category.

ADM's Phase III evaluation plan called for an impact evaluation of each initiative annually. This approach avoids the frequency versus rigor decisions that made up a large part of the plan review process for Duquesne Light and PECO. The FirstEnergy companies' evaluation plan review process was the most efficient in the state because the draft plan submitted to the SWE was detailed, included adequate sample sizes, and was consistent with the major expectations of the Evaluation Framework.

Phase III demand response performance goals begin in PY9, so the evaluation planning process for Penn Power's DR programs lagged the energy efficiency planning. Penn Power has the most AMI penetration of the FirstEnergy companies. The prevalence of interval meters in the residential sector allowed for a Behavioral Demand Response program that was not included for other FirstEnergy EDCs. [Figure 65](#) documents the timing of the major milestones associated with finalizing the Phase III evaluation plan for Penn Power.

Figure 65: Penn Power Evaluation Plan Review Timeline, 2016-17

- Model Selection for Home Energy Reports:** FirstEnergy reduced the number of homes receiving HERs in PY8 compared to Phase II totals. When the equivalence of the new treatment and control groups were assessed in the evaluation plan, some statistically significant differences in consumption during the pre-treatment period were identified. The SWE and ADM worked together on several simulation exercises to determine which regression model specification was best equipped to net out these differences and produce unbiased estimates of HER impacts.
- Estimation Approach for Behavioral DR:** BDR is a relatively new strategy and the expected impacts are very low on a per-customer basis (~ 75 Watts). Early evaluations from other jurisdictions showed that treatment group homes tend to reduce demand on non-event days and event days. The SWE worked through the implication of these findings on regression model specification with ADM during the review of the DR evaluation plan.
- Synthesis of Multiple Methods for NTG and Process:** Several of the key research questions for the NTG and process evaluations had multiple methods proposed. This approach is recommended in the Evaluation Framework, but the SWE requested additional detail on how results would be combined to arrive at conclusions.
- Low-Income Considerations:** Some offerings are delivered to both residential and residential low-income customers. The SWE requested clarification in several places on how savings from low-income participants would be separated from the residential class.

- **Mechanics of the Non-Residential Certainty Stratum:** For the largest C&I projects, ADM works alongside the ICSP to integrate M&V into the program delivery. In these cases, there is no reported savings estimate – ADM just calculates the gross verified savings. Because of the alternate process, the projects must be quarantined in the extrapolation of program savings from the evaluation sample. Certainty project results do not factor into the realization rate calculation for smaller strata where sampling is used.

In addition to reviewing FirstEnergy's evaluation plan, the SWE reviewed eleven survey instruments and one interview guide. Nine of these instruments were for residential programs while three were for C&I programs. The surveys and interviews addressed process, impact, and NTG topics.

G.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative." For 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 because of program delivery method or technology supported.

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. For example, projects from the three non-residential energy programs (C&I Energy Solutions for Business – Small, C&I Energy Solutions for Business – Large, and Government & Institutional Tariff) were assigned to one of five solutions.

- C&I Lighting
- C&I Custom
- C&I Prescriptive
- C&I Appliance Turn-In
- C&I Direct Install (minimal savings in PY8 – no evaluation sample)

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than the tariff-based program definitions, which each include the same mix of measures. It is also a more efficient sample design because lighting projects are more likely to

share similar characteristics across the Small C&I, Large C&I, and Government programs than a heterogeneous mixture of measures from a single program definition.

Table 149 lists evaluation initiatives along with the relative precision of the PY8 gross verified savings estimate at the 85% confidence level.

Table 149: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level ($\pm$)
Appliance Turn-In	6.0%
Low-Income ATI	10.4%
Kits	4.5%
Low-Income Kits	11.6%
C&I Lighting	8.5%
C&I Custom	3.4%
C&I Prescriptive	4.1%
Upstream Lighting	10.2%
C&I ATI	9.8%
Residential HVAC	8.7%
Residential Appliances	8.6%
Low-Income Appliances	12.3%
Residential Direct Install	18.3%
Low-Income Direct Install	9.8%
Residential New Construction	12.0%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants so there is no uncertainty associated with sampling. 14 of the 15 sampling initiatives shown in Table 149 produces verified gross savings estimates of better than $\pm 15\%$ precision at the 85% confidence level. The relative precision of the Residential Direct Install verified gross savings estimate is greater than $\pm 15\%$ in isolation, but the full Direct Install initiative (residential + low-income) meets the 85/15 requirement so the SWE has no concerns about the sample design.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of ADM's PY8 verification activities is discussed in detail in Appendix G.4.

G.3 REPORTED GROSS SAVINGS AUDITS

G.3.1 Tracking Data Review

This section summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penn Power's PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program
- Incentive dollars for each program

The SWE leveraged Penn Power's PY8 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request.

G.3.1.1 Audit Findings

Table 150 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Penn Power's PY8 Annual Report and 'No' otherwise. The SWE was able to replicate energy savings for each of Penn Power's programs.

Table 150: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	1,288	1,288	Yes
Energy Efficient Homes	10,902	10,902	Yes
Energy Efficient Products	6,202	6,202	Yes
Low-Income Energy Efficiency	3,280	3,280	Yes
C&I Energy Solutions for Business – Small	8,703	8,703	Yes
C&I Energy Solutions for Business – Large	3,046	3,046	Yes
Governmental & Institutional Tariff	1,424	1,424	Yes
Portfolio Total	34,846	34,846	Yes

Table 151 summarizes the SWE's findings regarding reported gross peak demand savings by program. Like with energy savings, the SWE was only able to replicate demand savings for each of Penn Power's programs.

Table 151: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.16	0.16	Yes
Energy Efficient Homes	1.72	1.72	Yes
Energy Efficient Products	0.75	0.75	Yes
Low-Income Energy Efficiency	0.43	0.43	Yes
C&I Energy Solutions for Business – Small	1.41	1.41	Yes
C&I Energy Solutions for Business – Large	0.29	0.29	Yes
Governmental & Institutional Tariff	0.06	0.06	Yes
Portfolio Total	4.83	4.83	Yes

Table 152 summarizes the SWE's findings regarding program participation. The SWE was able to replicate participation counts for all programs except for one – LIEE. For LIEE, the two data sources provide directionally similar participation counts.

Table 152: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	1,167	1,167	Yes
Energy Efficient Homes	40,404	40,404	Yes
Energy Efficient Products	67,382	67,382	Yes
Low-Income Energy Efficiency	7,841	7,488	No
C&I Energy Solutions for Business – Small	249	249	Yes
C&I Energy Solutions for Business – Large	18	18	Yes
Governmental & Institutional Tariff	186	186	Yes
Portfolio Total	117,247	116,894	No

Finally, [Table 153](#) summarizes the SWE’s findings regarding incentive dollars. Of the seven programs for which Penn Power reported non-zero incentive dollars in their annual report, the SWE was able to match (or nearly match) the incentives for four programs: the Low-Income EE, Governmental & Institutional Tariff, Appliance Turn-in, and C&I Energy Solutions for Business – Large. For the EE Products and Small C&I Energy Solutions programs, incentive dollars in the tracking data were directionally similar to the incentive dollars in Penn Power’s Annual Report. Additionally, the sum of the incentives for these two programs is \$862,000 in the annual report and \$864,000 in the tracking data. The difference at the program level is explained a product of upstream lighting cross-sector sales findings. FirstEnergy moves money between EE Products and Small C&I Energy to avoid cross subsidization between residential and commercial sectors, so we are not concerned about the differences in financials for these programs. It is a necessary change to ensure equitable cost recovery across rate classes.

For the EE Homes program, the two data sources differ by over \$600,000. The SWE believes this difference can be explained by EE&C kits. Penn Power notes that the incentive dollars shown in their annual report include direct install equipment costs and costs for EE&C kits. The kit costs are not in the tracking data. Indeed, the incentive amount that Penn Power has earmarked for kits in their PY8 EE&C plan is \$537,500. Ignoring this program, the portfolio totals for the two data sources line up well – \$1,191,000 in the tracking data and \$1,190,000 in the annual report.

Table 153: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	\$65	\$64	Yes
Energy Efficient Homes	\$826	\$222	---
Energy Efficient Products	\$350	\$372	No
Low-Income Energy Efficiency	\$23	\$23	Yes
C&I Energy Solutions for Business – Small	\$512	\$482	No
C&I Energy Solutions for Business – Large	\$168	\$168	Yes
Governmental & Institutional Tariff	\$72	\$72	Yes
Portfolio Total	\$2,016	\$1,412	---

G.3.1.2 Action Items

For all of Penn Power's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. For all programs except for LIEE, the SWE was able to replicate participation counts via the tracking data. For LIEE, the two data sources provide directionally similar participation counts. For six of the seven programs for which Penn Power reported non-zero incentive dollars, the SWE was able to calculate directionally similar incentive dollars via the tracking data extract. The portfolio totals for these six programs line up almost exactly. The difference could be a matter of rounding.

The SWE's only concern at this point is being able to replicate incentive dollars for the Energy Efficient Homes program. The SWE acknowledges that the discrepancy is due to the costs of the EE kits being correctly treated as incentives, and we do not view this as a major issue.

G.3.2 Project File Reviews

G.3.2.1 Residential¹²⁴

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 projects for PY8 using the project documentation provided by the evaluation contractor, ADM, in response to the SWE's standing quarterly data request. The

¹²⁴ The SWE also conducted a database review of Penn Power's quarterly tracking data to verify that Penn Power was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

project file packages included savings calculation worksheets, rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages included all documentation requested.

Project file documentation for all residential programs were generally well organized, but occasionally revealed inconsistencies with the tracking data. [Table 154](#) presents an overview of the results of the SWE's residential project file reviews. Note that [Table 154](#) includes project file reviews for all FirstEnergy EDCs. All comments and recommendations are similar in nature between all four FirstEnergy EDCs, when the findings of the project file review were consistent.

Table 154: Penn Power PY8 Residential Project File Review Summary

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?
Appliance Turn In	ATI	12	✓	✓	✓	✓
Energy Efficient Homes	New Homes	8	✓	✓	✓	✓
Energy Efficient Products	Appliances	8	✓	✓	✓	✓
Energy Efficient Products	Lighting	16	✓	✓	✓	✗
Energy Efficient Products	HVAC	8	✓	✓	✓	✓
Low-Income EE Program	New Homes	1	✓	✗	✓	✓
Low-Income EE Program	Appliances	8	✓	✓	✓	✓
Low-Income EE Program	ATI	4	✓	✓	✓	✓
Low-Income EE Program	Weatherization	8	✓	✓	✓	✓

As outlined above, an adequate number of project files and the supporting details were submitted for the residential program. Below is a summary of the project file reviews, including the few issues or discrepancies found between project files and tracking data.

For the New Homes Program, the project files were easily found within the tracking data; however, there was insufficient information to verify the rebated amount. The SWE could not determine whether the rebate was based on HERS Score, percent of savings over UDRH, or kWh saved.

There were minor issues found within the Low-Income Weatherization program. The SWE matched the project files with the tracking data for the following measures: lighting, faucet aerators, low flow showerheads, and smart power strips. However, for insulation, air sealing, and appliance replacement measures, the SWE could not match the project files to the tracking data and therefore could not verify the accuracy of the tracking database for these measures.

The following issue applies generally to the residential project files, but it is specifically noted in the review of the Appliance Turn-In and HVAC programs. The Account IDs listed in the project files were not listed accurately in the tracking data which made it difficult to match the projects to the data. It appeared that, at times, the fields in the tracking data containing the IDs had been rounded and were no longer able to be identified with the project file ID. The SWE was ultimately able to locate the project within the tracking data by using other information found in the project files, such as name and address. However, this is a time-consuming process.¹²⁵

While the PY8 review of residential project files found project file packages to be typically well-organized, the SWE found several instances of missing or inaccurate data. To ensure the accuracy of reported savings in upcoming program years, the SWE makes the following recommendations:

- Submitting project files and a matching sample of tracking data for each program, including a unique identifier to easily match data to the files.
- More clarity on how rebate amounts are calculated, specifically for the New Homes program.

G.3.2.2 Non-residential

The SWE reviewed Penn Power's C&I projects for PY8 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 project file packages included all documentation requested, with the exception of lighting projects, which consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Penn Power's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. However, the evaluator has implemented a process for PY9, through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes.

¹²⁵ ADM is working with CSPs to use an alternative matching key, such as rebate number, for PY9 and beyond.

Project files were generally well organized, but revealed a handful of issues impeding the SWE's ability to verify the reported savings. [Table 155](#) presents an overview of the results of the SWE's C&I project file reviews.

Table 155: Penn Power PY8 C&I Project File Review Summary

Project Number	Project Description	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?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
FESPPS1534043561	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043598	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534095884	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534074049	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534074060	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043585	Ice machine	✓	✓	✓	✓	✓	-
FESPPS1534363722	ECM	✓	✗	✓	✗	✓	-
FESPPS1534215457	Vacuum pump, heater, VFD-cooling	✓	✓	✓	✗	-	✗

A review of the project files revealed two issues impeding the SWE's ability to either understand or appropriately validate the reported savings. Specific issues aside from the missing Appendix C calculators are addressed individually by project below.

Project files for FESPPS1534363722 included two iterations of savings calculations. A file named "Custom Calculator REV1" detailed all the calculations with formulas intact, the end results of which did not match the reported savings in Penn Power's quarterly tracking data. A second file named "Custom Calculator REV2" displayed a reported savings value that did match the value in the tracking database; however, the values in this file were all hard-coded and could not be validated by the SWE.

Project FESPPS1534215457 included several custom measures for which there were no TRM algorithms. One measure detailed was the installation of a vacuum pump. The implementer calculated the energy consumption of the efficient vacuum pump as *rated power * % speed * 1.029*. Without a reference or supporting documentation for the equation, specifically the need for the undefined constant of 1.029, the SWE could not validate the reported savings.

The SWE PY7 annual report submits that Penn Power exhibited marked improvement in the consistency, orderliness, and organization of projects from previous years. The project documentation for PY8 was generally well organized, with necessary documentation provided for all projects excluding lighting projects. However, PY8 project files provide the SWE with cause for concern as custom calculations do not provide insight into formulas or describe the method of calculation. To ensure the accuracy of reported savings in upcoming program years, the SWE recommends more thorough audits of the methodology for custom calculations be performed to ensure savings calculations are logical and appropriate.

G.4 VERIFIED GROSS SAVINGS AUDITS

G.4.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the Pennsylvania Power portfolio of residential programs. Pennsylvania Power's portfolio of Residential programs includes the following: The Appliance Turn-In Initiative, The Energy Efficient Homes Initiative, The Energy Efficient Products Initiative, and the Low-Income Energy Efficiency Initiative. Each program contains various subprograms, which are addressed separately below in tables and text as needed. Note that the SWE reports the residential savings into the three following sections: upstream lighting, residential non-lighting, and behavior.

Overall, the verified savings followed proper TRM protocols and the verified savings are accurate. The SWE identified the evaluation activities that were used to verify savings for the residential programs. [Table 156](#) provides a summary of the evaluation and M&V approaches used by Penn Power in their PY8 verified savings calculations. [Table 157](#) provides a summary of discrepancies

that were discovered during the SWE audits of verified savings. Note that all the discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.¹²⁶

Table 156: Residential Program Evaluation Activities – Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review ^a	Billing Analysis	Applied PY7 RR
Appliance Turn-In (LI & Non-LI)	✓	--	✓	--	--
EE Kits (LI & Non-LI)	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	--	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting	✓	--	✓	--	--
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓		✓		
Low-Income WARM	--	✓	✓	✓	--

Table 157: Residential Program Verified Savings Discrepancies – Penn Power

Program/ Subprogram	Measure	Discrepancy	The SWE Recommendation
Appliance Turn-In (LI & Non-LI)	Dehumidifiers	Possible EDC gathered data quality issues, not used for savings calculations	Review data collection process for measure, incorporate gathered values in future PYs
Appliances	ENERGY STAR Clothes Washers	Outdated TRM default applied	Use correct/up-to-date TRM values

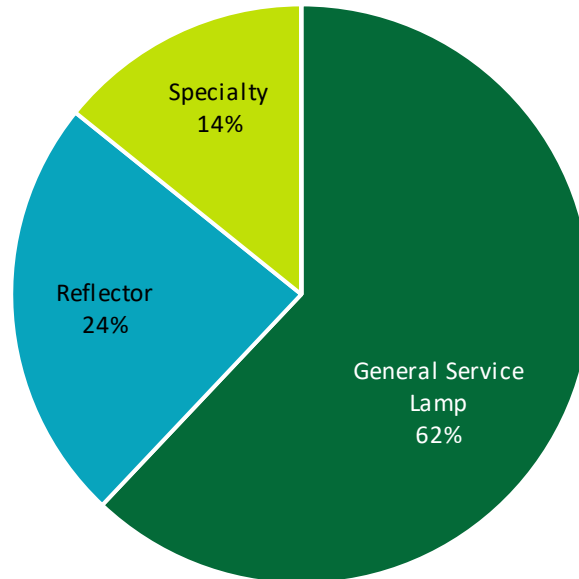
G.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 180 thousand efficient light bulbs and fixtures through Penn Power's PY8 upstream lighting program. [Figure 66](#) displays the distribution of sales by product type. Over

¹²⁶ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

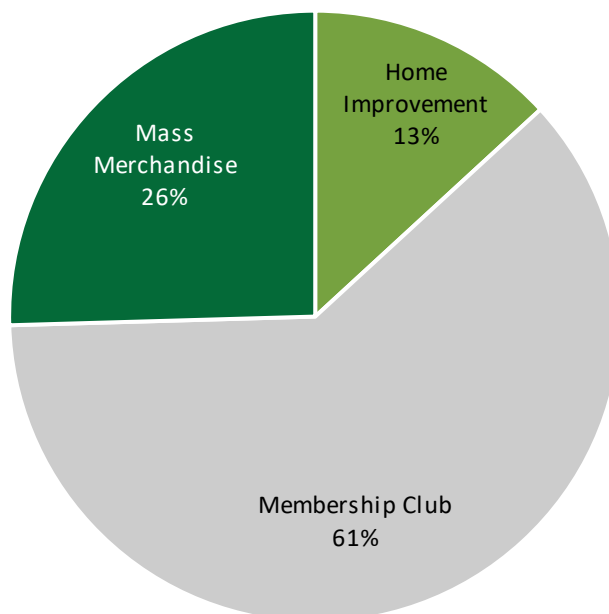
one-half (62%) of the products were general service lamps, while nearly one-quarter (24%) were reflectors.

Figure 66: Penn Power PY8 Upstream Lighting Sales by Product Type



Over one-half (61%) of Penn Power's PY8 upstream light bulbs and fixtures were sold through membership clubs, and over one-quarter (26%) were sold through mass merchandise stores (Figure 67).

Figure 67: Penn Power PY8 Upstream Lighting Sales by Retail Channel



G.4.1.1.1 Audit Findings

The SWE reviewed the data in Penn Power's tracking system to verify that ADM used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with ADM's verified gross savings for the Upstream Lighting Initiative.

The SWE observed 301 unique lighting model numbers in the PY8 tracking system, and was able to locate 232 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The 69 models the SWE was not able to verify as ENERGY STAR certified represent 28% of both bulbs sold and verified savings from upstream lighting. FirstEnergy had included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. However, TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. The SWE sent FirstEnergy a memo in October of 2017 recommending that beginning in PY9, the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products. According to FirstEnergy, its companies stopped rebating non-ENERGY STAR LEDs in PY9.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for all but one model. The team confirmed that ADM used the appropriate algorithms, interactive effects, ISR, residential HOU, and residential coincidence factor to calculate kWh and kW savings. The team found that ADM assigned baseline wattages were in accordance with TRM protocol 2.1.1 for all but three decorative models, which were mistakenly classified as EISA exempt. Combined, the impact of all discrepancies the SWE identified on initiative-level savings is negligible (less than two-tenths of 1%).

G.4.1.1.2 Cross-Sector Sales

ADM estimated 8.3% cross-sector sales for the combined FirstEnergy companies based on a general population survey. Survey respondents were asked how many bulbs they purchased and if they installed them in a residence, business, or both. Unfortunately, the survey was not designed to capture the proportion of residential versus commercial installations for the subset of respondents who reported installing bulbs in both a residence and a business (6% of respondents), necessitating a follow-up call to gather this information. ADM computed a weighted average HOU of 1,821 and coincident factor of 0.32 by mapping survey respondents' business types to the building types listed in Table 3-5 of the TRM.

G.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Ensure that all products are ENERGY STAR qualified.
 - FirstEnergy included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility

requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.¹²⁷

- Edit the general population survey so that in future program years, the proportion of bulbs installed in residences and businesses for respondents who claimed to install bulbs in both locations can be gathered during the survey without the need for a follow-up call.

G.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

G.4.1.2.1 Energy Efficient Homes Program

The SWE audited each of the four components of the Energy Efficient Homes Program: Energy Efficiency Kits (EE Kits, including low-income), HERs, Residential Direct Install, and New Homes by using the gross impact data submitted by FirstEnergy. Note that the SWE's audit of the HERs is reported in [Section G.4.1.3](#) of this appendix. The SWE audited the New Homes sample that was used to determine a realization rate for the sub-program. The audit included a review of REM/Rate models and, as specified in the 2016 TRM, application of 2016 TRM savings to ENERGY Star lighting and appliance measures used to verify savings. Overall, the SWE audits concluded that the correct TRM algorithms were applied and the verified savings were correct for all program kits, direct install measures, and new homes. The SWE noted a minor discrepancy between the survey sample size reported in the annual report and the survey sample size identified in the raw data provided by FirstEnergy for all program kits. ADM clarified the discrepancy, noting that they applied a 200-day cut-off, removing survey responses that were completed more than 200 days after the kit receipt date. In addition, respondents within the 200-day cut-off who could not remember receiving a kit were also removed from the reported survey sample.

G.4.1.2.2 Energy Efficient Products Program

Each component of the Energy Efficient Products (EEP) Program was audited by the SWE including appliances, HVAC equipment, and consumer electronics. Note that the SWE's audit of the upstream lighting portion of the EEP Program is reported in [Section G.4.1.1](#) of this appendix. The SWE audits of the consumer electronics portion of the program verified that correct TRM algorithms were used and the verified savings were correct.

The SWE audits of the HVAC measures included in the program found that nearly all of the verified savings were correct. However, minor discrepancies were found for ground source heat pumps (GSHPs) regarding adherence to correct TRM algorithms. The audit concluded that two GSHP systems were of commercial capacity based on their cooling capacity, but the savings calculations did not correctly follow the commercial GSHP algorithm in the TRM; data for two variables requiring EDC collection, necessary for TRM-based calculations, were missing from the

¹²⁷ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8.

FirstEnergy data. This situation is a grey area as the commercial GSHP measure in the TRM is for non-residential settings. In discussions with the SWE, ADM proposes a potential baseline of two residential ASHPs in cases moving forward. The SWE agrees this is likely a reasonable approach and recommends working with ADM to develop an IMP if this becomes a more popular measure in residential settings.

The SWE audit also discovered an incorrect application 2016 TRM deemed value for ENERGY Star Clothes Washers. The savings calculation used for verified savings was using an outdated cycle per year value. The SWE notes that the GSHP and ES Clothes Washer error accounted for less than 1% of measure level savings, and had a negligible impact on program and portfolio level savings. The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

G.4.1.2.3 Low-Income WARM Program

The Low-Income WARM Program is a low-income direct install initiative offering similar measures across three sub-programs: WARM-Plus, WARM-Extra Measure, and WARM-Multifamily. The WARM program includes LED lighting, smart power strips, domestic hot water measures, HVAC heating and cooling measures, refrigerator and freezer replacement and recycling, insulation, air sealing, and duct sealing. The SWE audited all measures included in the program using the full downstream dataset and the survey sample subset provided by FirstEnergy. SWE found that the correct TRM-approved methods were followed, survey sample sizes were correct, and the reported verified savings were correct.

G.4.1.2.4 Appliance Turn-In Program (Low-Income and Non-Low-Income)

The Appliance Turn-In Program is divided into low-income and non-low-income stratum, each offering turn-in options for refrigerators, freezers, room air conditioners, and dehumidifiers. The SWE audited EDC-provided data for each measure offered by the non-low-income and low-income strata of the program. Dehumidifiers were a newer addition to the turn-in program and used an approved IMP for savings calculations, while refrigerator, freezer, and room air conditioner turn-ins utilized TRM algorithms to determine savings. Auditors determined that the reported savings for all measures were correct, and that in almost all cases calculations correctly followed the relevant TRM and IMP algorithms and guidelines.

For dehumidifier turn-ins, auditors noticed that an outdated IMP default value for the Wilkes-Barre area was applied to Williamstown and Scranton, though this did not affect savings in an appreciable way. Also regarding dehumidifiers, auditors noticed that 68% of dehumidifiers in the sample were recorded in the EDC data collection process as having 10 pints of capacity, which stuck out as a possible data collection error. The SWE agrees with ADM's decision to use default IMP values for all dehumidifiers when calculating savings rather than using what is likely to be faulty data. while allowed by the IMP. The SWE recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.

G.4.1.3 Behavior

Approximately 20% of Penn Power's verified gross energy savings for PY8 came from Home Energy Reports issued to around 28,000 residential and residential-LI households. The SWE

reviewed ADM's methodology and accepts their verified MWh and MW savings values for Penn Power's HER offering in PY8. By cohort, [Table 158](#) shows average kWh savings and average percent savings per participant in PY8. Note that the 'Number of Participants' column shows the average number of participants during PY8.

Table 158: Average PY8 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY8 kWh Savings	Average PY8 % Savings
Low-income	July 2012	2,296	228	1.85%
Residential	July 2012	18,100	219	1.79%
Low-income	January 2014	945	294	1.78%
Residential	January 2014	7,491	376	2.21%

The following sections highlight some of the more important audit findings: errors in the coding of “pre” and “post” indicator variables, the calculation of lag terms, missing eligibility filters, and duplicating participant counts.

Pre- and Post-Coding Errors

In reviewing the HER billing data, the first item that the SWE checked was the coding of the pre- and post-indicator variables. For a given cohort, all months prior to the billing cycle in which the randomized controlled trial (RCT) starts should be coded as pre = 1 and post = 0, and all months after the billing cycle in which the RCT starts should be coded as pre = 0 and post = 1. When reviewing the distribution of the pre- and post-indicator variables, the SWE noticed one issue. For both 2012 cohorts (residential and low-income), there was an error in the coding of the post indicator variable. In December of 2013 and January of 2014, the post indicator variable was set equal to 0, though it should have been 1. (Note that the pre-indicator variable was coded correctly for these cohorts.) Because the lagged seasonal (LS) model is a post-only model, these records were being left out of the regression.

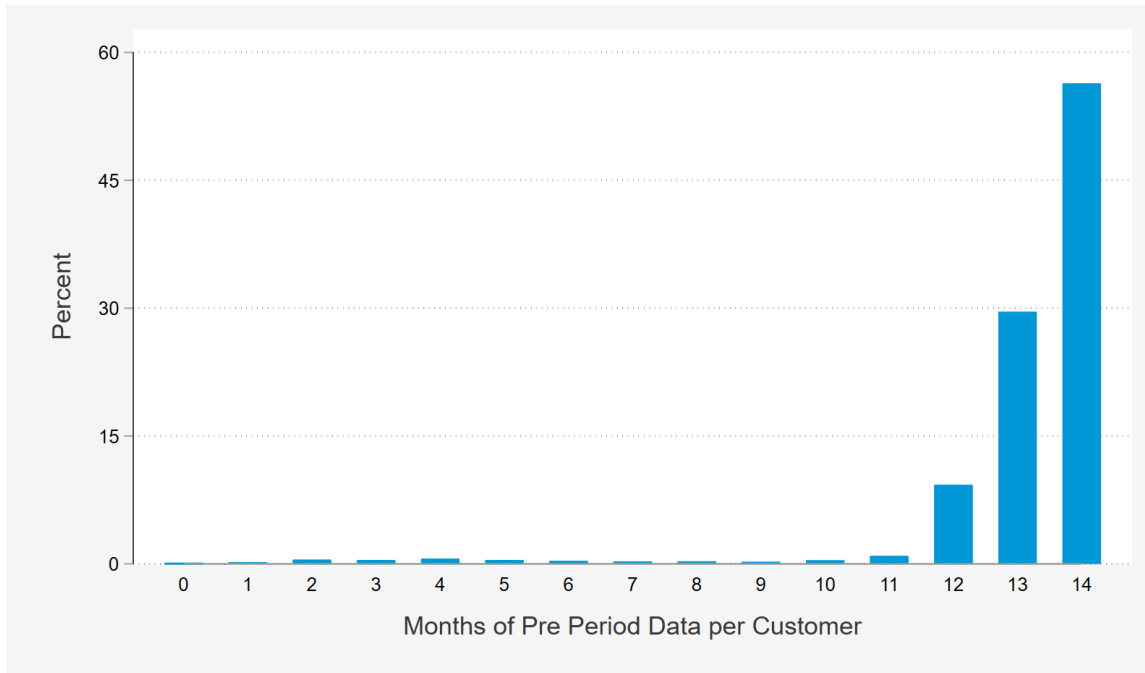
The SWE informed ADM about this issue, and ADM was able to update the numbers in their PY8 annual report before the report was submitted to the PUC. After fixing the coding issues, verified savings for Penn Power increased by 2 MWh – a 3 MWh increase for low-income cohorts and a 1 MWh decrease for residential cohorts. This was only possible because ADM submitted their data well in advance of the data request deadline.

Calculating Lag Terms

As noted, the LS regression model is a post-only model – only records from the post period are used in the regression. That said, some of the explanatory variables in the model are calculated based on pre-period data: (1) average daily consumption in the pre-period, (2) average daily consumption during the summer in the pre-period, and (3) average daily consumption during the winter in the pre-period. For a number of homes, there was not enough pre-period data to calculate these lag terms. [Figure 68](#) shows the distribution of the number of months of pre-period data per customer. Across all Penn Power cohorts, 4.8% of homes had less than twelve months of pre-period data, 2.6% of homes had less than seven months of pre-period data, and 0.3% of

homes had less than two months of pre-period data. Note that these percentages are substantially higher for the other FirstEnergy companies.

Figure 68: Number of Pre-period Months per Customer



The limited amount of pre-period data for some homes raises two issues:

1. An eligibility screen should have filtered these homes out of the RCT. The number of homes with no more than six months of pre-period data is not insignificant. Some homes even had zero months of pre-period data. Sufficient pre-period data is a key component of an unbiased impact evaluation.
2. How should the lag terms be calculated? As an example, suppose the only months of pre-data for a customer are April, May, and June. (This was the case for several participants.) The average winter usage in the pre-period for this customer is not known, thus this customer should have fallen out of the regression model. Instead, Oracle used average daily usage for April–June as the lagged winter variable (average daily consumption during the winter in the Pre-period). As another example, some customers had just one month of pre-period data – November. The average pre-period summer usage for these customers is not known, but Oracle used average daily usage in November as the lagged summer variable (average daily usage during the summer in the pre-period).

The SWE performed savings calculations using two approaches. First, to replicate ADM's savings values, we used Oracle's lag terms. After replicating ADM's savings values, the SWE dropped any participant without at least twelve months of pre-period data and re-ran the LS model for each cohort. Regression estimates were then used to calculate savings in exactly the same manner that ADM calculated savings (i.e., identical participant counts and adjustments were used). [Table 159](#) shows the results by cohort. On aggregate, the SWE estimate was approximately 187 MWh greater than the ADM estimate. Three of four cohorts saw an increase in MWh savings, ranging

from 17 MWh to 121 MWh. The fourth cohort saw a minimal decrease of 1 MWh. As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework provided no guidance on how to handle the calculation of lag terms when there is insufficient pre-period data.

Table 159: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	523	522	-1
Residential	July 2012	3,968	3,985	17
Low-income	January 2014	278	398	121
Residential	January 2014	2,819	2,869	51
Total		7,587	7,774	187

The issue described in this section is more of a program design issue than an evaluation issue. Homes with insufficient pre-period data should have been filtered out when homes were being selected for the RCT. If such a filter had been applied, then calculating the lag terms would be a straightforward process. For PY9, the SWE recommends Penn Power investigate homes with less than twelve months of pre-period data to see if additional billing records are available in FirstEnergy's billing system. If additional billing records are available, they can be included in the impact analysis. If additional billing records are not available, the SWE recommends dropping any homes without at least twelve months of pre-data from the LS model. The monthly impact estimates derived from the model can then be applied to the homes with insufficient pre-period data. (Note that the underlying assumption here is that homes without sufficient pre-period data do not systematically differ from homes with sufficient pre-period data. The SWE believes this is a reasonable assumption.)

Participation Counts

Participant counts are important because these are the totals used to convert the per-home savings estimates produced by the regression model to aggregate program impacts. The SWE's participation count audit began with the calendarized billing data provided by ADM. For any given month/cohort combination, we counted the number of unique Oracle IDs in the billing data. Presumably, the number of unique IDs for the given month/cohort combination would equal the number of participants for that combination. This was the case for approximately half of the month/cohort combinations. For the other month/cohort combinations, the number of unique IDs was less than the reported number of participants. Differences ranged from 1 to 6. Note that differences for the other FirstEnergy EDCs were significantly larger.

At this point, the SWE turned to the raw, un-calendarized billing data. Because billing cycles can exceed 31 days in length, the SWE took a different approach to calculating participants. Rather than calculate the number of unique IDs within a given cohort/month combination, we calculated the number of unique IDs beyond a certain date. As an illustrative example, suppose we wanted to compute the number of participants in Penn Power's 2012 LI cohort for March of 2017 (2,252).

We removed any records with a billing end date prior to 3/1/2017, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that tied up with the reported counts.

Demand Savings

As with energy savings, the SWE calculated demand savings using two approaches – mimic ADM’s approach, then re-run the LS model without any homes with less than twelve months of pre-period data. The results, which mirrored the results for energy savings, are shown in [Table 160](#). On aggregate, the SWE method returned an additional 0.021 MW in demand savings. The SWE approves the PY8 verified demand savings and recommends ADM runs the LS model without homes that have less than twelve months of pre-period data in the future.

Table 160: Demand Savings Comparison

Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.06	0.06	0.00
Residential	July 2012	0.44	0.44	0.00
Low-income	January 2014	0.03	0.04	0.01
Residential	January 2014	0.31	0.32	0.01
Total		0.84	0.86	0.02

In reviewing ADM’s methodology, only one issue arose. Step 3 of ADM’s demand savings calculation calls for a regression equation with terms for three different end uses – heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not use the ‘flat’ end use. That said, the results from using just the heat pump and interior lighting end uses are close to what they would be if flat was the only end use included.

G.4.2 Non-Residential Audit Activities

[Figure 69](#) provides a summary of the evaluation activities and M&V approaches utilized by Penn Power’s evaluation contractor in their PY8 verified savings calculations. ADM completed site visits for 98% of the evaluation sample; the site that did not receive a site visit was evaluated via billing analysis, which is considered an enhanced rigor method. Basic Rigor was the preferred M&V approach both by energy savings contribution and project count. IPMVP Options A through D were reserved only for projects in the Custom strata.

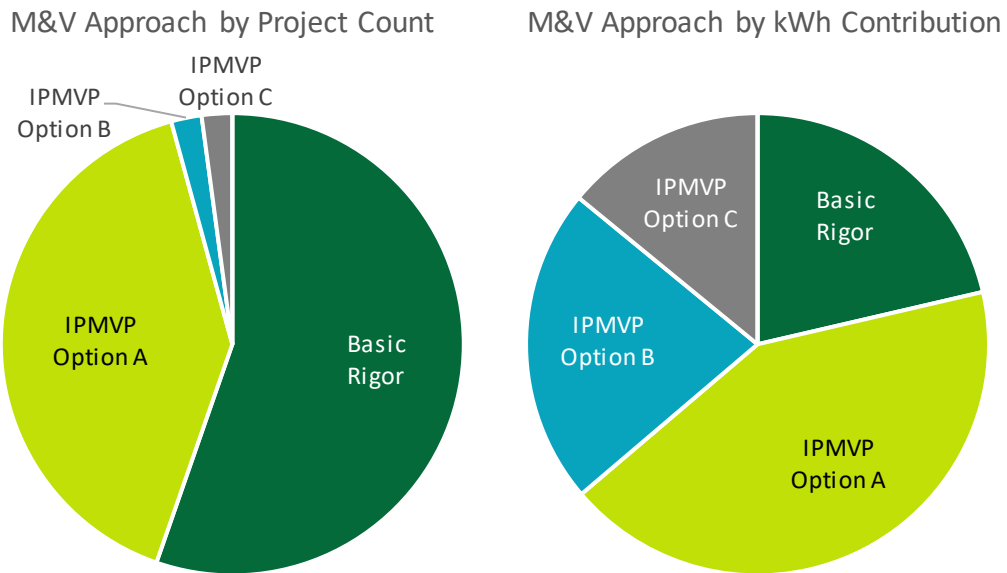
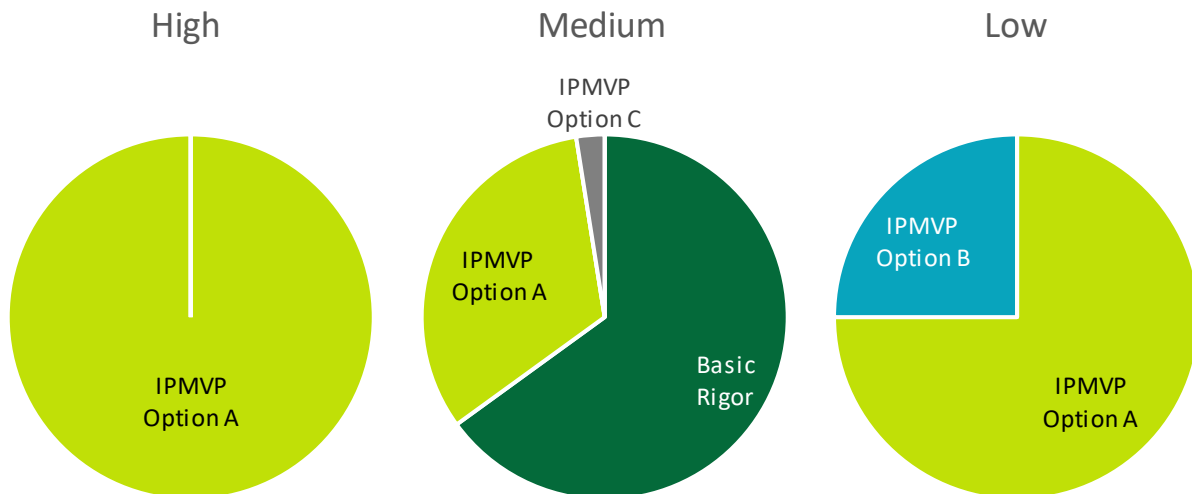
Figure 69: Summary of Penn Power's C&I Evaluation Activities

Figure 70 provides a summary of the evaluation activities and M&V approaches Penn Power's evaluation contractor used across strata. Penn Power's sampling plan consisted of 11 strata, which the SWE binned for the purposes of this comparison. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 70: Summary of Penn Power's C&I Evaluation Activities Across Strata

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

G.4.2.1 Ride-Along Site Visits

Table 161 provides an overview of the SWE milestones for the audit of Penn Power's site inspection efforts.

Table 161: Penn Power Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
2	105,772	1	1	100%

Overall, the SWE agreed with the methodology and calculations completed by Penn Power's evaluation contractors. Custom calculation files were sometimes difficult to follow; however, the evaluation contractor was readily available to discuss and update calculations whenever needed. The evaluation contractor's submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. The SWE agreed with all engineering decisions made by the evaluators, which included adjustments to reported savings where HOU values were deemed inappropriate and adjustments to include interactive effects where they had been excluded in reported savings. No errors were found in verified savings calculations, and no recommendations were posed by the SWE.

While the SWE was satisfied overall with the evaluator's final reports and verified savings calculations, SWE inclusion on flagged sites of interest proved to be challenging for ADM, and all evaluation contractors, in PY8. The SWE communicated the deficiencies in the site inspection process with the EDCs and their evaluation contractors via individualized phone conferences with all interested parties and through a guidance memo issued in October of 2017 detailing new tools implemented by the SWE to improve the process moving forward. The suggestions provided in the guidance memo were as follows:

- ADM should submit samples in keeping with their EM&V plan to the SWE as they are drawn for SWE review. The SWE has created a template that should be followed for future submissions to make sure all information needed to select an appropriate sample is included.
- ADM should attempt to coordinate with the SWE in advance of scheduling flagged projects of interest to ensure SWE inclusion.
- ADM should use the SWE's shared cloud-based calendar for scheduling and notification of upcoming site inspections.

G.4.2.2 Verified Savings Desk Reviews

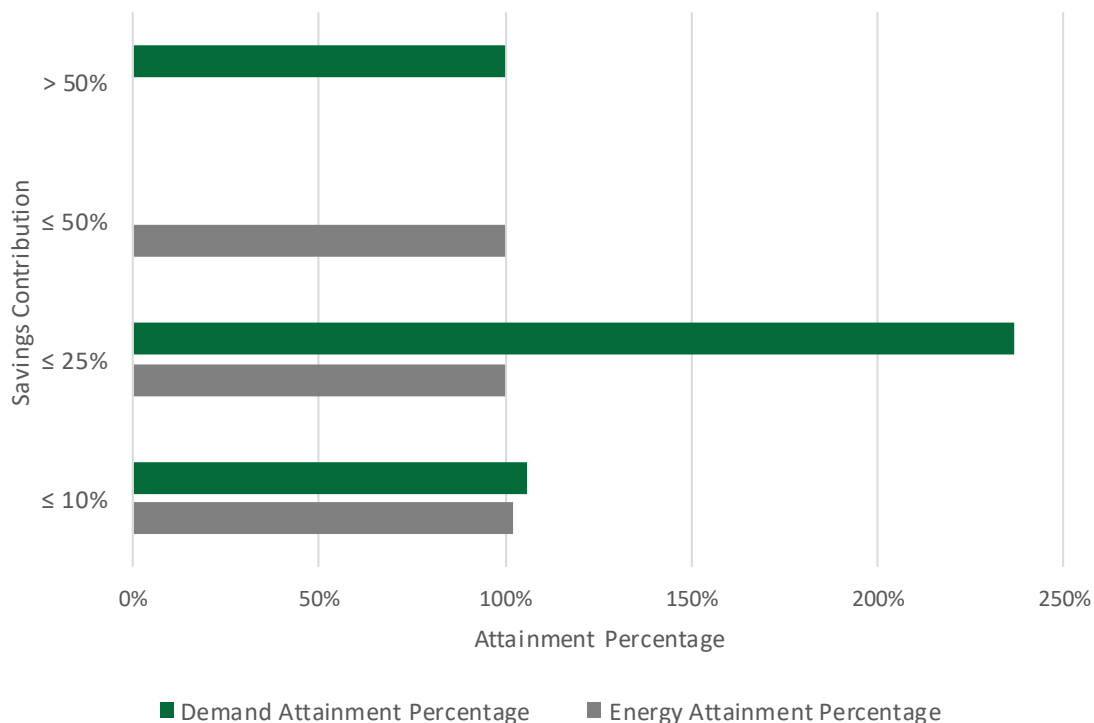
Table 162 provides an overview of the SWE milestones for the verified savings review of evaluated Penn Power projects.

Table 162: Penn Power Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
8	4,523,811	527	100%	157%

Overall, the SWE found that Penn Power's evaluation contractor, ADM, demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. ADM conducted appropriate M&V efforts, and sufficient documentation supporting savings analyses was provided.

Of the eight projects reviewed, the SWE calculated adjusted energy savings for only one project. Similarly, only two projects received adjusted demand savings. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand savings attainment percentages of reviewed projects were 100% and 157%, respectively. The distribution of the attainment percentages by savings contribution is presented in [Figure 71](#), and provides proof that greater scrutiny was applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 71: Penn Power Verified Savings Attainment Percentage

In general, the lighting projects consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. Penn Power's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. The evaluator however has implemented a process for PY9 through which each ICSP

lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes. The omission of Appendix C calculators had no effect on the attainment percentages, and has already been addressed by the evaluator.

Project PRJ-1881-C achieved savings for the installation of variable frequency drives (VFDs), electronically commutated motors (ECMs), and a ductless heat pump (DHP) within a newly constructed facility. The SWE corrected two errors in the savings calculations for this project. First, the SWE adjusted the motor power inputs used in the calculations for multiple units to match the motor powers shown on the provided equipment submittals. ADM had used the motor powers from the mechanical drawings, but the field engineer noted that based on the site visit findings, the submittals were a more accurate representation of installed equipment. The SWE made adjustments to the DHP measure as well. ADM had compared the installed unit to a standard-efficiency DHP, as is prescribed in TRM measure 2.2.3. However, as this is a commercial application the calculations should adhere to TRM measure 3.2.4, which specifies a new construction baseline analogous to a room air conditioner. These changes resulted in higher estimates of both kWh savings and peak kW demand reduction.

The SWE found an error in the calculations for project PRJ-9007-C similar to the issue noticed in Penelec project PRJ-1741-C and detailed in SECTION. PRJ-9007-C achieved savings for the installation of a multi-building chiller plant providing comfort cooling. Again, the evaluator used a coincidence factor to calculate peak demand savings whereby the evaluator compared the average CDD of the peak period to the max CDD of the peak period. The resulting ETDF of the evaluator's calculations was 21,125 signifying that the chiller plant peaks outside of the TRM-defined peak window. The SWE adjusted the peak adjustment formula to compare the average CDD of the peak period to the average daily consumption for the peak months. This resulted in an ETDF of 3,251, which is within the expected range for comfort cooling measures. The SWE found two additional errors in the calculation whereby the peak demand calculations erroneously referenced a tonnage value rather than a kW value for the baseline, and a dragged formula caused the averages to reference incorrect ranges. The SWE adjusted these errors which significantly increased the demand savings associated with the project.

Project PRJ-9002-C achieved savings through industrial process improvements. The SWE noted that the verified savings did not include a coincidence factor in the peak kW demand reduction calculation. The exclusion of a coincidence factor implies that average production is sustained throughout all of the peak period. This may be the case; however, no justification was provided to support this claim. The SWE has not calculated adjusted savings, but recommends that justification be provided for all custom CF calculations in the future.

While the review of Penn Power's verified savings calculations showed appropriate use of rigor across projects, the SWE makes the following recommendations to ensure the accuracy of verified savings in the upcoming program years:

- ADM should take greater care in selecting an appropriate TRM baseline where multiple options exist and have implications on savings calculations.
- ADM should provide justification for the custom calculation of all off-TRM assumptions such as coincidence factor and hours of use.

- ADM should provide more enhanced quality controls to ensure all calculations are sound. Ratios should have like terms in the numerator and denominator; unit analysis should confirm the correct units are obtained for all calculated values.

G.5 NTG

G.5.1 Residential Programs

ADM/Tetra Tech estimated a PY8 NTG for several programs: the Appliance Turn-in Program, the Energy Efficiency Kit component of the Energy Efficient Homes Program, and the Residential Energy Efficient Products Program.

For the Appliance Turn-In Program, ADM/Tetra Tech used primary data collection (participant surveys) to estimate NTG for all appliances in the program though the SWE recommends estimating NTG by measure. NTG was estimated with the recommended UMP appliance recycling protocol. ADM/Tetra Tech created a decision tree that depicted all the program's possible savings scenarios and took the weighted average of the decision trees values to inform NTG.

For the Energy Efficient Homes Program, ADM/Tetra Tech calculated NTG for the Energy Efficiency Kits component of the program; the kit component of the program was a high-impact measure (HIM). The Energy Efficiency Kits NTG was calculated using data from participant surveys and the common method. FirstEnergy provided Excel workbooks with the raw data from their NTG research and the SPSS syntax files used to calculate the NTGRs from the raw data that allowed the SWE to confirm methodology.

ADM/Tetra Tech assigned the HERs component of the program a NTG of one, in accordance with the Evaluation Framework, and was not informed by participant surveys, but assumes that the RCT design eliminates free-ridership and produces negligible spillover.

A NTG of 0.5 was applied to the Direct Install and New Homes components of the Program. The SWE could not determine the reason for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.

For the Residential Energy Efficient Products Program, ADM/Tetra Tech ADM/Tetra Tech applied the NTG from Phase II to the upstream Electronics component of the program. The upstream Lighting component NTG was estimated in PY8 and was informed by retailer and customer surveys. ADM/Tetra Tech provided retailer and customer syntax and data allowing NTG and method to be verified by the SWE. The Lighting NTG did not include Delphi panel NTG (as was the preferred method noted in the PY8 Evaluation Plan) or shelf stocking and or sales data analysis. ADM/Tetra Tech noted that the missing NTG estimation methods have not been completed nor data collected. The SWE recommends vigilance in acquiring pricing data, shelf stocking data, and completing the Delphi panel to avoid further delays that would hinder a more rigorous upstream lighting NTG.

The downstream components of the Program (Residential HVAC initiative and Residential Appliances) were based on customer survey data. NTG was weighted by measure energy savings and were confirmed by the SWE to be calculated with the common method. ADM/Tetra Tech

reported to have estimated HVAC NTG using self-report data from program participants using the common method recommended in the Evaluation Framework. ADM/Tetra Tech did not supply data files for the HVAC program meaning the SWE could not confirm methods or findings.

Table 163: Summary of NTG Estimates for Penn Power Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.50	0	0.50	152
Estimated	Upstream Lighting	0.61	0.0	0.39	183 (customers) 9 (retailers)
Estimated	EE Kits	0.20	0.02	0.82	143
RCT	Home Energy Reports	0	0	1	--
Applied	Direct Install and New Homes	--	--	0.50	--
HVAC	Estimated	0.47	0.03	0.56	46

G.5.2 Low-Income Residential Programs

ADM/Tetra Tech assigned LIEEP a NTG of one in keeping with the PY8 Evaluation Plan and SWE Phase III Evaluation Framework.

G.5.3 C&I Programs

ADM/Tetra Tech conducted NTG research in PY8 for the Business Lighting, Business Custom, and Business Prescriptive components of the C&I ES for Business Program for both small and large C&I. ADM/Tetra Tech utilized PY7 NTG ratios for the Business Appliance Turn-in and Business Direct Install components of the ES Program and has stated in the Phase III EMV plan that new NTG research will be conducted in PY9.

ADM/Tetra Tech utilized participant customer and vendor surveys to gather data for the ES Business Lighting component, the sample was stratified by participant MWh usage to capture the impacts of a small number of program participants who represent a large portion of the program savings. The data was then used to estimate NTG for the MWh strata as well as the overall program NTG. The data and method were reviewed by the SWE and found to be in keeping with the Phase III Evaluation Framework using the common method for estimation. ADM/Tetra Tech employed the same data gathering method utilized in the Lighting component with the Custom component to represent the small group of participants who contributed a large percentage of the overall program component savings. ADM/Tetra Tech had limited success recruiting the largest participants in their research and, to avoid this issue in the future, have proposed including NTG research as part of the rebate application package to ensure greater participation rates and higher levels of confidence. NTG was estimated by usage strata and total program component and the data and method were in keeping with the Framework and the common method of estimation. The SWE recommends presenting multiple years of Lighting NTG to observe the differences

between previous methods and methods including the additional participants. The NTG methodology for the Prescriptive component was identical to the Custom component methodology and found to be compatible with the Phase III guidelines and the common method. The SWE recommends that ADM/Tetra Tech describe their method of incorporating Program components NTG values to estimate total program NTG for the sake of transparency.

Table 164: Summary of NTG Estimates for Penn Power C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Small Energy Solutions for Business Lighting	0.28	0.03	0.75	45
Estimated	Small Energy Solutions for Business Custom	0.52	0.0	0.48	17
Estimated	Small Energy Solutions for Business Prescriptive	0.62	0.0	0.38	5
PY7	Small Energy Solutions for Business Appliance Turn-In	--	--	0.50	--
PY7	Small Energy Solutions for Business Direct Install	--	--	0.50	--
Estimated	Small Energy Solutions for Business Total	--	--	0.72	--
Estimated	Large Energy Solutions for Business Lighting	0.28	0.03	0.75	45
Estimated	Large Energy Solutions for Business Custom	0.52	0.0	0.48	17
Estimated	Large Energy Solutions for Business Prescriptive	0.62	0.0	0.38	5
Estimated	Large Energy Solutions for Business Total			0.60	

G.6 TRC

Table 165 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penn Power's PY8 individual programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY8 annual report.

Table 165: Summary of Penn Power's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Appliance Turn-in	319	266	1.41	159	226	0.71
Energy Efficient Homes	2,752	2,433	1.13	2,113	2,062	1.02
Energy Efficient Products	3,432	1,739	1.97	1,364	871	1.57
Low-Income Energy Efficiency	788	973	0.81	788	973	0.81
C&I Energy Solutions for Business - Small	4,210	1,793	2.35	3,026	1,308	2.31
C&I Energy Solutions for Business - Large	1,317	1,065	1.24	789	650	1.21
Governmental & Institutional Tariff	520	247	2.10	392	199	1.96
Portfolio Total ¹	13,339	8,600	1.55	8,631	6,413	1.35

¹ Program costs will not sum to Portfolio Total which includes costs from inactive Demand Response programs.

Of Penn Power's seven energy efficiency programs offered, six were found to be cost-effective and one was non-cost-effective using gross verified savings. Using net verified savings, five were found to be cost-effective and two were non-cost-effective using net verified savings. The Appliance Turn-in Program was cost-effective using gross verified savings, but non-cost-effective using net verified savings. The following is a list of cost-effective and non-cost-effective programs.

Gross Verified Savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business - Small
- C&I Energy Solutions for Business - Large
- Governmental & Institutional Tariff

Non-Cost-Effective Programs (TRC < 1):

- Low-income Energy Efficiency

Net Verified Savings

Cost-Effective Programs (TRC > 1):

- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business - Small
- C&I Energy Solutions for Business - Large
- Governmental & Institutional Tariff

Non-Cost-Effective Programs (TRC < 1):

- Appliance Turn-in
- Low-income Energy Efficiency

G.6.1 Additional Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template, but had independent inputs specific to that company.

- Penn Power used a discount rate of 6.89%, used to calculate the net present value of future program benefits, is consistent with what is stated in their EE&C plan. Line loss adjustment factors varied by Residential (1.0949), Small C&I (1.0545) and Large C&I (1.545) sectors.
- The incremental costs were derived from the PA SWE Database, historic actuals, the Database for Energy Efficiency Resources (DEER), EDC assumption and evaluations. The SWE spot checked the incremental costs used in the TRC model and found them to be consistent with Penn Power's EE&C plan.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to recreate 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 TRC Order directive for Phase III.
- The SWE found that the cost categories were handled correctly: incentives were not considered costs but administrative costs, incremental costs, and kits were incorporated as costs. The TRC model followed the protocol specified in the 2016 Test Order pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The TRC model reports the cost from increase heating usage due to lighting interactive effects from more efficient lighting as a negative Total NPV Lifetime Non-Electric Benefit. The SWE agrees that the cost should be accounted for as a non-electric benefit rather than a fossil fuel switching program cost.
- The Penn Power TRC model accounts for the dual baselines for residential lighting by reducing the EULs to adjust lifetime savings. FirstEnergy notes in their report that their 2016 TRM-compliant TRCs are conservative due to the growing uncertainty of the likelihood of DOE enforcement of EISA 2020 standards and presents gross and net TRCs with and without the dual baseline for comparison. [Table 166](#) shows that without the dual baseline included in the TRC model, the gross and net TRCs are higher than when the dual baselines are included.

Table 166: Penn Power Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.55	1.35
Without Dual Baseline	1.72	1.43

The SWE noted a handful of minor issues pertaining to the implementation of the TRC model which are included here. None of the items listed below are cause for concern about the material results of the TRC model, and are noted here as recommendations for adjustments to be made in future PY reporting.

- The PY8 TRC models used the avoided costs of energy and capacity estimated using the method approved in the Phase III EE&C. While the avoided costs in the TRC model appeared to be within reasonable ranges, the SWE was unable to directly compare the costs since the costs were not provided in the Phase III EE&C plan like it had been in prior program years. The SWE recommends an avoided costs table be included in future EE&C plans.
- The SWE verified the measure-specific EULs. The team found that the EULs were mostly consistent with the 2016 TRM. The EUL for Programmable Thermostats are 11 in the 2016 TRM and Penn Power's EE&C Plan, but is 15 in the TRC model. The SWE recommends updating the Programmable Thermostat EUL in future PY reporting.
- The TRC model ignores decreased fossil fuel consumption from energy efficient measures that saved space heating and water heating fuel, underestimating the benefits. The SWE recommends accounting for quantifiable water and fossil fuel avoided costs as stated in the 2016 TRM in future PY reporting.
- Penn Power's EE&C Plan states that the avoided cost data is based on the methodology prescribed in the 2016 TRC and savings values based on the protocols stated in the 2016 TRM. Annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broad peak definition which are unlike Act 129 peak hours defined in the 2016 TRM. The result are higher on-peak fractions than would otherwise be under the 2016 TRM with energy savings based on seasons. Despite this difference, the avoided costs and load profiles share common definitions. The SWE is convinced the results are sound.

G.7 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including Penn Power, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described for Met-Ed previously applies to all four FirstEnergy utilities, including Penn Power.

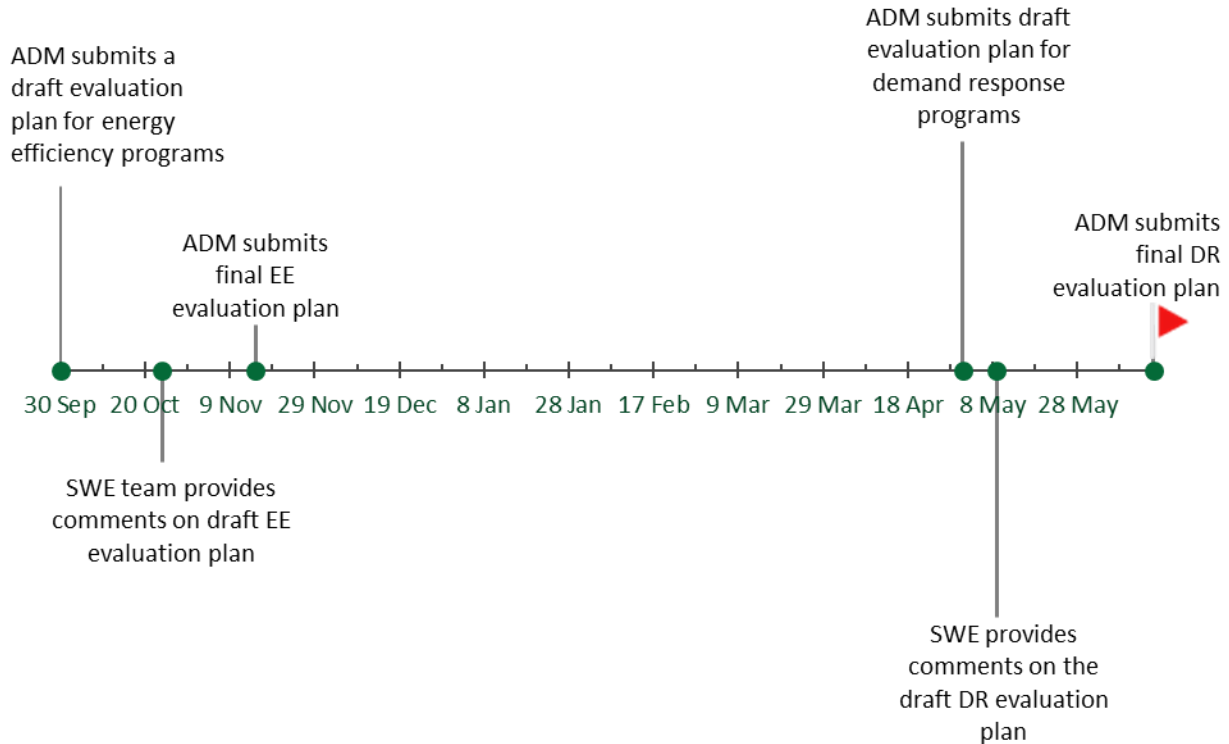
Appendix H West Penn Power Audit Detail

H.1 EM&V PLAN REVIEWS

The four FirstEnergy companies offer a similar portfolio of programs for Phase III of Act 129. Program offerings, measures offered, incentive levels, tracking system, and ICSPs are all determined company wide. Given the similarities across EDCs, FirstEnergy's evaluation contractor, ADM Associates, prepared a single evaluation plan for the four EDCs. EDC-specific considerations were addressed as needed throughout the plan. West Penn Power's EE&C plan programs are organized by sector with separate programs for Small C&I, Large C&I, and Government and Institutional rate classes. The separation between these three programs is dictated by tariffs, but in practice, the same offerings are available to all non-residential customers regardless of rate code. For evaluation purposes, ADM chose to organize non-residential energy efficiency projects into initiatives by equipment type (Lighting, HVAC, Custom etc.). The SWE supported this decision to organize non-residential research by equipment category.

ADM's Phase III evaluation plan called for an impact evaluation of each initiative annually. This approach avoids the frequency vs. rigor decisions that made up a large part of the plan review process for Duquesne Light and PECO. The FirstEnergy companies' evaluation plan review process was the most efficient in the state because the draft plan submitted to the SWE was detailed, included adequate sample sizes, and was consistent with the major expectations of the Evaluation Framework.

Phase III demand response performance goals begin in PY9, so the evaluation planning process for West Penn's DR programs lagged the energy efficiency planning. [Figure 72](#) documents the timing of the major milestones associated with finalizing the Phase III evaluation plan for West Penn.

Figure 72: West Penn Power Evaluation Plan Review Timeline, 2016-17

- When it is Appropriate to use FirstEnergy Wide Values:** In general, the four FirstEnergy EDCs need to be considered as separate entities with distinct evaluation and reporting. However, in some cases the nature of a parameter measurement is challenging to capture at an EDC-level with any degree of statistical precision. One example of this was the ISR for kit measures. The installation rate of kit measures like furnace whistles and faucet aerators tend to be quite low and this makes accurate measurement challenging. The SWE agreed that a more precise measurement of ISR across the four EDCs was better than four imprecise measurements.
- Model Selection for Home Energy Reports:** FirstEnergy reduced the number of homes receiving HERs in PY8 compared to Phase II totals. When the equivalence of the new treatment and control groups were assessed in the evaluation plan, some statistically significant differences in consumption during the pre-treatment period were identified. The SWE and ADM worked together on several simulation exercises to determine which regression model specification was best equipped to net out these differences and produce unbiased estimates of HER impacts.
- Treatment of DR Participants That Shave 5CP Loads:** Capacity costs are allocated to customers via a methodology that looks at metered load during the '5 coincident peak' hours of a year. Some large customers attempt to forecast and reduce loads during likely hours to reduce their cost obligation. ADM and the SWE ultimately agreed on an approach where this behavior is ignored and all weekdays that are not PJM or Act 129 DR events are eligible for inclusion in the DR baseline calculation.

- **Synthesis of Multiple Methods for NTG and Process:** Several of the key research questions for the NTG and process evaluations had multiple methods proposed. This approach is recommended in the Evaluation Framework, but the SWE requested additional detail on how results would be combined to arrive at conclusions.
- **Low-Income Considerations:** Some offerings are delivered to both residential and residential low-income customers. The SWE requested clarification in several places on how savings from low-income participants would be separated from the residential class.
- **Mechanics of the Non-Residential Certainty Stratum:** For the largest C&I projects, ADM works alongside the ICSP to integrate M&V into the program delivery. In these cases, there is no reported savings estimate – ADM just calculates the gross verified savings. Because of the alternate process, the projects must be quarantined in the extrapolation of program savings from the evaluation sample. Certainty project results do not factor into the realization rate calculation for smaller strata where sampling is used.

In addition to reviewing FirstEnergy's evaluation plan, the SWE reviewed eleven survey instruments and one interview guide. Nine of these instruments were for residential programs while three were for C&I programs. The surveys and interviews addressed process, impact, and NTG topics.

H.2 SAMPLE DESIGN REVIEW

When verified savings estimates rely on extrapolation from observations among a sample of projects to the population, there is an inherent risk that the evaluation sample may not be representative of the program population. This uncertainty is a function of the sample size and the correlation between reported and verified savings values in the sample. The amount of sampling error (or margin of error) is presented as the relative precision of the verified savings. If an offering has a verified savings estimate of 1,200 MWh/year and relative precision of $\pm 5\%$ at the 85% confidence level, we can infer an 85% chance that the true savings is between 1,140 MWh/year and 1,260 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of $\pm 15\%$ at 85% confidence level for each "initiative". For 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 because of program delivery method or technology supported.

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. For example, projects from the three non-residential energy programs (C&I Energy Solutions for Business – Small, C&I Energy Solutions for Business – Large, and Government & Institutional Tariff) were assigned to one of five solutions.

- C&I Lighting
- C&I Custom
- C&I Prescriptive

- C&I Appliance Turn-In
- C&I Direct Install (minimal savings in PY8 – no evaluation sample)

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than the tariff-based program definitions, which each include the same mix of measures. It is also a more efficient sample design because lighting projects are more likely to share similar characteristics across the Small C&I, Large C&I, and Government programs than a heterogeneous mixture of measures from a single program definition.

Table 167 lists evaluation initiatives along with the relative precision of the PY8 gross verified savings estimate at the 85% confidence level.

Table 167: Relative Precision of PY8 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level ($\pm$)
Appliance Turn-In	6.8%
Low-Income ATI	9.7%
Kits	4.2%
Low-Income Kits	9.3%
C&I Lighting	10.6%
C&I Custom	6.8%
C&I Prescriptive	8.7%
Upstream Lighting	10.2%
C&I ATI	28.3%
Residential HVAC	8.8%
Residential Appliances	8.5%
Low-Income Appliances	12.1%
Residential Direct Install	7.6%
Low-Income Direct Install	10.4%
Residential New Construction	11.0%

The evaluation of Home Energy Report impacts relies on a statistical billing analysis of all participants so there is no uncertainty associated with sampling. Fourteen of the 15 sampling initiatives shown in Table 167 produces verified gross savings estimates of better than $\pm 15\%$ precision at the 85% confidence level. The relative precision of the C&I Appliance Turn-In verified gross savings estimate is greater than $\pm 15\%$ in isolation, but the full Appliance Turn-In (residential + low-income + C&I) meets the 85/15 requirement so the SWE has no concerns about the sample design.

Sampling uncertainty does not consider the level of rigor of the verification activities. Results from a sampled project that receives a quick desk review from the evaluation contractor is handled the

same way as a sampled project that gets a site inspection with metering of equipment operating characteristics. The level of rigor of ADM's PY8 verification activities is discussed in detail in [Appendix H.4](#).

H.3 REPORTED GROSS SAVINGS AUDITS

H.3.1 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 PY8 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings for each program
- Reported gross peak demand savings for each program
- Participation for each program
- Incentive dollars for each program

The SWE leveraged West Penn Power's PY8 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY8 quarterly data request.

H.3.1.1 Audit Findings

[Table 168](#) summarizes the SWE's findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values in West Penn Power's PY8 Annual Report and 'No' otherwise. Our records match the values in the annual report for each of West Penn Power's programs.

Table 168: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	4,999	4,999	Yes
Energy Efficient Homes	45,219	45,219	Yes
Energy Efficient Products	31,349	31,349	Yes
Low-Income Energy Efficiency	10,388	10,388	Yes
C&I Energy Solutions for Business – Small	14,540	14,540	Yes
C&I Energy Solutions for Business – Large	10,477	10,477	Yes
Governmental & Institutional Tariff	5,489	5,489	Yes
Portfolio Total	122,461	122,461	Yes

Table 169 summarizes the SWE's findings regarding reported gross peak demand savings by program. The SWE's records matched West Penn Power's reported peak demand savings for all programs.

Table 169: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.63	0.63	Yes
Energy Efficient Homes	7.01	7.01	Yes
Energy Efficient Products	4.15	4.15	Yes
Low-Income Energy Efficiency	1.39	1.39	Yes
C&I Energy Solutions for Business – Small	2.31	2.31	Yes
C&I Energy Solutions for Business – Large	1.53	1.53	Yes
Governmental & Institutional Tariff	0.16	0.16	Yes
Portfolio Total	17.17	17.17	Yes

Table 170 summarizes the SWE's findings regarding program participation. For six of the seven programs with non-zero participation, the SWE was able to replicate participant counts via the tracking data. For the seventh program (LIEE), the two data sources disagree by just four participants (approximately 0.0007% of the portfolio total). The SWE views this difference as negligible.

Table 170: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	4,660	4,660	Yes
Energy Efficient Homes	208,421	208,421	Yes
Energy Efficient Products	364,320	364,320	Yes
Low-Income Energy Efficiency	31,238	31,242	No
C&I Energy Solutions for Business – Small	506	506	Yes
C&I Energy Solutions for Business – Large	68	68	Yes
Governmental & Institutional Tariff	229	229	Yes
Portfolio Total	609,442	609,446	Yes

Finally, [Table 171](#) summarizes the SWE’s comparison of incentive dollars in the program tracking data to the program totals in West Penn’s Annual Report. The SWE was able to replicate (or nearly replicate) program incentives for four of the seven programs for which West Penn Power reported non-zero incentive dollars. For two other programs (EE Products and Small C&I Energy Solutions), the SWE calculated incentives that are directionally similar to what West Penn Power reported. The difference at the program level is explained a product of upstream lighting cross-sector sales findings. FirstEnergy moves money between EE Products and Small C&I Energy to avoid cross subsidization between residential and commercial sectors, so we are not concerned about the differences in financials for these programs. It is a necessary change to ensure equitable cost recovery across rate classes. For these six programs, West Penn Power reports a portfolio total of \$3,629,000, and the tracking data shows a portfolio total of \$3,631,000.

For the remaining program – EE Homes – West Penn Power’s Annual Report and the tracking data disagree by a large margin. This can be attributed to the costs for EE&C kits. West Penn Power notes that incentive costs include direct install equipment costs and the costs for EE&C kits. The costs for such kits are not housed in the tracking data, so the discrepancy between sources should be expected in this case. Note that the discrepancy (\$1,568,000) is similar to the incentive amount West Penn Power had earmarked for kits in their PY8 EE&C plan (\$1,163,000).

Table 171: Incentives by Program (\$1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	\$261	\$260	Yes
Energy Efficient Homes	\$1,868	\$300	---
Energy Efficient Products	\$1,634	\$1,734	No
Low-Income Energy Efficiency	\$60	\$62	Yes
C&I Energy Solutions for Business – Small	\$877	\$779	No
C&I Energy Solutions for Business – Large	\$522	\$522	Yes
Governmental & Institutional Tariff	\$274	\$274	Yes
Portfolio Total	\$5,497	\$3,932	---

H.3.1.2 Action Items

For all of West Penn Power's programs, the SWE was able to replicate (or come very close to replicating) reported gross MWh savings, reported gross MW savings, and participation counts with the tracking data. For six of the seven programs for which West Penn Power reported non-zero incentive dollars, the SWE was able to calculate directionally similar (though not identical) incentive dollars via the tracking data. For these six programs, the portfolio totals line up almost exactly. Differences could be attributed to rounding.

The SWE's only concern at this point is being able to replicate incentive dollars for the Energy Efficient Homes program. The SWE acknowledges that the discrepancy is due to the costs of the EE kits being correctly treated as incentives, and we do not view this as a major issue.

H.3.2 Project File Reviews

H.3.2.1 Residential¹²⁸

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of West Penn Power's residential projects for PY8 using the project documentation provided by the evaluation contractor, ADM, 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 project file packages included all documentation requested.

Project file documentation for all residential programs were generally well organized and provided the data needed for review, but occasionally revealed inconsistencies with the tracking data.

¹²⁸ The SWE also conducted a database review of West Penn Power's quarterly tracking data to verify that West Penn Power was using the correct values and algorithms from the Pennsylvania TRM in their savings calculations.

Table 172 presents an overview of the results of the SWE's residential project file reviews. Note that Table 172 includes project file reviews for all FirstEnergy EDCs. All comments and recommendations are similar in nature between all four FirstEnergy EDCs, when the findings of the project file review were consistent.

Table 172: West Penn Power PY8 Residential Project File Review Summary

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?
Appliance Turn In	ATI	12	✓	✓	✓	✓
Energy Efficient Homes	New Homes	8	✓	✓	✓	✓
Energy Efficient Products	Appliances	8	✓	✓	✓	✓
Energy Efficient Products	Lighting	16	✓	✓	✓	✗
Energy Efficient Products	HVAC	8	✓	✓	✓	✓
Low-Income EE Program	New Homes	1	✓	✗	✓	✓
Low-Income EE Program	Appliances	8	✓	✓	✓	✓
Low-Income EE Program	ATI	4	✓	✓	✓	✓
Low-Income EE Program	Weatherization	8	✓	✓	✓	✓

As outlined above, an adequate number of project files and the supporting details were submitted for the residential program. Below is a summary of the project file reviews, including the few issues or discrepancies found between project files and tracking data.

For residential lighting, there were discrepancies in the wattage of lamps between the project files and tracking data. While discrepancies were found in most sampled projects, typically they differed by only one watt, or less. The SWE notes that a portion of the wattage discrepancies (smaller than one watt) may be due to rounding the wattages into the tracking database. However, there were a few cases where the discrepancy was several watts. For the New Homes Program, the project files were easily found within the tracking data, however there was insufficient information to verify the rebated amount. The SWE could not determine whether the rebate was based on HERS Score, percent of savings over UDRH, or kWh saved.

There were minor issues found within the Low-Income Weatherization program. The SWE matched the project files with the tracking data for the following measures: lighting, faucet aerators, low flow showerheads, and smart power strips. However, for insulation, air sealing, and appliance replacement measures, the SWE could not match the project files to the tracking data and therefore could not verify the accuracy of the tracking database for these measures.

The following issue applies generally to the residential project files, but it is specifically noted in the review of the Appliance Turn-In and HVAC programs. The Account IDs listed in the project files were not listed accurately in the tracking data which made it difficult to match the projects to the data. It appeared that, at times, the fields in the tracking data containing the IDs had been rounded and were no longer able to be identified with the project file ID. The SWE was ultimately able to locate the project within the tracking data by using other information found in the project files, such as name and address. However, this is a time-consuming process.¹²⁹

While the PY8 review of residential project files found project file packages to be typically well-organized, the SWE found several instances of missing or inaccurate data. To ensure the accuracy of reported savings in upcoming program years, the SWE makes the following recommendations:

- Submitting project files and a matching sample of tracking data for each program, including a unique identifier to easily match data to the files.
- More clarity on how rebate amounts are calculated, specifically for the New Homes program.
- More thorough document review to ensure accurate transcription of lighting wattages, including the eliminating the practice of rounding of wattages in the tracking database.

H.3.2.2 Non-residential

The SWE reviewed West Penn Power's C&I projects for PY8 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

¹²⁹ ADM is working with CSPs to use an alternative matching key, such as rebate number, for PY9 and beyond.

project file packages included all documentation requested with the exception of lighting projects which consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. West Penn Power's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. The evaluator however has implemented a process for PY9 through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes.

Project files were generally well organized, revealing no issues inhibiting the SWE's understanding of projects and their reported savings. [Table 173](#) presents an overview of the results of the SWE's C&I project file reviews.

Table 173: West Penn Power PY8 C&I Project File Review Summary

Project Number	Project Description	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?	For TRM measures, are correct algorithms and inputs used?	For custom measures, is the approach clear, auditable, and appropriate?
FESPPS1534043543	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043544	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534043591	HVAC	✓	✓	✓	✓	-	✓
FESPPS1534073976	ECM	✓	✓	✓	✓	-	✓
FESPPS1534073993	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534073995	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534074115	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534189305	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1534095837	HVAC	✓	✓	✓	✓	✓	-
FESPPS1534215436	Refrigeration	✓	✓	✓	✓	✓	-
FESPPS1534363679	HVAC	✓	✓	✓	✓	✓	-
FESPPS1534363682	Refrigeration	✓	✓	✓	✓	✓	-

The review process showed evidence of appropriate selection of algorithms and assumptions for both TRM-based and custom measures by West Penn Power's implementers.

H.4 VERIFIED GROSS SAVINGS AUDITS

H.4.1 Residential Audit Activities

This section presents a summary of the SWE's audit of the verified gross savings of the West Pennsylvania Power portfolio of residential programs. Pennsylvania Power's portfolio of Residential programs includes the following: The Appliance Turn-In Initiative, The Energy Efficient Homes Initiative, The Energy Efficient Products Initiative, and the Low-Income Energy Efficiency Initiative. Each program contains various subprograms, which are addressed separately below in tables and text as needed, if the SWE audits determined that certain subprograms showed discrepancies not shared by others in a program. Note that the SWE reports the residential savings into the three following sections: upstream lighting, residential non-lighting, and behavior.

Overall, the verified savings followed proper TRM protocols and the verified savings are accurate. The SWE identified the evaluation activities that were used to verify savings for the residential programs. [Table 174](#) provides a summary of the evaluation and M&V approaches used by West Penn Power in their PY8 verified savings calculations. [Table 175](#) provides a summary of discrepancies that were discovered during the SWE audits of verified savings. Note that all discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY9.¹³⁰

Table 174: Residential Program Evaluation Activities – West Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review	Billing Analysis	Applied PY7 RR
Appliance Turn-In (LI & Non-LI)	✓	--	✓	--	--
EE Kits (LI & Non-LI)	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	--	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting	✓	--	✓	--	--
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Low-Income WARM	--	✓	✓	✓	--

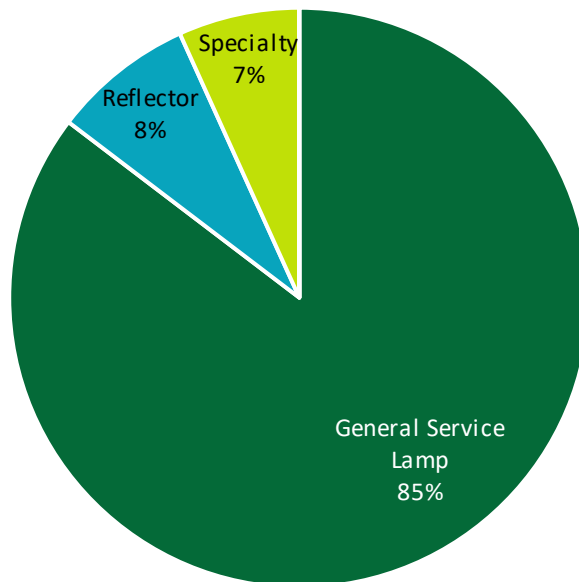
¹³⁰ The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio savings.

Table 175: Residential Program Verified Savings Discrepancies – West Penn Power

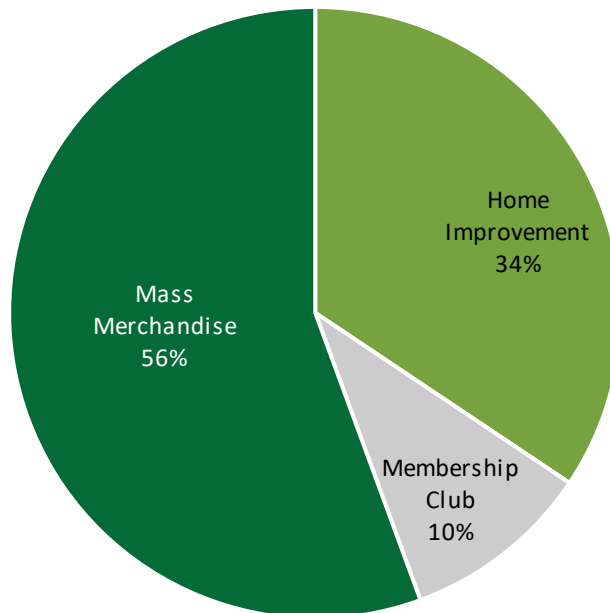
Program/ Subprogram	Measure	Discrepancy	The SWE Recommendation
Appliance Turn-In (LI & Non-LI)	Dehumidifiers	Possible EDC gathered data quality issues, not used for savings calculations	Review data collection process for measure, incorporate gathered values in future PYs
HVAC	Packaged Terminal ACs	No equipment-specific data used in savings calculations	Use individual equipment specs in future, rather than applying “market average” values for savings
Appliances	ENERGY STAR Clothes Washers	Outdated TRM default applied	Use correct/up-to-date TRM values

H.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 900 thousand efficient light bulbs and fixtures through West Penn Power’s PY8 upstream lighting program. [Figure 73](#) displays the distribution of sales by product type. Most (85%) of the products were general service lamps.

Figure 73: West Penn Power PY8 Upstream Lighting Sales by Product Type

Over one-half (56%) of West Penn Power’s PY8 upstream light bulbs and fixtures were sold through mass merchandise stores, while around one-third (34%) were sold through home improvement stores ([Figure 74](#)).

Figure 74: West Penn Power Upstream Lighting Sales by Retail Channel**H.4.1.1.1 Audit Findings**

The SWE reviewed the data in West Penn Power's tracking system to verify that ADM used the appropriate values and algorithms from the 2016 TRM to calculate verified gross savings. Although the team identified some minor discrepancies (described in the review below), the SWE agrees with ADM's verified gross savings for the Upstream Lighting Initiative.

The SWE observed 456 unique lighting model numbers in the PY8 tracking system, and was able to locate 351 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The 105 models the SWE was not able to verify as ENERGY STAR certified represent 21% of upstream bulbs sold and 20% of verified savings from upstream lighting. FirstEnergy had included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. However, TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. The SWE sent FirstEnergy a memo in October of 2017 recommending that beginning in PY9, the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products. According to FirstEnergy, its companies stopped rebating non-ENERGY STAR LEDs in PY9.

The SWE compared the product descriptions, lumens, and wattages in the tracking system to those in the ENERGY STAR certified products lists and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for three of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY8 tracking system, or errors in the ENERGY STAR certified products lists. The team confirmed that ADM used the appropriate algorithms, interactive effects, ISR, residential HOU, and residential coincidence factor to calculate kWh and kW savings. The team found that ADM assigned baseline wattages in accordance with TRM protocol 2.1.1 for all but three decorative models that were mistakenly classified as EISA exempt. Combined, the impact of all

discrepancies the SWE identified on initiative-level savings is negligible (less than one-half of 1%).

H.4.1.1.2 Cross-Sector Sales

ADM estimated 8.3% cross-sector sales for the combined FirstEnergy companies based on a general population survey. Survey respondents were asked how many bulbs they purchased and if they installed them in a residence, business, or both. Unfortunately, the survey was not designed to capture the proportion of residential versus commercial installations for the subset of respondents who reported installing bulbs in both a residence and a business (6% of respondents), necessitating a follow-up call to gather this information. ADM computed a weighted average HOU of 1,821 and coincident factor of 0.32 by mapping survey respondents' business types to the building types listed in Table 3-5 of the TRM.

H.4.1.1.3 Recommendations

The SWE makes the following recommendations for PY9 and beyond based on its review:

- Ensure that all products are ENERGY STAR qualified.
 - FirstEnergy included a number of value line LED models in the PY8 program that were not ENERGY STAR certified. TRM protocol 2.1.1 for residential lighting clearly states that LEDs must be ENERGY STAR qualified in the definition of efficient equipment. Beginning in PY9, the SWE recommends that the eligibility requirements of the 2016 TRM be enforced and value line LEDs be assigned zero kWh savings because they are not eligible products.¹³¹
- Edit the general population survey so that in future program years, the proportion of bulbs installed in residences and businesses for respondents who claimed to install bulbs in both locations can be gathered during the survey without the need for a follow-up call.

H.4.1.2 Residential Non-Lighting

The SWE's review of verified savings for residential non-lighting programs found that, overall, the verified savings followed proper TRM protocols and that the verified savings are accurate. The SWE notes a few minor issues that caused a negligible difference in savings, detailed below.

H.4.1.2.1 Energy Efficient Homes Program

The SWE audited each of the four components of the Energy Efficient Homes Program: Energy Efficiency Kits (EE Kits, including low-income), HERs, Residential Direct Install, and New Homes; using the gross impact data submitted by FirstEnergy. Note that the SWE's audit of the HERs is reported in [Section H.4.1.3](#) of this appendix. The SWE audited the New Homes sample that was used to determine a realization rate for the sub-program. The audit included a review of REM/Rate models and, as specified in the 2016 TRM, application of 2016 TRM savings to ENERGY Star lighting and appliance measures used to verify savings.

¹³¹ The SWE recognizes that a small number of lamps sold in PY8 may appear in PY9Q1 tracking data due to lags in retailer reporting and invoicing. These lamps would be exempt from this requirement since the sales transactions occurred in PY8.

Overall, SWE audits concluded that the correct TRM algorithms were applied and the verified savings were correct for all program kits, direct install measures, and new homes. The SWE noted a minor discrepancy between the survey sample size reported in the annual report and the survey sample size identified in the raw data provided by FirstEnergy for all program kits. ADM clarified the discrepancy, noting that they applied a 200-day cut-off, removing survey responses that were completed more than 200 days after the kit receipt date. In addition, respondents within the 200-day cut-off who could not remember receiving a kit were also removed from the reported survey sample.

H.4.1.2.2 Energy Efficient Products Program

Each component of the Energy Efficient Products (EEP) Program was audited by the SWE, including appliances, HVAC equipment, and consumer electronics. Note that the SWE's audit of the upstream lighting portion of the EEP Program is reported in [H.4.1.1](#) of this appendix. The SWE audits of the consumer electronics portion of the program verified that correct TRM algorithms were used and the verified savings were correct.

The SWE audits of the HVAC and appliance measures included in the program found that nearly all of the verified savings were correct. However, minor discrepancies were found for ground source heat pumps (GSHPs) and packaged terminal air conditioners (PTACs) regarding adherence to correct TRM algorithms.

The audit concluded that two GSHP systems were of commercial capacity based on their cooling capacity, but the savings calculations did not correctly follow the commercial GSHP algorithm in the TRM; data for two variables requiring EDC collection, necessary for TRM-based calculations, were missing from the FirstEnergy data. This situation is a grey area as the commercial GSHP measure in the TRM is for non-residential settings. In discussions with the SWE, ADM proposes a potential baseline of two residential ASHPs in cases moving forward. The SWE agrees this is likely a reasonable approach and recommends working with ADM to develop an IMP if this becomes a more popular measure in residential settings.

Savings for PTAC systems were reported in the data with no corresponding calculations to support the values. The SWE requested clarification from ADM, who reported that the parameters in the TRM algorithm were based on a market average for PTAC systems. The SWE recommends calculating savings based on individual PTAC system specifications in future program years.

The SWE audit also discovered an incorrect application 2016 TRM deemed value for ENERGY Star Clothes Washers. The savings calculation used for verified savings was using an outdated cycle per year value.

The SWE notes that the GSHP, PTACs, and ES Clothes Washer error accounted for less than 1% of measure level savings in each case, and had a negligible impact on program and portfolio level savings. The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

H.4.1.2.3 Low-Income WARM Program

The Low-Income WARM Program is a low-income direct install initiative offering similar measures across three sub-programs: WARM-Plus, WARM-Extra Measure, and WARM-Multifamily. The

WARM program includes LED lighting, smart power strips, domestic hot water measures, HVAC heating and cooling measures, refrigerator and freezer replacement and recycling, insulation, air sealing, and duct sealing. The SWE audited all measures included in the program using the full downstream dataset and the survey sample subset provided by FirstEnergy; and found that the correct TRM-approved methods were followed, survey sample sizes were correct, and the reported verified savings were correct.

H.4.1.2.4 Appliance Turn-In Program (Low-Income and Non-Low-Income)

The Appliance Turn-In Program is divided into low-income and non-low-income stratum, each offering turn-in options for refrigerators, freezers, room air conditioners, and dehumidifiers. The SWE audited EDC-provided data for each measure offered by the non-low-income and low-income strata of the program. Dehumidifiers were a newer addition to the turn-in program and used an approved IMP for savings calculations, while refrigerator, freezer, and room air conditioner turn-ins utilized TRM algorithms to determine savings. Auditors determined that the reported savings for all measures were correct, and that in almost all cases calculations correctly followed the relevant TRM and IMP algorithms and guidelines.

For dehumidifier turn-ins, auditors noticed that an outdated IMP default value for the Wilkes-Barre area was applied to Williamstown and Scranton, though this did not affect savings in an appreciable way. Also regarding dehumidifiers, auditors noticed that 68% of dehumidifiers in the sample were recorded in the EDC data collection process as having 10 pints of capacity, which stuck out as a possible data collection error. The SWE agrees with ADM's decision to use default IMP values for all dehumidifiers when calculating savings rather than using what is likely to be faulty data. while allowed by the IMP. The SWE recommends reviewing data collection processes to capture accurate dehumidifier capacities and incorporating EDC-collected data in future program years.

H.4.1.3 Behavior

Approximately 29% of West Penn Power's verified gross energy savings for PY8 came from Home Energy Reports issued to around 184,000 residential and residential-LI households. The SWE reviewed ADM's methodology and accepts their verified MWh and MW savings values for West Penn Power's HER offering in PY8. By cohort, [Table 176](#) shows average kWh savings and average percent savings per participant in PY8. Note that the 'Number of Participants' column shows the average number of participants during PY8.

Table 176: Average PY8 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY8 kWh Savings	Average PY8 % Savings
Low-income	June 2012	12,267	225	1.45%
Residential	June 2012	119,489	214	1.42%
Low-income	January 2014	4,710	197	1.46%
Residential	January 2014	18,788	247	1.38%
Residential	December 2014	29,694	127	0.93%

The following sections highlight some of the more important audit findings: errors in the coding of “pre” and “post” indicator variables, the calculation of lag terms, missing eligibility filters, and duplicating participant counts.

“Pre” and “Post” Coding Errors

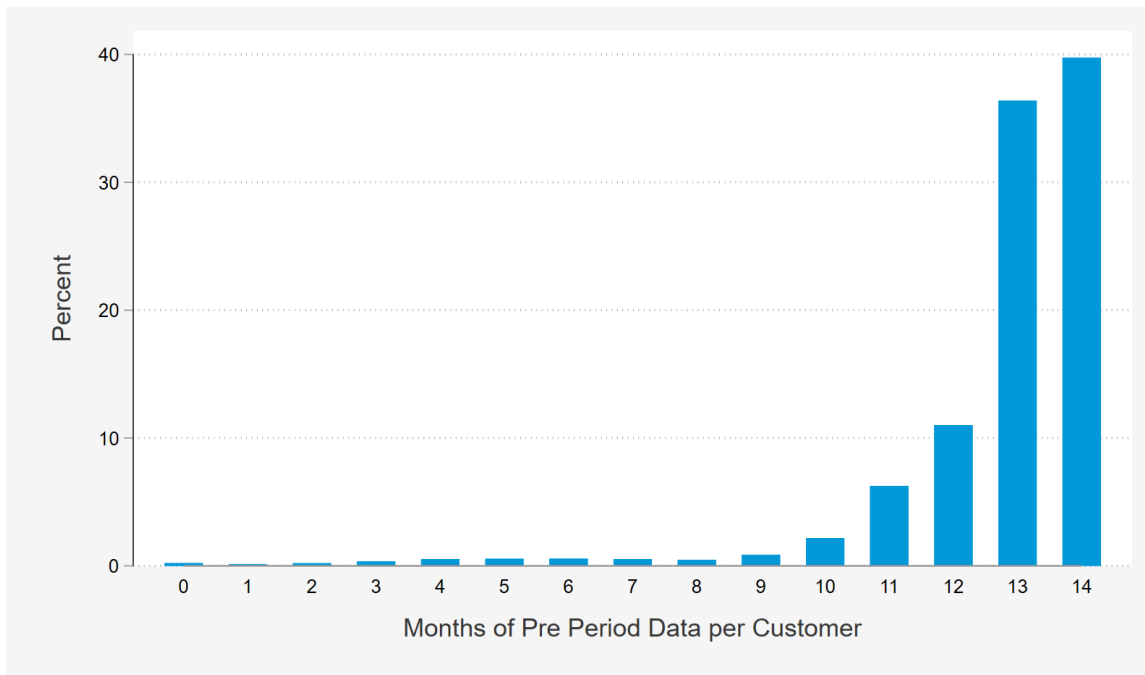
In reviewing the HER billing data, the first item that the SWE checked was the coding of the pre- and post-indicator variables. For a given cohort, all months prior to the billing cycle in which the randomized controlled trial (RCT) starts should be coded as pre = 1 and post = 0, and all months after the billing cycle in which the RCT starts should be coded as pre = 0 and post = 1. When reviewing the distribution of the pre- and post-indicator variables, the SWE noticed two issues:

1. For both 2012 cohorts (residential and low-income), there was an error in the coding of the post indicator variable. In December of 2013 and January of 2014, the post indicator variable was set equal to 0 though it should have been 1. (Note that the pre-indicator variable was coded correctly for these cohorts.) Because the lagged seasonal (LS) model is a post-only model, these records were being left out of the regression.
2. For the December 2014 cohort (residential), there was an error in the coding of the pre-indicator variable. Once again in December of 2013 and January of 2014, the pre-indicator variable was set equal to 0 instead of 1. This means that these months were not factoring into the calculation of the lagged terms used in the LS model.

The SWE informed ADM about these issues, and ADM was able to update the numbers in their PY8 annual report before the report was submitted to the PUC. After fixing the coding issues, verified savings for West Penn Power decreased by 81 MWh – a 4 MWh decrease for low-income cohorts and a 76 MWh decrease for residential cohorts. Note that the three other FirstEnergy companies saw an increase in savings rather than a decrease.

Calculating Lag Terms

As noted, the LS regression model is a post-only model – only records from the post period are used in the regression. That said, some of the explanatory variables in the model are calculated based on pre-period data: (1) average daily consumption in the pre-period, (2) average daily consumption during the summer in the pre-period, and (3) average daily consumption during the winter in the pre-period. For some homes, there was not enough pre-period data to calculate these lag terms. [Figure 75](#) shows the distribution of the number of months of pre-period data per customer. Across all West Penn Power cohorts, 12.9% of homes had less than twelve months of pre-period data, 2.6% of homes had less than seven months of pre-period data, and 0.4% of homes had less than two months of pre-period data.

Figure 75: Number of Pre-period Months per Customer

The limited amount of pre-period data for some homes raises two issues:

1. An eligibility screen should have filtered these homes out of the RCT. The number of homes with no more than six months of pre-period data is not insignificant. Some homes even had zero months of pre-period data. Sufficient pre-period data is a key component of an unbiased impact evaluation.
2. How should the lag terms be calculated? As an example, suppose the only months of pre-data for a customer are April, May, and June. (This was the case for several participants.) The average winter usage in the pre-period for this customer is not known, thus this customer should have fallen out of the regression model. Instead, Oracle used average daily usage for April–June as the lagged winter variable (average daily consumption during the winter in the pre-period). As another example, some customers had just one month of pre-period data – November. The average pre-period summer usage for these customers is not known, but Oracle used average daily usage in November as the lagged summer variable (average daily usage during the summer in the pre-period).

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we used Oracle's lag terms. After replicating ADM's savings values, the SWE dropped any participant without at least twelve months of pre-period data and re-ran the LS model for each cohort. Regression estimates were then used to calculate savings in exactly the same manner that ADM calculated savings (i.e., identical participant counts and adjustments were used). [Table 177](#) shows the results. On aggregate, the SWE estimate was approximately 102 MWh greater than the ADM estimate. The biggest differences were for the 2014 residential cohorts – a gain of 1,133 MWh for the January 2014 cohort and a loss of 1,072 MWh for the December 2014 cohort. As noted, the SWE approves of ADM's MWh and MW savings estimates

as the behavioral protocol of the Evaluation Framework provided no guidance on how to handle the calculation of lag terms when there is insufficient pre-period data.

Table 177: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	June 2012	2,754	2,776	21
Residential	June 2012	25,551	25,746	195
Low-income	January 2014	926	749	-177
Residential	January 2014	4,639	5,773	1,133
Residential	December 2014	3,766	2,695	-1,072
Total		37,637	37,739	102

The issue described in this section is more of a program design issue than an evaluation issue. Homes with insufficient pre-period data should have been filtered out when homes were being selected for the RCT. If such a filter had been applied, then calculating the lag terms would be a straightforward process. For PY9, the SWE recommends West Penn Power investigate homes with less than twelve months of pre-period data to see if additional billing records are available in FirstEnergy's billing system. If additional billing records are available, they can be included in the impact analysis. If additional billing records are not available, the SWE recommends dropping any homes without at least twelve months of pre-data from the LS model. The monthly impact estimates derived from the model can then be applied to the homes with insufficient pre-period data. (Note that the underlying assumption here is that homes without sufficient pre-period data do not systematically differ from homes with sufficient pre-period data. The SWE believes this is a reasonable assumption.)

Participation Counts

Participant counts are important because these are the totals used to convert the per-home savings estimates produced by the regression model to aggregate program impacts. The SWE's participation count audit began with the calendarized billing data provided by ADM. For any given month/cohort combination, we counted the number of unique Oracle IDs in the billing data. Presumably, the number of unique IDs for the given month/cohort combination would equal the number of participants for that combination. However, this was never the case – the number of unique IDs was less than the reported participation count for each month/cohort combination.

At this point, the SWE turned to the raw, un-calendarized billing data. Because billing cycles can exceed 31 days in length, the SWE took a different approach to calculating participants. Rather than calculate the number of unique IDs within a given cohort/month combination, we calculated the number of unique IDs beyond a certain date. As an illustrative example, suppose we wanted to compute the number of participants in West Penn Power's 2012 LI cohort for March of 2017 (12,021). We removed any records with a billing end date prior to 3/1/2017, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that tied up with the reported counts.

Demand Savings

As with energy savings, the SWE calculated demand savings using two approaches – mimic ADM’s approach, then re-run the LS model without any homes with less than twelve months of pre-period data. The results, which mirrored the results for energy savings, are shown in [Table 178](#). On aggregate, the SWE method returned an additional 0.008 MW in demand savings. The SWE approves the PY8 verified demand savings and recommends ADM runs the LS model without homes that have less than twelve months of pre-period data in the future.

Table 178: Demand Savings Comparison

Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	June 2012	0.31	0.31	0.00
Residential	June 2012	2.83	2.85	0.02
Low-income	January 2014	0.10	0.08	-0.02
Residential	January 2014	0.51	0.63	0.12
Residential	December 2014	0.41	0.30	-0.12
Total		4.15	4.16	0.01

In reviewing ADM’s methodology, only one issue arose. Step 3 of ADM’s demand savings calculation calls for a regression equation with terms for three different end uses – heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not use the ‘flat’ end use. That said, the results from using just the heat pump and interior lighting end uses are close to what they would be if flat was the only end use included.

H.4.2 Non-Residential Audit Activities

[Figure 76](#) provides a summary of the evaluation activities and M&V approaches utilized by West Penn Power’s evaluation contractor in their PY8 verified savings calculations. ADM completed site visits for 98% of the evaluation sample; the site that did not receive a site visit was evaluated via billing analysis, which is considered an enhanced rigor method. Basic Rigor was the preferred M&V approach both by energy savings contribution and project count. IPMVP Options A through D were reserved only for projects in the Custom strata.

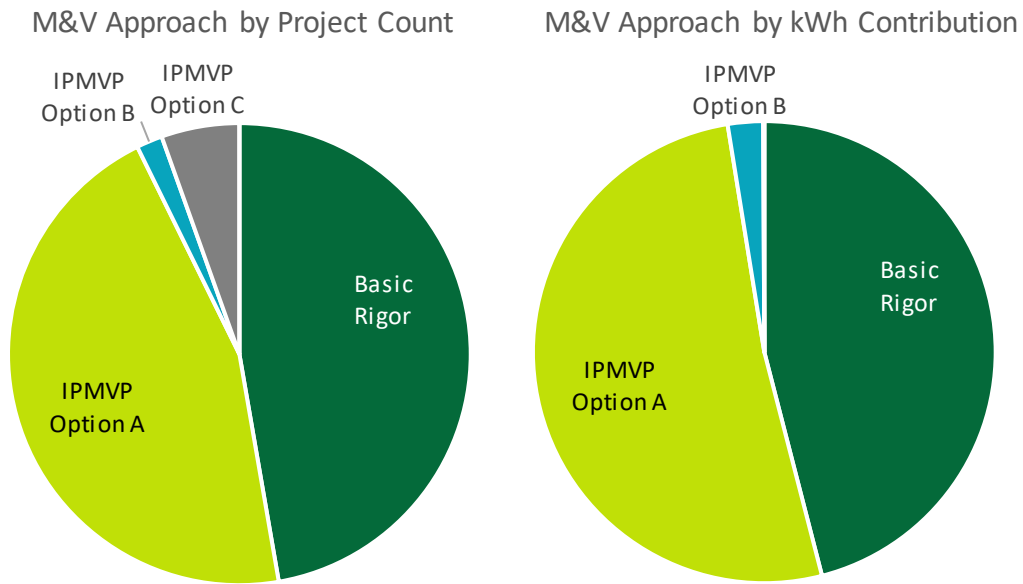
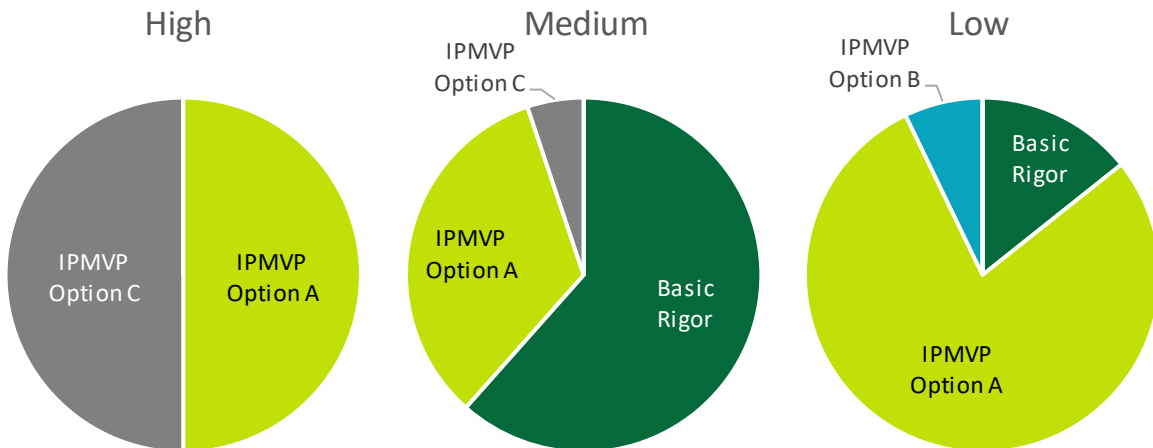
Figure 76: Summary of West Penn Power's C&I Evaluation Activities

Figure 77 provides a summary of the evaluation activities and M&V approaches West Penn Power's evaluation contractor used across strata. West Penn Power's sampling plan consisted of 11 strata, which the SWE binned for the purposes of this comparison. The distribution of rigor across sample strata is in keeping with Table 3-2 of the Phase III Evaluation Framework, whereby enhanced rigor methods are to be reserved for measures with the highest impact and/or level of uncertainty.

Figure 77: Summary of West Penn Power's C&I Evaluation Activities Across Strata

The SWE audited the activities above through a combination of Ride-Along Site Visits and Desk Reviews. The details of the SWE's findings are presented in the following subsections.

H.4.2.1 Ride-Along Site Visits

Table 179 provides an overview of the SWE milestones for the audit of West Penn Power's site inspection efforts.

Table 179: West Penn Power Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
9	1,277,049	1	4	100%

Overall, the SWE agreed with the methodology and calculations completed by West Penn Power's evaluation contractors. Custom calculation files were sometimes difficult to follow; however, the evaluation contractor was readily available to discuss and update calculations whenever needed. The evaluation contractor's submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. The SWE agreed with all engineering decisions made by the evaluators, which included adjustments to reported savings where HOU values were deemed inappropriate and adjustments to include interactive effects where they had been excluded in reported savings. No errors were found in verified savings calculations, and no recommendations were posed by the SWE.

While the SWE was satisfied overall with the evaluator's final reports and verified savings calculations, SWE inclusion on flagged sites of interest proved to be challenging for ADM, and all evaluation contractors, in PY8. The SWE communicated the deficiencies in the site inspection process with the EDCs and their evaluation contractors via individualized phone conferences with all interested parties and through a guidance memo issued in October of 2017 detailing new tools implemented by the SWE to improve the process moving forward. The suggestions provided in the guidance memo were as follows:

- ADM should submit samples in keeping with their EM&V plan to the SWE as they are drawn for SWE review. The SWE has created a template that should be followed for future submissions to make sure all information needed to select an appropriate sample is included.
- ADM should attempt to coordinate with the SWE in advance of scheduling flagged projects of interest to ensure SWE inclusion.
- ADM should use the SWE's shared cloud-based calendar for scheduling and notification of upcoming site inspections.

H.4.2.2 Verified Savings Desk Reviews

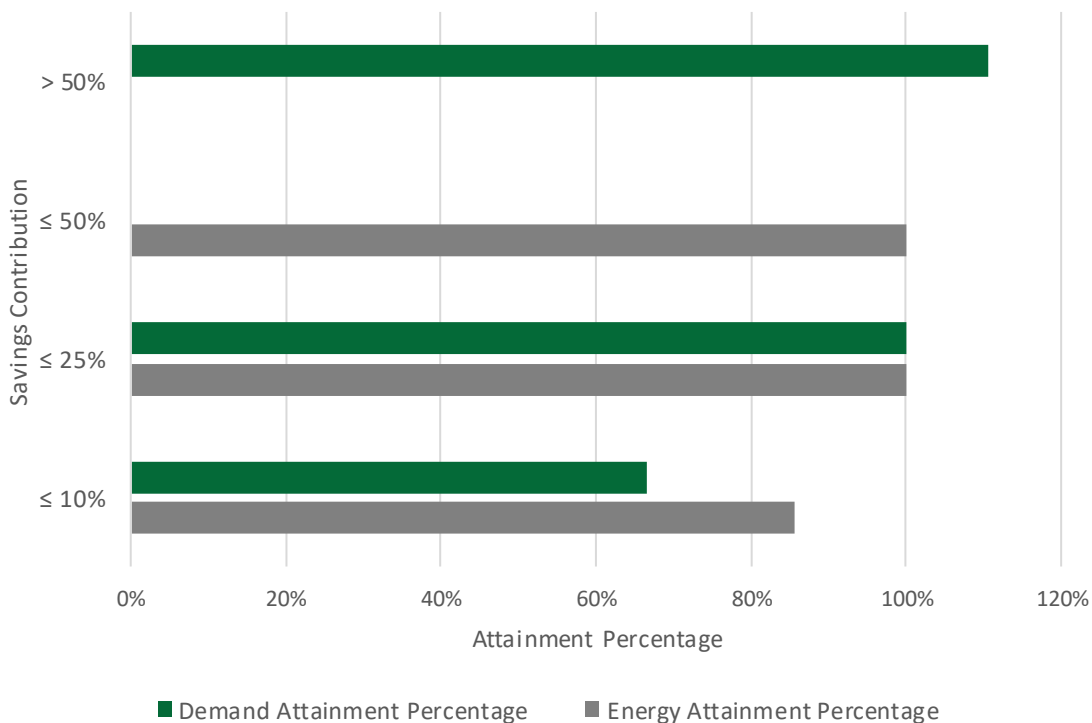
Table 180 provides an overview of the SWE milestones for the verified savings review of evaluated West Penn Power projects.

Table 180: West Penn Power Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
8	3,018,876	560	99%	106%

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 to evaluate custom projects. The SWE asserts that ADM conducted appropriate M&V efforts, and that sufficient documentation supporting savings analyses was provided in most cases.

Of the eight projects reviewed, the SWE calculated adjusted energy savings for only one project. Similarly, only two projects received adjusted demand savings. A third project was found to have deficiencies for which there was insufficient information for the SWE to make adjustments to the savings. For any project receiving SWE adjustments, the SWE calculated an attainment percentage as the ratio of adjusted savings to verified savings. The overall energy and demand savings attainment percentages of reviewed projects were 99% and 106% respectively. The distribution of the attainment percentages by savings contribution is presented in [Figure 78](#), and provides proof that greater scrutiny was applied to projects with the greatest savings contributions. Adjustments contributing to the attainment percentages are described individually by project in the following paragraphs.

Figure 78: West Penn Power Verified Savings Attainment Percentage

In general, lighting projects consistently excluded the Appendix C calculator required for all lighting projects by Section 3.1.1 of the TRM. West Penn Power's ICSP has created their own lighting calculator that has been used in place of the TRM-provided Appendix C calculator for all lighting projects. The evaluator however has implemented a process for PY9 through which each ICSP lighting workbook will be transcribed into an Appendix C calculator for evaluation purposes. The omission of Appendix C calculators had no effect on the attainment percentages, and has already been addressed by the evaluator.

Project PRJ-1961-H achieved energy savings for the installation of a ground-source heat pump (GSHP) in keeping with TRM measure 3.2.3. The TRM algorithm for GSHP savings is the summation of the GSHP Heating, Cooling, and Pump savings/penalties where the pump penalty can be ignored in the event that the baseline equipment is also a GSHP. However, this project was new construction, and so was comparing the GSHP to an assumed Air-Source Heat Pump (ASHP) baseline per the TRM. ADM's calculations did not account for the additional proposed energy associated with the GSHP's pump. The SWE added the algorithms from the TRM which account for the GSHP pump energy, which resulted in a significant increase in proposed energy use, and thus a significant decrease in estimated energy and demand savings. This project only accounts for 1% of the SWE's sample and as such produced only a minimal effect on the attainment percentage.

Project PRJ-9003-C achieved energy savings for plant retro commissioning. The SWE identified issues with the calculation of peak kW demand reductions for this project. The SWE's review of the project documentation showed that ADM calculated peak kW reduction based on the average kW demand over the course of entire summer weekdays, which was then divided by 24. This type of calculation assumes that the load shape is consistent across each hour of each day, which the SWE feels is unlikely. The SWE modified this calculation to focus on the peak hours of 2:00 PM to 6:00 PM by determining a ratio of average dry-bulb temperature (DB) during peak hours to average DB during all summer weekday hours, and applying this ratio to ADM's calculated average summer weekday kW reduction.

Project PRJ-1904-C achieved energy savings for a variety of custom measures. The reported analysis for this project did not show demand savings. However, ADM revised this analysis in a manner that incurred a reduction in average kW demand, but did not calculate the coincidence of this reduction with the peak period. The information provided was insufficient for the SWE to determine the peak demand reduction, therefore the SWE left the peak kW demand reduction for this project at zero.

Additional negligible adjustments were incurred due to inconsistent rounding precisions across reviewed projects that the SWE corrected.

While the review of West Penn Power's verified savings calculations showed appropriate use of rigor across projects, the SWE makes the following recommendations to ensure the accuracy of verified savings in the upcoming program years:

- ADM should take greater care in selecting an appropriate TRM baseline where multiple options exist and have implications on savings calculations.

- ADM should complete custom peak demand reduction calculations at the most granular level possible given the data available.

H.5 NTG

H.5.1 Residential Programs

ADM/Tetra Tech estimated a PY8 NTG for several programs: the Appliance Turn-in Program, the Energy Efficiency Kit component of the Energy Efficient Homes Program, and the Residential Energy Efficient Products Program.

For the Appliance Turn-In Program, ADM/Tetra Tech used primary data collection (participant surveys) to estimate NTG for all appliances in the program though the SWE recommends estimating NTG by measure. NTG was estimated with the recommended UMP appliance recycling protocol. ADM/Tetra Tech created a decision tree that depicted all the program's possible savings scenarios and took the weighted average of the decision trees values to inform NTG.

For the Energy Efficient Homes Program, ADM/Tetra Tech calculated NTG for the Energy Efficiency Kits component of the program; the kit component of the program was a high-impact measure (HIM). The Energy Efficiency Kits NTG was calculated using data from participant surveys and the common method. FirstEnergy provided Excel workbooks with the raw data from their NTG research and the SPSS syntax files used to calculate the NTGRs from the raw data that allowed the SWE to confirm methodology.

ADM/Tetra Tech assigned the HERs component of the program a NTG of 1, in accordance with the Evaluation Framework, and was not informed by participant surveys, but assumes that the RCT design eliminates free-ridership and produces negligible spillover.

A NTG of 0.5 was applied to the Direct Install and New Homes components of the Program. The SWE could not determine the data source for the New Homes and Direct Install NTG and recommends that ADM/Tetra Tech provide documentation on either the values source or an explanation.

For the Residential Energy Efficient Products Program, ADM/Tetra Tech applied the NTG from Phase II to the upstream Electronics component of the program. The upstream Lighting component NTG was estimated in PY8 and was informed by retailer and customer surveys. ADM/Tetra Tech provided retailer and customer syntax and data allowing NTG and method to be verified by the SWE. The Lighting NTG did not include Delphi panel NTG (as was the preferred method noted in the PY8 Evaluation Plan) or shelf stocking and or sales data analysis. ADM/Tetra Tech noted that the missing NTG estimation methods have not been completed nor data collected. The SWE recommends vigilance in acquiring pricing data, shelf stocking data, and completing the Delphi panel to avoid further delays that would hinder a more rigorous upstream lighting NTG.

The downstream components of the Program (Residential HVAC initiative and Residential Appliances) were based on customer survey data. NTG was weighted by measure energy savings and were confirmed by the SWE to be calculated with the common method. ADM/Tetra Tech

estimated HVAC NTG using self-report data from program participants using the common method recommended in the Evaluation Framework which was verified by the SWE audit.

Table 181: Summary of NTG Estimates for WPP Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.55	0.0	0.45	173
Estimated	Upstream Lighting	0.73	0.0	0.27	143 (customers) 19 (retailers)
Estimated	EE Kits	0.20	0.02	0.82	154
RCT	Home Energy Reports	0	0	1	--
Applied	Direct Install and New Homes	--	--	0.50	--
HVAC	Estimated	0.52	0.01	0.49	74

H.5.2 Low-Income Residential Programs

ADM/Tetra Tech assigned LIEEP a NTG of one in keeping with the PY8 Evaluation Plan and SWE Phase III Evaluation Framework.

H.5.3 C&I Programs

ADM/Tetra Tech conducted NTG research in PY8 for the Business Lighting, Business Custom, and Business Prescriptive components of the C&I ES for Business Program for both small and large C&I. ADM/Tetra Tech utilized PY7 NTG ratios for the Business Appliance Turn-in and Business Direct Install components of the ES Program and has stated in the Phase III EMV plan that new NTG research will be conducted in PY9.

ADM/Tetra Tech utilized participant customer and vendor surveys to gather data for the ES Business Lighting component, the sample was stratified by participant MWh usage to capture the impacts of a small number of program participants who represent a large portion of the program savings. The data was then used to estimate NTG for the MWh strata as well as the overall program NTG. The data and method were reviewed by the SWE and found to be in keeping with the Phase III Evaluation Framework using the common method for estimation. ADM/Tetra Tech employed the same data gathering method utilized in the Lighting component with the Custom component to represent the small group of participants who contributed a large percentage of the overall program component savings. ADM/Tetra Tech had limited success recruiting the largest participants in their research and, in order to avoid this issue in the future, have proposed including NTG research as part of the rebate application package to ensure greater participation rates and higher levels of confidence. NTG was estimated by usage strata and total program component and the data and method were in keeping with the Framework and the common method of estimation. The SWE recommends presenting multiple years of Lighting NTG in order to observe the differences between previous methods and methods including the additional participants. The

NTG methodology for the Prescriptive component was identical to the Custom component methodology and found to be compatible with the Phase III guidelines and the common method. The SWE recommends that ADM/Tetra Tech describe their method of incorporating Program components NTG values to estimate total program NTG for the sake of transparency.

Table 182: Summary of NTG Estimates for WPP C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Small Energy Solutions for Business Lighting	0.22	0.05	0.83	70
Estimated	Small Energy Solutions for Business Custom	0.47	0.0	0.53	14
Estimated	Small Energy Solutions for Business Prescriptive	0.0	0.0	1	21
PY7	Small Energy Solutions for Business Appliance Turn-In	--	--	0.45	--
PY7	Small Energy Solutions for Business Direct Install	--	--	0.50	--
Estimated	Small Energy Solutions for Business Total	--	--	0.82	--
Estimated	Large Energy Solutions for Business Lighting	0.22	0.05	0.83	70
Estimated	Large Energy Solutions for Business Custom	0.47	0.0	0.53	14
Estimated	Large Energy Solutions for Business Prescriptive	0.0	0.0	1	21
Estimated	Large Energy Solutions for Business Total			0.74	

H.6 TRC

Table 183 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for West Penn's PY8 individual energy efficiency programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY8 annual report.

Table 183: Summary of West Penn's PY8 TRC Results

Program Name	TRC NPV Gross Benefits (\$1000)	TRC NPV Gross Costs (\$1000)	Gross TRC	TRC NPV Net Benefits (\$1000)	TRC NPV Net Costs (\$1000)	Net TRC
Appliance Turn-in	1,444	775	1.86	650	775	0.84
Energy Efficient Homes	7,111	6,547	1.09	5,842	5,986	0.98
Energy Efficient Products	15,324	7,776	1.97	4,334	3,540	1.22
Low-Income Energy Efficiency	2,599	3,573	0.73	2,599	3,573	0.73
C&I Energy Solutions for Business - Small	6,974	6,173	1.13	5,746	5,276	1.09
C&I Energy Solutions for Business - Large	4,582	4,173	1.10	3,408	3,308	1.03
Governmental & Institutional Tariff	2,035	2,178	0.93	1,686	1,839	0.92
Portfolio Total	40,069	31,752	1.26	24,265	24,854	0.98

¹ Program costs will not sum to Portfolio Total which includes costs from inactive Demand Response programs.

Of West Penn's seven energy efficiency programs offered, five were found to be cost-effective and two were non-cost-effective using gross verified savings. Using net verified savings, three were found to be cost-effective and four were non-cost-effective. The Appliance Turn-in and Energy Efficient Homes Programs were cost-effective when using gross verified savings, but non-cost-effective when using net verified savings. The following is a list of cost-effective and non-cost-effective programs.

Gross verified savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Homes
- Energy Efficient Products
- C&I Energy Solutions for Business - Small
- C&I Energy Solutions for Business - Large

Net verified savings

Cost-Effective Programs (TRC > 1):

- Energy Efficient Products
- C&I Energy Solutions for Business - Small
- C&I Energy Solutions for Business - Large

Non-Cost-Effective Programs (TRC < 1):

- Low-income Energy Efficiency Products
- Governmental & Institutional Tariff

Non-Cost-Effective Programs (TRC < 1):

- Appliance Turn-in
- Energy Efficient Homes
- Low-income Energy Efficiency Products
- Governmental & Institutional Tariff

H.6.1 Additional Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template, but had independent inputs specific to that company.

- West Penn used a discount rate of 6.68%, used to calculate the net present value of future program benefits, is consistent with what is stated in their EE&C plan. Line loss adjustment factors varied by Residential (1.0943), Small C&I (1.079), and Large C&I (1.079) sectors.
- The incremental costs were derived from the PA SWE Database, historic actuals, the Database for Energy Efficiency Resources (DEER), company assumption and evaluations. The SWE spot checked the incremental costs used in the TRC model and found them to be consistent with West Penn's EE&C plan.
- Realization rates for energy and demand impacts were applied to the reported gross program impacts in the TRC model to recreate 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 TRC Order directive for Phase III.
- The SWE found that the cost categories were handled correctly: incentives were not considered costs but administrative costs, incremental costs, and kits were incorporated as costs. The TRC model followed the protocol specified in the 2016 Test Order pertaining to the treatment of free-rider participant costs; free-ridership participant costs are not included in net program costs.
- The TRC model reports the cost from increase heating usage due to lighting interactive effects from more efficient lighting as a negative Total NPV Lifetime Non-Electric Benefit. The SWE agrees that the cost should be accounted for as a non-electric benefit rather than a fossil fuel switching program cost.
- The West Penn TRC model accounts for the dual baselines for residential lighting by reducing the EULs to adjust lifetime savings. FirstEnergy notes in their report that their 2016 TRM-compliant TRCs are conservative due to the growing uncertainty of the likelihood of DOE enforcement of EISA 2020 standards and presents gross and net TRCs with and without the dual baseline for comparison. [Table 184](#) shows that without the dual baseline included in the TRC model, the gross and net TRCs are higher than when the dual baselines are included.

Table 184: West Penn Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.26	0.98
Without Dual Baseline	1.40	1.02

The SWE noted a handful of minor issues pertaining to the implementation of the TRC model which are included here. None of the items listed below are cause for concern about the material results of the TRC model, and are noted here as recommendations for adjustments to be made in future PY reporting.

- The PY8 TRC models used the avoided costs of energy and capacity estimated using the method approved in the Phase III EE&C. While the avoided costs in the TRC model appeared to be within reasonable ranges, the SWE was unable to directly compare the costs since the costs were not provided in the Phase III EE&C plan like it had been in prior program years. The SWE recommends an avoided costs table be included in future EE&C plans.
- Table 340 of the PY8 report for CI Lighting Initiative Net-to-Gross needs to be revised so that the NTG Ratio for Lighting-Certainty is “n/a” rather than #VALUE! and the program total Relative Precision is #VALUE! And needs to include only Lighting-1, Lighting-2, and Lighting-3. The SWE recommends more thorough proofing of the tables and calculations to make sure measures with missing information do not impact the overall program calculation.
- The SWE verified the measure-specific EULs. The team found that the EULs were mostly consistent with the 2016 TRM. The EUL for Programmable Thermostats are 11 in the 2016 TRM and West Penn’s EE&C Plan, but is 15 in the TRC model. The SWE recommends updating the Programmable Thermostat EUL in future PY reporting.
- The TRC model ignores decreased fossil fuel consumption from energy efficient measures that saved space heating and water heating fuel, underestimating the benefits. The SWE recommends accounting for quantifiable water and fossil fuel avoided costs as stated in in the 2016 TRM in future PY reporting.
- West Penn’s EE&C Plan states that the avoided cost data is based on the methodology prescribed in the 2016 TRC and savings values based on the protocols stated in the 2016 TRM. Annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broad peak definition, which are unlike Act 129 peak hours defined in the 2016 TRM. The result are higher on-peak fractions than would otherwise be under the 2016 TRM with energy savings based on seasons. Despite this difference, the avoided costs and load profiles share common definitions. The SWE is convinced the results are sound.

H.7 PROCESS

FirstEnergy's evaluation contractor, ADM/Tetra Tech, took unified process evaluation approaches to these programs across the four FirstEnergy EDCs, including West Penn, so the annual evaluation reports of the four FirstEnergy EDCs report identical information about the process evaluation. Therefore, the SWE's audit summary described for previously applies to all four FirstEnergy utilities, including West Penn.

Appendix I 2016 TRM SWE Clarification Memo

I.1 TRM SECTION 2.2.3 DUCTLESS MINI-SPLIT HEAT PUMPS

- Issue: Missing Inputs to Estimate Peak Demand Savings. Table 2-21 (DHP – Values and References) of the protocol does not provide the necessary input (EERbase) to estimate peak demand savings for air source heat pumps (ASHP).
- Clarification: The existing EERbase value for ductless heat pumps (DHP) applies to ASHP (i.e., the EERbase value for ASHPs equals $(12/14) \times \text{SEERbase}$).

I.2 TRM SECTION 2.4.4 ENERGY STAR CLOTHES WASHERS

- Issue: Clothes Washer Capacity Variables. In Section 2.4.4 (ENERGY STAR Clothes Washers), Table 2-80 (ENERGY STAR Clothes Washers - References), the procedure of using the EDC data gathering option for the capacity term (CAPYee and CAPYbase) is unclear because the default capacity values are smaller than the average capacity of clothes washers that are currently available in the marketplace. Using the EDC data gathering for CAPYee will result in a CAPYee value that greatly exceeds the current default value of CAPYbase, and the discrepancy in CAPYee and CAPYbase results in a reduction in calculated energy and demand savings.
- Clarification: If the EDC data gathering option is used to determine CAPYee, CAPYbase should be set equal to CAPYee. The default capacity values of 3.1 cubic feet for CAPYbase and CAPYee are based on the EPA's ENERGY STAR Appliance Savings Calculator available at the time the 2016 TRM was issued. However, the ENERGY STAR Calculator was updated in October 2016, after the release of the 2016 TRM, and the default capacity—based on the available clothes washers on the ENERGY STAR qualified products list—is now 4.5 cubic feet. The EDC data gathering option is no longer viable because of the increased average capacity of the efficient unit and because there is currently no EDC data gathering option for CAPYbase.

I.3 TRM SECTION 3.1.1 LIGHTING IMPROVEMENTS (COMMERCIAL)

- Issue: Clarification of Default Values for Lighting Controls. In Table 3-4 (Savings Control Factors Assumptions), EDCs asked the SWE to clarify whether the values in the column labelled “Savings %” provide default values for baseline savings factors (SVGbase) only or if the column provides savings factor values for both baseline and installed lighting controls (SVGee).
- Clarification: In Table 3-4 (Savings Control Factors Assumptions), the values in the column “Savings %” provide default values for both SVGbase and SVGee. Note that the default values from Table 3-4 are used in the Lighting Controls protocol, section 3.1.3. Table 3-15 (Lighting Controls Assumptions) of section 3.1.3 refers the TRM user to Table 3-4 for default values for both SVGbase and SVGee.

I.4 TRM SECTION 3.1.1 LIGHTING IMPROVEMENTS (COMMERCIAL)

- Issue: Clarification of Application of Default Hours of Use (HOU). Table 3-5 (Lighting HOU and CF by Building Type for Screw-Based Bulbs) and Table 3-6 (Lighting HOU and CF by Building Type for Other General Service Lighting) provide HOU by building type and also for exterior and street lighting, but the tables do not specify if the HOU for each distinct building type are for interior or exterior lighting. In addition, the protocol does not provide guidance for determining whether to use street lighting or exterior lighting HOU.
- Clarification: The default HOU specified by building type in Tables 3-5 and 3-6 of section 3.1.1 are applicable to interior lighting with the exception of the HOU specified for exterior lighting and street lighting. Exterior lighting and street lighting address similar, but slightly different, lighting applications. Street lighting is generally municipally owned, operates from dusk to dawn, and is not connected to a specific facility; street lighting projects should use dusk to dawn HOU reported in Table 3-7 (Street lighting HOU by EDC). Exterior lighting, in contrast, is connected to a specific facility and does not always operate from dusk to dawn. If an exterior lighting project cannot demonstrate that the lighting operates from dusk to dawn, the exterior lighting HOU reported in tables 3-5 and 3-6 should be used. However, if the exterior lighting operates from dusk to dawn, the street lighting HOU in Table 3-7 are the appropriate HOU.

I.5 TRM SECTION 3.1.1 LIGHTING IMPROVEMENTS (COMMERCIAL)

- Issue: Source for Interactive Factors. EDCs asked the SWE to clarify the source for the Interactive Factors (IF) reported in Table 3-9 of section 3.1.1 (Lighting Improvements).
- Clarification: The source is listed in Table 3-8 (Interactive Factors for All Bulb Types): Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. <http://www.puc.pa.gov/pcdocs/1340978.pdf>

I.6 TRM SECTION 3.1.2 NEW CONSTRUCTION LIGHTING & APPENDIX C

- Issue: Distinguishing between Tradable and Non-Tradable Lighting Spaces. Neither the TRM section (3.1.2) nor App C provide guidance on distinguishing between tradable and non-tradable lighting spaces (as ASHRAE 90.1-2007 does).
- Clarification: Section 3.1.2 of the TRM (New Construction Lighting) and the associated functionality in the Appendix C: Lighting Audit and Design Tool calculate energy and peak demand savings for new construction lighting projects by comparing the installed lighting power density (LPD) of projects with the allowed LPD according to ASHRAE 90.1-2007. Buildings or spaces that use less lighting power than allowed by code generate energy and peak savings according to appropriate hours of use and coincidence factors for the building type and HVAC system. For exterior lighting spaces, ASHRAE 90.1-2007 distinguishes between “tradable” and “non-tradable” spaces. The 2016 PA TRM does not make this distinction and considers all spaces to be tradable. The intent of the TRM and Act 129 programs is not code enforcement. If a particular non-tradable space is over-lit

according to ASHRAE 90.1-2007 design standards, the extent to which the space exceeds allowed levels simply counts as a penalty – or negative savings that reduce the total energy savings attributed to the project. It is important that the TRM and Appendix C calculator not exclude such spaces, or zero out the penalty to estimate accurate energy and peak demand savings at the facility level. EDCs may choose to include data validation rules in their production versions of the Appendix C calculator to ensure that over-lit spaces are not the result of data entry errors to square footage or wattage values.

I.7 TRM SECTION 3.1.3 LIGHTING CONTROLS (COMMERCIAL)

- Issue: Clarify Value of Variable. EDCs asked the SWE to clarify whether the variable kWcontrolled in Table 3-15 (Lighting Controls Assumptions) of section 3.1.1 (Lighting Improvements) should be based on “per controlled system” or “per control.”
- Clarification: The variable kWcontrolled should be based on “per controlled system” rather than “per control.”

I.8 TRM SECTION 3.1.3 LIGHTING CONTROLS (COMMERCIAL)

- Issue: Clarify the Baseline Savings (SVGbase) Default Values and Source. EDCs asked the SWE to clarify the explanation of and source for the default baseline savings factor (SVGbase) description in footnote 259 (footnoted to Table 3-15).
- Clarification: Lighting controls are required in three new construction space types: classrooms, meeting/conference areas, and lounge/break rooms. The percentage of connected load found in these three spaces varies by commercial building type. The default values for SVGbase for New Construction, reported in Table 3-14 (Default Baseline Savings Control Factors Assumptions for New Construction Only), are estimated per building type and based on the percentage of connected load found in the three new construction space types that require lighting controls (classrooms, meeting/conference areas, and lounge/break rooms). The percentage of connected load is based on the lighting metering study: Pennsylvania Statewide Act 129 2014 Commercial & Residential Light Metering Study (<http://www.puc.pa.gov/pcdocs/1340978.pdf>). In section 3.1.3 (Lighting Controls), Table 3-15 (Lighting Controls Assumptions) reports the terms used in the savings algorithms. The savings factors variables (SVGbase and SVGee) refer to default values reported earlier in section 3.1 (Lighting Improvements, Commercial). Footnote 259, associated with the SVGbase variable in Table 3-15, provides context for the default values reported in Table 3-14. Footnote 259 should also be associated with Table 3-14, and the full title of the lighting metering study referenced in footnote 259 is the Pennsylvania Statewide Act 129 2014 Commercial & Residential Light Metering Study (<http://www.puc.pa.gov/pcdocs/1340978.pdf>).

I.9 TRM SECTION 3.2.1 HVAC SYSTEMS

- Issue: Footnote Clarification. EDCs asked the SWE to clarify whether footnote 278 should be linked to a single row, Multi-Family (Common Areas), in Table 3-25 (Air Conditioning Equivalent Full Load Hours [EFLHs] for Pennsylvania Cities) or linked to the entire table.
- Clarification: The footnote applies only to the single row of the table, Multi-Family (Common Areas). The rest of the EFLH values in Table 3-25 were calculated based on Nexant's eQuest modeling analysis 2014, as reported in Table 3-23 (Variables for HVAC Systems).

I.10 TRM SECTION 3.2.1 HVAC SYSTEMS

- Issue: Heating EFLH Values. EDCs asked the SWE to clarify whether Table 3-27 (Heat Pump EFLHs for Pennsylvania Cities) includes both heating and cooling ELFHs for heat pumps or whether it is limited to heating ELFHs.
- Clarification: The ELFHs reported in table 3-27 are for heating only (i.e., Table 3-27 reports heating EFLHs for heat pumps). Total EFLH for a heat pump is the sum of the ELFH values in Table 3-25 and Table 3-27. It is important to note that the heating EFLH values in Table 3-27 are used as the EFLH values for gas furnaces and other heating equipment measures for several other measure protocols (for example, 3.2.4 Ductless Mini-Split Heat Pumps and 3.3.3 ECM Circulating Fan).

I.11 TRM SECTION 3.2.2 ELECTRIC CHILLERS

- Issue: Measure Variable Values. The introductory table for section 3.2.2 provides a summary of the measure vintages for which the TRM protocol is applicable (Replace on Burnout, New Construction, or Early Replacement). Table 3-28 (Electric Chiller Variables) lists the IPLVbase value (Integrated Part Load Value of the baseline unit) for two of the three measure vintages (new construction and replace on burnout units), but it does not provide the IPLVbase for the third (early replacement units).
- Clarification: For the IPLVbase value of early replacement units, the nameplate value of existing unit that is replaced should be used (i.e., "Early Replacement: Nameplate Data") and the data source should be "EDC Data Gathering."

I.12 TRM SECTION 3.2.3 WATER SOURCE AND GEOTHERMAL HEAT PUMPS

- Issue: Footnote Clarification. The EDCs asked the SWE to clarify whether footnote 285, associated with Table 3-33 (Geothermal Heat Pump–Values and Assumptions) is meant to direct users to use the value zero for the parameter HPbasemotor when the baseline system is an ASHP.

- Clarification: Footnote 285 is meant to direct users to use the value zero for the parameter HPbasemotor when the baseline system is an ASHP. The intent is to capture the energy penalty associated with the ground loop pumps of a ground-source heat pump.

I.13 TRM SECTION 3.3.2 VARIABLE FREQUENCY DRIVES (VFD) IMPROVEMENTS

- Issue: Missing Conversion Factor. The EDCs asked whether the algorithms for energy and demand savings (p. 322) are missing a conversion factor for horsepower to kW.
- Clarification: The algorithms are not missing the conversion factor. The conversion factor was removed in an Errata update to the 2013 TRM (<http://www.puc.state.pa.us/pcdocs/1278197.docx>). Before the correction, the savings algorithm included a factor to convert horsepower to kW. The factor was redundant because the Energy Savings Factor (ESF) and Demand Savings Factor (DSF) used in the 2013 TRM already accounted for the conversion factor. As such, the algorithm effectively multiplied the factor twice, which miscalculates savings. The conversion factor has been taken into account in the default ESF and DSF values reported in Table 3-65 (ESF and DSF for Typical Commercial VFD Installations).

I.14 TRM SECTION 3.3.3 ECM CIRCULATING FAN

- Issue: Heating EFLH Values for other HVAC Equipment. EDCs asked the SWE to clarify Heating EFLH values. In Table 3-65 of section 3.3.3 (ECM Circulating Fan), the default value for EFLHheat refers to Table 3-27 (Heat Pump EFLHs for Pennsylvania Cities) in section 3.2.1. EDCs asked whether the default EFLHheat hours apply to furnaces and other HVAC equipment.
- Clarification: As discussed in the guidance for TRM Section 3.2.1 (HVAC Systems) in this memo, the values in Table 3-27 are intended to be used as proxy default EFLHheat for furnaces and other heating equipment.

I.15 TRM SECTION 3.5.6 CONTROLS: ANTI-SWEAT HEATER CONTROLS

- Issue: Measure Unit Definition. The EDCs asked the SWE to clarify whether the Measure Unit should include “linear feet of case” in addition to “case door.”
- Clarification: The “Measure Unit” should include both “Case Door” and “Linear Feet of Case.”

I.16 TRM SECTION 3.5.12 DOOR GASKETS FOR WALK-IN AND REACH-IN COOLERS AND FREEZERS

- Issue: Measure Eligibility. The EDCs asked the SWE to clarify whether reach-in coolers and freezers are eligible under the protocol. The summary table at the beginning of section

3.5.12 only includes “walk-in coolers and freezers” and the eligibility section only mentions walk-ins, while the section title and protocol summary includes reach-in coolers and freezers.

- Clarification: Reach-in coolers and freezers are eligible measures.