SWE Annual Report

Act 129 Program Year 9

Version 1.1

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SUBMITTED TO:
Pennsylvania Public Utility Commission

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Acknowledgments

The Act 129 Phase III Statewide Evaluation (SWE) Team 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 9 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
CHP	Combined Heat and Power
CSP	Conservation Service Provider or Curtailment Service Provider
CV	Coefficient of Variation
DLC	Direct Load Control
DR	Demand Response
EDC	Electric Distribution Company
EDT	Eastern Daylight Time
EE&C	Energy Efficiency and Conservation
EM&V	Evaluation, Measurement, and Verification
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
IDI	In-depth Interview
ISR	In-service Rate
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
LI	Low-Income
LIURP	Low-Income Usage Reduction Program
MSRP	Manufacturer Suggested Retail Price
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
RCT	Randomized Control Trial
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 as 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 9 (PY9), June 1, 2017 to May 31, 2018, is the second 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 2021.[1] 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 PY9 annual reports to the PUC, the seven EDCs claimed a total of 1,455,531 MWh/year of verified gross energy savings for PY9 (approximately 25% of the statewide Phase III target) and a total of 2,536,350 MWh/year of verified gross energy savings for Phase III to date (approximately 44% 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 PY9. The SWE audit validated most of the savings calculations. Errors were discovered in the verified savings calculations of six of the seven EDCs that led to both increases and decreases in the MWh and MW totals for those EDCs and a net increase statewide in savings for a revised PY9 gross verified statewide total of 1,457,892 MWh/year (approximately 26% of the statewide Phase III target) and phase-to-date verified gross savings of 2,536,712 MWh/year (44% 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 PY10 and beyond. [2]

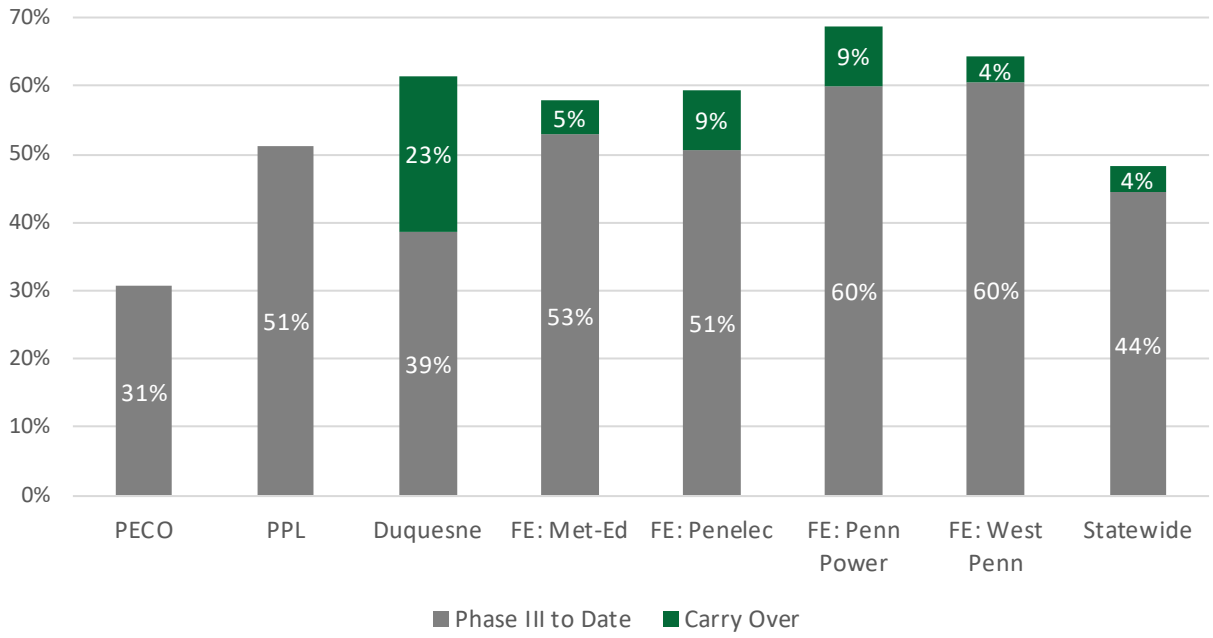
Progress Towards Portfolio Targets

Progress toward the individual EDC Phase III compliance targets to date in verified gross energy savings ranged from 31% (PECO) to 60% (Penn Power and West Penn) (see Figure 1). Including carryover savings from Phase II, total progress toward Phase III targets ranged from 31% (PECO) to 69% (Penn Power). 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/pcdocs/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: Phase III to Date Verified Savings Progress Toward Phase III Compliance Target, by EDC and Statewide*

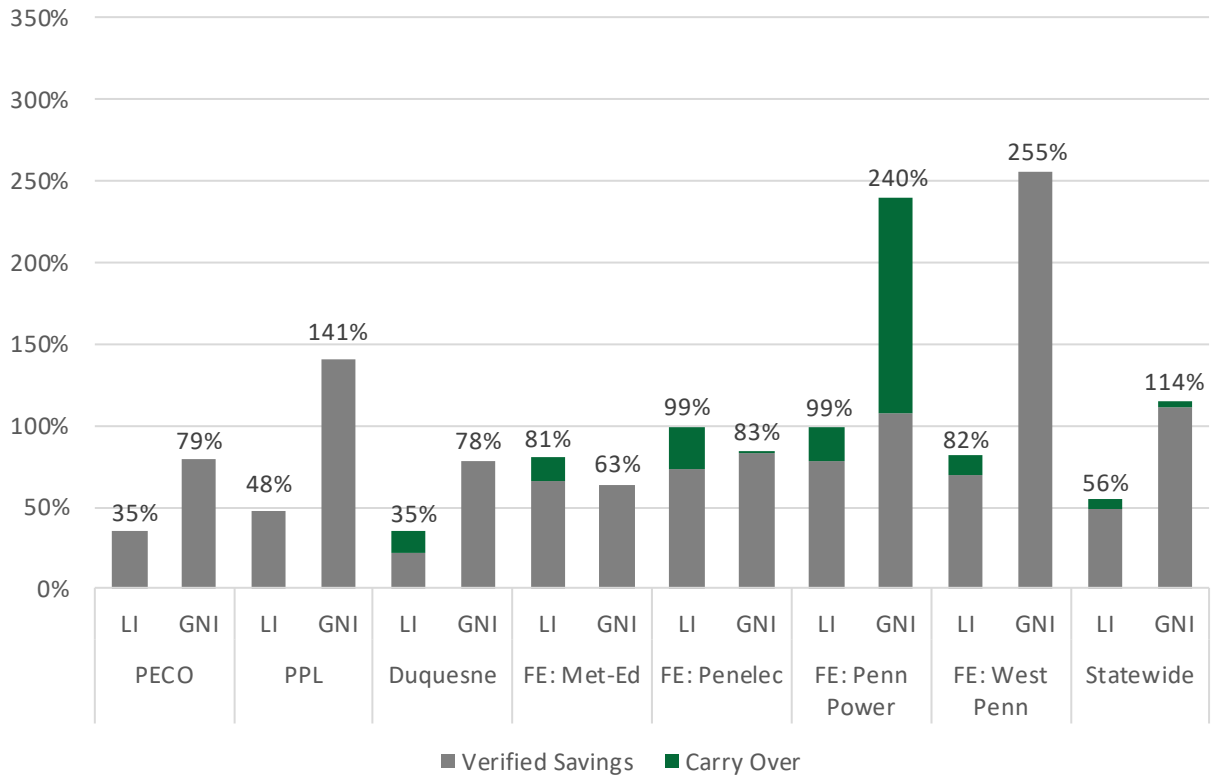


* The overall progress to target may not be equal to the sum of verified and carryover savings due to rounding.

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 Phase III to date progress toward their targets. Progress toward the low-income target ranged from 21% (Duquesne Light) to 78% (Penn Power) in Phase III to date verified gross savings and 35% (Duquesne Light and PECO) to 99% (Penn Power and Penelec) when Phase II carryover savings are included. Progress toward the GNI target ranged from 63% (Met-Ed) to 255% (West Penn) in Phase III to date verified gross savings and 63% (Met-Ed) to 240% (Penn Power) when Phase II carryover savings are included.

Figure 2: Phase III to Date 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 in PY9. 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, PY9

EDC	Proportionate Number of Measures Target	PY9 Proportionate Number of Measures, Reported	PY9 Proportionate Number of Measures, SWE Verified
PECO	8.80%	43.5%	29.1%
PPL	9.95%	22.1%	25.4%
Duquesne Light	8.40%	19.8%	23.7%
FE: Met-Ed	8.79%	37.3%	34.4%
FE: Penelec	10.23%	37.3%	34.4%
FE: Penn Power	10.64%	37.3%	34.4%
FE: West Penn	8.79%	37.3%	34.4%

Phase III Performance by Customer Segment

Figure 3 presents the PY9 verified gross savings by customer segment and Figure 4 presents Phase III to date 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 half (50%) of verified gross savings in PY9 and just over half (54% in Phase III to date verified gross savings.

[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: PY9 Verified Gross Savings by Customer Segment, Statewide

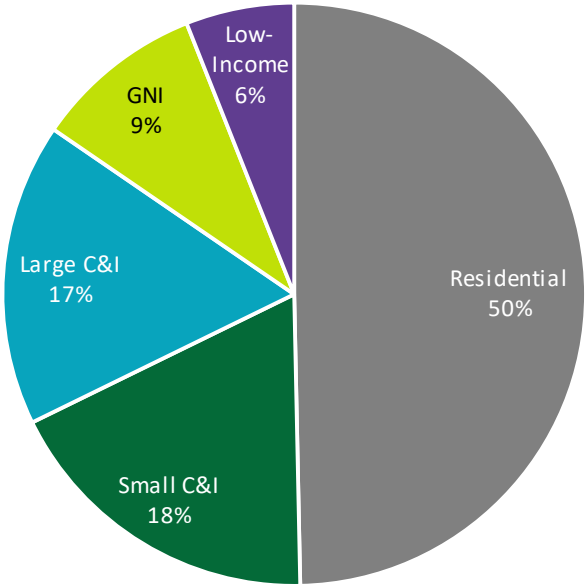
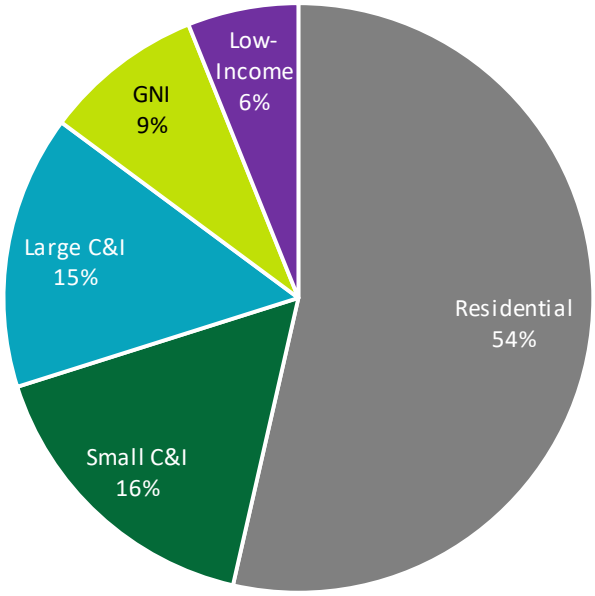


Figure 4: Phase III to Date Verified Gross Savings by Customer Segment, Statewide

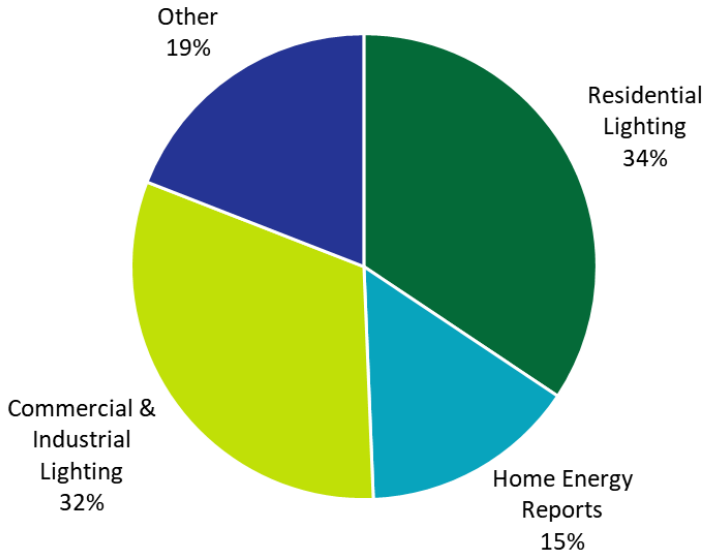


TOP SAVING PROGRAMS

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, PY9 gross verified energy savings came overwhelmingly from three offerings: residential 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 PY9, the three offerings contributed 81% of the verified gross energy savings in the Commonwealth. The SWE notes that this total value for the top three offerings matches the findings for PY8, when lighting and HERs accounted for 81% of PY8 verified gross savings.

Figure 5 shows the contribution to PY9 verified gross portfolio MWh savings from lighting, HERs, and all other offerings combined.

Figure 5: Top Saving Program Types in PY9



Seventy-seven percent of the PY9 residential lighting energy savings came from upstream retail lighting programs, while the other 23% was achieved via lighting distributed through kits and direct install offerings. Overall, lighting accounts for 66% of statewide PY9 verified gross savings. In PY8, lighting measures accounted for 62% of all MWh savings and HERs accounted for 19%.

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 PY9. 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.

DEMAND RESPONSE SUMMARY

The final Phase III Implementation Order[5] established demand response targets for each EDC covered by Act 129 (with no DR target for Penelec). The peak demand reduction targets, in MW, are presented in Table 2 along with the average performance across the three PY9 DR events. Act 129 DR events are triggered on non-holiday summer weekdays when PJM's day-ahead load forecast for the RTO is greater than or equal to 96% of the peak load forecast for the summer. Each event is four hours in length. It is important to note that the EDCs were not required to obtain peak demand reductions in the first program year of Phase III (PY8). The targets reported in Table 2 are for the average performance across events in PY9 through PY12.

Table 2: Act 129 Phase III Demand Response Compliance Targets

EDC	Phase III Demand Response Target (MW)	PY9 Average Event Performance (MW)
PECO	161	149.4
PPL	92	126.7
Duquesne Light	42	59.1
FE: Met-Ed	49	46.0
FE: Penelec	0	0
FE: Penn Power	17	33.5
FE: West Penn	64	81.9
Statewide	**425**	**496.6**

Compliance with Phase III demand response targets is based on average performance across all Phase III DR events. PY9 comparisons with Phase III targets are presented for informational purposes. Any determination of compliance will require data from all four performance years. The Commission's Phase III Implementation Order also established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. The EDC-specific demand response discussions in Section 3 compare DR performance on individual event days to this 85% threshold.

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

[5] http://www.puc.state.pa.us/pcdocs/1367313.doc. From the Public Meeting of June 11, 2015. Docket No. M-2014-2424864.

Test Order[6] to document the methodology and assumptions EDCs should use when calculating the costs and benefits of Phase III EE&C portfolios.

Table 3 shows the net present value (NPV) costs and benefits for each EDC portfolio in PY9, 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 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.*"[7] On a gross basis, PY9 programs saved the Commonwealth an estimated $208.9 million dollars (benefits minus costs). On a net basis, statewide savings from PY9 programs are estimated at $108.0 million dollars.

Table 3: PY9 TRC Test Results by EDC

EDC	Gross Benefits ($1000)	Gross Costs ($1000)	Gross TRC	Net Benefits ($1000)	Net Costs ($1000)	Net TRC
PECO	$159,898	$126,609	1.26	$110,513	$105,576	1.05
PPL	$201,533	$129,012	1.56	$156,236	$102,748	1.52
Duquesne Light	$53,703	$20,675	2.60	$31,507	$17,067	1.85
FE: Met-Ed	$69,444	$36,930	1.88	$44,191	$26,097	1.69
FE: Penelec	$57,169	$44,386	1.29	$40,162	$35,729	1.12
FE: Penn Power	$24,252	$16,224	1.49	$16,823	$12,203	1.38
FE: West Penn	$76,355	$59,608	1.28	$53,716	$45,680	1.18
Statewide*	**$642,354**	**$433,444**	**1.48**	**$453,148**	**$345,100**	**1.31**

*Throughout this report, individual columns in tables may not sum to the total due to rounding.

One of the key findings from the review of PY8 TRC calculations was that the EDCs were not monetizing the water and fossil impacts of measures. For PY9, each of the EDCs included fossil fuel and water impacts in their TRC calculations.

PY9 was the first year in Phase III where demand response programs were active. Table 4 shows TRC results for energy-efficiency programs and Table 5 presents the results for demand response.

[6] 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
[7] 2016 TRC Order. Page 66.

Table 4: PY9 TRC Results by EDC: Energy-Efficiency Programs Only

EDC	Gross Benefits ($1000)	Gross Costs ($1000)	Gross TRC	Net Benefits ($1000)	Net Costs ($1000)	Net TRC
PECO	$145,938	$121,685	1.20	$96,553	$100,652	0.96
PPL	$195,877	$127,521	1.54	$150,580	$101,257	1.49
Duquesne Light	$48,261	$19,035	2.54	$26,065	$15,427	1.69
FE: Met-Ed	$65,543	$35,556	1.84	$40,290	$24,723	1.63
FE: Penelec	$57,169	$44,386	1.29	$40,162	$35,729	1.12
FE: Penn Power	$21,412	$15,403	1.39	$13,983	$11,382	1.23
FE: West Penn	$69,403	$58,027	1.20	$46,764	$44,099	1.06
Statewide	**$603,603**	**$421,613**	**1.43**	**$414,397**	**$333,269**	**1.24**

Table 5: PY9 TRC Results by EDC: Demand Response Programs Only

EDC	Gross Benefits ($1000)	Gross Costs ($1000)	Gross TRC	Net Benefits ($1000)	Net Costs ($1000)	Net TRC
PECO	$13,960	$4,924	2.84	$13,960	$4,924	2.84
PPL	$5,656	$1,491	3.79	$5,656	$1,491	3.79
Duquesne Light	$5,442	$1,640	3.32	$5,442	$1,640	3.32
FE: Met-Ed	$3,901	$1,374	2.84	$3,901	$1,374	2.84
FE: Penelec	$0	$0	N/A	$0	$0	N/A
FE: Penn Power	$2,840	$821	3.46	$2,840	$821	3.46
FE: West Penn	$6,952	$1,581	4.40	$6,952	$1,581	4.40
Statewide	**$38,751**	**$11,831**	**3.28**	**$38,751**	**$11,831**	**3.28**

A comparison of the values in Table 4 and Table 5 suggests that demand response programs were far more cost-effective than energy efficiency in PY9, but there are several key issues to keep in mind when reviewing the cost-effectiveness of DR programs:

- Demand response programs include a mix of fixed "reservation" payments to participants for enrolling and volumetric performance payments for actual load shed during events. Because there were only three DR events in PY9, the volumetric costs were lower than planned. In PY10, there were six DR events[8], so we would expect the volumetric program costs to be higher.

[8] Demand response events occur during the summer, which is the beginning of the Act 129 program years (June-May). Although PY10 does not end until 5/31/2019, the DR timeframe for this program year has already ended. Thus, we refer to PY10 in the past tense here.

  - The calculation of TRC benefits is based on *average* MW performance across events so the TRC benefits are decoupled from event frequency
- The 2016 TRC Order assumes a 1:1 reduction in avoided generation capacity for the average MW reduction each program year. This planning assumption now appears to be overstated based on discussions in PJM's Summer-Only Demand Response Senior Task Force.[9] Modeling efforts by PJM indicate that 1 MW of summer peak shaving from programs like Act 129 produce a *less than 1 MW* reduction in the peak load forecast and zonal capacity obligations. While consistent with the 2016 TRC Order, the TRC benefits from the avoided cost of generation capacity likely overstate the true benefit to the Commonwealth.
- PECO and FirstEnergy calculated TRC benefits inconsistently with the 2016 TRC Order and applied avoided cost of distribution capacity benefits to all DR impacts. The 2016 TRC Order stated that "*Peak demand reductions achieved by DR participation from all sectors would also be multiplied by an avoided cost of transmission capacity ($/kW-year) as calculated by the SWE and presented in the DR Potential Study. Peak demand reductions achieved by DR participation from the residential and commercial sectors would be multiplied by an avoided cost of distribution capacity ($/kW-year) as calculated by the SWE and presented in the DR Potential Study. We proposed to not include industrial customers who are excluded from this benefits calculation because many of these large accounts receive service at high voltage and largely bypass the distribution system. As such, peak demand reductions achieved by this sector were presumed unlikely to avoid or defer load growth related investments in an EDC distribution system*."
  - A large portion of the PY9 DR impacts for these EDCs come from a small number of large industrial sites that take service at primary voltage.
  - The PECO calculations include an additional $45/kW-year of avoided distribution capacity benefit for these participants and the FirstEnergy calculations include an additional $26/kW-year.

While PY9 demand response programs were certainly cost-effective, the TRC ratios in Table 5 likely overstate the true benefit-cost ratios for the programs. The SWE will work with the EDCs and their evaluation contractors in PY10 to standardize the calculation of TRC benefits from demand response programs.

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 P3TD expenditures and verified gross energy savings to the EE&C plan projections for the first two years of the phase. Demand response programs do not achieve energy savings but do have program spending, so the SWE removed all DR expenditures and calculated ratios (actual/planned) to develop the values shown in Figure 6. PPL and the four FirstEnergy companies are ahead of projected energy savings totals despite spending less than projected. Duquesne Light's P3TD spending and energy

[9] https://www.pjm.com/committees-and-groups/task-forces/sodrstf.aspx

savings were both lower than planned. PECO is the only EDC with a PY9 spending ratio (87%) that is higher than the PY9 energy savings ratio (73%).

Figure 6: P3TD Energy-Efficiency Spending and Savings Compared to EE&C Plan

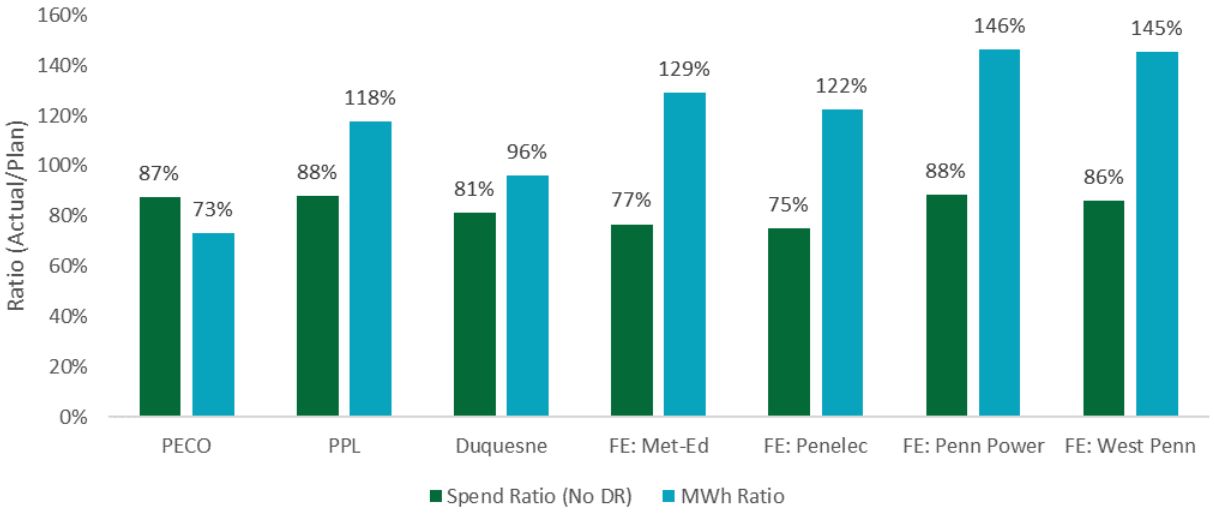


Table 6 provides an overview of the EDC's planned and actual expenditures for energy-efficiency programs in PY9.

Table 6: Comparison of PY9 Statewide EE Budgets and Expenditures[1]

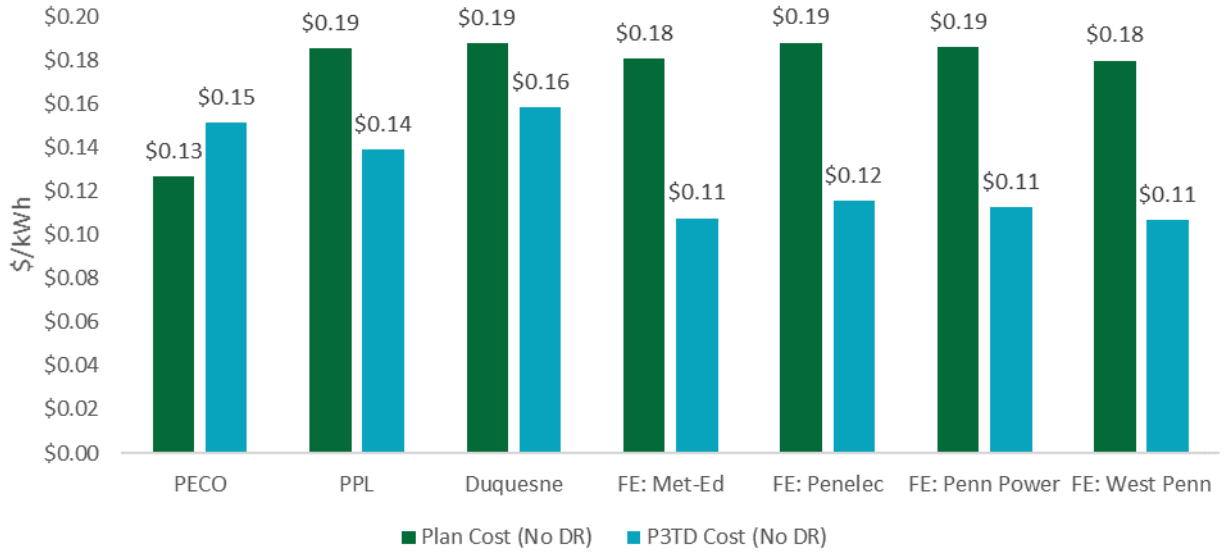
EDC	Actual PY9 Expenditures	Approved Budget for PY9	Difference Between Actual and EE&C Plan	Percent Difference from EE&C Plan
PECO	$57,241,000	$56,200,000	$1,041,000	2%
PPL	$52,962,000	$55,561,000	-$2,599,000	-5%
Duquesne Light	$15,801,000	$17,889,801	-$2,088,801	-12%
FE: Met-Ed	$16,838,598	$21,528,539	-$4,689,941	-22%
FE: Penelec	$16,521,734	$21,628,711	-$5,106,976	-24%
FE: Penn Power	$5,570,477	$5,695,022	-$127,526	-2%
FE: West Penn	$18,304,503	$19,615,544	-$1,311,041	-7%
Statewide	**$183,239,312**	**$198,121,598**	**-$14,882,285**	**-8%**

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

Because of the emphasis on Act 129 goal achievement and the fact that EDC budgets are fixed, acquisition cost is an important metric for EDCs subject to Act 129. Acquisition cost is a performance metric of dollars per first-year kWh – or spending divided by verified gross savings. Figure 7 compares the projected phase-to-date energy-efficiency acquisition cost from the Phase III EE&C plan to actual phase-to-date energy-efficiency acquisition costs. All demand response expenditures are removed from the numerator of the calculations. All EDCs except PECO are

delivering energy savings at a lower cost than projected through PY9. PECO's actual phase-to-date acquisition cost is above their EE&C plan projections. The FirstEnergy companies are delivering energy-efficiency savings at a cost well below plan values.

Figure 7: Planned vs. Actual P3TD Energy-Efficiency Acquisition Cost



PECO's PY9 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's Combined Heat and Power program has significantly underperformed relative to plan, with actual MWh savings of just 2% of EE&C plan projection through PY9. PECO will need to increase the pace of program spending, while being mindful of acquisition cost, to meet its Phase III portfolio reduction target.

Table 7 provides an overview of the EDC's planned and actual energy-efficiency acquisition costs in PY9.

Table 7: Planned Versus Actual Energy-Efficiency Acquisition costs in PY9

EDC	PY9 Verified Savings (MWh/yr)	Forecasted PY9 Acquisition Cost per First-Year kWh Saved	Actual PY9 Acquisition Cost per First-Year kWh Saved	Percent Change from Forecasted Acquisition cost
PECO	390,151	$0.13	$0.15	10.0%
PPL	382,522	$0.18	$0.14	-21.2%
Duquesne Light	101,065	$0.16	$0.16	-13.1%
FE: Met-Ed	176,665	$0.17	$0.10	-43.6%
FE: Penelec	154,637	$0.18	$0.11	-39.6%
FE: Penn Power	57,354	$0.17	$0.10	-42.8%
FE: West Penn	195,498	$0.17	$0.09	-44.1%
Statewide	**1,457,892**	**$0.16**	**$0.13**	**-20.6%**

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 CO_2 emissions and climate change. Table 8 was compiled using the gross verified first-year and lifetime MWh savings in PY9 and an average of the 2017 marginal on-peak and off-peak CO_2 emissions rate in PJM's spring 2017 Emissions Report.[10]

Table 8: PY9 Carbon Dioxide Emission Impacts

Performance Metric	Value
PY9 Verified Gross MWh/yr	1,457,892
PY9 Verified Gross Lifetime MWh	13,766,718
Weighted Average Measure Life (years)	9.4
Marginal Off-Peak CO_2 Emissions Rate (lbs./MWh)	1,374
First-Year Avoided Tons of CO_2	1,001,572
Lifetime Avoided Tons CO_2	9,457,735

The lifetime emission impacts in Table 8 are calculated using the 2017 CO_2 emission rates. If the generation fuel mix in the region becomes cleaner over the life of the measures installed in PY9, the emissions rate would decrease, and the lifetime CO_2 impacts would be lower.

[10] https://www.pjm.com/-/media/library/reports-notices/special-reports/20180315-2017-emissions-report.ashx?la=en

PROCESS EVALUATION

Table 9 provides an overview of the PY9 process evaluations conducted by each EDC.

Table 9: PY9 Process Evaluations by EDC

EDC	# of PY9 Programs	# Evaluated	# of Findings	# of Recomm-endations	% of Satisfied Residential Customers*	% of Satisfied C&I Customers*
PECO**	6	4	16	16	87%	84%
PPL	9	9	49	24	94%	96%
Duquesne Light	13	9	23	13	N/A	N/A
FirstEnergy EDCs***	9	5	15	15	95%	100%

* Average across all programs for which participant surveys were conducted. Average is weighted by number of PY9 participants in each program.
** The six programs include 19 program solutions within four PECO energy-efficiency target areas: residential, low-income, small C&I, large C&I, CHP, and DR. For PY9, 11 of these 19 program solutions were evaluated.
*** 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 9, the SWE is not able to report on overall participant satisfaction for the PY9 programs evaluated by Duquesne Light. The reason for this is that the EDC provided only mean satisfaction ratings, rather than the percentage distribution of responses to the satisfaction questions.

SUMMARY OF SWE FINDINGS AND RECOMMENDATIONS

- **Finding**: Program Year 9 included the first summer in Phase III that demand response programs were active. A total of three demand response events were called. The EDC programs were generally successful in PY9 with EDCs achieving at least 85% of their compliance target on each event day. The point estimate of West Penn Power's DR performance on the July 21, 2017 event was below the 85% threshold, but the margin of error included the 85% threshold of 54.4 MW. West Penn's average PY9 DR performance was well above its Phase III DR compliance target. PECO and Met-Ed's average PY9 DR performance was slightly below the Phase III target.
    - **Recommendation**: DR compliance is based on average performance over all Phase III demand response events. PECO and Met-Ed will need to increase their performance in PY10-PY12 to meet Phase III goals. West Penn Power will need to be mindful of baseline volatility from large industrial participants to meet event-specific DR performance goals.
- **Finding**: The SWE found inconsistency among EDCs with the ISR and interactive effects applied to cross-sector upstream lighting sales. The TRM instructs EDCs to "use the CF

and hours of use by business type present in 3.1 Lighting for non-residential bulb savings estimates" for cross-sector sales but does not provide any guidance regarding the ISR or interactive effects for cross-sector sales. Some EDCs applied the ISR for residential bulb savings to cross-sector bulbs, while others followed the algorithm for non-residential bulb savings which omits the ISR. In addition, some EDCs applied the default interactive effect factors for residential bulbs to cross-sector sales, while others applied the default interactive effect factors for non-residential bulbs.

  - **Recommendation**: The SWE will provide guidance on the appropriate cross-sector sales ISR and interactive effects for PY10.

- **Finding**: Home Energy Report programs accounted for 15% of all PY9 gross verified savings. The EDC evaluations of Home Energy Report programs showed increased attention to detail in PY9 compared to PY8. In PY8, the SWE audit identified issues with the HER analysis for all EDCs except PPL. In PY9, PPL was the only EDC with HER analysis errors.

  - **Recommendation**: Home Energy Report evaluations require efficient processing of significant volumes of participant billing data. It's important that the data structures are sounds and the calculation of participant counts are sound so that aggregate MWh and MW impacts are accurate. EDC evaluation contractors should peer review all analysis code and calculations prior to finalizing HER impacts given the large role these programs play in Phase III EE&C plans.

- **Finding**: PPL and the four FirstEnergy companies are ahead of projected energy savings totals despite spending less than projected. Duquesne Light's phase-to-date spending was also lower than planned while energy savings were close to planned (96%). Through PY9, PECO is the only EDC with a phase-to-date spending ratio that is higher (87%) than the phase-to-date energy savings ratio (73%). In addition, all EDCs except PECO have delivered energy savings at a lower cost than projected to the phase-to-date. PECO's phase-to-date acquisition cost was above their EE&C plan projections. PECO has reached 31% of their compliance target through PY9.

  - **Recommendation**: PECO and its ICSPs will need to deliver energy-efficiency programs more efficiently in PY10 through PY12 to meet its compliance target.

- **Finding**: The 2016 TRM began to show its age in 2018. The 2016 Technical Reference Manual was developed in 2014-2015 and approved July 8, 2015. Unlike previous TRMs which were updated annually, the 2016 TRM is effective for the five-year duration of Phase III. Over time certain aspects of the TRM have become outdated. For example, in late 2016 federal standards for water heaters were updated and in 2018 Pennsylvania adopted IECC 2015 building code. As a result, the baseline assumptions in the 2016 TRM are no longer aligned with the current codes and standards in the Commonwealth. The TRM is the basis for Act 129 compliance savings so changes to codes and standards do not affect EDC evaluation activities or the SWE audit findings. However, it does raise a policy question about the ideal effective period for the TRM.

- **Recommendation**: If the 2021 TRM will be in place for five years, include a mechanism by which changes to codes and standards can be updated to reflect updates that were not known at the time of TRM development. Given the rapid pace of technological progress and increasing recognition of the value of energy efficiency, there is greater risk that a five-year TRM will become misaligned with the marketplace if baselines are held static or limited to known changes at the time of TRM development. This will be especially important for the 2021 TRM, which will be released for comment and reply comment over two years before it becomes effective June 1, 2021. The SWE recommends including a process for this in the 2021 TRM Tentative Order.

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 companies[11] 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."[12]
- 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."[13]

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."[14] 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.[15]

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 10 contains

[11] This Act 129 requirement does not apply to an electric distribution company with fewer than 100,000 customers.
[12] 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.
[13] 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.
[14] 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
[15] Phase III Implementation Order.

these targets as percentages and five-year cumulative totals in MWh/year for each of the seven EDCs.

Table 10: Act 129 Phase III Five-Year Energy-Efficiency Reduction Compliance Targets[1]

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 Light	$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%**

[1] Note that the values reported in this table are from the Addendum to Phase III Final Implementation Order http://www.puc.state.pa.us/pcdocs/1367057.docx

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 11. It is important to note that the EDCs were not required to obtain peak demand reductions in the first program year of Phase III (PY8). The targets reported in Table 11 are for the other four program years in Phase III.

Table 11: Act 129 Phase III Five-Year Energy Demand Response Reduction Compliance Targets[1]

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 Light	$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] Note that the values reported in this table are from the Addendum to Phase III Final Implementation Order http://www.puc.state.pa.us/pcdocs/1367057.docx

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 non-profit 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.[16] 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.[17]

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 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.[18]

A summary of the low-income and GNI carve-out information is provided in Table 12.

[16] 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.
[17] 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)
[18] Act 129 Phase II Final Compliance Order.

Table 12: 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 Light	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**

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, PY9 gross verified energy savings came overwhelmingly from three offerings: residential lighting (including upstream and non-upstream lighting), Home Energy Reports (HERs), and non-residential lighting. All seven EDCs offer residential lighting, HERs, and non-residential lighting in Phase III; in PY9, the three offerings contributed 81% of the verified gross energy savings in the Commonwealth. Table 13 shows the contribution to PY9 portfolio savings from each of the three primary offerings by EDC.

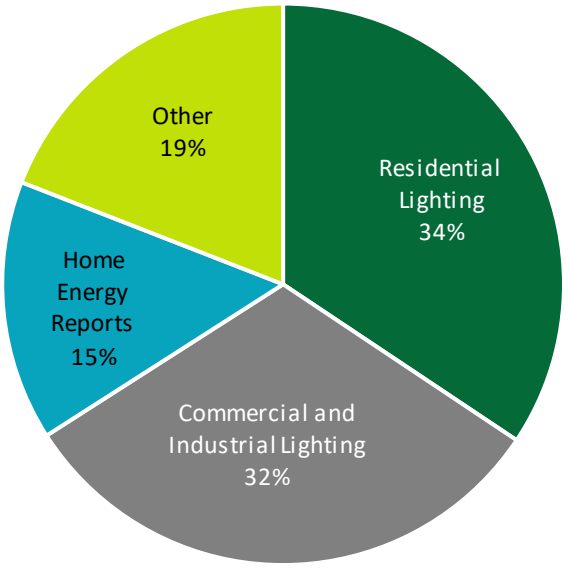
Table 13: PY9 Energy Savings from Three Top Offerings

EDC	PY9 Verified Gross (MWh)	Residential Lighting (MWh)*	HER (MWh)	Non-Residential Lighting (MWh)	Percent of PY9 MWh from Big 3
PECO	390,151	142,792	78,396	94,955	81.0%
PPL	382,522	142,869	30,311	128,317	78.8%
Duquesne Light	101,065	36,142	8,055	37,912	81.2%
FE: Met-Ed	176,665	53,558	38,148	58,058	84.8%
FE: Penelec	154,637	54,222	21,716	55,421	84.9%
FE: Penn Power	57,354	19,916	7,085	21,388	84.4%
FE: West Penn	195,498	53,560	34,751	64,163	78.0%
Statewide	**1,457,892**	**501,109**	**218,462**	**460,214**	**81.1%**

*Upstream residential lighting (including savings from cross-sector sales) plus non-upstream residential lighting.

Figure 8 displays the distribution of energy savings from residential lighting, non-residential lighting, HERs, and all other offerings. Only 19% of statewide savings occurred outside of the three largest offerings. The SWE notes that the percentage of verified gross energy savings from the three largest offerings increased from 74% in PY8 to 81% in PY9.

Figure 8: PY9 Distribution of Energy Savings from Top Three and All Other Offerings



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 RESIDENTIAL LIGHTING

Upstream residential lighting is the single largest program offering among the EDCs, accounting for 26% of statewide PY9 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 PY9 verified gross savings, and residential lighting programs overall equaled 34% of statewide PY9 verified gross savings (see Table 14).

Table 14: PY9 Energy Savings, Upstream Residential Lighting, Non-Upstream Residential Lighting, and All Residential Lighting

EDC	PY9 Verified Gross (MWh/yr)	Upstream Res Lighting (MWh/yr)*	Non-Upstream Res Lighting (MWh/yr)	All Res Lighting (MWh/yr)	Percent of PY9 MWh from Res Lighting
PECO	390,151	127,344	15,448	142,792	37%
PPL	382,522	128,036	14,833	142,869	37%
Duquesne Light	101,065	28,877	7,265	36,142	36%
FE: Met-Ed	176,665	28,321	25,237	53,558	30%
FE: Penelec	154,637	30,357	23,865	54,222	35%
FE: Penn Power	57,354	12,439	7,478	19,916	35%
FE: West Penn	195,498	29,561	23,999	53,560	27%
Statewide	**1,457,892**	**384,934**	**118,125**	**503,159**	**35%**

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

2.1.1 Upstream Lighting: Lighting Technologies and Sales Channels

PY9 continued the shift from CFLs to LEDs in the EDC's upstream programs (Figure 9). One hundred percent of statewide PY9 upstream lighting products sold were LEDs.

Figure 9: PY5-PY9 Upstream Lighting Technologies

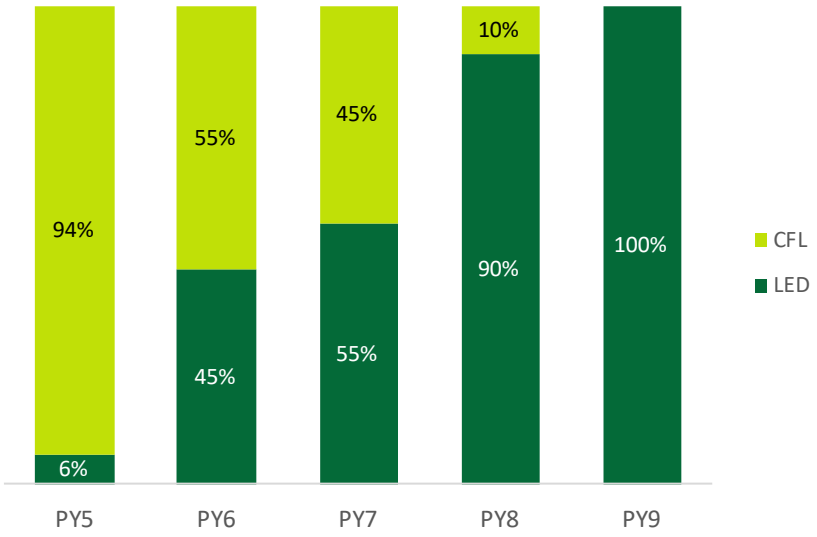
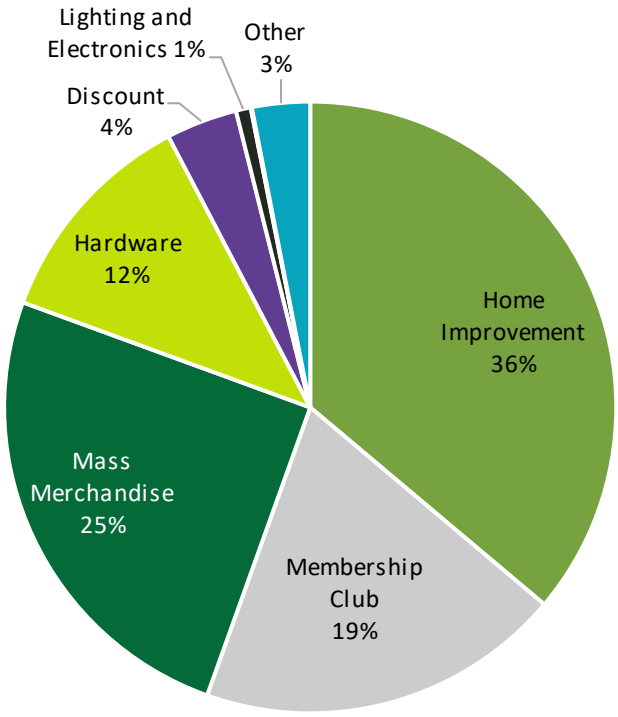


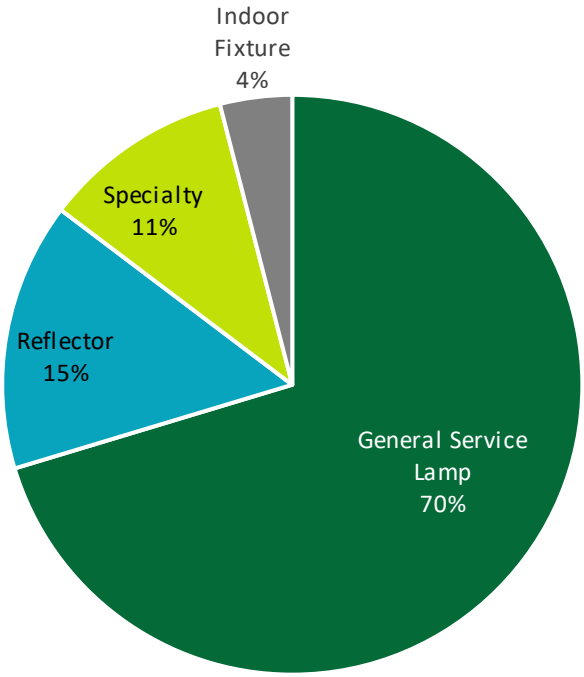
Figure 10 displays the distribution of statewide PY9 upstream lighting products by retail channel. Over one-third (36%) of upstream lighting products were sold through home improvement stores, one-quarter (25%) were sold through mass merchandise stores, and around one-fifth (19%) were sold through membership clubs. 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: PY9 Upstream Lighting Sales by Retail Channel



Over two-thirds (70%) of PY9 upstream lighting products were general service lamps, followed by reflectors (15%) and specialty bulbs (11%). Four percent of PY9 upstream lighting products were indoor fixtures (Figure 11).

Figure 11: PY9 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. Duquesne Light conducted cross-sector sales research in PY9, while PECO, PPL, and FirstEnergy assumed the cross-sector sales rates estimated in PY8 (Table 15). The cross-sector sales rates of 3.8%[19] (Duquesne Light) 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.

[19] Navigant reported 3.7% as the weighted average cross-sector sales rate for standard and specialty LEDs in the PY9 annual report. However, the SWE determined that 3.7% is a typo and the correct value is 3.8%.

Table 15: PY9 Upstream Lighting Cross-Sector Sales Rates

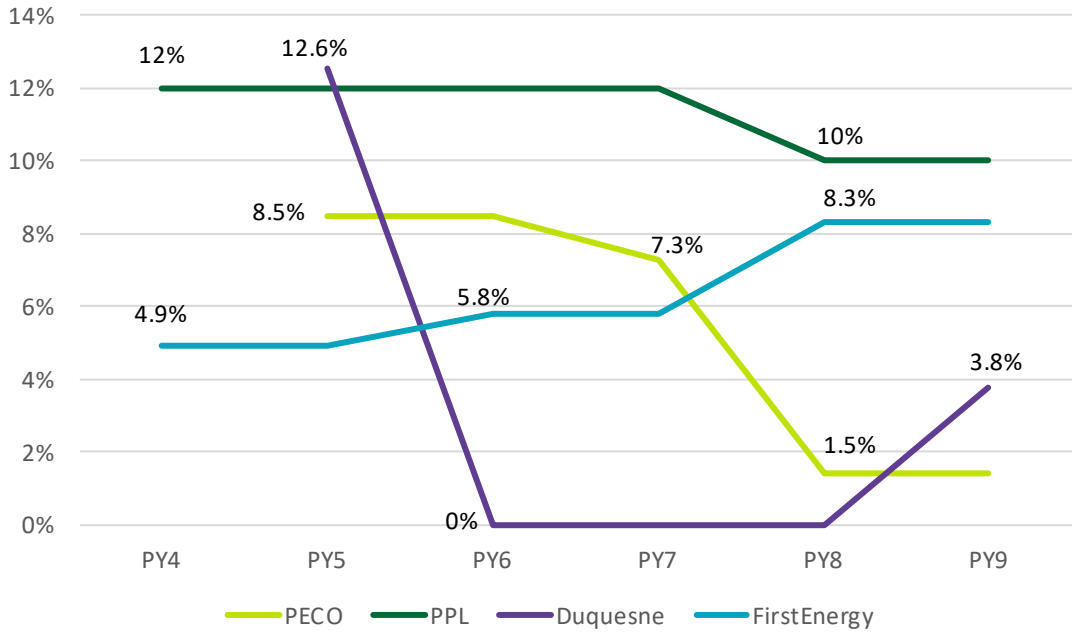
EDC	Cross-Sector Sales Rate	Study Period	Method
PECO	1.5%*	PY8	in-store intercept survey
PPL	10%	PY8	general population surveys of residential and small business customers
Duquesne Light	3.8%**	PY9	in-store intercept survey
FE Companies	8.3%	PY8	general population survey of residential customers

* Respondent bulb weighted average of 0.73% for standard LEDs and 2.0% for specialty LEDs.
** Respondent bulb weighted average of 3.5 % for standard LEDs and 4.2% for specialty LEDs.

Figure 12 displays the cross-sector sales rates for each EDC from PY5 to PY9. 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.[20] In addition, the EDCs consistently used the same research methods from PY5 to PY9: in-store intercept surveys for PECO and Duquesne Light, and telephone surveys for PPL and FirstEnergy. The SWE has proposed a default rate for cross-sector sales in the draft 2021 TRM based on a savings-weighted average of EDC-reported cross-sector sales values for PY6-PY9.[21]

[20] 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. Duquesne conducted primary research on cross-sector sales in PY9.
[21] Each of the different study methods have advantages and disadvantages and are susceptible to various types of bias. By using a savings-weighted average of EDC-reported cross-sector sales across multiple years we minimize the bias of any given study and method.

Figure 12: Cross-Sector Sales Rates over Time



2.1.3 LED Price Trends, PY9

Figure 13 shows quarterly sales-weighted average manufacturer suggested retail prices (MSRPs) for A-lines since the beginning of PY8.[22] Average MSRPs among A-line LEDS with 310-749 lumens have steadily declined since the first quarter of PY8, as have average prices among A-line LEDs with 750-1049 lumens. Average MSRPs for A-line LEDs in the higher lumen bins (1050-1489 lumens and 1490-2600) have seen more dramatic price decreases than the lower lumen A-line LEDs. In the last two quarters of PY9, average sales-weighted MSRPs for A-line LEDs in the highest lumen bin ticked back up. That said, non-sales-weighted averages continued to decline. Figure 14 shows quarterly sales-weighted average MSRPs for other LED bulb types. Like A-line LEDs, average MSRPs have steadily declined since the first quarter of PY8. LED reflectors have seen the steepest decline, dropping from about $10 per bulb to under $6 per bulb.

[22] FirstEnergy companies did not provide MSRP data in PY8 or PY9. Their upstream lighting bulbs are not included in the figure.

Figure 13: PY8 – PY9 Quarterly LED Prices – A-lines

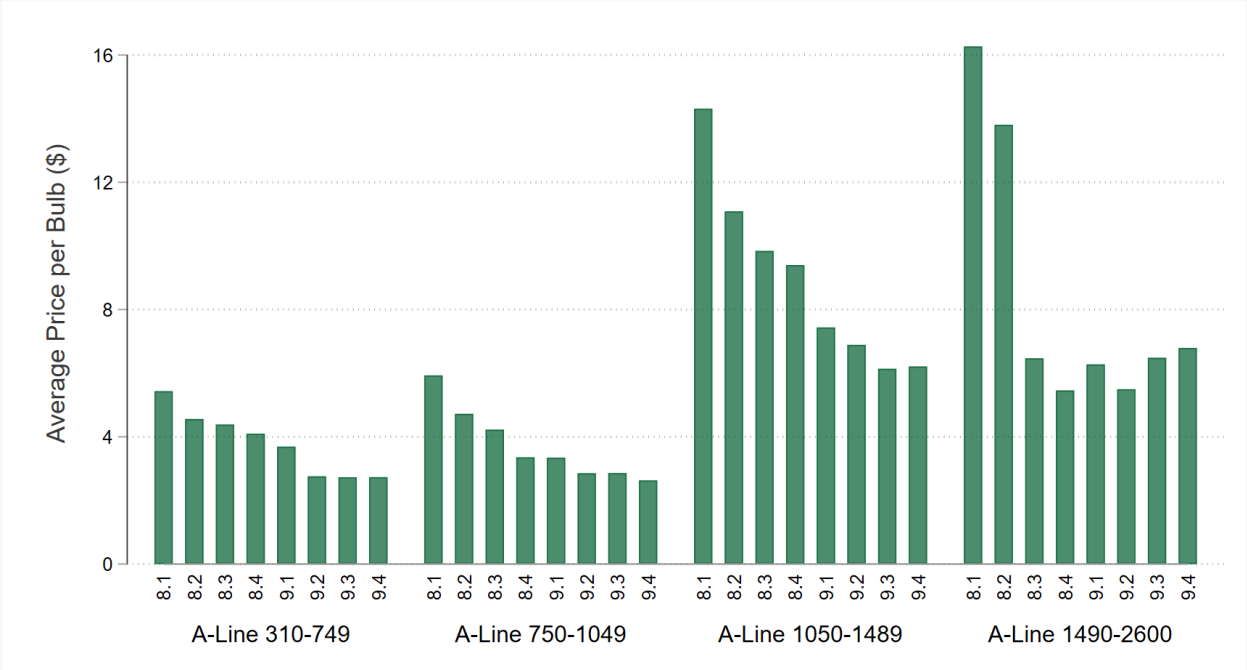
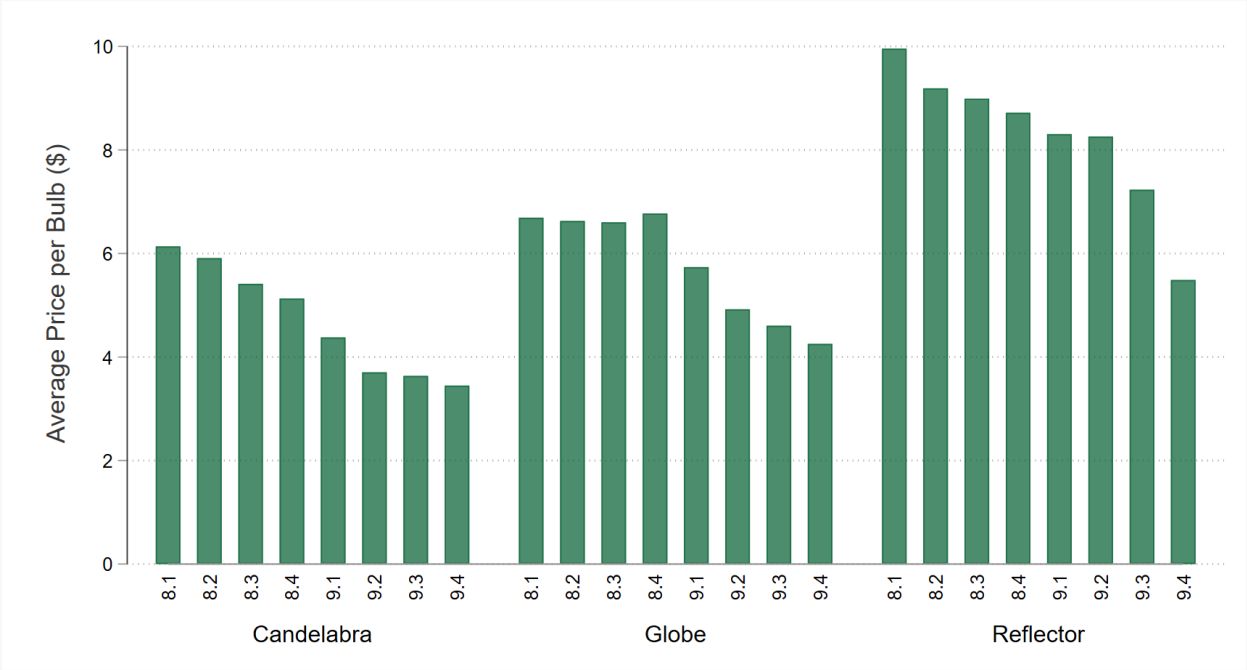


Figure 14: PY8 – PY9 Quarterly LED Prices – Candelabras, Globes, and Reflectors



2.1.4 EDC Upstream Lighting Incentive Levels and Sales Volume

The SWE reviewed sales-weighted average MSRPs, rebated prices, and incentive levels for the LED bulbs in the PY9 upstream lighting programs. For each EDC, summary statistics are shown in Table 16. Note that the summaries in the table exclude low-income upstream bulbs and records

with manufacturer incentives. Also note that the average prices and incentive levels are per bulb (not pack). PPL offered the largest percent discount per bulb (38%), followed by PECO (36%) and Duquesne Light (27%). Compared to PY8, PECO's percent discount increased, from 21% to 36%, while PPL's and Duquesne Light's percent discount decreased, from 60% to 38% and from 31% to 27%, respectively. FirstEnergy companies did not provide MSRPs, so percent discounts could not be calculated for FirstEnergy companies. That said, their sales-weighted average incentive level is in line with the other EDCs. As an aside, PECO reported identical MSRPs and rebated prices for all PY9 lighting records. The SWE recalculated retail prices for PECO by adding per-bulb incentives to per-bulb discounted prices.

Table 16: Variation in LED Incentives Across EDCs

EDC	MSRP	Discounted Price	Incentive	% Discount	PY9 LED Bulbs	Bulbs / Household
PECO	$4.36	$2.78	$1.58	36%	3,115,303	2.1
PPL	$4.98	$3.11	$1.87	38%	1,958,811	1.6
Duquesne Light	$4.57	$3.35	$1.22	27%	587,304	1.1
FirstEnergy Companies	NA	NA	$1.45	NA	2,727,563	1.5

2.2 Home Energy Reports

Almost 1.2 million Pennsylvania homes received Home Energy Reports in PY9. This represents approximately 23% of the residential electric accounts served by the EDCs subject to Act 129. Table 17 summarizes the average number of residential accounts and PY9 HER recipients by EDC. Recipient counts are PY9 averages rounded to the nearest thousand.

Table 17: PY9 Statewide HER Summary Statistics

EDC	Residential Premises	PY9 HER Recipients	Percent of Homes Receiving HER
PECO	1,463,000	400,000	27%
PPL	1,247,000	162,000	13%
Duquesne Light	533,000	71,000	13%
FE: Met-Ed	499,000	148,000	30%
FE: Penelec	498,000	157,000	32%
FE: Penn Power	144,000	27,000	19%
FE: West Penn	625,000	176,000	28%
Total	**5,009,000**	**1,141,000**	**23%**

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 18 presents the average evaluated PY9 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 1.2% to 1.9% per household.

Table 18: HER Average Impacts by EDC

EDC	PY9 kWh Usage (HER Recipients)	Average PY9 kWh Savings per Recipient	Average Percent Reduction
PECO	13,788	209	1.5%
PPL	16,205	198	1.2%
Duquesne Light	9,543	113	1.2%
FE: Met-Ed	13,691	258	1.8%
FE: Penelec	9,705	139	1.4%
FE: Penn Power	13,590	259	1.9%
FE: West Penn	15,129	198	1.3%
Statewide Total	**13,582**	**198**	**1.5%**

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.

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 PY9. PPL had two cohorts of low-income households receiving HERs in PY9. These two cohorts included approximately 60,000 low-income households and produced approximately 3,000 MWh of gross verified savings in PY9. However, PPL did not claim the energy savings achieved by these cohorts toward the low-income target. Table 19 shows the PY9 verified gross low-income savings for each EDC and how much of the energy savings came from HER programs.

Table 19: Contribution Towards LI Targets from Home Energy Reports

EDC	PYVTD Low-Income MWh	PYVTD Low-Income MWh from Home Energy Reports	Percent of PY9 LI Savings from HER
PECO	20,628	0	0.0%
PPL	26,241	0	0.0%
Duquesne Light	3,787	1,531	40.4%
FE: Met-Ed	11,577	4,151	35.9%
FE: Penelec	10,839	2,370	21.9%
FE: Penn Power	3,533	782	22.1%
FE: West Penn	10,556	3,344	31.7%
Statewide Total	**86,138**	**12,178**	**14.1%**

2.2.2 HER Cost Considerations

HER programs are an interesting offering from a cost standpoint. While the TRC ratios are marginal at approximately 1.0 statewide, the program delivery cost per first-year kWh is quite low (between five and seven cents per first-year kWh). This makes HERs an attractive offering for EDCs tasked with a compliance target and a fixed budget. One of the reasons the TRC ratios for HER programs are marginal is the Act 129 measure life assumption. The status quo for HER programs is one year, which means that the savings measured at the meter each year are new incremental savings. This assumption was used in the Phase III Market Potential Study to set Phase III compliance targets and by each of the EDCs in their Phase III EE&C plans.

Towards the end of Phase II, the SWE conducted an analysis of HER persistence using households served by PPL and Duquesne Light who had their HER exposure paused. This analysis suggested that HER impacts persisted for more than one year. A longer measure life assumption would increase the cost-effectiveness of HER programs but increase the acquisition cost ($/first-year kWh) because less of the savings measured at the meter each year would be considered first-year compliance savings. In Fall 2018, the SWE completed a similar analysis on households served by the FirstEnergy EDCs who stopped receiving HERs at the beginning of Phase III.

2.2.3 SWE HER Persistence Study

At the beginning of Phase III (June 2016), FirstEnergy reduced the number of homes in the treatment groups of most of the market rate and low-income HER waves for its Pennsylvania EDCs. This created a natural experiment to assess the persistence of HER impacts once reports stop being issued. The SWE requested historical monthly billing records for all households, including the twelve-month pre-treatment period, and estimated monthly impacts for the persistence cells of each HER cohort.

Figure 15 illustrates the analysis. The key metric of interest to quantify the effect of persistence is how long it takes for impacts to reach zero. Once the monthly impacts are determined and converted to percent reductions a linear regression is fit through the period after HER exposure

stopped. The intercept and slope from this regression is used to calculate the number of months it would take for the trend in impacts to go to zero. This is shown graphically below, where it takes approximately 37 months for the orange trend line to cross the y-axis at zero. The intercept for the persistence regression line is set equal to the average savings in the prior 12-months (shown in blue circles and the grey squares at month = 0). The underlying assumption with this model is that the HER savings will continue to decay at the same rate observed in months 1-24 until reaching zero.

Figure 15: Persistence Modeling Example

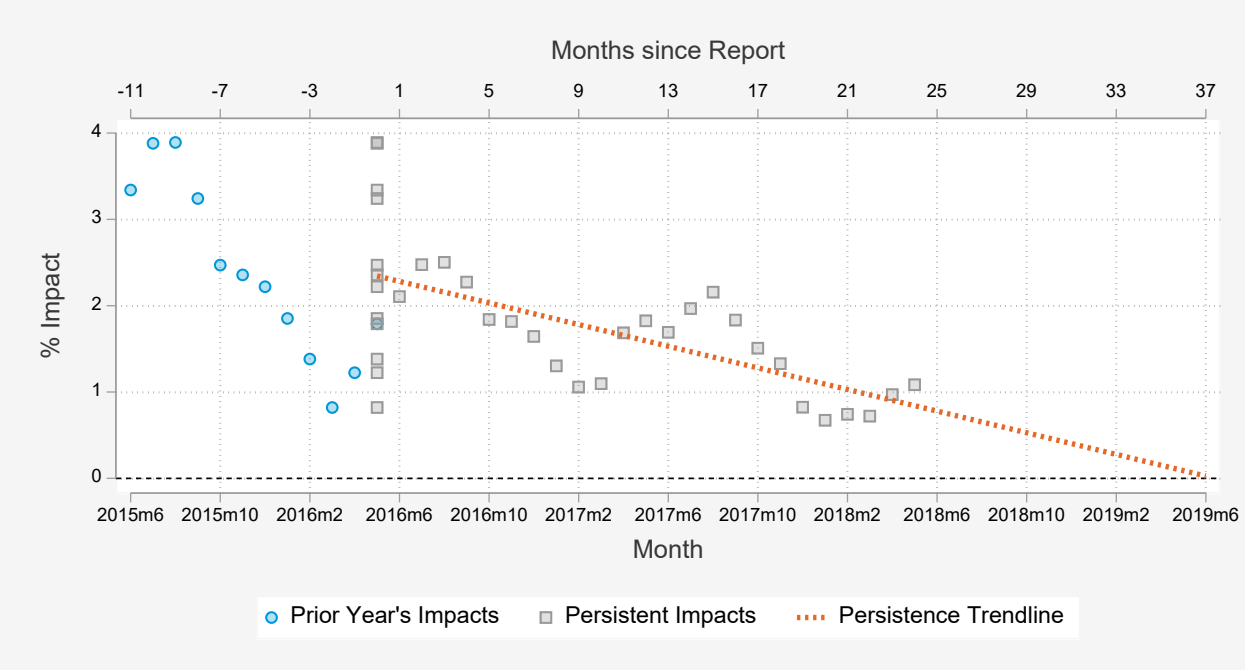


Table 20 shows the results of the FirstEnergy analysis along with the PPL and Duquesne Light results from the 2015 study. Because the Duquesne Light results were such an outlier, the SWE elected to calculate a statewide result using the PPL and FirstEnergy findings.

Table 20: HER Persistence Results by EDC

EDC	Cohort	Population	Months of Test	Intercept	Slope	Months to No Impact
PPL	Legacy	48,700	16	2.350%	-0.060%	39.2
	Expansion	52,900	16	2.040%	-0.040%	51.0
Duquesne Light	All	52,200	21	1.210%	-0.001%	1,210.0
First Energy	All	81,746	24	1.613%	-0.054%	29.7

The key output of the study is that HER savings are estimated to last 38.3 months after exposure is discontinued. This equates to a 31.3% annual rate of decay. That is, if it takes 38.3 months for

savings to go to zero, savings must decline 31.3% each year (12/38.3 = 31.3%). The Tentative 2021 TRM Manual will include a protocol for calculation of first-year compliance and lifetime savings based on this study finding.

Report URL

2.3 NON-RESIDENTIAL LIGHTING

Non-residential lighting improvements accounted for 32% of statewide PY9 energy savings, largely utilizing TRM provided measure methodologies. Within non-residential lighting improvements, light emitted diode (LED) technologies have rapidly increased market share in the last several years to account for at least 85% of all PY9 non-residential lighting improvements and fluorescent lighting technologies have rapidly diminished market share with no more than 3% of all PY9 non-residential lighting improvements (LED improvement savings were less than 40% in PY7 and fluorescent measures were approximately 50% of non-residential lighting savings). The adoption of a T8 baseline in the TRM beginning PY8 most likely contributed to this shift.

LED technology improvements have rapidly matured in the last several years, which have been readily accepted by non-residential customers and lighting contractors. LED technologies include direct lamp replacement options for linear, screw-in, and high intensity applications, along with integral LED fixture replacements for interior low-bay and high-bay applications, exterior lighting, and street lighting. In addition to LED lighting lamp and fixture technologies, enhanced control options are starting to become available and adopted integral with LED improvements.

Downstream offerings continue to dominate the lighting programs across the EDC's. Two EDCs, Duquesne Light and PPL, offered a midstream lighting program in PY9.[23] In addition to current offerings by PPL and Duquesne Light, PECO is expected to offer a midstream lighting program in PY10 and beyond. Downstream programs provide direct incentives for business customers who upgrade their facilities with energy-efficient equipment. Typically, pre-determined incentives are made available to customers for common energy-efficiency measures to facilitate the implementation of cost-effective energy-efficiency improvements. To participate in a downstream program, a customer typically submits an application with requested project documentation, such as invoices, project specification sheets, and other applicable information. The utility primarily leverages the relationship between the account manager and/or lighting contractor and their customers to promote the program. Midstream programs provide instant discounts at the point-of-sale of energy-efficient qualified products, as opposed to having to submit individual customer applications as is required by downstream programs. This type of program is typically open to distributors selling directly to commercial and industrial end-use customers, as well as contractors, within the utility service territory and leverages the relationship between lighting distributors and their customers to promote the program.

While the savings from PPL's and Duquesne Light's midstream offerings combined were less than 5% of all verified non-residential lighting savings in PY9, both programs significantly increased participation. Duquesne Light's midstream program increased over 140% from PY8

[23] Both PPL and Duquesne Light's midstream lighting programs began in PY8

and PPL's midstream program increased over 650% from PY8. The SWE expects significant non-residential savings will shift from downstream lighting programs to the midstream program delivery approach in upcoming program years. Energy savings contribution results from the two EDCs offering midstream lighting programs in PY9 are presented in Table 21.

Table 21: Midstream Lighting Verified Energy Savings and Realization Rate by EDC

EDC	Total Non-Residential Lighting (MWh)	Midstream Lighting (MWh)	Midstream Lighting Realization Rate
Duquesne Light	38,112	4,300	**173%**
PPL	128,317	15,519	**79%**

Along with Pennsylvania, midstream lighting programs are an increasing trend in Demand Side Management program offerings across the country. Midstream programs are often seen as a more cost-effective program approach to the traditional downstream program. They typically require less marketing, lower implementation costs, and reduced paperwork burden for program participants. However, midstream programs also result in less direct customer interaction with the utility, often leading to the customer not being aware that the utility was involved in the lower cost of the incented measures. Another drawback of a midstream lighting program is the loss of participant information that in a downstream program is captured on the program application. The point-of-sale nature of a midstream program and the lack of a formal participant application means that the amount of data collected is significantly reduced. The lack of available data, such as baseline information and operating schedules, can be problematic for verification and evaluation purposes. This lack of direct customer information can introduce uncertainty, which results in less precise energy and demand savings estimates. To address increasing midstream lighting program participation and provide a conservative methodology for energy savings, the SWE has approved an interim measure protocol (IMP) for non-residential midstream lighting for the balance of the Phase III of Act129. The SWE expects that this protocol will be a permanent measure protocol in the Phase IV TRM. The IMP will be updated for PY10 based on the results of PPL's PY8 and PY9 evaluation findings.

Additionally, as noted in Table 21, the realization rates for the two EDC's offering midstream programs were contradictory, both correlated to the lack of customer specific data within the reported energy savings estimate. PPL's realization rate was found to be 79% while the realization rate for Duquesne Light was much higher at 173%.

Duquesne Light's evaluation contractor noted that the main reasons for the high realization rate were the CSP using an installation in-service rate lower than found in the sampled projects and the reported hours of use also being lower than found during the verification activities. The hours of use variance was due to installation in buildings with 24/7 operation and this building type and schedule were not an option in the reporting. Duquesne Light does intend to remedy the issue in PY10 by adding a 24/7 hour of use option for reported savings. As such, the SWE cautions against applying the realization rate from PY9 to PY10 reported savings as this could result in artificially high verified savings. In addition, due to the variance found in the customer-reported hours of use

value, the resulting precision of the verified savings for the Midstream program was ±15.7% at the 85% confidence level and the program failed to meet the precision threshold of at least ±15%.

PPL's evaluation contractor, had different evaluation findings from a large sample (209 projects across 88 customer sites), resulting in a realization rate of 79%. The realization rate less than one is due to several factors, including a lack of direct customer information, such as knowledge of the baseline conditions; program eligibility requirements; installation in-service rate; and the building type with the corresponding hours of use. PPL's midstream lighting program evaluation exceeded the allowable level of sampling uncertainty. Cadmus noted in the PPL PY9 Annual Report that this was the first time that any EDC offered a midstream option within Act 129 and despite implementing a conservative sample design, the high level of uncertainty around energy savings lead to a large relative precision value. Further, Cadmus noted in their report that the gross savings verification effort under-achieved sample targets in the larger strata, and error ratios were high across all strata due to duplicate and program-ineligible jobs and updates to savings calculations reflecting in situ conditions. In PY10, Cadmus plans to use an exploratory analysis to determine which variables are correlated with high/low realization rates and use a stratification method that includes those variables in order to achieve the 85/15 requirement. The gross verified energy savings estimates for all other programs were within the allowable levels of sampling error for PY9.

While there is work to be done in fine-tuning the midstream lighting program offerings, the program delivery method is expected to help drive market transformation and 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.

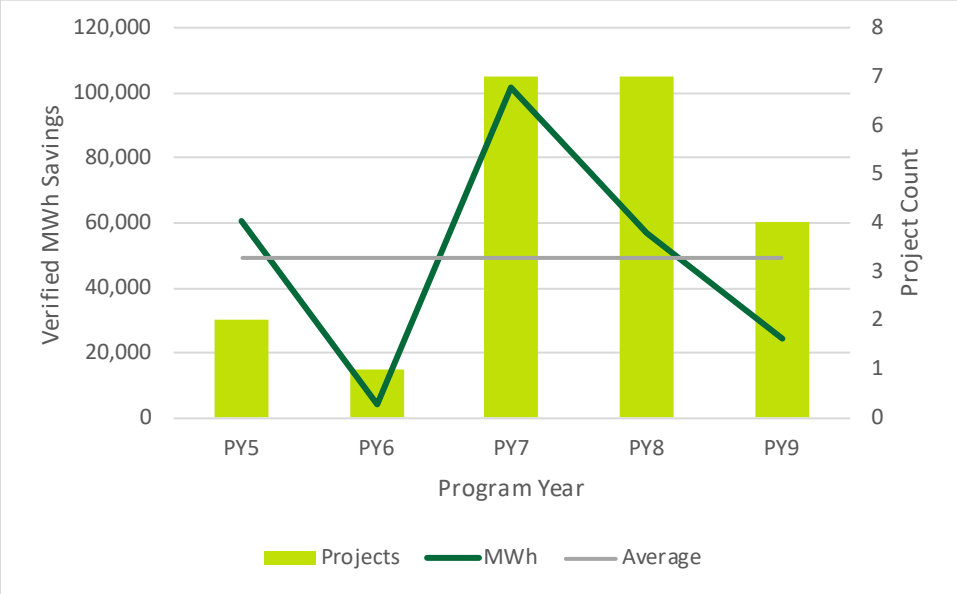
2.4 Combined Heat and Power

The PUC has made a commitment to advancing the prevalence of Combined Heat and Power (CHP) and released a Final Policy Statement on Combined Heat and Power in April of 2018, designed to advance the deployment of CHP technology throughout Pennsylvania. While not a top offering in PY9, CHP projects accounted for just under 2% of the statewide gross verified savings.

Figure 16 shows the energy savings contributions from Act 129 CHP projects over the past five years.[24] Of note, is the variance of CHP contributions over the past program years, averaging 49,125 MWh per program year. The variance of annual impacts from CHP projects is largely due to the long development timelines for these projects, often exceeding 24 months for planning, construction, and financing.

[24] Energy savings contributions for CHP projects from PY5-PY7 are derived from annual reports issued in Phase II of Act 129.

Figure 16: Historical Combined Heat and Power Savings



Of concern is the limited contribution from PECO, which continues to struggle with CHP. PECO has attracted only two CHP projects thus far, representing energy savings of 3,707 MWh to-date. These energy savings represent approximately 2% of PECO's CHP program plan-to-date goal of 160,516 MWh. PECO's Phase III EE&C Plan details that they expect to contribute 363,535 MWh of Phase III energy savings from CHP projects alone, which is 18% of their planned Phase III savings. PECO's evaluation contractor says that the program underwent significant changes in PY8 that took longer than expected, delaying the program launch until the end of PY8. PECO notes that the program has a promising pipeline that will not be realized until later in Phase III due to the construction timeline of CHP projects. Additionally, the evaluation contractor conducted targeted process evaluation activities in PY9 to identify program improvement opportunities and increase participation.

PECO's CHP program participation in the next few years warrants further observation to determine if planned targets are obtainable. If expected additional projects in future Phase III years are completed, the share of CHP projects toward Act 129's compliance and top offerings would significantly increase.

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, demand response performance, and TRC benefit-cost ratios for each EDC.

Table 22 presents a statewide overview of PY9 and phase-to-date savings while Table 23 presents an overview of statewide EDC spending on incentives and program overhead costs and overall benefits in PY9.

Table 22: Summary of Statewide PY9 and Phase III Impacts: Gross and Net Annual and Lifetime Savings

Savings Category	Statewide Total
Phase III Reported Gross Savings (MWh/yr)	2,515,409
Phase III Verified Gross Savings (MWh/yr)	2,536,712
Phase III Net Savings (MWh/yr)	1,872,435
Phase III Gross Lifetime Savings (MWh)	22,897,048
Phase III Net Lifetime Savings (MWh)	16,940,150
PY9 Reported Gross Savings (MWh/yr)	1,446,851
PY9 Verified Gross Savings (MWh/yr)	1,457,892
PY9 Net Savings (MWh/yr)	1,063,069
PY9 Gross Lifetime Savings (MWh)	13,766,718
PY9 Net Lifetime Savings (MWh)	10,038,462

Table 23: Summary of Statewide Portfolio Finances**

Row #	Element	PY9 ($1000)
1	EDC Incentives to Participants [1]	$79,495
2	EDC Incentives to Trade Allies	$0
3	Participant Costs (net of incentives/rebates paid by utilities)	$224,313
4	**Incremental Measure Costs (Sum of rows 1 through 3)**	**$303,810**
5	Design & Development [2]	$1,809
6	Administration, Management, and Technical Assistance [3]	$12,587
7	Marketing [4]	$14,418
8	Program Delivery [5]	$73,559
9	EDC Evaluation Costs	$3,885
	EDC common costs not allocated to individual program overhead cost categories	$18,891
10	SWE Audit Costs	$1,203
11*	**Program Overhead Costs (Sum of rows 5 through 10)**	**$126,351**
12	NPV of increases in costs of natural gas (or other fuels) for fuel switching programs	**$3,274**
13	**Total NPV TRC Costs [6] (Net present value of sum of rows 4, 11, and 12)**	**$433,444**
14	Total NPV Lifetime Electric Energy Benefits	$430,195
15	Total NPV Lifetime Electric Capacity Benefits	$148,484
16	Total NPV Lifetime Operation and Maintenance (O&M) Benefits	$46,697
17	Total NPV Lifetime Non-Electric Benefits (Fossil Fuel, Water)	$16,972
18	**Total NPV TRC Benefits [7] (Sum of rows 14 through 17)**	**$642,354**
19	**Statewide TRC Ratio[8]**	**1.48**

1] Includes direct install equipment costs and costs for EE&C kits.
[2] Includes direct costs attributable to plan and advance the programs. Note: The design of the HERs program should be included here, while the actual development and mailing of HERs would be attributable to Program Delivery.
[3] Includes rebate processing, tracking system, general administration, program management, general management and legal, and technical assistance. Any common portfolio costs that are allocated across programs should be shown in this row.
[4] Includes the marketing CSP and marketing costs by program CSPs.
[5] Direct program implementation costs. Labor, fuel, and vehicle operation costs for appliance recycling and direct install programs. For behavioral programs, this includes the printing and postage of HERs.
[6] Total TRC Costs includes Total EDC Costs and Participant Costs.
[7] Total TRC Benefits equals the sum of Total Lifetime Electric and Non-Electric Benefits. Benefits include: avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase II are not to be included as a part of Total TRC Benefits for Phase III.
[8] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
* Rows 1-11 are presented in nominal dollars
** Totals will not equal sum of the rows due to rounding when aggregating costs and benefits across the seven EDCs.

3.1 PECO

3.1.1 Impact Evaluation

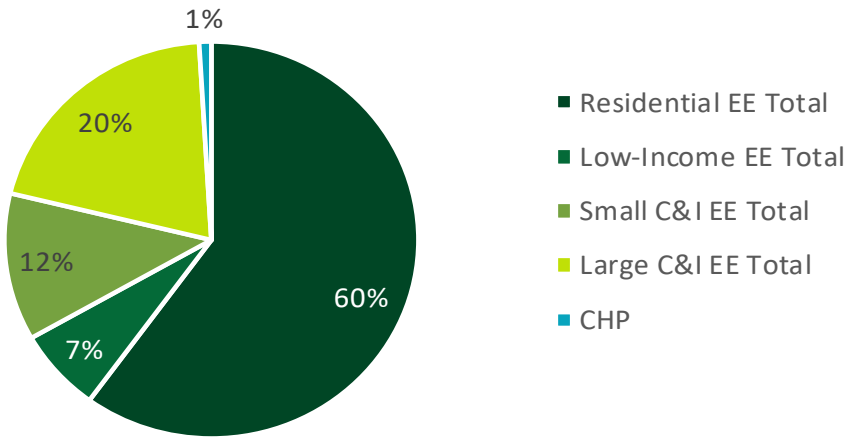
A summary of energy impacts by program for PY9 is presented in Table 24. The bulk of savings (60%) is attributable to the Residential Energy Efficiency Program, which is an umbrella program containing solutions for lighting, appliances, and HVAC; appliance recycling; whole home; new construction; multifamily; and behavioral adjustment (see Figure 17). 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 24: PY9 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	235,786	99%	234,211	0.68	159,264
LI EE Program	29,104	90%	26,335	1.00	26,335
Small C&I EE Program	48,572	96%	46,853	0.75	35,140
Large C&I EE Program	82,041	96%	79,044	0.77	60,864
CHP	3,254	114%	3,707	0.89	3,300
Portfolio Total	**398,757**	**98%**	**390,151**	**0.73**	**284,902**

* Rows may not sum to totals due to rounding.

Figure 17: Percent of Portfolio PY9VTD Gross Savings, by Program – PECO



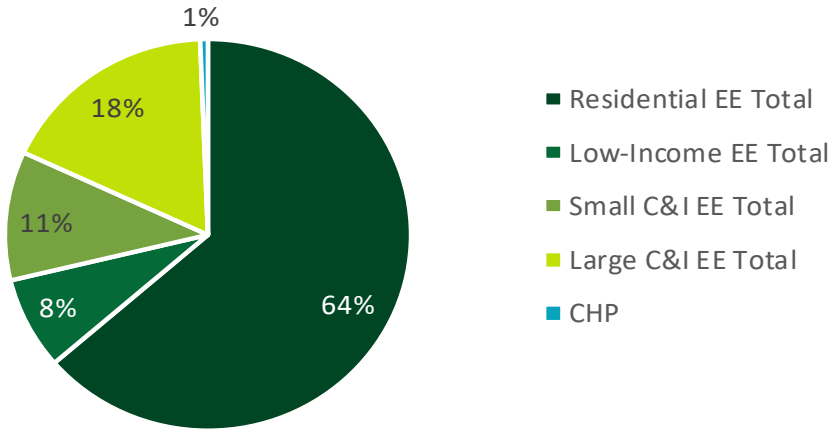
A summary of phase-to-date energy impacts by program is presented in Table 25. Consistent with PY9, the bulk of savings (64%) in the phase is attributable to the Residential Energy Efficiency Program.

Table 25: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)*

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Res. EE Program	383,705	100%	382,412	0.69	263,257
LI EE Program	48,969	93%	45,720	1.00	45,720
Small C&I EE Program	66,355	96%	63,990	0.75	47,944
Large C&I EE Program	108,006	97%	105,010	0.73	77,489
CHP	3,254	114%	3,707	0.89	3,300
Portfolio Total	**610,289**	**98%**	**600,840**	**0.73**	**437,710**

* Rows may not sum to totals due to rounding.

Figure 18: Percent of Portfolio VTD Gross Savings, by Program – PECO



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 26 and phase-to-date in Table 27.

Table 26: PY9 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	20.46	145%	29.69	0.66	19.51
LI EE Program	3.48	90%	3.13	1.00	3.13
Small C&I EE Program	6.06	85%	5.16	0.74	3.84
Large C&I EE Program	11.63	97%	11.28	0.77	8.66
CHP	0.49	96%	0.47	0.89	0.42
Portfolio Total	**42.11**	**118%**	**49.73**	**0.71**	**35.56**

* Rows may not sum to totals due to rounding.

Table 27: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)*

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Res. EE Program	32.16	154%	49.44	0.66	32.74
LI EE Program	5.72	93%	5.30	1.00	5.30
Small C&I EE Program	8.99	88%	7.93	0.74	5.87
Large C&I EE Program	15.55	98%	15.22	0.74	11.21
CHP	0.49	96%	0.47	0.89	0.42
Portfolio Total	**62.91**	**125%**	**78.36**	**0.71**	**55.54**

* Rows may not sum to totals due to rounding.

3.1.2 Demand Response

PECO has three Demand Response Programs: Residential, Small C&I, and Large C&I. Each of these programs define participation differently due to variations in delivery and/or data tracking methodologies. Table 28 provides the definitions used and the counts of PY9 and Phase III participation for each included DR program.

Table 28: PECO Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Residential DR	A participant is defined as a unique account number where DLC equipment is installed. One participant may have more than one DLC device installed at the home. Accounts listed as being disconnected, opted-out, or removed are not included in the participant count.	60,846	*61,440
Small C&I DR	A participant is defined as a unique account number where DLC equipment is installed. One participant may have more than one DLC device installed on the premises. Accounts listed as being disconnected, opted-out, or removed are not included in the participant count.	1,564	*1,586
Large C&I DR	A participant is defined as a large C&I customer (defined by PECO account number) enrolled with a DR program CSP for at least one hour of at least one event occurring in any given program year.	261	261

**DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. P3TD Participation levels indicate the number participants that were active in PY8 if the PY8 participant count was greater than the PY9 participant count.*

PECO's three Demand Response programs had three event days in PY9. The Phase III DR performance target for PECO is 161.0 MW. Table 29 shows the DR savings for each program, as well as the portfolio average for each event day. Average performance across all event days is included at the bottom of the table.

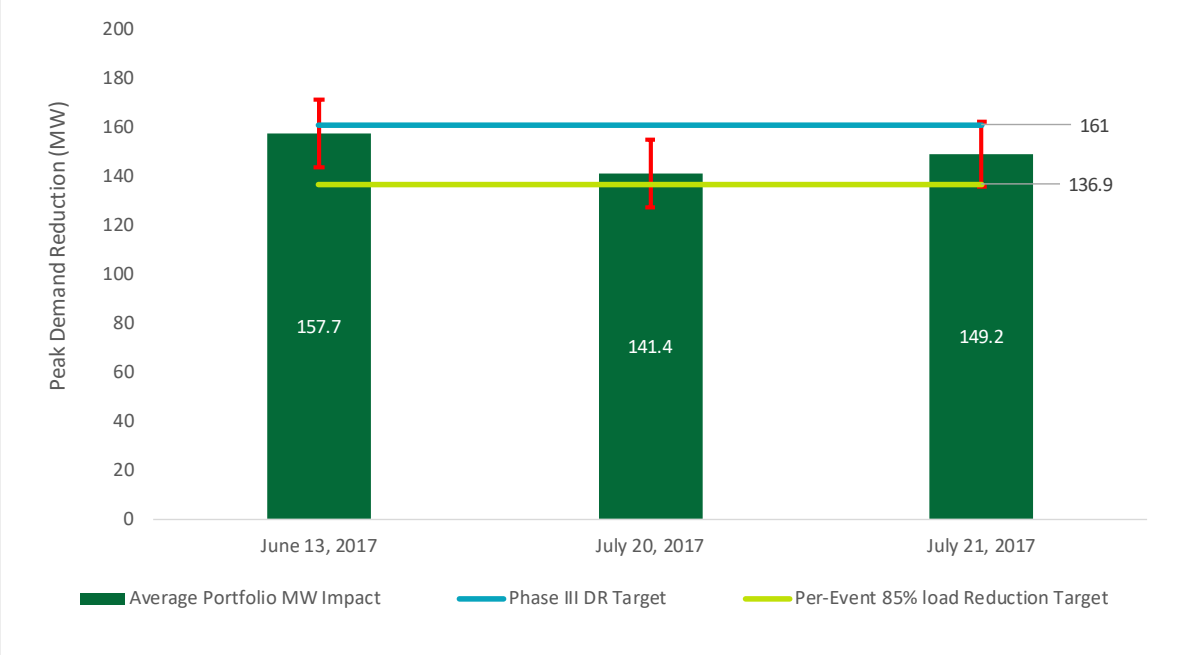
Table 29: PECO Demand Response Performance by Program

Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	Residential DR Program (Verified MW)	Small C&I DR Program (Verified MW)	Large C&I DR Program (Verified MW)	Average Portfolio (Verified MW) w/ 90% CI
June 13, 2017	15	18	39.5	0.0	118.2	157.7±13.9
July 20, 2017	15	18	33.5	0.0	107.9	141.4±13.8
July 21, 2017	14	17	23.3	0.0	125.8	149.2±13.4
PYVTD– Average PY9 DR Event Performance						149.4±13.4
***VTD– Average Phase III DR Event Performance**						149.4±13.4

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will likely differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For PECO, this translates to a 136.9 MW minimum for each DR event. Figure 19 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For each event, PECO exceeded the 85% threshold, but fell short of the target of 161 MW.

Figure 19: PECO Event Performance Compared to 85% Per-Event Target



3.1.3 Cost-Effectiveness

TRC benefit-cost ratios are calculated by comparing the total NPV TRC benefits and the total NPV TRC costs. It is important to note that TRC costs are materially different from the EDC spending and rate recovery tables presented elsewhere in the report. TRC costs include estimates of the full cost incurred by program participants to install efficient equipment, not just the portion covered by the EDC rebate. Table 30 shows the TRC ratios by program and for the portfolio. The benefits in Table 30 were calculated using gross verified impacts. Costs and benefits are expressed in 2017 dollars.

Table 30: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits[1]	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Residential EE	$78,465	$36,358	2.16	$42,107
Low-Income EE	$11,233	$9,266	1.21	$1,967
Residential DR	$3,000	$3,191	0.94	-$191
Residential Total	**$92,699**	**$48,815**	**1.90**	**$43,883**
Small C&I EE	$18,333	$22,570	0.81	-$4,237
Large C&I EE	$35,945	$35,333	1.02	$613
CHP	$1,962	$7,920	0.25	-$5,958
Small C&I DR	$0	$154	0.00	-$154
Large C&I DR	$10,959	$1,579	6.94	$9,380
Non-Residential Subtotal	**$67,199**	**$67,555**	**0.99**	**-$356**
Cross-Cutting	$0	$10,239	0.00	-$10,239
Portfolio Total	**$159,898**	**$126,609**	**1.26**	**$33,288**

[1] TRC values were updated based on corrections to verified MWh savings for the EE Programs and corrections to DR TRC values due to double counting of line losses (Appendix B). This resulted in an overall $728 decrease in gross TRC benefits, which decreased the overall TRC ratio.

3.1.4 Process Evaluation

Navigant reported on PY9 process evaluations for the following PECO programs and program solutions.

Table 31: PY9 Process Evaluations Conducted for Program Solutions

Programs and Program Solutions	
Residential EE Program[25]	**Low-Income EE Program**[26, 25]
Lighting,[25] Appliances, & HVAC Solution	Whole Home Solution[26]
Appliance Recycling Solution	Lighting Solution[26]
Whole Home Solution	
New Construction Solution	**Large C&I EE Program**[28]
Multifamily Targeted Market Segment Solution[25, 27]	Equipment and Systems Solution
Behavioral Solution[28]	New Construction Solution
	Multifamily Targeted Market Segment[27, 28]
Small C&I EE Program[28]	Data Centers Targeted Market Segment[28]
Equipment and Systems Solution	
New Construction Solution	
Whole Building Solution	**Demand Response Programs**
Multifamily Targeted Market Segment[27, 28]	Residential DR Program
Data Centers Targeted Market Segment[28]	Small C&I DR Program
Behavioral Solution[28]	Large C&I DR Program
Combined Heat and Power Program[29]	

[25] Navigant did not conduct a full process evaluation for the Residential Lighting component of the Lighting, Appliances, & HVAC Solution, the Residential Appliance Recycling Solution, the Residential Behavioral Solution, or the Multifamily Targeted Market Segment in PY9, other than process interviews with program staff. Full process evaluations are planned for these solutions and segments in PY10.
[26] Navigant did not conduct a full process evaluation for the Low-Income Whole Home Solution or the Low-Income Lighting Solution in PY9, other than process interviews with program staff.
[27] The evaluation of the Multifamily Targeted Market Segment was a single evaluation across residential and small and large C&I programs
[28] Navigant did not conduct a process evaluation for the Small and Large C&I Behavioral solutions as it was not implemented in PY9. It also did not conduct a full process analysis of the Small or Large C&I Data Centers Targeted Market Segments other than interviews with program and implementation staff and reviews of program materials; this was due to no participation in the Small Data Center segment and minimal participation in the Large Data Center Segment in PY9. Navigant also did not conduct a process evaluation for the Multifamily Targeted Market Segment in PY9. Full process evaluations are planned for the Small and Large C&I Behavioral solutions and the Multifamily Targeted Market Segment in PY10.
[29] Navigant did not complete all the PY9 activities listed in the evaluation plan for this program. However, Navigant plans on conducting additional process evaluation work in PY10 to support and monitor performance of the program.

For PY9, Navigant conducted and reported on full process evaluations for a total of 11 program solutions within the PECO residential, small and large C&I, and demand response programs. From these evaluations, it produced a total of 16 process evaluation findings, which resulted in 16 recommendations, seven of which were accepted and nine are under consideration. A key cross-program finding was program satisfaction from participants and trade allies. Participant satisfaction information was collected for two residential program solutions (Whole Home and Residential DR), four small C&I program solutions (Equipment and Systems, New Construction, Whole Building, and Small C&I DR), and three large C&I program solutions (Equipment and Systems, New Construction, and Large C&I DR). On average, across these participant surveys, 87% of residential participants and 84% of C&I participants were satisfied with the programs overall.[30] Satisfaction information was also collected for trade allies in two residential solution programs, with an average of 83% satisfaction for trade allies active with the Appliances and HVAC components of the residential Lighting, Appliances, & HVAC Solution, and an average of 72% satisfaction for builders in the New Construction Solution.

For the *PECO Residential EE program*, the PY9 process evaluation provided a total of five findings and five recommendations: one for Appliance Recycling, two for the Whole Home Solution, and two for the New Construction Solution. Across the individual residential program solutions, all five of the recommendations were accepted. A key cross-program finding was on program satisfaction from trade ally, participant, and builder surveys. The evaluation conducted a trade ally survey for the Appliances & HVAC components of the Residential Lighting, Appliances, & HVAC Solution, a participant survey for the Whole Home Solution, and a builder survey for the New Construction Solution. On average, 83% of trade allies, 85% of the participants, and 72% of builders were satisfied with the programs overall.[31] Solution-specific findings for these residential program solutions addressed a broad range of topics beyond satisfaction, including the following:[32]

- Primary sources of program information
- Strengths and areas of improvement in program marketing and outreach
- Awareness of other PECO solutions
- Drivers and barriers of program participation
- Barriers to program delivery
- Customer or trade ally perceptions of incentive amounts or processing time
- Non-Energy Benefits experienced by customers
- Suggestions for program improvement
- Customer energy-saving habits
- Trade ally interactions with PECO staff

[30] Weighted by the number of PY9 participants in each solution.
[31] Weighted by the number of PY9 participants in each solution.
[32] The PECO annual report provides further detail regarding these topics.

- Challenges to meeting ENERGY STAR and Code Plus standards in new construction
- Percentage of sales through the solution

For the PECO *Small and Large C&I EE programs*, the PY9 process evaluation provided a total of four findings and four recommendations. By program, one of the recommendations was for the Equipment and Systems Solution, two were for the New Construction Solution, and one was for the Data Centers Solution. Across both Small and Large C&I EE program solutions, all four of the recommendations are under consideration. A key cross-program finding was on program satisfaction from participant surveys, which were conducted for the Small and Large Equipment and Systems Solution, the Small and Large New Construction Solution, and the Small and Large Whole Building Solution. On average, 85% of the participants were satisfied with the Small C&I program overall and 88% of the participants were satisfied with the Large C&I program overall.[33] Solution-specific findings for these Small and Large C&I program solutions addressed a broad range of topics beyond satisfaction, including the following:[34]

- Primary sources of program information
- Strengths and areas of improvement in program outreach and marketing
- Awareness of other PECO solutions
- Drivers and barriers of program participation
- Barriers to program delivery
- Customer or trade ally perceptions of incentive amounts or processing time

For the PECO *Combined Heat and Power (CHP) Program*, PY9 process evaluation provided a total of two findings and two recommendations. One of the recommendations was accepted and the other recommendation is under consideration. Key program findings were that market actors indicated a general lack of awareness of PECO's CHP program and that lack of developer interest in the program is reducing program participation.

For the PECO *Demand Response programs*, the PY9 process evaluation provided a total of five findings and five recommendations across all three programs. Two of the recommendations were for the Residential DR Program, two were for the Small C&I DR Program, and one was for the Large C&I DR Program. Across all three program solutions, all five of the recommendations are under consideration. A key cross-program finding was on program satisfaction from participant surveys, which were conducted for all three programs. On average, 87% of the participants were satisfied with the Demand Response programs overall.[35] Solution-specific findings for these Demand Response programs addressed a broad range of topics beyond satisfaction, including the following:[36]

- Participant awareness of the DR event

[33] Weighted by the number of PY9 participants in each solution.
[34] The PECO annual report provides further detail regarding these topics.
[35] Weighted by the number of PY9 participants in each solution.
[36] The PECO annual report provides further detail regarding these topics.

- Home comfort during the DR event
- Perceptions of the duration of, the timing of, and notifications about the DR events
- Participant perceptions of monthly bill credits
- Likelihood to recommend the program to others
- Reasons for participation in the program
- Drivers and barriers of program success

3.1.5 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the PECO PY9 Annual Report and the supporting detail provided by PECO's evaluation contractor. The detailed audit findings can be found in Appendix B.

- The PY9 demand response analysis was impacted by data quality issues. The most important aspect of the PY10 DR evaluation will be PECO supplying Navigant with a more complete record of interval load data for summer 2018. The PECO/Navigant team has held regular check-in calls with the SWE in PY10 and meter data quality for summer 2018 appears to be much improved. Some of the issues identified in the audit, such as tie-breaking logic, should be non-issues with a clean data set. Given the data available for PY9, the Navigant selection of methods was consistent with the Evaluation Framework and the implementation of those methods was well thought-out. Regression analysis – which is the preferred approach for C&I DR analysis in the PA TRM and Evaluation Framework was used for all sites. We noted several issues for consideration in PY10 and beyond.
  - A lack of attention to detail regarding data management. All data preparation and analysis code should be peer-reviewed by senior staff at Navigant for errors before results are computed. This will cut down on re-filing of reports and the amount of QA\QC that falls to the SWE. The Navigant team appears to have addressed this in PY10 based on regular check-in calls with the SWE and the PY10 results and data files presented to date.
  - The participant count calculation was unclear for the Residential DR program from the data provided. The description of participant count logic provided in Section 2.3 of the DR report referenced fields that were not provided to the SWE in the participant list. The standardized format of the SWE DR Data Request should not deter PECO/Navigant from providing all necessary information to replicate the participant count.
  - Check the order of operations for procedural steps across baselines to ensure consistency. The issue the SWE flagged in this memo dealt with where the check for at least 75% non-missing reads in the day occurred. With a clean and complete data set this will not be an issue because all days will have meter reads for each interval.
- In the Tracking Data Review audit activity, the SWE was able to replicate reported gross energy savings, reported gross demand savings, and incentive totals for all programs in PECO's portfolio. Except for the Multifamily Targeted Solution, the SWE was also able to replicate participation counts. The SWE will work with the PECO/Navigant team to better

understand the participant count logic and required fields for the Multifamily Targeted Solution in PY10.

- The PY9 analysis of the PECO's Behavioral Solution (Home Energy Reports) was well-documented and free of errors. Over 20% of PECO's PY9 MWh savings came from HERs mailed to approximately 400,000 residential customers so attention to detail is critical for data management and regression analysis.
- The SWE's review of verified savings for non-residential solutions found verified savings followed proper TRM protocols. However, the SWE did identify calculation errors with some custom projects. Additionally, the evaluation activity for samples within the High Impact stratum did not follow the approved EM&V plan.
- The SWE's review of verified savings for non-HER residential solutions found that, overall, the verified savings followed proper TRM protocols and that most of the verified savings are accurate. However, the SWE found discrepancies in the application of TRM algorithms for several solutions that resulted in underestimated verified savings of 2,132 MWh - or 0.55% of portfolio savings - in PECO's PY9 Annual Report. The SWE had identified one of these discrepancies involving the commercial coincidence factor and HOU for cross-sector upstream lighting sales in its PY8 report, but it was not resolved in PY9. The residential solutions audit is detailed in Appendix B.4.1 with recommendations for improvement.
- Adequate numbers of project files were submitted for the residential solutions in PY9, and the sampled project file packages included most of the documentation requested and further documentation was readily provided upon request. Navigant continued to work with the SWE to clarify questions and processes, both general and specific, that resulted from the ex-ante review for PY9 and improvements were made to quarterly data submissions throughout PY9.
- Overall, Navigant estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.
- The PY9 TRC model included benefits from fossil fuel and/or water savings in accordance to the *Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test*.
- The PY9 TRC model incorporated DR impacts, though the PECO model calculated TRC benefits inconsistently with the 2016 TRC Order and applied avoided cost of distribution capacity benefits to all DR impacts instead of limiting them to the residential and Small C&I sectors. In addition, PECO's model applied line loss assumptions a second time to DR impacts that had already been grossed up for losses for reporting. This inflated TRC benefits by 7.99%.
- PECO's definition of a program is very broad, and comprises, for example, 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.
- In general, for all the process evaluations, the SWE determined that the reporting followed the SWE guidelines. PECO's PY9 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: Whole Home Solution. There were no references to the statistical test(s) used to evaluate the strength of differences reported between PY9 and prior program years. It would have been useful to know, for example, how the significant difference in sources of program awareness were assessed across program years. 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 PY9 is presented in Table 32. The largest portion of savings (42%) is attributable to the Non-Residential Energy Efficiency program, a combination of the previous C&I custom and efficient equipment programs, followed by the Efficient Lighting program (see also Figure 20).

Table 32: PY9 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	13,454	80%	10,731	0.66	7,082
Efficient Lighting	128,298	100%	128,036	0.83	106,270
EE Kits and Education	12,205	97%	11,829	1.00	11,829
EE Home	21,705	87%	18,802	0.75	14,148
Home Energy Education	33,876	107%	30,311*	1.00	30,311
LI WRAP	17,530	82%	14,412	1.00	14,412
Non-Res EE	167,510	97%	162,377	0.71	114,870
SEEE	5,597	108%	6,024	1.00	6,024
Portfolio Total	**400,175**	**97%**	**382,522**	**0.80**	**304,946**

* Verified savings were adjusted to account for uplift (double counting) in the Home Energy Education program.

Figure 20: Percent of Portfolio PY9VTD Gross Savings, by Program– PPL

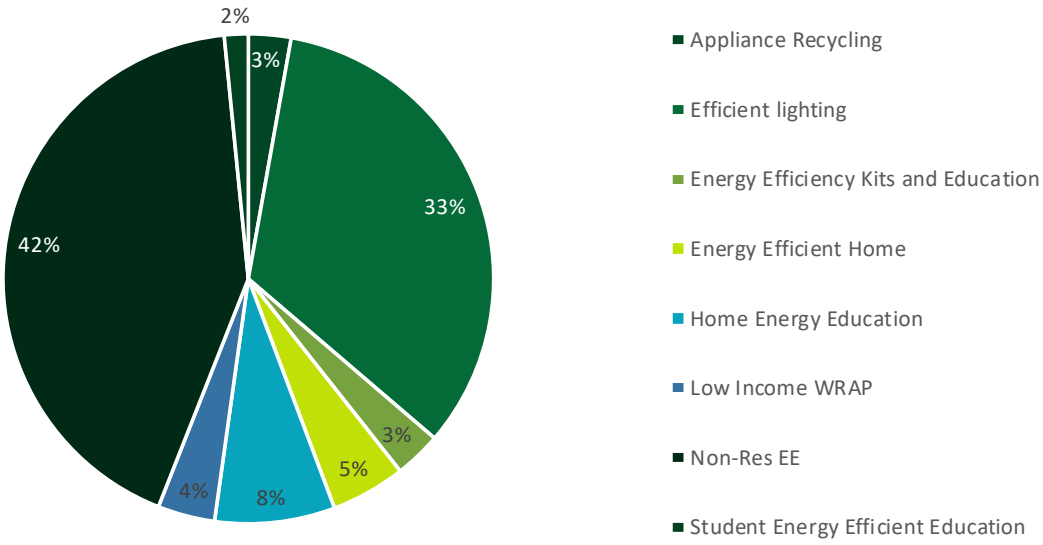
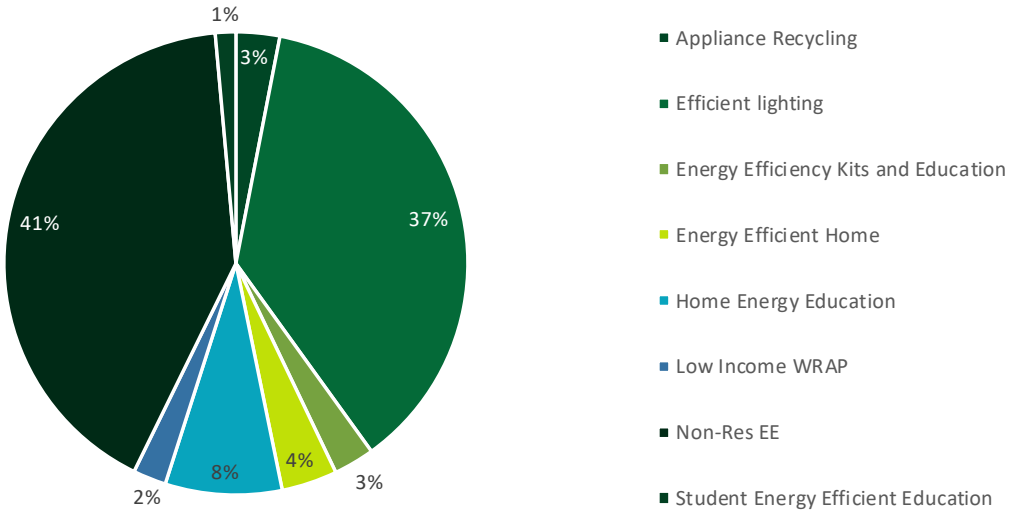


Table 33: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTGR	VTD Net (MWh/yr)
Appliance Recycling	25,489	89%	22,575	0.66	14,900
Efficient Lighting	278,674	98%	273,965	0.83	227,391
EE Kits and Education	22,625	93%	21,049	1.00	21,049
EE Home	32,327	89%	28,746	0.73	20,884
Home Energy Education	74,343	81%	60,243*	1.00	60,243
LI WRAP	21,021	81%	17,075	1.00	17,075
Non-Res EE	315,011	97%	305,950	0.74	227,046
SEEE	10,715	99%	10,562	1.00	10,562
Portfolio Total	**780,204**	**95%**	**740,165**	**0.81**	**599,150**

* Verified savings were adjusted to account for uplift (double counting) in the Home Energy Education program.

Figure 21: Percent of Portfolio VTD Gross Savings, by Program– PPL



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 34.

Table 34: PY9 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 Recycling	1.89	84%	1.59	0.66	1.05
Efficient Lighting	18.01	96%	17.37	0.83	14.42
EE Kits and Education	0.90	122%	1.10	1.00	1.10
EE Home	3.68	96%	3.55	0.75**	2.45
Home Energy Education	6.54	82%	5.34*	1.00	5.34
LI WRAP	1.76	93%	1.63	1.00	1.63
Non-Res EE	22.22	102%	22.67	0.71	15.87
SEEE	0.56	111%	0.63	1.00	0.63
Portfolio Total	**55.56**	**97%**	**53.88**	**0.79**	**42.49**

*Verified demand savings were adjusted to account for uplift (double counting) in the Home Energy Education program.
** PY9 evaluated NTG ratios used for refrigerator and dehumidifier measures. PY8 evaluated NTG ratios used for all other measures. The 0.75 NTG ratio for the overall program is the verified gross population energy savings weighted average of the NTG ratios applied to each measure

Table 35: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Appliance Recycling	3.54	91%	3.21	0.66	2.12
Efficient Lighting	40.15	93%	37.19	0.83	30.87
EE Kits and Education	1.65	120%	1.98	1.00	1.98
EE Home	5.63	95%	5.33	0.68	3.61
Home Energy Education	60.93	20%	12.09	1.00	12.09
LI WRAP	2.10	91%	1.92	1.00	1.92
Non-Res EE	41.34	100%	41.40	0.74	30.49
SEEE	1.02	109%	1.11	1.00	1.11
Portfolio Total	**156.37**	**67%**	**104.23**	**0.81**	**84.19**

3.2.2 Demand Response

PPL has one Demand Response Program with participants from three sectors – Small C&I, Large C&I, and GNI. Table 36 provides the definition used and the counts of PY9 and Phase III participation for the DR program.

Table 36: PPL Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Demand Response	Unique job number; corresponds to a customer that participated in a demand response event.	93	93

PPL's DR program had three event days in PY9. The Phase III DR performance target for PPL is 92.0 MW. Table 37 shows the DR savings for the program, as well as the portfolio average for each event day. Because PPL has only one DR program, the portfolio average will be the same as the program's performance. Average performance across all event days is included at the bottom of the table.

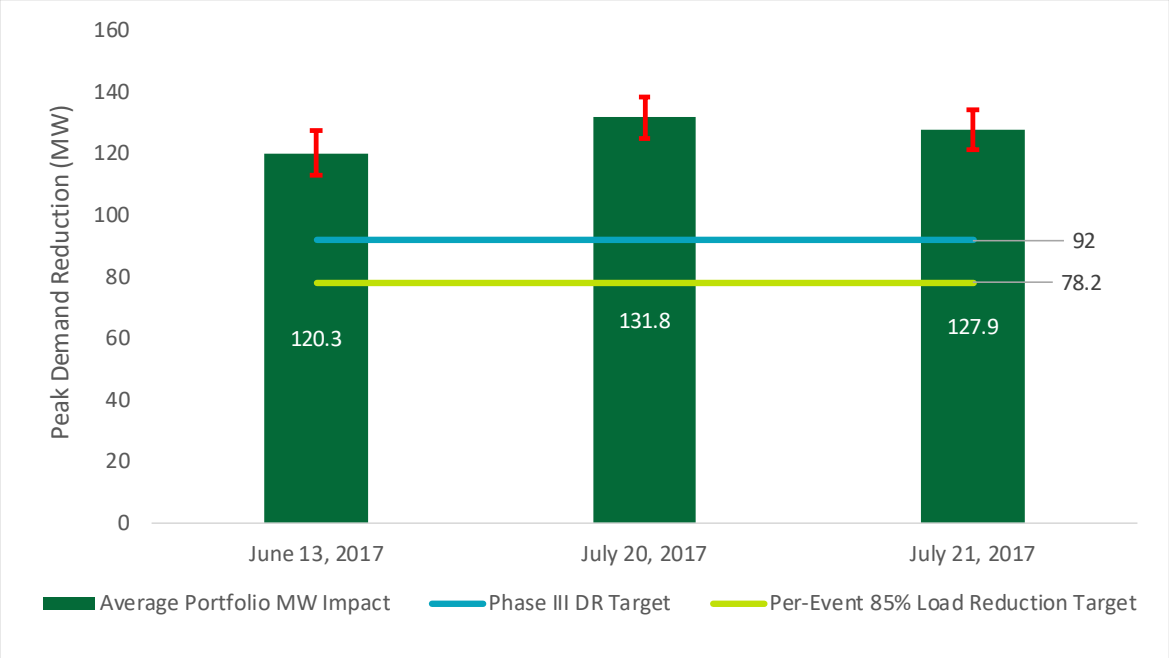
Table 37: PPL Demand Response Performance by Program

Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	Demand Response	Average Portfolio MW/event Impact w/ 90% CI
June 13, 2017	15	18	120.3	120.3±7.2
July 20, 2017	15	18	131.8	131.8±6.6
July 21, 2017	15	18	127.9	127.9±6.4
PYVTD– Average PY9 DR Event Performance				**126.7±3.8**
***VTD– Average Phase III DR Event Performance**				**126.7±3.8**

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For PPL, this translates to a 78.2 MW minimum for each DR event. Figure 22 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For each event, PPL exceeded both the 85% threshold and the target of 92 MW.

Figure 22: PPL Event Performance Compared to 85% Per-Event Target



3.2.3 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 2017 dollars.

Table 38: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits – Costs)
Appliance Recycling	3,780	2,074	1.82	1,705
Efficient Lighting	60,993	13,546	4.50	47,447
EE Kits & Education	5,618	2,032	2.76	3,586
EE Home	14,364	16,547	0.87	(2,182)
Home Energy Education	1,476	1,623	0.91	(147)
LI WRAP	6,472	9,371	0.69	(2,899)
SEEE	2,230	1,103	2.02	1,128
Residential (Including LI) Subtotal	**94,933**	**46,296**	**2.05**	**48,637**
Custom	17,354	29,333	0.59	(11,979)
Efficient Equipment	83,590	43,240	1.93	40,350
Non-Residential Subtotal	**100,944**	**72,573**	**1.39**	**28,371**
Demand Response	5,656	1,491	3.79	4,165
Common Portfolio Costs	-	8,652	-	(8,652)
Portfolio Total	**201,533**	**129,012**	**1.56**	**72,521**

3.2.4 Process Evaluation

Cadmus reported on PY9 process evaluations for the following PPL programs.

Table 39: PY9 Process Evaluations

Residential and C&I Programs	
Residential Programs	Energy Efficiency Kits and Education
Appliance Recycling	**C&I Programs**
Energy Efficient Home	Efficient Equipment
Home Energy Education	Midstream Lighting
Student Energy Efficient Education	Continuous Energy Improvement
Efficient Lighting	Custom
Residential Low-Income Programs	Demand Response
Weatherization Relief Assistance (WRAP)	

For PY9, Cadmus evaluated and reported on a total of nine programs within the PPL residential, low-income, and C&I sectors; one of the programs in the C&I sector has four distinct program components with separate evaluations. These evaluations generated a total of 49 process evaluation findings, which resulted in 24 recommendations, six of which were accepted, one rejected, and 17 are under consideration.[37] A key cross-program finding was on program satisfaction from participant surveys, which were conducted for all programs. On average, across all participant surveys, 75% of residential and low-income participants and 96% of C&I participants were satisfied with the programs or program measures overall.[38]

For the *PPL Residential programs*, the PY9 process evaluation provided a total of 32 findings and 21 recommendations. Five of the recommendations were accepted and the remainder are under consideration. A key cross-program finding was on program satisfaction from participant surveys. On average, across all residential program solutions, 72% of the participants were satisfied with the programs or program measures overall.[38] Program-specific findings for these residential program solutions addressed a broad range of topics, including the following:[39]

- 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

[37] There are additional findings and recommendations in the PY9 report; however, this section reports only findings and recommendations that were specifically related to the process evaluation.
[38] Weighted by the number of PY9 participants in each program. For residential programs, the Efficient Lighting Program is not included because program satisfaction was not evaluated in PY9.
[39] The PPL annual report provides further detail regarding these topics.

- Program paperwork requirements

For the PPL *Residential Low-Income programs*, the PY9 process evaluation provided a total of 18 findings and six recommendations. Two of the recommendations were accepted, one was rejected, and three are under consideration. A key cross-program finding was program satisfaction from participant surveys. On average, across both the WRAP and Kits programs, 94% of the participants were satisfied with the program overall.[38] Program-specific findings for the low-income programs addressed strengths and weaknesses in program outreach and drivers and barriers to program success.

For the PPL *C&I programs*, the PY9 process evaluation provided a total of 20 findings and ten recommendations. Two recommendations were accepted and eight are under consideration. A key cross-program finding was on program satisfaction from participant surveys. On average, across both the Efficient Equipment and Custom programs, 96% of the participants were satisfied with the program overall. [38] Program-specific findings for the C&I programs primarily addressed drivers and barriers of program success.

3.2.5 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the PPL PY9 Annual Report and the supporting detail provided by PPL's evaluation contractor. The detailed audit findings can be found in Appendix C.

- The SWE found the Cadmus demand response verified savings analysis to be thorough and well-documented for PY9. Of the six EDCs with Phase III targets, the PPL/Cadmus evaluation procedures were best-aligned with the Evaluation Framework. Because the evaluation was so robust, our audit findings consist largely of observations about key customers. The SWE agrees with the baseline selection procedures and found no errors in the calculations for the 20 sites examined. We recommend the Commission adopt the PPL/Cadmus verified savings estimates when assessing compliance at the end of Phase III.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in PPL's Annual Report to the tracking data provided to the SWE on a quarterly basis. For all programs represented in the tracking data, the SWE was able to replicate the reported MWh savings, reported MW savings, and the number of participants. We were unable to replicate incentives using the tracking data, but we did not expect to be able to do so.
- The SWE audit of PPL's Home Energy Education (HEE) program uncovered several errors in the calculation of gross verified savings.[40] After correcting these issues, the verified gross PY9 energy savings is reduced 79 MWh, the verified gross peak demand savings is reduced 4.88 MW and the TRC benefits are lower by approximately $342,000. Appendix C.4.1.5 discusses the technical issues. After correcting the errors in Cadmus' analysis, the program has a gross TRC ratio of 0.90. Whether or not the program is cost-

[40] The SWE notes that PPL's HEE program is commonly referred to as a "Home Energy Report" or HER program in the energy-efficiency industry.

effective depends on the treatment of "uplift" in other programs. The Act 129 status quo is to subtract these savings from HER programs to prevent double-counting. In fact, these savings may be more attributable to the HER program than the other EE&C programs. If uplift savings were deducted from other residential programs, or at the portfolio-level, PPL's HEE program would have a TRC ratio greater than 1.0 for PY9.

- 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. However, the SWE found discrepancies in the application of TRM algorithms for several solutions that resulted in overestimated verified savings of 362 MWh – or 0.09% of portfolio savings – in PPL's PY9 Annual Report. The SWE had identified one of these discrepancies involving the commercial coincidence factor and HOU for cross-sector upstream lighting sales in its PY8 report, but it was not resolved in PY9. In keeping with its approved PY9 and PY10 EM&V plans, Cadmus will update the inputs in the PY10 analysis. The residential programs audit is detailed in Appendix C.4.1 with recommendations for improvement.
- The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation was aligned with the Evaluation Framework followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate.
- In the SWE audit of the non-residential midstream lighting program, the SWE found that PPL's evaluation contractor executed with an appropriate measurement and verification approach across a generous sample of projects in PY8 and PY9. The midstream impact evaluation outcomes found a realization rate of 79% with a higher than expected uncertainty due to challenges with the baseline assumptions, differences in the business type affecting the hours of use, and in-service rate of installed lamps and fixtures.
- PY9 residential project files responses were adequate and the supporting details were provided. Cadmus continued to work with the SWE to clarify questions and processes, both general and specific. Improvements were made to quarterly data submissions, such as providing a project file key, which allowed the SWE auditors to conduct thorough reviews of project file packages, TRM equations and values, and the tracking data.
- The TRC model accounted for fossil fuel and water savings benefits. However, the monetization of water savings was not clearly calculated and avoided water costs were not transparent.
- Compliance with demand response targets is reported at the system level, meaning that MW performance totals are already adjusted for line losses. In demand response TRC calculations Cadmus applied line losses a second time, which overstated TRC benefits by 4-8% depending on sector. The TRC values in this report show the corrected values.
- Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.
- 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 mostly sufficient detail to assess the methods, findings, and recommendations. Wherever there

were deviations from the Phase III Evaluation Plan, Cadmus generally 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 LIGHT

3.3.1 Impact Evaluation

A summary of energy impacts by program through PY9 is presented in Table 40. The bulk of savings (24%) 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 23).

Table 40: PY9 Incremental Annual Energy Savings by Program (MWh/Year)

Program	PYRTD (MWh/yr)	Realization Rate	PYVTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
REEP	7,730	78%	6,046	0.72	4,324
REEP (Upstream Lighting)	25,298	100%	25,178	0.43	10,791
Res. Appliance Recycling	2,703	92%	2,496	0.47	1,166
Res. Behavioral Savings	7,376	88%	6,524	1.00	6,524
Res. Whole House Retrofit	118	84%	99	1.00	99
LI Energy Efficiency	4,246	89%	3,787	1.00	3,787
Express Efficiency	10,818	132%	14,329	0.55	7,950
Small/Medium Midstream Lighting	1,329	140%	1,860	0.88	1,646
Small Commercial Direct Install	6,264	97%	6,093	0.99	6,050
Multifamily Housing Retrofit	107	95%	101	0.45	46
Commercial Efficiency	8,653	99%	8,565	0.60	5,123
Large Midstream Lighting	1,159	210%	2,440	0.88	2,159
Industrial Efficiency	16,050	103%	16,491	0.31	5,047
Public Agency Partnership	5,599	101%	5,631	0.45	2,562
Community Education	1,372	104%	1,426	0.45	649
Large C&I Demand Response Curtailable	0	-	0	-	0
Portfolio Total	**98,882**	**102%**	**101,065**	**0.57**	**57,923**

Figure 23: Percent of Portfolio PY9VTD Gross Savings, by Program – Duquesne Light

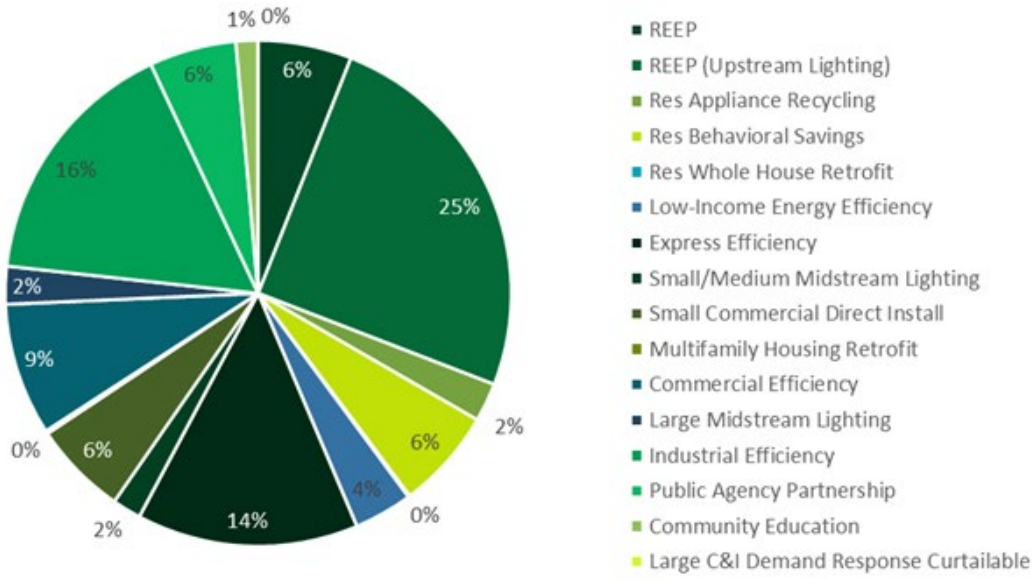
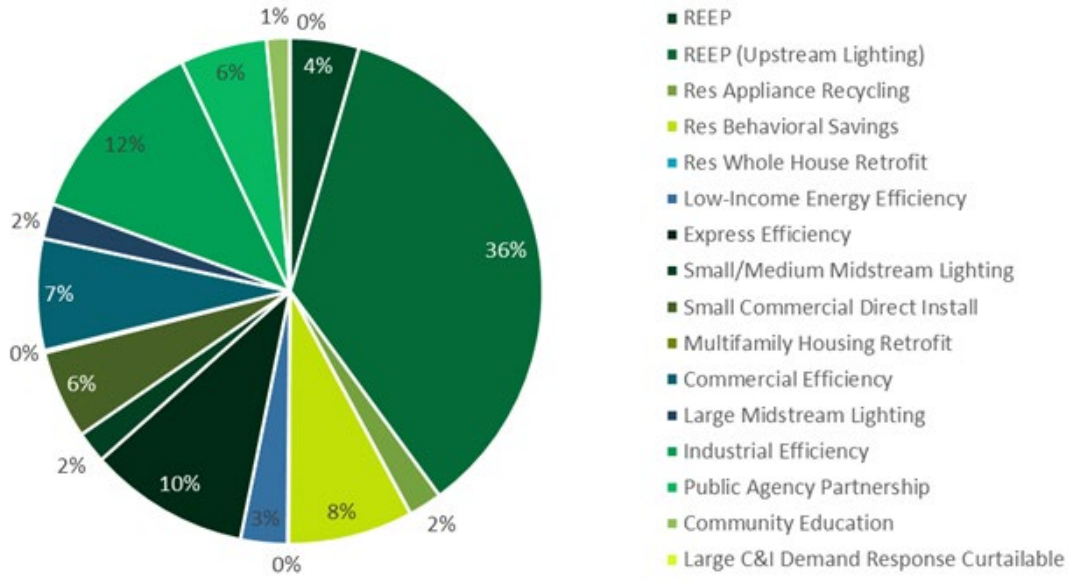


Table 41: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
REEP	9,870	76%	7,533	0.69	5,182
REEP (Upstream Lighting)	59,656	102%	60,674	0.58	35,356
Res. Appliance Recycling	3,965	92%	3,660	0.47	1,709
Res. Behavioral Savings	13,912	98%	13,686	1.00	13,686
Res. Whole House Retrofit	118	84%	99	1.00	99
LI Energy Efficiency	5,565	92%	5,113	0.98	5,019
Express Efficiency	14,057	125%	17,512	0.56	9,723
Small/Medium Midstream Lighting	2,353	147%	3,456	0.88	3,058
Small Commercial Direct Install	9,890	98%	9,655	0.99	9,587
Multifamily Housing Retrofit	265	95%	252	0.69	174
Commercial Efficiency	12,296	99%	12,144	0.59	7,116
Large Midstream Lighting	2,063	186%	3,847	0.88	3,404
Industrial Efficiency	20,701	102%	21,118	0.39	8,213
Public Agency Partnership	9,393	101%	9,476	0.60	5,655
Community Education	2,455	104%	2,541	0.61	1,546
Large C&I Demand Response Curtailable	0	-	0	-	0
Portfolio Total	**166,558**	**103%**	**170,768**	**0.64**	**109,534**

Figure 24: Percent of Portfolio VTD Gross Savings, by Program – Duquesne Light



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 42.

Table 42: PY9 Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	PYRTD (MW/yr)	Realization Rate	PYVTD Gross (MW/yr)	NTG	PYVTD Net (MW/yr)
REEP	1.07	88%	0.94	0.60	0.56
REEP (Upstream Lighting)	2.56	97%	2.55	0.43	1.09
Res. Appliance Recycling	0.30	92%	0.28	0.47	0.13
Res. Behavioral Savings	0.84	88%	0.74	1.00	0.74
Res. Whole House Retrofit	0.01	84%	0.01	1.00	0.01
LI Energy Efficiency	0.43	91%	0.39	1.00	0.39
Express Efficiency	1.73	131%	2.27	0.55	1.27
Small/Medium Midstream Lighting	0.23	119%	0.28	0.88	0.24
Small Commercial Direct Install	0.88	102%	0.90	0.99	0.89
Multifamily Housing Retrofit	0.01	93%	0.01	0.45	0.01
Commercial Efficiency	1.01	103%	1.04	0.60	0.62
Large Midstream Lighting	0.22	213%	0.47	0.88	0.41
Industrial Efficiency	1.17	110%	1.29	0.31	0.40
Public Agency Partnership	0.65	88%	0.57	0.45	0.26
Community Education	0.18	95%	0.17	0.45	0.08
Large C&I Demand Response Curtailable	0	-	0	-	0
Portfolio Total	**11.30**	**105%**	**11.91**	**0.60**	**7.09**

Table 43: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
REEP	1.42	86%	1.22	0.61	0.74
REEP (Upstream Lighting)	6.04	102%	6.14	0.58	3.56
Res. Appliance Recycling	0.44	93%	0.41	0.46	0.19
Res. Behavioral Savings	1.59	98%	1.56	1.00	1.56
Res. Whole House Retrofit	0.01	100%	0.01	1.00	0.01
LI Energy Efficiency	0.56	95%	0.53	0.98	0.52
Express Efficiency	2.17	126%	2.72	0.56	1.53
Small/Medium Midstream Lighting	0.39	138%	0.54	0.89	0.48
Small Commercial Direct Install	1.24	102%	1.27	0.99	1.26
Multifamily Housing Retrofit	0.03	100%	0.03	0.67	0.02
Commercial Efficiency	1.27	102%	1.30	0.59	0.77
Large Midstream Lighting	0.37	195%	0.72	0.89	0.64
Industrial Efficiency	1.76	106%	1.87	0.42	0.79
Public Agency Partnership	1.01	88%	0.89	0.58	0.52
Community Education	0.41	95%	0.39	0.67	0.26
Large C&I Demand Response Curtailable	0	-	0	-	0
Portfolio Total	**18.73**	**105%**	**19.60**	**0.66**	**12.84**

3.3.2 Demand Response

Duquesne Light Company has one Demand Response Program – the Large Curtailable Load Program – which operates over two sectors, Small C&I and Large C&I. Table 44 provides the definition used and the counts of PY9 and Phase III participation for the DR program.

Table 44: Duquesne Light Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Large Curtailable Load Program	A participant is a customer participating in the program within the program event period for the program year (e.g., June-September 2017), represented by a unique participant account number. This count represents the summation of the unique customer participant account numbers in the tracking system for the program, including all account numbers for which DR activity has been reported for at least one event during the program period for the year.	74	74

Duquesne Light's Large Curtailable Load program had three event days in PY9. The Phase III DR performance target for Duquesne Light is 42.0 MW. Table 45 shows the DR savings for the program, as well as the portfolio average for each event day. Because Duquesne Light has only one DR program, the portfolio average will be the same as the program's performance. Average performance across all event days is included at the bottom of the table.

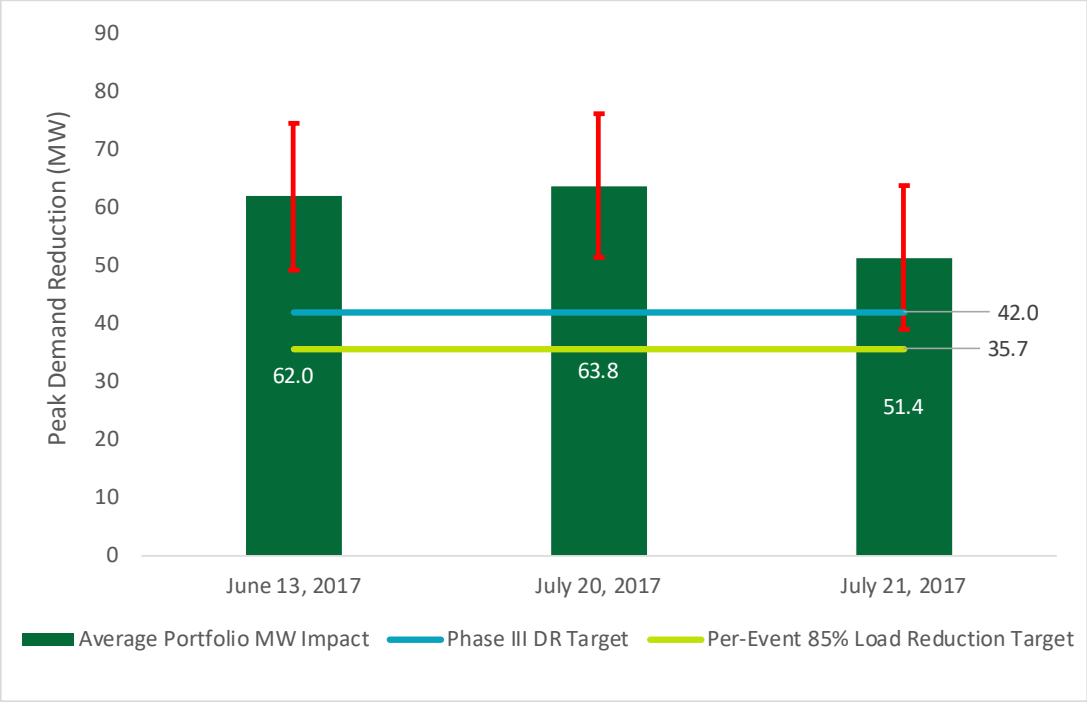
Table 45: Duquesne Light Demand Response Performance by Program

Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	Large Curtailable Load Program	Average Portfolio MW Impact w/ 90% CI
June 13, 2017	15	18	62.0	62.0±12.7
July 20, 2017	15	18	63.8	63.8±12.5
July 21, 2017	15	18	51.4	51.4±12.5
PYVTD– Average PY9 DR Event Performance				**59.1±7.1**
***VTD– Average Phase III DR Event Performance**				**59.1±7.1**

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For Duquesne Light, this translates to a 35.7 MW minimum for each DR event. Figure 25 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For each event, Duquesne Light exceeded both the 85% threshold and the target of 42 MW.

Figure 25: Duquesne Light Event Performance Compared to 85% Per-Event Target



3.3.3 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 46 shows the TRC ratios by program and for the portfolio. The benefits in Table 46 were calculated using gross verified impacts. Costs and benefits are expressed in 2017 dollars.

Table 46: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
REEP	13,161	7,001	1.88	6,160
Res. Appliance Recycling	749	410	1.83	339
Res. Behavioral Savings	331	456	0.73	(125)
Res. Whole House Retrofit	55	236	0.23	(181)
LI Energy Efficiency	1,152	1,238	0.93	(86)
Residential Subtotal	**15,448**	**9,341**	**1.65**	**6,107**
Express Efficiency	8,256	1,682	4.91	6,574
Small/Medium Midstream Lighting	782	277	2.82	504
Small Commercial Direct Install	3,536	1,630	2.17	1,906
Multifamily Housing Retrofit	62	427	0.15	(365)
Commercial Efficiency	5,424	1,169	4.64	4,255
Large Midstream Lighting	1,011	606	1.67	405
Industrial Efficiency	9,499	2,113	4.50	7,386
Public Agency Partnership	3,371	1,254	2.69	2,117
Community Education	872	535	1.63	337
Large C&I Demand Response Curtailable	5,442	1,640	3.32	3,801
Non-Residential Subtotal	**38,255**	**11,334**	**3.38**	**26,922**
Portfolio Total	**53,703**	**20,675**	**2.60**	**33,028**

3.3.4 Process Evaluation

Navigant reported on PY9 process evaluations for the following Duquesne Light programs.

Table 47: PY9 Process Evaluations

Residential and C&I Programs	
Residential Programs[41]	**C&I Programs**[42]
Residential Energy Efficiency Program (REEP)	Express Efficiency
Whole House Retrofit (WHRP)	Commercial Efficiency (CEP)
Behavioral Savings/Home Energy Report (HER)	Multifamily Housing Retrofit (MHRP)
	Industrial Efficiency (IEP)
	Public Agency Partnership (PARP)
	Community Education Energy Efficiency (CEEEP)

For PY9, Navigant evaluated and reported on a total of nine programs within the Duquesne Light residential and C&I sectors. From these evaluations, it produced a total of 23 process evaluation findings, which resulted in 13 recommendations. Two recommendations were accepted, two were rejected, and nine are under consideration.

For the *Duquesne Light Residential programs*, the PY9 process evaluation provided a total of 16 findings and seven recommendations. One recommendation was accepted, two were rejected, and four are under consideration by Duquesne Light. A key cross-program finding was on 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:[43]

- Primary sources of program information
- Customer awareness of programs
- Customer or trade ally perceptions of incentive amounts or processing time

For the Duquesne Light *C&I* Midstream Lighting program, the PY9 process evaluation provided seven findings and six recommendations. One recommendation was accepted and five are under consideration by Duquesne Light. All C&I programs evaluated in PY9 shared key findings and recommendations; program-specific findings were not reported on separately due to low response rates by program. A key cross-program finding was on program satisfaction from participant surveys, although this was an overall satisfaction score not

[41] Navigant did not conduct a PY9 process evaluation for the Residential Appliance Recycling Program (RARP). A full evaluation was not conducted for LIEEP, but findings for low-income WHRP and HER participants were reported alongside findings for market-rate participants.
[42] Navigant did not conduct a PY9 process evaluation for Midstream Lighting or the Small Commercial Direct Install Program (SCDI). SCDI reached its savings goals in PY9 and is expected to be discontinued.
[43] The Duquesne Light annual report provides further detail regarding these topics.

broken out by program. 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:[43]

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

3.3.5 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Duquesne Light PY9 Annual Report and the supporting detail provided by Duquesne Light's evaluation contractor. The detailed audit findings can be found in Appendix D.

- The SWE found the Navigant demand response verified savings analysis to be systematic and well-documented for PY9. We recommend more thoroughly vetting raw data and any calculation parameters supplied by the ICSP in PY10. One useful check is to compare the sum of the hourly load data to the billed energy in Duquesne Light's billing system for the same period. The PY9 baseline selection procedures were consistent with the Evaluation Framework and will be strengthened in PY10 when the baseline roster expands significantly. The SWE recommends the PUC adopt the DR performance totals in Duquesne Light's PY9 Final Annual Report when assessing compliance with Phase III targets.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in Duquesne Light's Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE was able to use the tracking data to perfectly replicate reported gross energy savings and reported gross demand savings for all of Duquesne Light's programs. We were also able to mostly replicate participation counts and incentives for most of Duquesne Light's programs. In the cases where we were unable to replicate exact participation counts or incentives, the two sources provided directionally similar answers. We have no major concerns.
- All Issues identified in the PY8 Behavioral evaluation have been mitigated in PY9, resulting in improved data processing and analysis for Duquesne Light's HER programs. The SWE was able to independently replicate the energy and demand impacts provided by Navigant in the PY9 annual report. The SWE recommends a few minor data management adjustments for PY10 relating to accounts with multiple inactive dates and duration adjustments.
- Duquesne Light's TRC model correctly included water savings and costs from increased fossil fuel use from fuel-switching.
- 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. However, the SWE found discrepancies in the application of TRM algorithms

for upstream lighting that resulted in underestimated verified savings of 755 MWh – or 0.75% of portfolio savings – in Duquesne Light's PY9 Annual Report. A couple of the discrepancies the SWE identified in PY8, including mischaracterizations of candelabra-base and 3-way bulbs in the upstream lighting tracking data, were not resolved in PY9. The residential upstream lighting audit is detailed in Appendix D.4.1.1 with recommendations for improvement.

- The SWE's review of PY9 verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The SWE does recommend that in future program years, the evaluator conduct unique measurement and verification activities for projects that have a long lag time between the initial CSP metering and the EM&V verification and in cases where large discrepancies are found. In addition, it is recommended that closer attention be made regarding the submission of complete project records to the SWE for review, such as original project documents that include ex ante savings calculation or equipment cut sheets, raw and prepared logger data, baseline conditions, detailed accounts of customer interviews, etc. (as applicable). Lastly, the evaluators should be wary of incorporating too many assumptions and factors into constructed baselines and should consider whether more simplistic usage of measured data could give a result that is easier to defend for some projects.
- In the SWE audit of the non-residential midstream lighting program, the SWE found that Duquesne Light's evaluation contractor executed an appropriate measurement and verification approach across an appropriate sample of projects in PY9. The midstream impact evaluation outcomes found a realization rate of 173% with a higher than expected uncertainty due to challenges with customer reported hours of use and the reported in-service rate of installed lamps and fixtures.
- PY9 residential project files responses were adequate and the supporting details were provided. The evaluator, Navigant, was cooperative in working with the SWE on questions and comments during the project file review.
- The SWE notes that Navigant relied on the PY8 realization rate to calculate verified savings for the Residential Appliance Recycling Program rather than using the available customer-specific data. While this follows their approved evaluation plan, the SWE encourages Navigant 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 the process evaluations, the SWE determined that, with some exceptions, the reporting followed the SWE guidelines. The annual report included descriptions of the methods and a summary of findings. Although the process evaluations generally were consistent with the Phase III evaluation plans and the report provided sufficient detail on the findings and recommendations, it also had some shortcomings (noted below). 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. Duquesne Light's responses to the recommendations were included in the report following each recommendation; however, the SWE recommends explicit language regarding each recommendation's status (accepted, under consideration, or rejected) be used in future reporting.

- Further, 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 Energy Efficiency Program (REEP)
  - The sampling plan and methodology could benefit from additional tables or figures which include total participation, sampling targets, and sample achieved.
- Process Evaluation of Low-Income Energy Efficiency Program (LIEEP)
  - Navigant reported on process findings for LIEEP alongside the market rate components of this program, which includes LI HER, LI Kits, and LI WHRP. Thus, there are no key findings following from the process evaluation specifically for LIEEP; however, there are some LIEEP-specific observations within the WHRP and HER process evaluation report sections. Report clarity would have improved if these survey results had been summarized in the LIEEP section of the report, even if they are also mentioned in context alongside process findings for market rate survey respondents.
- Process Evaluation of Home Energy Report Program
  - In the evaluation plan, Navigant indicated that a process evaluation for the Home Energy Report program would entail a review of program materials, interviews with two to four key program personnel at Duquesne Light and Oracle, creation of a program theory and logic model, and participant phone surveys. The audit team only observed findings from the participant survey in the PY9 process evaluation. Additionally, the target sample size for participant surveys in the evaluation plan was 150 (75 low income and 75 market rate customers), but the report indicated Navigant fell short of the target of 240 participants due to a high "no contact" rate. Navigant recommends alternatives to telephone surveys in future evaluations, given the low response rate in the PY9 evaluation.
- Process Evaluation of Whole House Retrofit Program (WHRP)
  - Overall, the report on the WHRP process evaluation could have benefited from a complete description of the methodology. Notably, sampling and reporting for the process evaluation of WHRP was rather opaque with respect to the sample frame, stratification by market rate and low-income participants, and targeted versus actual sample sizes.
- Process Evaluation of C&I Programs
  - Throughout the report on the process evaluation, Navigant did not present program-specific findings. Due to low response rates by program, results from the participant survey and trade ally interviews were also presented together. Thus, even though all planned evaluation activities were completed, process evaluation plans for each program were presented separately in the planning document but conflated in the PY9

report, making it difficult to discern program-specific trends or findings. Key findings were not program specific and applied across all six programs evaluated.

3.4 MET-ED

3.4.1 Impact Evaluation

A summary of energy impacts by program through PY9 is presented in Table 48. The bulk of savings is attributable to the Energy Efficient Homes Program, the Small C&I Energy Solutions for Business Program, and the Large C&I Energy Solutions for Business Program (see also Figure 26).

Table 48: PY9 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	4,808	96%	4,593	0.49	2,250
Energy Efficient Homes	54,239	111%	60,247	0.92	55,322
Energy Efficient Products	24,082	128%	30,723	0.38	11,644
LI Energy Efficiency	10,281	111%	11,417	1.00	11,417
C&I Energy Solutions for Business (Small)	36,935	101%	37,424	0.62	23,062
C&I Energy Solutions for Business (Large)	31,334	101%	31,633	0.56	17,693
Governmental & Institutional Tariff	619	102%	628	0.63	396
Portfolio Total	**162,297**	**109%**	**176,665**	**0.69**	**121,784**

Figure 26: Percent of Portfolio PY9VTD Gross Savings, by Program – Met-Ed

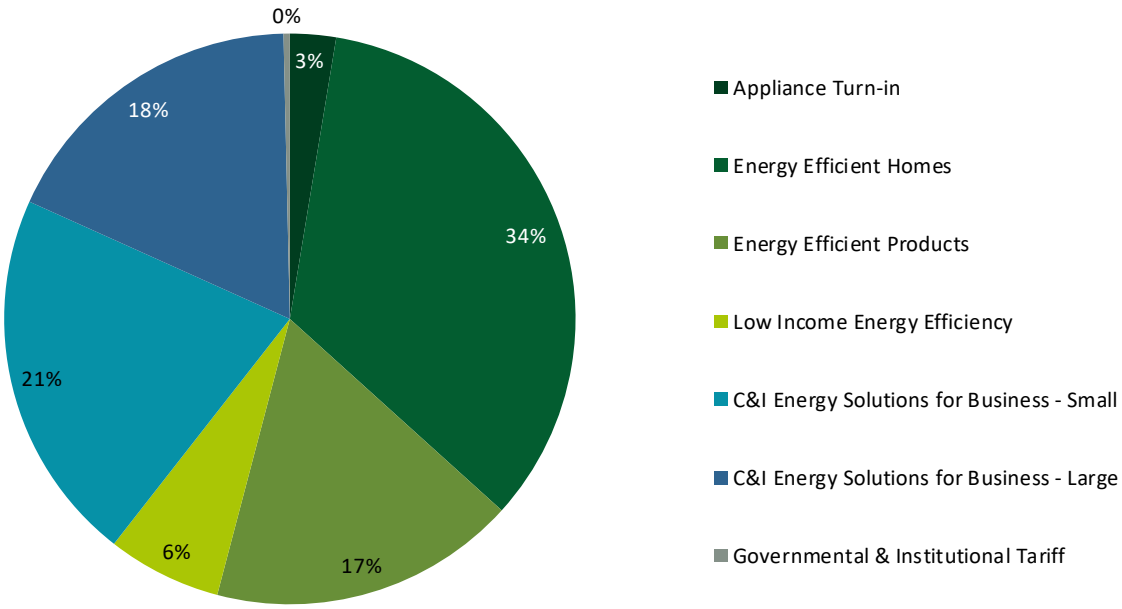
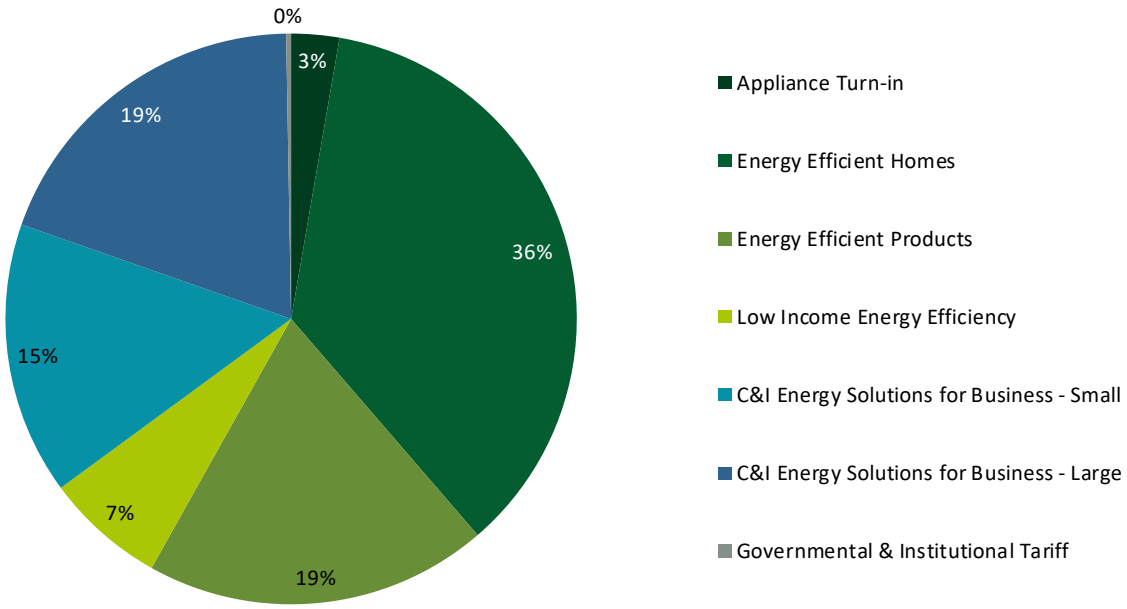


Table 49: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Appliance Turn-in	8,817	98%	8,607	0.49	4,257
Energy Efficient Homes	102,365	111%	113,816	0.92	104,767
Energy Efficient Products	49,542	124%	61,548	0.38	23,300
LI Energy Efficiency	19,388	111%	21,523	1.00	21,523
C&I Energy Solutions for Business (Small)	49,461	99%	48,893	0.62	30,503
C&I Energy Solutions for Business (Large)	62,253	98%	61,276	0.55	33,881
Governmental & Institutional Tariff	892	98%	878	0.64	562
Portfolio Total	**292,719**	**108%**	**316,540**	**0.69**	**218,793**

Figure 27: Percent of Portfolio VTD Gross Savings, by Program – Met-Ed



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 50.

Table 50: PY9 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	0.68	93%	0.63	0.49	0.31
Energy Efficient Homes	6.72	110%	7.39	0.92	6.61
Energy Efficient Products	3.04	138%	4.18	0.38	1.58
LI Energy Efficiency	1.20	111%	1.33	1.00	1.33
C&I Energy Solutions for Business (Small)	5.43	100%	5.42	0.62	3.37
C&I Energy Solutions for Business (large)	4.69	96%	4.49	0.56	2.50
Governmental & Institutional Tariff	0	-	0	-	0
Portfolio Total	**21.75**	**108%**	**23.44**	**0.67**	**15.70**

Table 51: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Appliance Turn-in	1.24	94%	1.16	0.49	0.57
Energy Efficient Homes	13.27	103%	13.61	0.90	12.24
Energy Efficient Products	6.22	134%	8.35	0.38	3.19
LI Energy Efficiency	2.34	106%	2.48	1.00	2.48
C&I Energy Solutions for Business (Small)	7.35	101%	7.44	0.63	4.68
C&I Energy Solutions for Business (large)	8.79	100%	8.76	0.54	4.77
Governmental & Institutional Tariff	0.01	100%	0.01	1.00	0.01
Portfolio Total	**39.23**	**107%**	**41.81**	**0.67**	**27.94**

3.4.2 Demand Response

In PY9, Met-Ed had two active Demand Response Programs: C&I Demand Response Program – Small and C&I Demand Response Program – Large. Met-Ed's Behavioral Demand Response (BDR) offering is a sub-program within the Energy-Efficient Homes Program that was not active in PY9 but will be active in PY10 in Met-Ed's service territory. Each of these programs define participation slightly differently due to variations in delivery and/or data tracking methodologies. Table 52 provides the definitions used and the counts of PY9 and Phase III participation to date for each included DR program.

Table 52: Met-Ed Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Energy-Efficient Homes – Behavioral Demand Response	The number of individual accounts in Oracle's treatment group for the summer of 2017.	0	0
C&I Demand Response Program – Small	The number of participants who participated in one or more demand response events.	37	37
C&I Demand Response Program – Large	The number of participants who participated in one or more demand response events.	67	67

Met-Ed's two PY9 DR programs had three event days in PY9. The Phase III DR performance target for Met-Ed is 49.0 MW. Table 53 shows the DR savings for each program, as well as the portfolio average for each event day. Average performance across all event days is included at the bottom of the table.

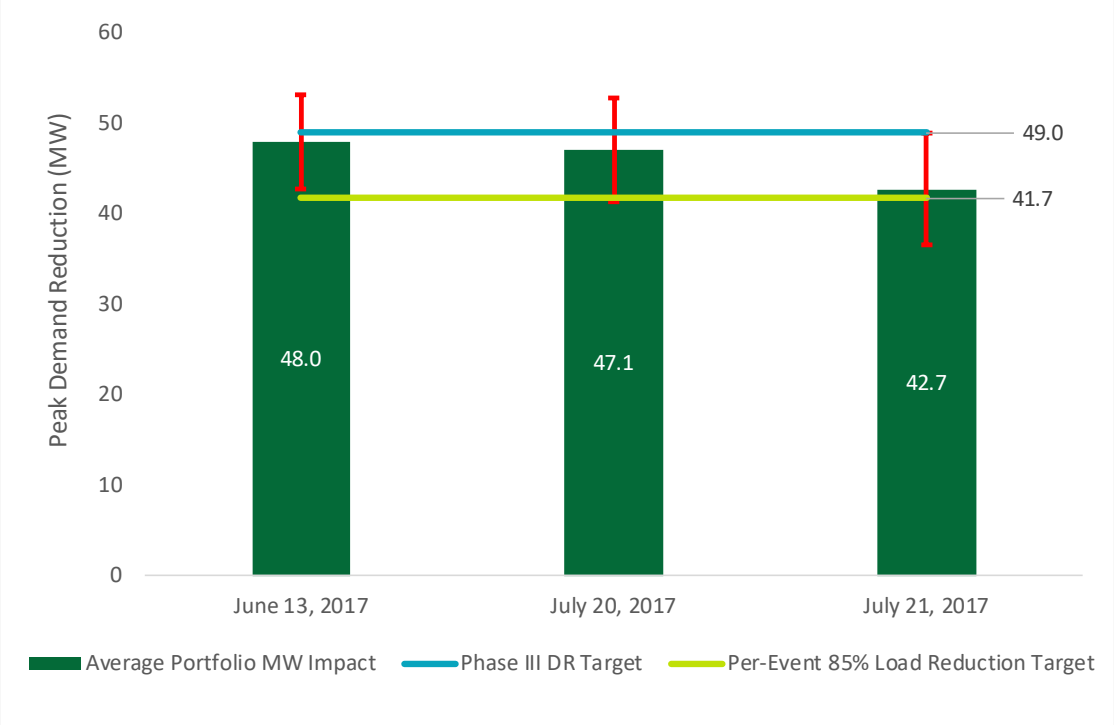
Table 53: Met-Ed Demand Response Performance by Program

Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	C&I Demand Response – Small	C&I Demand Response – Large	Average Portfolio MW Impact w/ 90% CI
June 13, 2017	15	18	3.0	45.0	48.0±5.2
July 20, 2017	15	18	3.0	44.1	47.1±5.7
July 21, 2017	15	18	1.9	40.8	42.7±6.2
PYVTD– Average PY9 DR Event Performance					**46.0±3.6**
***VTD– Average Phase III DR Event Performance**					**46.0±3.6**

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For Met-Ed, this translates to a 41.7 MW minimum for each DR event. Figure 28 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For each event, Met-Ed exceeded the 85% threshold, but fell short of the target of 49 MW.

Figure 28: Met-Ed Event Performance Compared to 85% Per-Event Target



3.4.3 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 54 shows the TRC ratios by program and for the portfolio. The benefits in Table 54 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 54: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Turn-in	1,482	757	1.96	726
Energy Efficient Homes	15,060	7,272	2.07	7,788
Energy Efficient Products	13,480	8,002	1.68	5,485
LI Energy Efficiency	2,582	3,568	0.72	(986)
Residential Subtotal	**32,604**	**19,599**	**1.66**	**13,005**
C&I Energy Solutions for Business (Small)	17,721	7,580	2.34	10,141
C&I Energy Solutions for Business (Large)	14,990	8,304	1.81	6,686
Governmental & Institutional Tariff	228	163	1.40	65
C&I Demand Response Program (Small)	226	91	2.47	134
C&I Demand Response Program (Large)	3,675	1,192	3.08	2,483
Non-Residential Subtotal	**36,840**	**17,331**	**2.13**	**19,509**
Portfolio Total	**69,444**	**36,930**	**1.88**	**32,515**

3.4.4 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 PY9 process evaluations for the following FirstEnergy Utilities programs.

Table 55: PY9 Process Evaluations

Residential and C&I Programs	
Appliance Turn-In	C&I Demand Response– Small
Energy Efficient Homes[44]	C&I Demand Response– Large
Energy Efficient Products[45]	

For PY9, ADM/Tetra Tech evaluated and reported on a total of five programs within the Met-Ed residential and C&I sectors. These evaluations generated a total of 15 process evaluation findings, which resulted in 15 recommendations, 11 of which were accepted and four are under consideration. A key cross-program finding was on program satisfaction from participant surveys, which were conducted for Residential Appliance Turn-in and C&I Demand Response programs. On average, across all FirstEnergy Companies, 95% of Residential Appliance Turn-in participants and 100% of C&I Demand Response participants were satisfied with the programs overall.[46]

For the *Met-Ed Residential programs*, the PY9 process evaluation provided a total of ten findings and ten recommendations, six of which were accepted and four are under consideration. A key cross-program finding was on program satisfaction from a survey of participants in the Appliance Turn-in Program and from a survey of appliance retailers. Among the participants in the Appliance Turn-in Program, 95% of Met-Ed participants, 94% of Penelec participants, 96% of Penn Power participants, and 96% of West Penn Power participants were satisfied with the program overall. Program-specific findings addressed topics that included the following:

- Primary sources of program information
- Satisfaction levels and reasons for dissatisfaction with the program
- Improvements in program administration
- Opportunities to improve trade ally communications and assist them with marketing
- Customer purchase decision drivers

For the Met-Ed *Small and Large C&I Demand Response Program*s, the PY9 process evaluation provided five findings and five recommendations, all of which were accepted. A key cross-program finding was on program satisfaction from a participant survey. Across all the FirstEnergy Companies, 100% of C&I Demand Response participants were satisfied with the program overall. Program-specific findings addressed topics that included drivers of program performance,

[44] In PY9, ADM/Tetra Tech conducted process evaluations for one of five program components: New Homes. The program components for which process evaluation were not conducted in PY9 are: Energy Efficiency Kits, Home Energy Reports, Residential Direct Install, and Behavioral Demand Response. Process evaluations of Energy Efficiency Kits (EE Kits) and Home Energy Reports were conducted in PY8. The PY9 report also notes that "Tetra Tech is presently conducting a process evaluation of this program. The process evaluation results and recommendations will be included in the PY10 report.".

[45] In PY9, ADM/Tetra Tech conducted process evaluations for one of four program components: Appliances. For PY8, the evaluation included process evaluations of the Appliances, HVAC, and Upstream Lighting program components. The PY9 report notes that "Process and Net Impact evaluation is planned for the fourth program element – Upstream Electronics, in PY10.

[46] Weighted by the number of PY9 program participants from each FirstEnergy EDC. The satisfaction rating for C&I Demand Response programs was provided for all FirstEnergy Companies.

program impact on customer perceptions of EDC, sources of confusion or lack of clarity about program features and participation.

3.4.5 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Met-Ed's PY9 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in Appendix E.

- The SWE agrees with ADM's demand response baseline selection procedures and found no errors in the calculations for the twelve sites examined. We will recommend the Commission adopt the Met-Ed/ADM verified savings estimates when assessing compliance at the end of Phase III. Met-Ed's average DR performance in PY9 was slightly below the Phase III goal, so we also suggest Met-Ed work with its ICSPs to either enroll additional participants or secure larger load reduction commitments from existing participants to pull up the P3TD performance total.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in FirstEnergy's Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE has no major concerns. For all Met-Ed's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. We also calculated directionally similar (if not equal) participation counts for all programs. For six of the seven programs, the SWE was able to calculate directionally similar (though not the same) incentive dollars via the tracking data. The SWE's only difference of note is the incentive dollars for the Energy Efficient Homes program, which is due to the costs of the EE kits being correctly treated as incentives in the Annual Report, but not recorded in the program tracking data.
- Met-Ed's TRC model included space heating and water heating fuel savings from reduced fossil fuel consumption from energy-efficient measures. Costs from increased fossil fuel use from fuel-switching are also included.
- Met-Ed's PY9 demand response offerings showed a gross and net TRC ratio of 2.84. One driver of the high ratio is the inclusion of avoided cost of distribution capacity for Large C&I participants. In the PY10 calculations, the SWE recommends only applying the avoided cost of generation and transmission capacity to the MW impacts in the C&I Demand Response – Large program.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. The SWE noted only a few minor discrepancies.
- The SWE's review of ADM's verified savings analysis for the non-residential programs found that the recommended procedures outlined in the Phase III evaluation framework were generally followed. TRM protocols were applied correctly, and verified savings calculations were generally appropriate.
- PY9 residential project files responses were adequate and, overall, the supporting details were provided. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place, and ADM was able to address and clarify any questions from the SWE.
- 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. However, the SWE found discrepancies in the application of TRM algorithms for upstream lighting that resulted in overestimated verified savings of 55 MWh – or 0.03% of portfolio savings – in FirstEnergy's PY9 Annual Report. The residential upstream lighting audit is detailed in Appendix E.4.1.1 with recommendations for improvement.

- The SWE also found a minor error in the low-income carveout savings, but the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting in PY10.
- Overall, the ADM/Tetra Tech team estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.
- The process evaluations of these programs appear to have been mostly consistent with the Phase III evaluation plan. Although the description of the process evaluation in the PY9 final annual report included limited information, the evaluation contractor submitted separate memos providing more detailed results of specific process evaluation tasks. These memos included descriptions of the methods, summary of findings, recommendations, and a description of whether Met-Ed was implementing or considering those recommendations. With some exceptions (noted below), the memos included mostly sufficient detail to assess the methods, findings, and recommendations.
- In response to SWE comments on the PY8 report, the PY9 memos provided the percentage of satisfied or very satisfied participants for just the C&I Demand Response Program and just the percentage "very satisfied" for the Residential Appliance Turn-in Program. While this is helpful, it would have been more useful to see the percentage of respondents selecting each point on the satisfaction scale, as was requested in the SWE's comments on the PY8 report. Other program-specific exceptions uncovered by the SWE audit are listed below.
    - Process Evaluation of Residential Appliance Turn-In Program, Energy Efficient Homes Program
        - While noting that the process evaluation also included interviews with program staff and the Implementation Conservation Service Provider (ICSP), the memos did not provide any further information on these interviews or associated findings.
    - Process Evaluation of Residential Energy Efficient Products Program
        - The process evaluation of the Energy Efficient Products Program appears to have been generally consistent with the Phase III evaluation plan. However, the plan also called for interviews with nonparticipating trade allies; it is not clear if or when this would be done. Additionally, in a discussion of the evaluation of the Upstream Lighting program component, the previous report for PY8 observed that the "evaluation planned additional activities to inform the process evaluation, including a survey of participating retailers and a shelf-stocking study. These activities are on-going, and the results will be included in the PY9 annual report." There was no mention of these activities in the PY9 report or memos.
    - Process Evaluation of C&I Demand Response Program – Small, C&I Demand Response Program – Large
        - The process evaluation of the Large and Small C&I Demand Response programs appears to have gone above and beyond the research design in the Phase III

evaluation plan. The plan called for a survey of participants and the evaluation did that. The evaluation additionally did a documentation and tracking data review, in-depth interviews (IDIs) with program and CSP staff, and participated in one of the CSP's marketing outreach webinars. However, neither the final report nor the separate memo that provided detailed results from the survey of participants provided any detail on these other process evaluation tasks.

3.5 PENELEC

3.5.1 Impact Evaluation

A summary of energy impacts by program through PY9 is presented in Table 56. The bulk of savings is attributable to the Energy Efficient Homes Program and the Large C&I Energy Solutions for Business Program (see also Figure 29).

Table 56: PY9 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	4,565	94%	4,301	0.45	1,935
Energy Efficient Homes	37,281	113%	42,091	0.91	38,193
Energy Efficient Products	27,048	119%	32,176	0.35	11,165
LI Energy Efficiency	9,730	109%	10,563	1.00	10,563
C&I Energy Solutions for Business (Small)	28,898	87%	25,168	0.79	19,929
C&I Energy Solutions for Business (large)	45,092	87%	39,348	0.78	30,753
Governmental & Institutional Tariff	1,152	86%	990	0.84	827
Portfolio Total	**153,766**	**101%**	**154,637**	**0.73**	**113,365**

Figure 29: Percent of Portfolio PY9VTD Gross Savings, by Program– Penelec

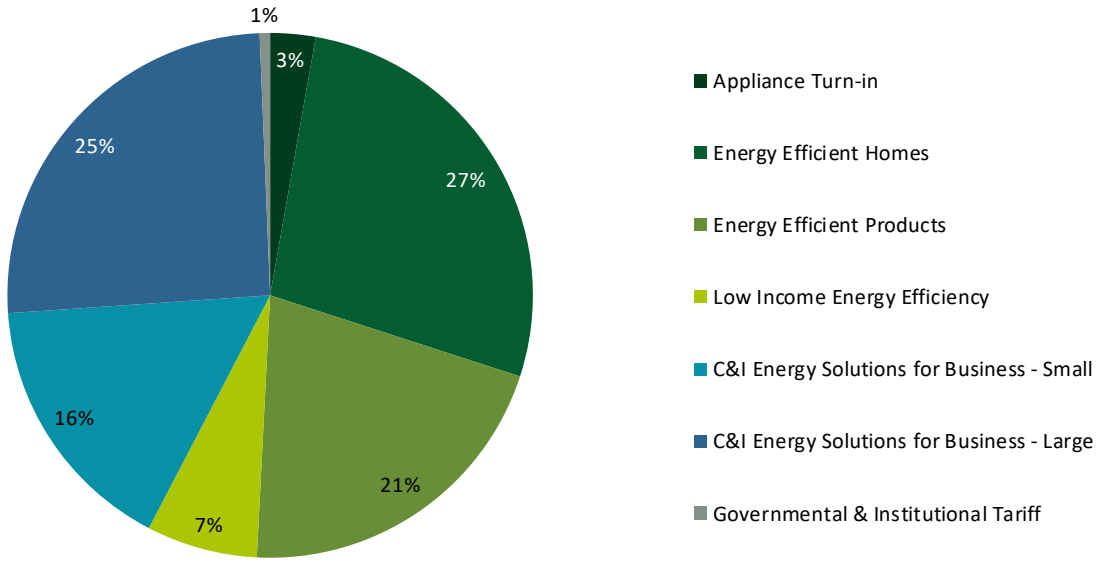
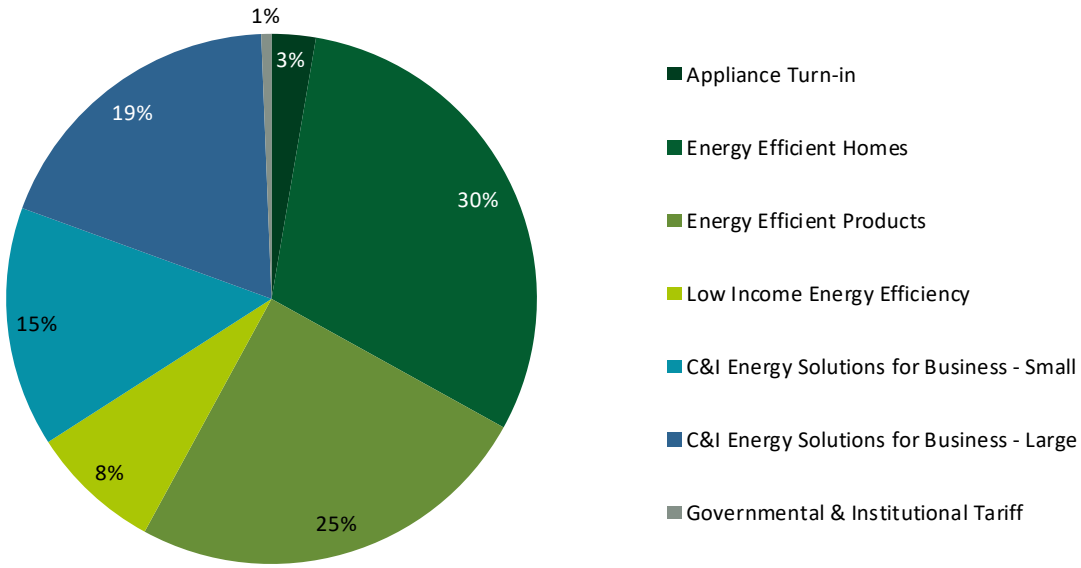


Table 57: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	PYVTD Net (MWh/yr)
Appliance Turn-in	8,392	92%	7,708	0.44	3,400
Energy Efficient Homes	75,804	115%	87,196	0.91	79,155
Energy Efficient Products	60,549	118%	71,417	0.35	24,693
LI Energy Efficiency	20,679	111%	22,921	1.00	22,921
C&I Energy Solutions for Business (Small)	46,970	90%	42,043	0.80	33,818
C&I Energy Solutions for Business (large)	60,902	89%	54,015	0.77	41,859
Governmental & Institutional Tariff	2,004	89%	1,786	0.84	1,501
Portfolio Total	**275,300**	**104%**	**287,087**	**0.72**	**207,347**

Figure 30: Percent of Portfolio VTD Gross Savings, by Program– Penelec



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 58.

Table 58: PY9 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	0.61	92%	0.56	0.45	0.25
Energy Efficient Homes	4.92	94%	4.64	0.91	4.20
Energy Efficient Products	3.07	126%	3.88	0.35	1.36
LI Energy Efficiency	1.15	97%	1.11	1.00	1.11
C&I Energy Solutions for Business (Small)	4.11	94%	3.84	0.79	3.11
C&I Energy Solutions for Business (large)	5.78	93%	5.34	0.78	4.24
Governmental & Institutional Tariff	0.02	95%	0.02	0.84	0.02
Portfolio Total	**19.66**	**99%**	**19.40**	**0.74**	**14.30**

Table 59: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Appliance Turn-in	1.11	90%	1.00	0.44	0.44
Energy Efficient Homes	9.88	97%	9.54	0.91	8.64
Energy Efficient Products	6.68	129%	8.63	0.35	3.01
LI Energy Efficiency	2.45	100%	2.44	1.00	2.44
C&I Energy Solutions for Business (Small)	7.10	95%	6.78	0.82	5.54
C&I Energy Solutions for Business (large)	7.64	92%	7.00	0.80	5.57
Governmental & Institutional Tariff	0.04	75%	0.03	1.00	0.03
Portfolio Total	**34.89**	**102%**	**35.42**	**0.72**	**25.67**

3.5.2 Demand Response

Penelec does not have a Phase III demand response target.

3.5.3 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 60 shows the TRC ratios by program and for the portfolio. The benefits in Table 60 were calculated using gross verified impacts. Costs and benefits are expressed in 2017 dollars.

Table 60: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Turn-in	1,323	687	1.93	637
Energy Efficient Homes	11,431	6,111	1.87	5,320
Energy Efficient Products	12,914	6,270	2.06	6,644
LI Energy Efficiency	2,559	3,441	0.74	(882)
Residential Subtotal	**28,227**	**16,508**	**1.71**	**11,718**
C&I Energy Solutions for Business (Small)	11,350	10,905	1.04	445
C&I Energy Solutions for Business (Large)	17,244	16,456	1.05	787
Governmental & Institutional Tariff	348	517	0.67	(169)
Non-Residential Subtotal	**28,941**	**27,879**	**1.04**	**1,063**
Portfolio Total	**57,169**	**44,386**	**1.29**	**12,783**

3.5.4 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.

3.5.5 Key Audit Findings

In this section, the SWE provides a summary of key audit findings of the SWE's audit of the Penelec's PY9 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in Appendix F.

- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in FirstEnergy's Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE has no major concerns. For all Penelec's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. We also calculated directionally similar (if not equal) participation counts for all programs. For six of the seven programs, the SWE was able to calculate directionally similar (though not the same) incentive dollars via the tracking data. The SWE's only difference of note is the incentive dollars for the Energy Efficient Homes program, which is due to the costs of the EE kits being correctly treated as incentives in the Annual Report, but not recorded in the program tracking data.

- Penelec's TRC model included space heating and water heating fuel savings from reduced fossil fuel consumption from energy-efficient measures. Costs from increased fossil fuel use from fuel-switching are also included.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. The SWE noted only a few minor discrepancies.
- The SWE's review of ADM's verified savings analysis for the non-residential programs found that the recommended procedures outlined in the Phase III evaluation framework were generally followed. TRM protocols were applied correctly, and verified savings calculations were generally appropriate.
- PY9 residential project files responses were adequate and, overall, the supporting details were provided. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place, and ADM was able to address and clarify any questions from the SWE.
- 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. However, the SWE found discrepancies in the application of TRM algorithms for upstream lighting that resulted in overestimated verified savings of 67 MWh – or 0.04% of portfolio savings – in FirstEnergy's PY9 Annual Report. The residential upstream lighting audit is detailed in Appendix F.4.1.1 with recommendations for improvement.
- The SWE also found a minor error in the low-income carveout savings, but the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting in PY10.
- Overall, the ADM/Tetra Tech team estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.

3.6 PENN POWER

3.6.1 Impact Evaluation

A summary of energy impacts by program through PY9 is presented in Table 61. The bulk of savings is attributable to the Small C&I Energy Solutions for Business Program, the Energy Efficient Homes Program, and the Energy Efficient Products Program (see also Figure 31).

Table 61: PY9 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	1,695	83%	1,412	0.58	819
Energy Efficient Homes	12,282	111%	13,683	0.89	12,197
Energy Efficient Products	10,250	128%	13,145	0.40	5,192
LI Energy Efficiency	3,215	108%	3,478	1.00	3,478
C&I Energy Solutions for Business (Small)	13,729	100%	13,722	0.73	9,975
C&I Energy Solutions for Business (large)	11,449	99%	11,317	0.67	7,564
Governmental & Institutional Tariff	605	99%	598	0.75	449
Portfolio Total	**53,225**	**108%**	**57,354**	**0.69**	**39,674**

Figure 31: Percent of Portfolio PY9VTD Gross Savings, by Program – Penn Power

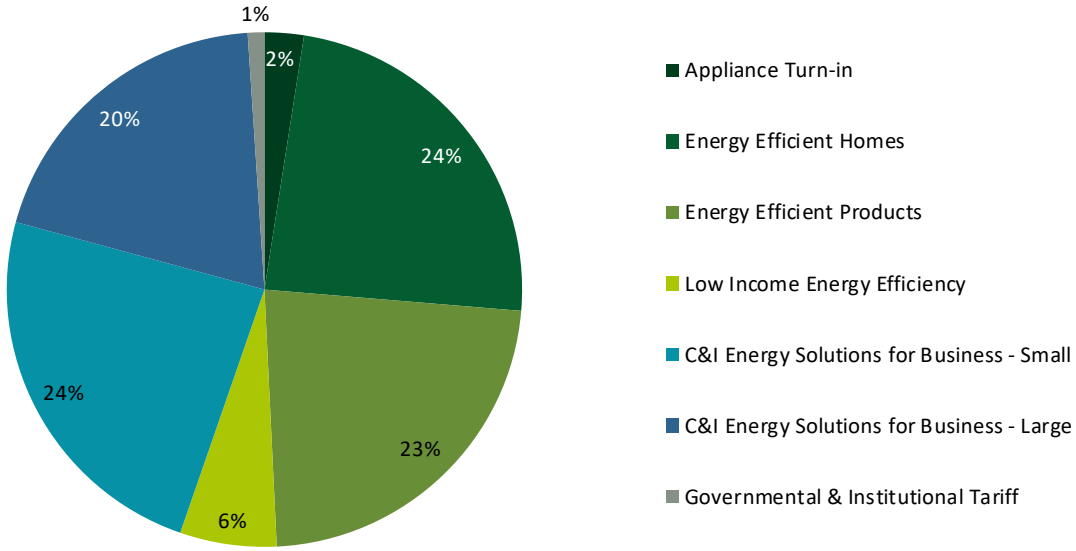
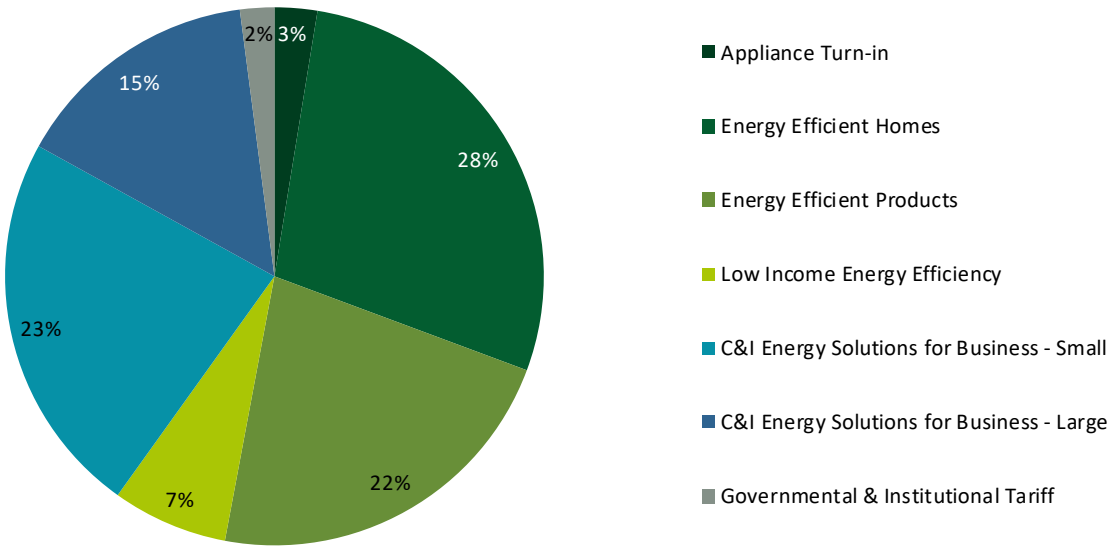


Table 62: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Appliance Turn-in	2,983	81%	2,419	0.55	1,322
Energy Efficient Homes	23,184	115%	26,565	0.89	23,761
Energy Efficient Products	16,452	128%	21,041	0.40	8,323
LI Energy Efficiency	6,496	101%	6,558	1.00	6,558
C&I Energy Solutions for Business (Small)	22,432	98%	21,873	0.72	15,854
C&I Energy Solutions for Business (large)	14,495	97%	14,085	0.65	9,225
Governmental & Institutional Tariff	2,030	96%	1,943	0.75	1,461
Portfolio Total	**88,071**	**107%**	**94,484**	**0.70**	**66,505**

Figure 32: Percent of Portfolio VTD Gross Savings, by Program – Penn Power



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 63.

Table 63: PY9 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	0.22	84%	0.18	0.58	0.11
Energy Efficient Homes	1.96	104%	2.04	0.89	1.68
Energy Efficient Products	1.24	139%	1.72	0.40	0.69
LI Energy Efficiency	0.41	103%	0.42	1.00	0.42
C&I Energy Solutions for Business (Small)	1.93	96%	1.86	0.73	1.35
C&I Energy Solutions for Business (Large)	1.34	92%	1.22	0.67	0.83
Governmental & Institutional Tariff	0	-	0	-	0
Portfolio Total	**7.10**	**105%**	**7.44**	**0.68**	**5.07**

Table 64: Phase-to-date 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	0.38	82%	0.31	0.55	0.17
Energy Efficient Homes	3.68	103%	3.79	0.83	3.13
Energy Efficient Products	1.98	139%	2.76	0.40	1.10
LI Energy Efficiency	0.84	92%	0.77	1.00	0.77
C&I Energy Solutions for Business (Small)	3.35	99%	3.33	0.72	2.41
C&I Energy Solutions for Business (Large)	1.63	95%	1.55	0.66	1.03
Governmental & Institutional Tariff	0.06	117%	0.07	0.71	0.05
Portfolio Total	**11.93**	**105%**	**12.57**	**0.69**	**8.67**

3.6.2 Demand Response

Penn Power has three Demand Response Programs: C&I Demand Response – Small, C&I Demand Response – Large, and Energy-Efficient Homes – Behavioral Demand Response (BDR). Penn Power's Behavioral Demand Response (BDR) offering is a sub-program within the Energy-Efficient Homes Program. Each of these programs define participation slightly differently due to variations in delivery and/or data tracking methodologies. Table 65 provides the definitions used and the counts of PY9 and Phase III participation for each included DR program.

Table 65: Penn Power Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Energy-Efficient Homes – Behavioral Demand Response	The number of individual accounts in Oracle's treatment group for the summer of 2017.	*30,186	30,186
C&I Demand Response Program – Small	The number of participants who participated in one or more demand response events.	3	3
C&I Demand Response Program – Large	The number of participants who participated in one or more demand response events.	6	6

**As of the beginning of the 2017 summer DR season, there were 30,186 premises in the treatment group and another 19,120 premises in the control group used for measurement purposes. At the end of the DR season, these numbers were 28,864 and 18,310, respectively.*

Penn Power's three DR programs had three event days in PY9. The Phase III DR performance target for Penn Power is 17.0 MW. Table 66 shows the DR savings for each program, as well as the portfolio average for each event day. Average performance across all event days is included at the bottom of the table.

Table 66: Penn Power Demand Response Performance by Program

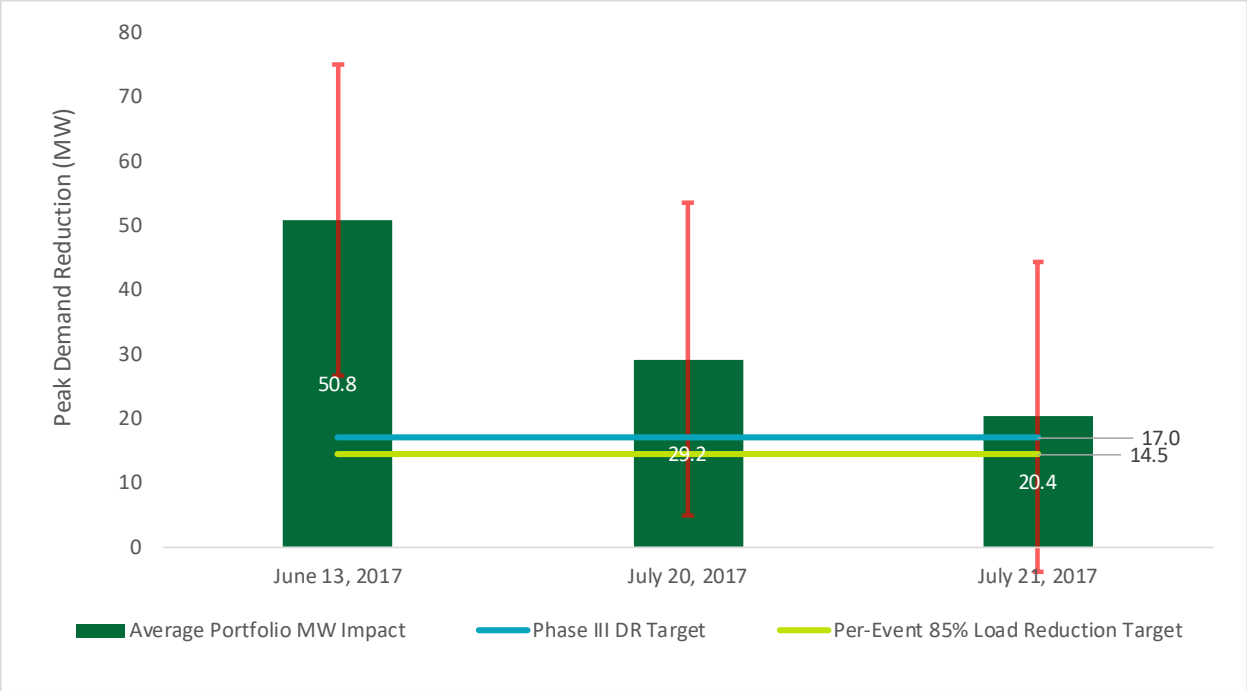
Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	C&I Demand Response– Small	C&I Demand Response– Large	Energy-Efficient Homes (Behavioral DR)	Average Portfolio MW Impact w/ 90% CI
June 13, 2017	15	18	0.1	48.7	2.0	50.8±24.2
July 20, 2017	15	18	0.2	26.4	2.5	29.2±24.3
July 21, 2017	15	18	0.2	18.1	2.0	20.4±24.1
PYVTD– Average PY9 DR Event Performance						**33.5±18.1**
***VTD– Average Phase III DR Event Performance**						**33.5±18.1**

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For Penn Power, this

translates to a 14.5 MW minimum for each DR event. Figure 33 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For each event, Penn Power exceeded both the 85% threshold and the Phase III target of 17 MW.

Figure 33: Penn Power Event Performance Compared to 85% Per-Event Target



3.6.3 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 67 shows the TRC ratios by program and for the portfolio. The benefits in Table 67 were calculated using gross verified impacts. Costs and benefits are expressed in 2017 dollars.

Table 67: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Turn-in	434	261	1.66	173
Energy Efficient Homes	4,266	2,817	1.51	1,449
Energy Efficient Products	5,175	2,379	2.17	2,796
LI Energy Efficiency	865	1,265	0.68	(400)
Residential Subtotal	**10,741**	**6,723**	**1.60**	**4,018**
C&I Energy Solutions for Business (Small)	5,873	4,876	1.20	997
C&I Energy Solutions for Business (Large)	4,788	3,898	1.23	890
Governmental & Institutional Tariff	194	223	0.87	(29)
C&I Demand Response Program (Small)	16	10	1.59	6
C&I Demand Response Program (Large)	2,641	493	5.35	2,147
Non-Residential Subtotal	**13,512**	**9,501**	**1.42**	**4,011**
Portfolio Total	**24,252**	**16,224**	**1.49**	**8,028**

3.6.4 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.

3.6.5 Key Audit Findings

In this section, the SWE provides a summary of key findings of the SWE's audit of the Penn Power's PY9 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in Appendix G.

- The Penn Power demand response impact evaluation was robust and well-organized. The SWE agrees with ADM's baseline selection procedures and found no errors in the calculations for the five C&I sites examined. For the residential behavioral demand response (BDR) component, the ADM team leveraged a lagged seasonal model, which the SWE views as a reasonable approach. We recommend a similar approach be utilized when the BDR program is active for Met-Ed and West Penn Power in PY10. Though the SWE's BDR per-event average impacts differed slightly from those calculated by ADM,

the two averages were equal when impacts were averaged across all PY9 DR event hours. The SWE recommends the Commission adopt the Penn Power/ADM verified savings estimates when assessing compliance at the end of Phase III.

- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in FirstEnergy's Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE has no major concerns. For all Penn Power's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. The SWE also calculated directionally similar (if not equal) participation counts for all programs. For six of the seven programs, the SWE calculated the same total incentive dollars with small offsetting variations at the program level. The SWE's only difference of note is the incentive dollars for the Energy Efficient Homes program, which is due to the costs of the EE kits being correctly treated as incentives in the Annual Report, but not recorded in the program tracking data.
- Penn Power's TRC model included space heating and water heating fuel savings from reduced fossil fuel consumption from energy- efficient measures. Costs from increased fossil fuel use from fuel-switching are also included.
- Penn Power's PY9 demand response offerings showed a gross and net TRC ratio of 3.46. One driver of the high ratio is the inclusion of avoided cost of distribution capacity for Large C&I participants. In the PY10 calculations, the SWE recommends only applying the avoided cost of generation and transmission capacity to the MW impacts in the C&I Demand Response – Large program.
- Project documentation for the non-residentials program submitted to the SWE for review was generally thorough and complete. The SWE noted only a few minor discrepancies.
- The SWE's review of ADM's verified savings analysis for the non-residential programs found that the recommended procedures outlined in the Phase III evaluation framework were generally followed. TRM protocols were applied correctly, and verified savings calculations were generally appropriate.
- PY9 residential project files responses were adequate and, overall, the supporting details were provided. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place, and ADM was able to address and clarify any questions from the SWE.
- 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 also found a minor error in the low-income carveout savings, but the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting in PY10.
- Overall, the ADM/Tetra Tech team estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.

3.7 WEST PENN

3.7.1 Impact Evaluation

A summary of energy impacts by program through PY9 is presented in Table 68. The bulk of savings is attributable to the Energy Efficient Homes Program and the Energy Efficient Products Program (see also Figure 34).

Table 68: PY9 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	5,884	99%	5,820	0.51	2,968
Energy Efficient Homes	54,502	105%	57,009	0.92	52,143
Energy Efficient Products	27,051	122%	32,908	0.29	9,510
LI Energy Efficiency	9,606	104%	10,026	1.00	10,026
C&I Energy Solutions for Business (Small)	31,549	113%	35,789	0.82	29,367
C&I Energy Solutions for Business (large)	41,790	103%	43,021	0.64	27,359
Governmental & Institutional Tariff	9,426	116%	10,925	0.83	9,103
Portfolio Total	**179,808**	**109%**	**195,498**	**0.72**	**140,476**

Figure 34: Percent of Portfolio PY9VTD Gross Savings, by Program – West Penn

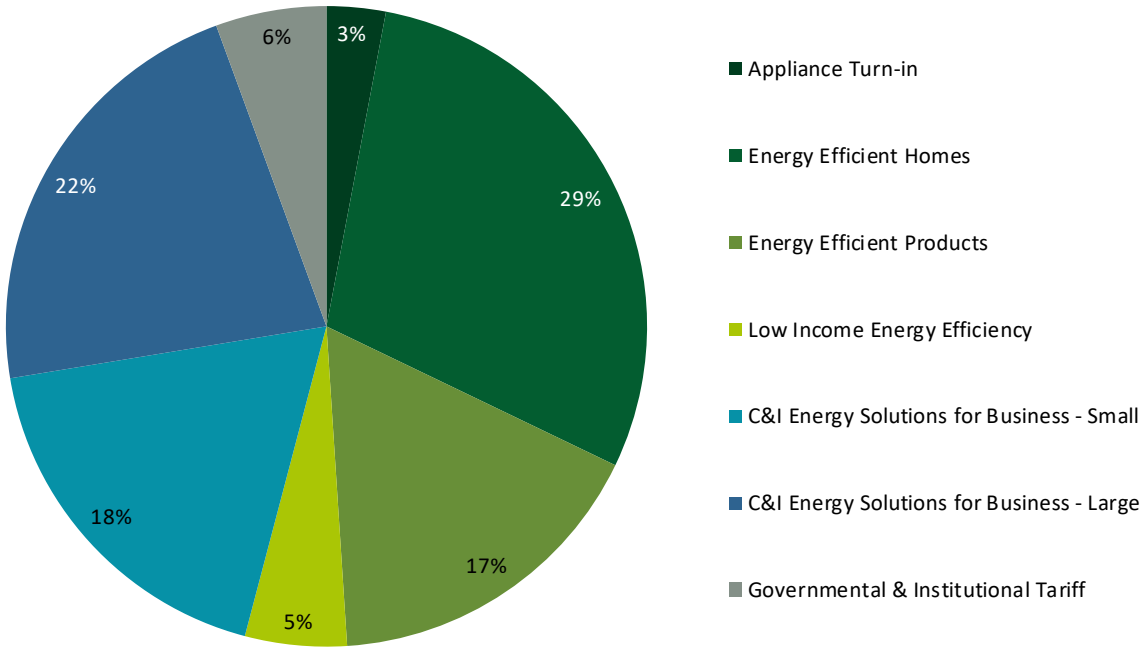
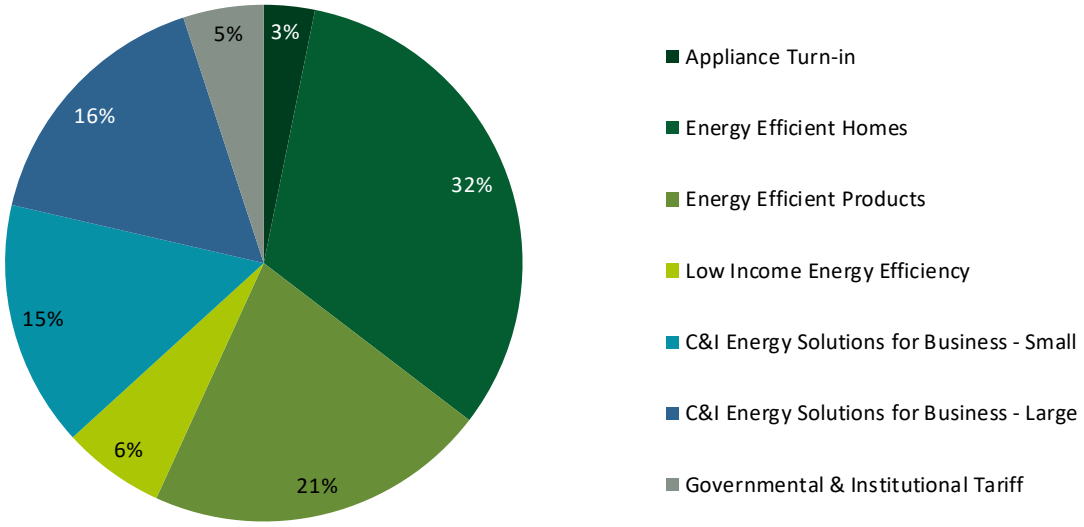


Table 69: Phase-to-date Incremental Annual Energy Savings by Program (MWh/Year)

Program	RTD (MWh/yr)	Realization Rate	VTD Gross (MWh/yr)	NTG	VTD Net (MWh/yr)
Appliance Turn-in	10,882	95%	10,385	0.48	5,023
Energy Efficient Homes	99,721	106%	105,300	0.93	97,467
Energy Efficient Products	58,400	120%	70,003	0.29	19,967
LI Energy Efficiency	19,994	105%	20,941	1.00	20,941
C&I Energy Solutions for Business (Small)	46,089	109%	50,312	0.82	41,286
C&I Energy Solutions for Business (large)	52,268	102%	53,435	0.66	35,032
Governmental & Institutional Tariff	14,915	110%	16,543	0.83	13,683
Portfolio Total	**302,268**	**108%**	**326,828**	**0.71**	**233,399**

Figure 35: Percent of Portfolio VTD Gross Savings, by Program – West Penn



A summary of the peak demand impacts by energy-efficiency program for PY9 are presented in Table 70.

Table 70: PY9 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	0.76	97%	0.74	0.51	0.38
Energy Efficient Homes	7.98	93%	7.44	0.92	6.53
Energy Efficient Products	3.72	126%	4.68	0.29	1.40
LI Energy Efficiency	1.25	96%	1.20	1.00	1.20
C&I Energy Solutions for Business (Small)	4.43	105%	4.65	0.82	3.82
C&I Energy Solutions for Business (large)	4.95	93%	4.58	0.64	3.24
Governmental & Institutional Tariff	0.02	107%	0.02	0.83	0.02
Portfolio Total	**23.11**	**101%**	**23.30**	**0.71**	**16.59**

Table 71: Phase-to-date Peak Demand Savings by Energy-Efficiency Program (MW/Year)

Program	RTD (MW/yr)	Realization Rate	VTD Gross (MW/yr)	NTG	VTD Net (MW/yr)
Appliance Turn-in	1.39	97%	1.35	0.48	0.65
Energy Efficient Homes	14.99	89%	13.37	0.89	11.89
Energy Efficient Products	7.86	125%	9.86	0.29	2.89
LI Energy Efficiency	2.65	93%	2.46	1.00	2.46
C&I Energy Solutions for Business (Small)	6.74	102%	6.87	0.82	5.65
C&I Energy Solutions for Business (large)	6.47	94%	6.05	0.71	4.28
Governmental & Institutional Tariff	0.18	100%	0.18	0.83	0.15
Portfolio Total	**40.28**	**100%**	**40.15**	**0.70**	**27.97**

3.7.2 Demand Response

In PY9, West Penn Power (WPP) had two active Demand Response Programs: C&I Demand Response Program – Small and C&I Demand Response Program – Large. WPP's Behavioral Demand Response (BDR) offering is a sub-program within the Energy Efficient Homes Program. The BDR Program was not active in PY9 but will be active in PY10 in WPP's service territory. Each of these programs define participation slightly differently due to variations in delivery and/or data tracking methodologies. Table 72 provides the definitions used and the counts of PY9 and Phase III participation for each included DR program.

Table 72: West Penn Power Participation by Program

Program	Definition of Participant	PYTD Participation	P3TD Participation
Energy Efficient Homes – Behavioral Demand Response	The number of individual accounts in Oracle's treatment group for the summer of 2017.	0	0
C&I Demand Response Program – Small	The number of participants who participated in one or more demand response events.	19	19
C&I Demand Response Program – Large	The number of participants who participated in one or more demand response events.	12	12

West Penn Power's two DR programs had three event days in PY9. The Phase III DR performance target for West Penn Power is 64.0 MW. Table 73 shows the DR savings for each program, as well as the portfolio average for each event day. Average performance across all event days is included at the bottom of the table.

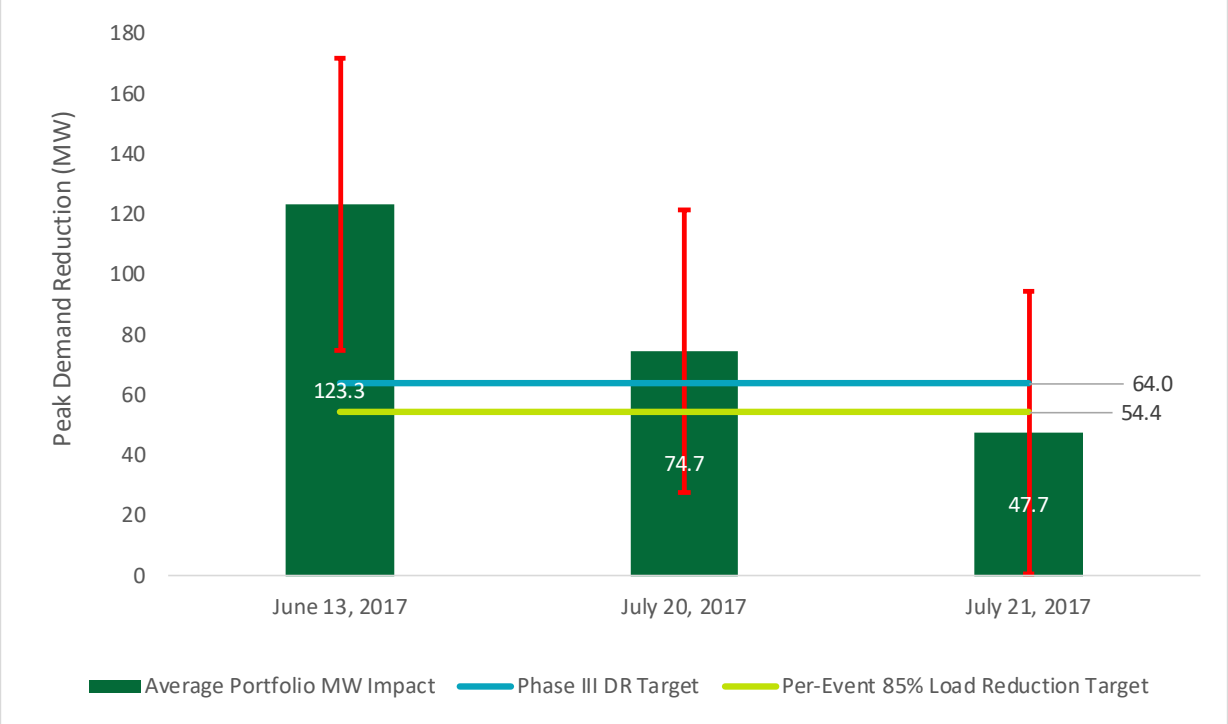
Table 73: West Penn Power Demand Response Performance by Program

Event Date	Start Hour (Hour Ending)	End Hour (Hour Ending)	C&I Demand Response– Small	C&I Demand Response– Large	Average Portfolio MW Impact w/ 90% CI
June 13, 2017	15	18	3.3	119.9	123.3±48.5
July 20, 2017	15	18	2.4	72.3	74.7±46.7
July 21, 2017	15	18	2.3	45.4	47.7±47.0
PYVTD– Average PY9 DR Event Performance					**81.9±29.9**
***VTD– Average Phase III DR Event Performance**					**81.9±29.9**

**Because PY9 is the first year, PY9 and Phase III are, by definition, identical. Both values are included for future iterations where the values will differ.*

The Commission's Phase III Implementation Order established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For West Penn Power, this translates to a 54.4 MW minimum for each DR event. Figure 36 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. For each event day, 90% Confidence Intervals are indicated with a red bar. For the first two events, WPP exceeded the 85% threshold and the target of 64 MW. For the final event day, July 21, West Penn Power did not meet the 85% threshold. However, the 85% threshold was within the margin of error for the July 21 impact estimate.

Figure 36: West Penn Event Performance Compared to 85% Per-Event Target



3.7.3 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 74 shows the TRC ratios by program and for the portfolio. The benefits in Table 74 were calculated using gross verified impacts. Costs and benefits are expressed in 2016 dollars.

Table 74: PY9 Gross TRC Ratios by Program ($1,000)

Program	TRC NPV Benefits	TRC NPV Costs	TRC Ratio	TRC Net Benefits (Benefits–Costs)
Appliance Turn-in	1,782	835	2.14	947
Energy Efficient Homes	14,541	7,975	1.82	6,566
Energy Efficient Products	12,103	8,595	1.41	3,508
LI Energy Efficiency	2,266	3,160	0.72	(894)
Residential Subtotal	**30,692**	**20,565**	**1.49**	**10,127**
C&I Energy Solutions for Business (Small)	15,496	16,010	0.97	(514)
C&I Energy Solutions for Business (Large)	19,629	16,641	1.18	2,987
Governmental & Institutional Tariff	3,585	4,849	0.74	(1,264)
C&I Demand Response Program (Small)	229	51	4.44	177
C&I Demand Response Program (Large)	6,724	1,491	4.51	5,233
Non-Residential Subtotal	**45,662**	**39,043**	**1.17**	**6,620**
Portfolio Total	**76,355**	**59,608**	**1.28**	**16,747**

3.7.4 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 Met-Ed previously applies to all four FirstEnergy utilities, including West Penn.

3.7.5 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 PY9 Annual Report and the supporting detail provided by FirstEnergy's evaluation contractor. The detailed audit findings can be found in Appendix H.

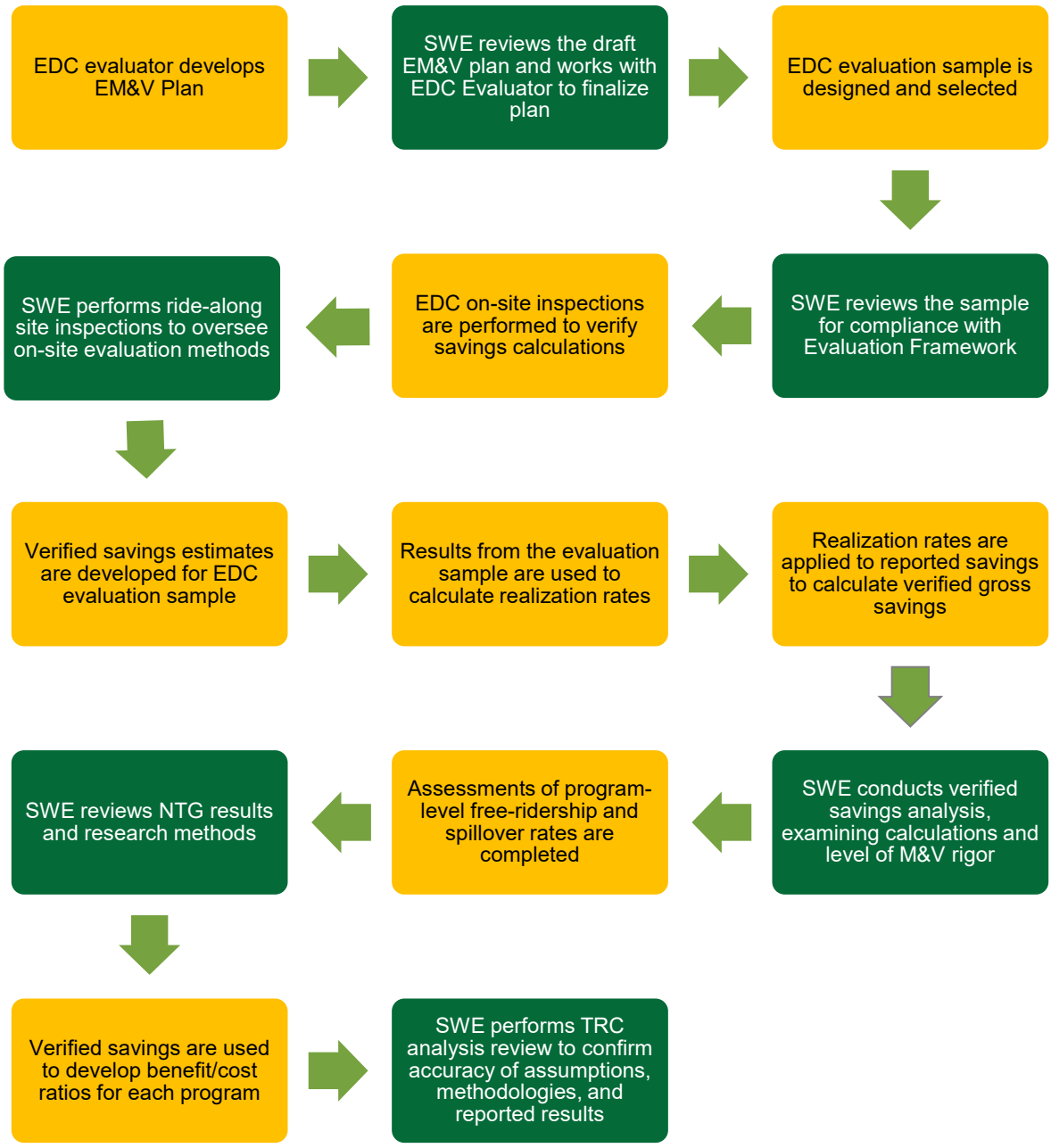
- The PY9 demand response impact evaluation for West Penn was robust and well-organized. The SWE agrees with the baseline selection procedures for C&I participants and found no errors in the calculations for the eleven sites examined. The SWE recommends the Commission adopt the West Penn Power/ADM verified savings estimates when assessing compliance at the end of Phase III. The SWE also recommends that the margin of error be taken into consideration when examining performance on 7/21 against the 85% threshold. The volatile load patterns for several of the largest DR participants in West Penn's program make the baseline estimates inherently uncertain – particularly for individual events. This uncertainty is reduced as the average performance across multiple events is considered.
- The SWE performed a detailed comparison of the energy, demand, participation, and incentive amounts in FirstEnergy's Annual Report to the tracking data provided to the SWE on a quarterly basis. The SWE has no major concerns. For all West Penn's programs, the SWE was able to replicate reported MWh savings and reported MW savings via the tracking data. The SWE also calculated directionally similar (if not equal) participation counts for all programs. For six of the seven programs, the SWE was able to replicate incentive calculations within a few thousand dollars. The SWE's only difference of note is the incentive dollars for the Energy Efficient Homes program, which is due to the costs of the EE kits being correctly treated as incentives in the Annual Report, but not recorded in the program tracking data. However, the incentive differential for EE homes is a quite a bit larger than the amount earmarked for kits in PY9 in West Penn Power's EE&C Plan.
- West Penn Power's TRC model included space heating and water heating fuel savings from reduced fossil fuel consumption from energy-efficient measures. Costs from increased fossil fuel use from fuel-switching are also included.
- West Penn Power's PY9 demand response offerings showed a gross and net TRC ratio of 4.40. One driver of the high ratio is the inclusion of avoided cost of distribution capacity for Large C&I participants. In the PY10 calculations, the SWE recommends only applying the avoided cost of generation and transmission capacity to the MW impacts in the C&I Demand Response – Large program.
- Project documentation for the non-residential programs submitted to the SWE for review was generally thorough and complete. The SWE noted only a few minor discrepancies.
- The SWE's review of ADM's verified savings analysis for the non-residential programs found that the recommended procedures outlined in the Phase III evaluation framework were generally followed. TRM protocols were applied correctly, and verified savings calculations were generally appropriate.
- PY9 residential project files responses were adequate and, overall, the supporting details were provided. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place, and ADM was able to address and clarify any questions from the SWE.
- 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. However, the SWE found discrepancies in the application of TRM algorithms for upstream lighting that resulted in overestimated verified savings of 44 MWh – or 0.02% of portfolio savings – in FirstEnergy's PY9 Annual Report. The residential upstream lighting audit is detailed in Appendix H.4.1.1 with recommendations for improvement.

- The SWE also found a minor error in the low-income carveout savings, but the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting in PY10.
- Overall, the ADM/Tetra Tech team estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework

Section 4 Cross-Cutting SWE Activities

This section presents a summary of the audit and cross-cutting activities conducted by the SWE during PY9, 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 37 shows the C&I sector specific SWE audit activities and their correspondence to the evaluation steps.

Figure 37: The SWE Audit Activities



4.1 Evaluation Framework Update

In May 2018, the SWE completed a minor update to the Pennsylvania Evaluation Framework. Language in the Demand Response chapter of the Framework (6.2) was updated to address PJM's transition of its 7-day load forecast from the legacy Oasis system to Data Miner 2. The update clarified that EDCs should use the most recent forecast available in Data Miner 2 at 10:15 am Eastern Daylight Time to determine whether the following day would be an Act 129 demand response event day. The SWE also corrected a table in the Evaluation Framework that listed incorrect Phase III low-income compliance targets for several EDCs.

Hyperlink to the current Pennsylvania Evaluation Framework.

4.2 Technical Reference Manual Update

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

4.2.1 2021 TRM Update

The SWE conducted a detailed review of the 2016 TRM in preparation for the 2021 TRM Update. The 2021 TRM will be released in 2019 and take effect in June 2021 at the beginning of Phase IV of Act 129. The 2021 TRM will also serve as a technical foundation for the SWE's Phase IV Market Potential Study. Key areas of focus for the TRM update include the following:

- Updates to federal standards, ENERGY STAR specifications, and building codes
- Updated climate assumptions for weather-dependent measures
- Updated measure assumptions to reflect the most recent industry equipment studies on operating characteristics and the results of the 2018 Act 129 baseline studies
- Adapting measures to allow for a midstream program delivery model
- Updated Equivalent Full Load Hours (EFLH) and Coincidence Factor (CF) assumptions for residential HVAC measures
- Addition of new measures. Many new measures were submitted in PY8 and PY9 as Interim Measure Protocols
- General TRM consistency and clarity

4.2.2 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 75 presents the four IMPs the SWE reviewed and approved to be effective during PY9 (all of which will continue to be effective for the remainder of Phase III).

Table 75: IMPs Approved During PY9

IMP	Effective as of:
ENERGY STAR Refrigeration / Freezer Cases	PY9
Weather Stripping, Caulking and Outlet Gaskets (Limited Air Sealing)	PY9
Low-rise Multifamily New Construction	PY9
Residential Thermostat, revised 2018-02-28	PY9

4.3 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 PY8, the SWE reviewed and provided feedback on detailed evaluation plans that addressed evaluation activities for all of Phase III. For PY9, EDC evaluation contractors submitted redline versions for proposed adjustments and modifications for evaluation activities in PY9.

The SWE reviewed the revised PY9 draft evaluation plans and provided suggestions and requests for clarification. EDC evaluation contractors addressed the feedback and prepare revised plans for review and approval. The EDC-specific appendices of this report each include an “EM&V Plan Review” section that documents the evaluation plan review and approval process for PY9.

4.4 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.

4.5 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.[47] 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.

4.6 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, and the SWE quantifies different verified savings. If the magnitude of the error is greater than 1% of savings (MWh) at the portfolio level, EDCs refile their annual

[47] 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.

report to correct the error. If the magnitude of the error is less than 1% of savings (MWh), EDCs are expected to update their phase-to-date verified savings going forward.

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.

4.7 Baseline Studies

In 2018, the SWE conducted a residential baseline study and a non-residential baseline study. These end-use saturation studies examine the penetration, saturation, and fuel shares of various end-use equipment as well as building envelope characteristics that affect energy consumption. The results of the baseline studies are used to update the Pennsylvania TRM and provide key inputs for the Phase IV Market Potential Study. The 2018 studies are the third set of Act 129 baseline assessments with prior studies conducted in 2011 and 2013. This allows for useful time-series comparisons of equipment characteristics over time.

- Residential Baseline Study Report[48]
- Non-Residential Baseline Study Report

4.8 Ad Hoc Tasks

4.8.1 Guidance Memo on Inclusion of Fossil Fuel and Water Benefits in TRC Test

One of the key findings in the SWE PY8 Annual Report was that the EDCs were consistently failing to account for the fossil fuel and water impacts when calculating the cost-effectiveness of EE&C programs. On March 25, 2018 the SWE issued a memo to the EDCs and their evaluation contractors with guidance on incorporating these benefits in TRC calculations for PY9.

It's important to note that fossil fuel and water impacts are considered TRC benefits regardless of whether they are positive or negative. One of the largest fossil fuel impacts of Phase III programs is the interactive effect of LED lighting. LED lighting produces less waste heat than less efficient lighting technologies and this heat must be made up by the heating system of the home or business during the winter. In the summer, the cooler lighting reduces the work of the air conditioning system. Most homes and businesses in Pennsylvania are heated using fossil fuel systems so the interactive effects of LED lighting generally take the form of a penalty, or negative benefit. This is different from fuel switching measures, where the increased fuel usage is considered a TRC cost. The guidance memo included instructions for calculating interactive effects for residential and non-residential lighting programs.

The SWE guidance memo included a practical interpretation of the Commission's directive to include "reasonably quantifiable" fossil fuel and water benefits in the TRC Test by citing measures

[48] Note that the SWE anticipates the baseline studies will be public before the PY9 Annual Report is finalized and will add hyperlinks to the studies in the final PY9 Annual Report.

where these impacts were reasonably quantifiable and measures where the fossil fuel and water impacts were not reasonably quantifiable.

The guidance memo also included a discussion of avoided costs and provided EDCs with a default marginal cost per gallon of $0.01 to use in TRC calculations. EDCs were directed to ignore increased water usage by participants installing CHP systems as the increased water usage at the site is expected to be offset by reduced water consumption at central power plants.

4.8.2 Addendum to Act 129 Behavioral Persistence Study

In November 2018 the SWE released an addendum to the Act 129 Behavioral Persistence Study conducted by the Phase II SWE in 2015. This study focused on HER cohorts served by the FirstEnergy EDCs. These homes received HERs in Phase II of Act 129 and stopped receiving HERs at the beginning of Phase III (June 2016). The analysis examines the decay of savings in the two years after HER treatment was discontinued. The report combines new findings from the FirstEnergy EDCs with the prior research on HER persistence in PPL and Duquesne Light service territories to develop a Pennsylvania-specific assumption about the measure life and decay rate of Act 129 Home Energy Report programs. Additional detail on the methodology and findings is presented in Section 2.2.3.

Report Hyperlink

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 EDCs are well ahead of plan with respect to compliance MWh and under budget. The companies Phase III EE&C plans assumed an acquisition cost of 18-19 cents per first-year kWh. To date, the FirstEnergy EDCs are delivering savings at 11-12 cents per kWh. FirstEnergy is in a strong position to explore new offerings or technologies in PY10-PY12. Testing emerging technologies or delivery models can be risky because the customer adoption and energy savings are not well understood. However, given FirstEnergy's progress to date on compliance savings and budget, they are well-positioned to test new offerings in Phase III that could help make up for the decreased lighting opportunity in PY12 and beyond.
- PPL and the four FirstEnergy companies are ahead of projected energy savings totals despite spending less than projected. Duquesne Light's phase-to-date spending was also lower than planned while energy savings were close to planned (96%). Through PY9, PECO is the only EDC with a phase-to-date spending ratio that is higher (87%) than the phase-to-date energy savings ratio (73%). In addition, all EDCs except PECO have delivered energy savings at a lower cost than projected to the phase-to-date. PECO's phase-to-date acquisition cost was above EE&C plan projections for the phase-to-date and PECO has reached 31% of the compliance target through PY9. PECO and its ICSPs will need to deliver energy-efficiency programs more efficiently in PY10 through PY12 to meet its compliance target.
- All seven EDCs remain heavily reliant on the lighting measures, with over 60% of PY9 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 PY10 through PY11 while also looking ahead at other program opportunities.
- Overall, PY9 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.
- Midstream program delivery approaches are expected to grow substantially in the balance of Act 129 Phase III, and beyond. While the savings from PPL's and Duquesne Light's midstream lighting offerings combined were less than 5% of all verified non-residential lighting savings in PY9, both programs significantly increased participation, with PPL's midstream program increasing over 650% from PY8. The EDCs have reported interest in expanding and/or adding midstream program delivery to include non-lighting equipment, such as ductless heat pumps units, heat pump water heaters, and vending misers. Along with Pennsylvania, midstream delivery programs are an increasing trend in Demand Side Management program offerings across the country. Midstream programs are often perceived as a more cost-effective program approach to the traditional downstream program; they typically require less marketing, less implementation costs, and reduced

paperwork burden for program participants. However, midstream programs also result in less direct customer interactions with the utility, often leading to the customer not being aware that the utility was involved in the lower cost of the incented measures. Another limitation observed by the SWE for the PA midstream programs, is a limited amount of participant premise information captured on the program application, which may be necessary to utilize TRM savings protocols. This lack of direct customer information can introduce uncertainty, which can result in less precise energy and demand saving estimates. Along with specific interim measure protocols to address this uncertainty, the SWE expects to address additional challenges with EDCs and their evaluators as these programs mature and increase in prevalence.

- Non-residential project file reviews generally found most of the project file packages for sampled projects to be complete. Except, for the midstream programs for Duquesne Light and PPL, most of the reviewed project file packages included all documentation requested and were well organized, allowing for a comprehensive review of the projects. Deficiencies were identified for some of PECO's program solutions due to either misaligned values between the quarterly program tracking data and project documentation or due to a lack of project documentation. Deficiencies were minimal and were within the evaluation framework allowances.
- Non-residential project file reviews showed strong adherence to the appropriate algorithms and assumptions for TRM-based and custom measures by the ICSPs of the seven EDCs. For FirstEnergy, the process by which the ICSP's calculators are transcribed into the Appendix C calculator preserves much of the Appendix C functionality but does overwrite some functions. For future years, the ICSP and the evaluator could consider improving the transcription process so that these parameters are calculated directly by the Appendix C calculator as intended. Additionally, calculators submitted for prescriptive measures are locked. Worksheet and cell permissions could be modified to allow the SWE to view inputs and algorithms in the calculator. This would facilitate more thorough project reviews and evaluations in the future.

5.2 EVALUATION

The Pennsylvania EDCs and their evaluation contractors conducted a significant volume of verification and program design research in PY9. Some of the key findings and recommendations from their research – and the SWE audit activities – included the following:

- While the impact evaluation of PY9 demand response programs was well-executed, the EDCs and their evaluation contractors struggled with the TRC calculations for DR programs. PPL used the wrong savings values in their calculations and both PPL and PECO applied line loss factors to impacts that had already been adjusted for losses. FirstEnergy and PECO applied the avoided cost of distribution capacity to impacts from large industrial participants while the 2016 TRC Order directed EDCs to only use the avoided cost of generation and transmission capacity for these DR participants.
- The SWE notes that there is inconsistency among EDCs with the ISR and interactive effects applied to cross-sector upstream lighting sales. The TRM instructs EDCs to "use

the CF and hours of use by business type present in 3.1 Lighting for non-residential bulb savings estimates" for cross-sector sales; however, it does not provide any guidance regarding the ISR or interactive effects for cross-sector sales. The algorithm in 3.1 Lighting for non-residential bulb savings estimates is virtually identical to the algorithm in 2.1 Lighting for residential bulb savings, except that it does not contain an ISR. Some EDCs applied the ISR of 92% in 2.1 Lighting for residential bulb savings, while others followed the 3.1 Lighting for non-residential bulb savings algorithm and omitted an ISR. In addition, the default interactive effect factors present in 2.1 Lighting for residential bulbs differ from those present in 3.1 Lighting for non-residential bulbs. The SWE plans to provide guidance on the appropriate cross-sector sales ISR and interactive effects for PY10 due to the ambiguity in the TRM regarding these issues.

- The SWE's review of verified savings for non-residential programs for all EDC's found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate.
- Home Energy Report programs accounted for 15% of all PY9 gross verified savings. The EDC evaluations of Home Energy Report programs showed increased attention to detail in PY9 compared to PY8. In PY8, the SWE audit identified issues with the HER analysis for all EDCs except PPL. In PY9, PPL was the only EDC with HER analysis errors.
- 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. However, the SWE did discover errors in the verified savings calculations of six of the seven EDCs that led to both increases and decreases in the MWh and MW totals for those EDCs and a net increase statewide in savings of 2,359 MWh. The verified savings reviews are detailed in the appendices along with recommendations for improvement.
- The 2016 TRM began to show its age in 2018. The 2016 Technical Reference Manual was developed in 2014-2015 and approved July 8, 2015. Unlike previous TRMs which were updated annually, the 2016 TRM is effective for the five-year duration of Phase III. Over time certain aspects of the TRM have become outdated. For example, in late 2016 federal standards for water heaters were updated and in 2018 Pennsylvania adopted IECC 2015 building code. As a result, the baseline assumptions in the 2016 TRM are no longer aligned with the current codes and standards in the Commonwealth. The TRM is the basis for Act 129 compliance savings so changes to codes and standards do not affect EDC evaluation activities or the SWE audit findings. However, it does raise a policy question about the ideal effective period for the TRM.
- 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.
- Overall, the EDC evaluators estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework. The SWE identified a few overarching issues, leading to the following recommendations for future efforts. First, 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 or very small samples. Second, C&I participants are notoriously hard to recruit for analysis, but special effort should be made to incorporate C&I participants into NTG research, a possibility would be including feedback into program eligibility requirements.

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 PY9 verified gross savings by customer segment.

Table 76: Summary of PY9 Verified Savings and Phase III Portfolio Targets*

EDC	Phase III Compliance Targets (MWh)			PY9 Verified Gross Savings (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	390,151	20,628	42,382
PPL	1,443,035	79,367	50,507	382,522	26,241	27,376
Duquesne Light	440,916	24,250	15,432	101,065	3,787	7,057
FE: Met-Ed	599,352	32,964	20,977	176,665	11,577	8,104
FE: Penelec	566,168	31,139	19,816	154,637	10,839	9.929
FE: Penn Power	157,371	8,655	5,508	57,354	3,533	3,639
FE: West Penn	540,986	29,754	18,935	195,498	10,556	38,050
Statewide	**5,710,488**	**314,075**	**199,868**	**1,457,892**	**87,161**	**136,537**

*Rows may not sum to statewide totals due to rounding

Table 77: Summary of Phase-to-date Verified Savings and Phase III Portfolio Targets*

EDC	Phase III Compliance Targets (MWh)			Phase-to-date Verified Gross Savings (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	600,840	37,802	54,254
PPL	1,443,035	79,367	50,507	740,165	38,124	71,215
Duquesne Light	440,916	24,250	15,432	170,768	5,210	12,017
FE: Met-Ed	599,352	32,964	20,977	316,540	21,645	13,219
FE: Penelec	566,168	31,139	19,816	287,087	22,878	16,462
FE: Penn Power	157,371	8,655	5,508	94,484	6,724	5,896
FE: West Penn	540,986	29,754	18,935	326,828	20,900	48,287
Statewide	**5,710,487**	**314,075**	**199,868**	**2,536,712**	**153,283**	**221,350**

* Phase-to-date totals include PY8 savings verified in PY9. As a result, the sum of the PY8 verified savings in the SWE PY8 Annual Report and PY9 verified savings is less than the phase-to-date savings.

Table 78: 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 Light	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 79: Summary of PY9 Verified Savings and Phase II Carryover

EDC	Phase III Compliance Targets (MWh)			PY9 Verified Gross Savings + CO (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	390,151	20,628	42,382
PPL	1,443,035	79,367	50,507	382,522	26,241	27,376
Duquesne Light	440,916	24,250	15,432	201,532	7,053	7,057
FE: Met-Ed	599,352	32,964	20,977	207,147	16,602	8,104
FE: Penelec	566,168	31,139	19,816	204,332	18,711	10,011
FE: Penn Power	157,371	8,655	5,508	71,220	5,338	10,955
FE: West Penn	540,986	29,754	18,935	216,038	13,910	38,050
Statewide	**5,710,487**	**314,075**	**199,868**	**1,672,942**	**108,483**	**143,935**

Table 80: Summary of Phase-to-date Verified Savings and Phase II Carryover*

EDC	Phase III Compliance Targets (MWh)			Phase-to-date Verified Gross Savings + CO (MWh)		
	Overall	LI	GNI	Overall	LI	GNI
PECO	1,962,659	107,946	68,693	600,840	37,802	54,254
PPL	1,443,035	79,367	50,507	740,165	38,124	71,215
Duquesne Light	440,916	24,250	15,432	271,235	8,476	12,017
FE: Met-Ed	599,352	32,964	20,977	347,022	26,670	13,219
FE: Penelec	566,168	31,139	19,816	336,782	30,750	16,544
FE: Penn Power	157,371	8,655	5,508	108,350	8,529	13.212
FE: West Penn	540,986	29,754	18,935	347,368	24,254	48,287
Statewide	**5,710,487**	**314,075**	**199,868**	**2,751,762**	**174,605**	**228,748**

* Phase-to-date totals include PY8 savings verified in PY9. As a result, the sum of the PY8 verified savings in the SWE PY8 Annual Report and PY9 verified savings is less than the phase-to-date savings.

Table 81: Summary of PY9 Verified Savings by Customer Segment[1]

EDC	Residential (MWh)	Small C&I (MWh)	Large C&I (MWh)	GNI (MWh)	LI* (MWh)
PECO	234,414	34,328	56,875	42,382	22,152
PPL	165,734	99,521	63,860	28,187	25,218
Duquesne Light	40,342	22,383	27,496	7,057	3,787
FE: Met-Ed	91,450	39,437	26,096	8,105	11,577
FE: Penelec	74,345	23,515	36,010	9,929	10,839
FE: Penn Power	26,558	12,570	11,054	3,638	3,533
FE: West Penn	91,275	31,941	23,677	38,049	10,556
Statewide	**724,118**	**263,695**	**245,069**	**137,347**	**87,662**

[1] Does not include carryover savings

*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).

Table 82: Summary of Phase-to-date Verified Savings by Customer Segment[1]

EDC	Residential (MWh)	Small C&I (MWh)	Large C&I (MWh)	GNI (MWh)	LI* (MWh)
PECO	381,036	53,655	72,569	54,254	39,326
PPL	334,962	169,696	126,381	72,243	36,884
Duquesne Light	85,654	30,875	37,109	12,017	5,113
FE: Met-Ed	175,852	53,512	52,274	13,219	21,682
FE: Penelec	157,207	42,265	47,955	16,462	23,198
FE: Penn Power	47,383	20,779	13,812	5,896	6,614
FE: West Penn	176,650	49,337	31,083	48,287	21,471
Statewide	**1,358,744**	**420,120**	**381,184**	**222,377**	**154,287**

[1] Does not include carryover savings

*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).

Table 83: PY9 Costs, kWh Savings, and Cost per First-Year kWh Saved

Category	Sector	Program Year 9 Performance
Total Utility Costs ($1000)	Residential Non-Low-Income	$86,084
	Residential Low-Income	$32,736
	Residential Total	$118,820
	Non-Residential Total	$64,860
	Total	$183,680
First-Year kWh Saved	Residential Non-Low-Income	724,119
	Residential Low-Income	87,662
	Residential Total	811,781
	Non-Residential Total	646,111
	Total	1,457,892
Utility $/kWh Saved	**Residential Non-Low-Income**	**$0.12**
	Residential Low-Income	**$0.37**
	Residential Total	**$0.15**
	Non-Residential Total	**$0.10**
	Total	**$0.13**

A.2 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 84 reports the required minimum proportions and results of the SWE's verification analysis.

Table 84: Low-Income Measure Proportionality Targets and SWE Verification Results

EDC	Proportionate Number of Measures Target	PY9 Proportionate Number of Measures, Reported	PY9 Proportionate Number of Measures, SWE Verified
PECO	8.80%	43.5%	29.1%
PPL	9.95%	22.1%	25.4%
Duquesne Light	8.40%	19.8%	23.7%
FE: Met-Ed	8.79%	37.3%	34.4%
FE: Penelec	10.23%	37.3%	34.4%
FE: Penn Power	10.64%	37.3%	34.4%
FE: West Penn	8.79%	37.3%	34.4%

A.2.1 Matching Measures to TRM Algorithms

EDCs reported compliance with the proportionate number of measures target in their individual PY9 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."[49]

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

[49] Evaluation Framework.

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 lists [50] 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 or (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) (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 to be low-income if it included any EDC-reported, low-income qualified measures.

[50] 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.2.2 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 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. When EDCs specified the Tier 1 and Tier 2 measures separately, the analysis counts them separately. When EDCs did not specify, the analysis counts only a single measure.
- **Refrigerator/Freezer Replacement and Recycling:** The TRM has one section (*2.4.3*) that encapsulates all refrigerator and freezer early replacement (replacing an inefficient appliance that has remaining working with life 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.2.3 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.2.3.1 PECO

PECO reported that 43.5% of its 269 conservation measures qualified as low-income measures, which surpasses it's 8.8% requirement. By the SWE's analysis, when the EDC-reported measures are matched to TRM algorithm sections, 29.1% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 32.9% 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 51 measures that should be counted twice in the denominator. Matching measures to the TRM and double counting the proper measures resulted in 206 individual measures, 38 of which do not match to individual TRM sections and algorithms.

A.2.3.2 PPL

PPL reported that 22.1% of its 95 conservation measures qualified as low-income measures, which surpasses it 9.95% requirement. By the SWE's analysis, when the EDC-reported measures are matched to TRM algorithm sections, 25.4% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 16.8% qualify as low-income. Matching measures to the TRM resulted in 126 individual measures, thirteen 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.2.3.3 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, 23.7% qualify as low-income measures with measures unmatched to the TRM included. When unmatched measures are excluded, 23.5% qualify as low-income. Matching measures to the TRM resulted in 76 individual measures, six of which do not match to individual TRM sections and algorithms. The SWE analysis counted thirteen 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 correctly double counted those measures.

A.2.3.4 FirstEnergy Companies

While the FirstEnergy EDCs were all assessed as a group since their measure counts are identical, the SWE reports the findings by individual EDC. In their Phase III plans, the FirstEnergy Companies reported that 37.3% 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, 34.4% of measures are low-income with measures unmatched to the TRM included. When unmatched measures are excluded, 25.0% of measures are low-income. Matching measures to the TRM resulted in 154 individual measures, 38 of which do not match individual TRM sections and algorithms. The SWE analysis counted 14 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.2.4 Low-Income Measure Offerings

Table 85 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 First Energy EDCs (Met-Ed, Penelec, Penn Power, and West Penn) had identical low-income measures and are included as a single column: *First Energy 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 85: Summary of Low-Income Measures Provided by EDCs

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs[1]
N	*85*	*60*	*32*	*18*	*53*
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	✓	✓		✓

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs[1]
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	✓		✓	✓
Packaged Terminal AC	2.2.10a	✓			
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 Early 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 General	2.5.3			✓	✓
Smart Strip Plug Outlets Tier 1	2.5.3a	✓			
Smart Strip Plug Outlets Tier 2	2.5.3b	✓	✓		

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs[1]
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	✓	✓		
Lighting Improvements	3.1.1	✓		✓	
Lighting Controls	3.1.3	✓			
Traffic Lights	3.1.4				
LED Exit Signs	3.1.5	✓			
LED Channel Signage	3.1.6	✓			
HVAC Systems	3.2.1	✓			
Electric Chillers	3.2.2	✓			
Controls: Economizer	3.2.9	✓			
Premium Efficiency Motors	3.3.1	✓			
ECM Circulating Fan	3.3.3	✓			
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			✓	
High Efficiency Ventilation Fan	4.1.3	✓			
Behavioral/Energy Education	5.2		✓	✓	
Basement Wall Insulation	IMP	✓			
ECM Circulator Pump	IMP	✓			
Furnace Maintenance	IMP	✓			✓
Permanent Fixture Removal	IMP	✓			
Permanent Lamp Removal	IMP	✓			
Residential Thermostats	IMP	✓	✓	✓	
Window Film	IMP	✓			✓
Window Repair	IMP	✓			✓
Weather Stripping	IMP		✓	✓	✓

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs[1]
“Water Heater Timer”	Unmatched	✓			
“HVAC Controls EMS	Unmatched	✓			
“Retrocommissioning”	Unmatched	✓			
“Interior Lighting Controls Combination”	Unmatched	✓			
“Interior Daylighting Controls”	Unmatched	✓			
“Setback Thermostat”	Unmatched		✓		
“DI crawler and heater insulation”	Unmatched			✓	
“Electric Heating Repair or Replacements”	Unmatched			✓	
“Clothes Line Installation”	Unmatched				✓
“Room Air Conditioner Cover”	Unmatched				✓
“Water Heater Replacement”	Unmatched				✓
“Electric Furnace”	Unmatched				✓
“Electric Dryer Venting Repair or Replacement”	Unmatched				✓
“Electrical Repairs”	Unmatched				✓
“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				✓
“Storm Windows and Doors”	Unmatched				✓
“Vapor Barrier”	Unmatched				✓
“Vents (Roof, Gable, Soffit and Ridge)”	Unmatched				✓
“Appliance Timers”	Unmatched				✓
“Well Pump”	Unmatched				✓

Measure	TRM Algorithm Section	PECO	PPL	Duquesne Light	FirstEnergy EDCs[1]
"Window Quilt"	Unmatched				✓
"Window Tint"	Unmatched				✓
"Door Repair or Replacement"	Unmatched				✓
"Electric Baseboard Heater Replacement"	Unmatched				✓
"Smoke Detector"	Unmatched		✓		
"CO2 Detector"	Unmatched		✓		
"Replacing Smoke or CO2 Battery"	Unmatched		✓		

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

A.3 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 was mostly consistent among EDCs: PECO and PPL reported their lowest residential NTG values for the Appliance Turn-In Program and Duquesne Light, 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.

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. The SWE identified a few overarching issues, leading to the following recommendations for future efforts:

- 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 or very small samples.
- C&I participants are notoriously hard to recruit for analysis, but special effort should be made to incorporate C&I participants into NTG research. Recruitment should also take into account previous participation in NTG research to avoid customer fatigue.

Appendix B PECO Audit Detail

B.1 EM&V Plan Reviews

PECO's evaluation contractor, Navigant, submitted a redline version of their PY9 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, Navigant submitted several memos updating their sampling approach for several solutions and programs, including their targeted multifamily solution, residential whole home solution, and the Small and Large C&I EE programs. The SWE reviewed and approved the plans, generally with minor revisions.

In addition to reviewing PECO's revised evaluation and sampling plans, the SWE reviewed six survey instruments and one interview guide. Three of these instruments were for residential programs and four were for C&I programs.

B.2 Sample Design Review

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

Sampling allows evaluators to decrease verification costs by reducing the number of verifications that need to be conducted. However, not including enough sites in the sample, particularly when there is expected to be high uncertainty in savings, can lead to large uncertainty in savings estimates. To guide sample construction, the Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 15% at 85% confidence level for each "initiative." Initiative level reporting was implemented specifically for EDCs like PECO, who define EE&C programs broadly, but have specific offerings that are a more logical grouping for evaluation purposes. PECO referrers to its initiatives as "solutions." The Navigant evaluation activities for PECO were broken down by sector (residential or non-residential), program (Large C&I, Small C&I, Residential, Residential Low-Income), and reported in the PECO PY9 Annual Report by solution. Samples were designed to meet the 85/15 sampling requirement for each solution. Table 86 shows the energy savings relative precision values for each solution.

Table 86: Relative Precision of PY9 Gross Verified Energy Savings by Program

Program	Solution/Initiative	Relative Precision at 85% Confidence Level (±)
Residential EE Program	Lighting, Appliances, and HVAC	0.3%
Residential EE Program	Appliance Recycling	0.4%
Residential EE Program	Whole Home	8.5%
Residential EE Program	New Construction	0.0%
Residential EE Program	Multifamily Targeted	8.2%
Low-Income EE Program	Whole Home	17.0%
Low-Income EE Program	Lighting	0.0%
Small C&I EE Program	Equipment and Systems	9.5%
Small C&I EE Program	New Construction	4.1%
Small C&I EE Program	Multifamily Targeted	17.0%
Small C&I EE Program	Whole Building	3.4%
Large C&I EE Program	Equipment and Systems	5.9%
Large C&I EE Program	New Construction	3.8%
Large C&I EE Program	Multifamily Targeted	4.0%
Large C&I EE Program	Data Centers	0.0%

The PECO estimated verified savings for some programs, including the new construction offerings, are evaluated over two-year cycles. The PY9 report totals for sample size and verified savings reflect only those that occurred in PY9, but the relative precision values in the PY9 report reflect the uncertainty of the total sample across both PY8 and PY9.

There are two values in Table 86 above the ± 15% threshold, the Whole Home solution within the Low-Income Program, and the Multifamily Targeted solution within the Small C&I EE program. For the Low-Income initiative, low realization rates may have led to a failure to meet the relative precision threshold. Regarding the Small C&I EE Multifamily Targeted solution, Navigant reported limited access at certain apartment units and the unavailability of maintenance staff to escort the field technicians, which prevented one of the sample sites from being verified. The achieved PY9 relative precision was an improvement over the PY8 results. It is also important to note that the Multifamily Targeted solution includes samples 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 ±15% and met the requirements of the Evaluation Framework. The same is true for the Whole Home initiative across Residential and Low-Income.

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 PY9 verification activities is discussed in detail in Appendix B.4.

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

Similar to the Behavioral Program, the Demand Response evaluations do not rely on sampling because a census is used. PECO's DR Programs include Residential DR, Small C&I DR, and Large C&I DR. Impact analysis employed econometric regression methods to estimate the demand savings from the program by utilizing AMI data at hourly or sub-hourly intervals. These regressions do not capture all the variation in the data, and as a result the impacts include estimation error. This error is captured in the relative precision values in Table 87.

Table 87: Gross DR Savings Impact Evaluation Relative Precision by Program

DR Program	Relative Precision at 90% Confidence Interval (±)
Residential	6%
Small C&I	N/A
Large C&I	12%

The Small C&I DR program does not have a relative precision value because there were no verified demand savings for any of the DR events.

B.3 Reported Gross Savings Audits

B.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the savings, participation counts, and incentives reported in PECO's PY9 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings (MWh) for each program;
- Reported gross peak demand savings (MW) for each program;
- Participation counts for each program; and
- 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 PY9 quarterly data request. Also note that demand response (DR) and home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding PECO's demand response programs can be found in Appendix B.5, and our findings regarding the behavioral component of PECO's Residential Energy Efficiency program can be found in Appendix B.4.1.3.

Table 88 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values in PECO's PY9 Annual Report and 'No' otherwise. Note that the tracking data supported PECO's reported MWh savings for each program.

Table 88: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Residential EE Program	153,852	153,852	Yes*
Low-Income EE Program	29,104	29,104	Yes
Small C&I Program	48,752	48,752	Yes
Large C&I Program	82,041	82,041	Yes
CHP	3,254	3,254	Yes
Portfolio Total	**317,003**	**317,003**	**Yes**

*The Residential EE program has an HER component not represented in this table.

Table 89 summarizes the SWE's findings regarding reported gross peak demand savings by program. Like with reported gross energy savings, the tracking data supports the Annual Report for all programs except.

Table 89: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Residential EE Program	20.46	20.46	Yes*
Low-Income EE Program	3.48	3.48	Yes
Small C&I Program	6.06	6.06	Yes
Large C&I Program	11.63	11.63	Yes
CHP	0.49	0.49	Yes
Portfolio Total	**42.12**	**42.12**	**Yes**

*The Residential EE program has an HER component, but it does have reported demand savings.

Table 90 shows participation counts for each of PECO's programs. The SWE was unable to perfectly replicate participation counts for any of PECO's programs except for CHP. For the

Residential EE and the Low-Income EE programs, the SWE was able to replicate directionally similar participation counts.

Participation for each component of the Small and Large C&I EE programs is defined as a unique project number. For both programs, the SWE was able to replicate the participation counts shown in Table 2-6 of PECO's Annual Report for all solutions except for the Multifamily Targeted solution. The number of unique project numbers for this solution in the tracking data exceeds the participation count shown in Table 2-6 by a large margin. This is true for both the Small C&I EE and Large C&I EE programs. Thus, the difference in portfolio totals between the two sources is largely attributable to the Multifamily Targeted solution.

Table 90: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Residential EE Program	935,783	935,544	No*
Low-Income EE Program	121,802	120,190	No
Small C&I Program	1,568	4,088	No
Large C&I Program	466	4,649	No
CHP	2	2	Yes
Portfolio Total	**1,059,621**	**1,064,473**	**No**

*The Residential EE program has an HER component not represented in this table.

Finally, Table 91 summarizes the SWE's ex-ante findings regarding incentive dollars. For all of PECO's programs, the SWE was able to replicate the incentives shown in PECO's Annual Report.

Table 91: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Residential EE Program	$7,841	$7,841	Yes
Low-Income EE Program	$554	$554	Yes
Small C&I Program	$2,255	$2,255	Yes
Large C&I Program	$3,648	$3,648	Yes
CHP	$211	$211	Yes
Portfolio Total	**$14,509**	**$14,509**	**Yes**

B.3.2 Project File Reviews

B.3.2.1 Residential[51]

The SWE conducted a project file review for a sample of PECO's residential and low-income solutions in PY9 as part of the reported savings (i.e., ex-ante) review. The project file documentation was provided by PECO, the program implementors, and the evaluation contractor, Navigant, in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. The sampled project file packages included most of the documentation requested. Upon additional request, project file documentation was provided for the New Construction Solution and the Upstream Lighting portion of the Lighting, Appliance, and HVAC Solution. This documentation will be included in quarterly data requests beginning PY10.

Table 92 presents an overview of the results of the SWE's residential project file reviews. As stated in the project file review section of the PY8 annual report, Navigant continued to work with the SWE to clarify questions and processes, both general and specific, that resulted from the ex-ante review for PY9. Improvements were made to quarterly data submissions, such as providing a project file key, which allowed the SWE auditors to conduct thorough reviews of project file packages, TRM equations and values, and the tracking data.

[51] 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 92: PECO PY9 Residential Project File Review Summary

Program	Solution	Number of files reviewed	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data?[1]
Residential Energy Efficiency Program	Upstream Lighting	8	✓	✓	✓	✓
Residential Energy Efficiency Program	Appliance and HVAC	25	✓	✓	✓	✓
Residential Energy Efficiency Program	Appliance Recycling	33	✓	✓	✓	✓
Residential Energy Efficiency Program	Whole Home Solutions	24	✓	✓	✓	✓
Residential Energy Efficiency Program	New Construction	8	✓	✓	✓	✓
Residential Energy Efficiency Program	Multifamily Targeted Segment	27	✓	✓	✓	✓
Low-Income Energy Efficiency Program	LI Whole Home Solutions	28	✓	✓	✓	✓

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

As detailed above, the requested number of project files and supporting details were submitted for the residential program. Below is a summary of the discrepancies between the project file packages and quarterly tracking data found during the SWE's residential project file review.

Lighting, Appliance, and HVAC (LAH) Solution

The upstream lighting project file review included manufacturer invoices. Typically, quantities and rebate amounts were matched with the tracking data. The base wattage values corresponded with appropriate lumen ranges and bulb types specified in the TRM. The SWE notes that model numbers for lightbulbs are not included in the tracking data and recommends that they be included in the tracking data moving forward in PY10. Appliance and HVAC project files typically matched the quarterly tracking data; however, some discrepancies between the project files and tracking data were found.

- One project file was not found in the tracking data.
- One case for which the tracking data listed two central air-conditioners, while the equipment invoice suggested one system was installed. The reported savings included both systems, potentially overstating reported savings. The rebated amount suggested the opposite. In the tracking data only one system was rebated, while the project file documentation indicated a $200 rebate received (which may be a result of a furnace installation that was completed at the same time).
- Identical project file documentation (equipment invoice and Salesforce documentation) was provided for two separate projects in the tracking data.

The SWE reviewed the discrepancies with PECO's evaluator, Navigant, and Navigant reported that they conduct a similar review of a sample of project files for their ex-post, verified savings analysis and adjust realization rates when similar issues are found.

New Construction Solution

The residential New Construction Solution project files matched the tracking data. Project files included energy modeling software, counts of installed light bulbs, and supplementary information for individual projects. The reported savings matched the savings generated in REM/Rate. The SWE notified Navigant in September 2018 that reported savings did not follow the TRM protocol and included the lighting and appliance kWh savings.[52] The SWE noted the same error in the PY8 SWE Annual Report. Note that the overall savings for the solution were 1,451 MWh, approximately 0.4% of entire savings from the PY9 portfolio, meaning that any changes due to this deviation from TRM protocol would have a fairly small impact on overall reported savings.

Appliance Recycling Solution

The SWE located and reviewed the Appliance Recycling Solution (ARS) project files within the tracking database. The SWE found several cases for which the appliance characteristics were not recorded in the on-site data collection form.

[52] The TRM specifies that 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.

- The SWE observed that the age and size (cubic feet) of the recycled appliances did not match between the project file documents in five cases. The discrepancy was observed between the on-site data collection form and the electronic project summary. This data is not provided in the quarterly tracking data, and the reported savings associated with this solution are deemed.
- The SWE observed five cases for which the model number was not recorded, and capacity or age was not included in the on-site data collection form. However, an age or capacity value was provided in the electronic database.

In PECO's approved EM&V plan it states that: each program year's appliance stock – average age, cubic feet, and configuration will be taken into account to develop a more accurate estimate of savings.

The SWE reviewed the discrepancies between the tracking database and project files with Navigant. Navigant reported that for PY9, the discrepancies are corrected via a phone survey of a random sample of 200 participants that collects appliance characteristics, which are used to calculate verified savings and realization rates. The SWE notes that that Navigant is slated to conduct a project file review for the ARS in PY10, in accordance with the approved Phase III evaluation plan. The SWE recommends that Navigant include a systematic review of on-site data collection, database entry and database management during their review, in order to ensure that accurate inputs for verified savings are recorded.

Multifamily Targeted Segment

The Multifamily Targeted Segment matched the tracking data in most cases; however, some discrepancies between the project files and tracking data were observed. The SWE reviewed the discrepancies between the tracking database and project files with Navigant and Navigant reported that these discrepancies are addressed during their verified savings review. Navigant conducts site visits for a random sample of projects, verifies quantities of measures installed and calculates verified savings and an associated realization rate on the evaluated sample.

The discrepancies we observed between the project files and tracking data are as follows:

- Four project file packages recorded directly installed measures that were not found in the tracking database.[53]
- Tracking database rounded reported savings for three of the sampled projects. In these cases, the SWE notes that reported savings in project files and tracking database do not align, but that this results in negligible differences.[54]
- One project file was missing low-flow showerhead and faucet aerators in the tracking data.

It should be noted that the tracking data indicated an "unknown water heater" for low-flow showerhead and faucet aerator measures, while the reviewed project file documents and reported

[53] Navigant will examine the missing projects and measures (for all solutions) through process evaluation activities with PECO.
[54] Navigant addresses this issue during the verified savings review by using the savings found in the project file documentation and presents this finding in the PY9 final report.

savings indicated an electric water heater was present. This inconsistency in the tracking data may lead to an incorrect application of the TRM equation, or cause confusion during the verified savings calculation and subsequent SWE review.[55]

Whole Home Solution

The SWE determined most project files matched the tracking database for the Whole Home Solution. The SWE observed a few instances in which identical directly installed bulbs had different base wattages recorded in the tracking database. For example, a light bulb had the same naming convention and lumen range, but a different wattage was applied in the equation, resulting in inconsistent reported savings. The SWE reviewed the discrepancies between the tracking database and project files with Navigant and Navigant reported that these discrepancies are addressed during their verified savings review of the tracking database and project files.

The discrepancies we observed between the project files and tracking data are as follows:

- In five cases, the base wattage did not match the TRM default wattage for that lumen range.[56]
- Twelve direct install globe bulbs were given a base wattage that corresponded with the quantity variable rather than the lumen range provided in the tracking data. It should be noted that lumen values were provided in the tracking data, which were used to inform the baseline wattage variable in the equation. There were several different baseline wattage values observed within the tracking data for the same bulb type and defined lumen value.[57]
- In one case the fuel switching (electric to fossil fuel heating) system type in the tracking data (electric furnace) did not match the type indicated in project file (ASHP). The tracking data used a heating capacity that did not correspond with the model specifications that are associated with the project file. The reported savings for the sampled project were 30,011 kWh and the SWE saving calculation was 5,895 kWh.

Low-income Whole Home Solution

The SWE found only minor discrepancies in the sampled project file documentation and tracking data. However, the SWE was unable to locate several project files in the tracking data. The SWE reviewed the discrepancies between the tracking database and project files with Navigant and Navigant reported they will examine these projects during its process evaluation activities (the projects are currently being excluded from reported savings).

The discrepancies we observed between the project files and tracking data are as follows:

[55] Navigant confirmed with the CSP that showerhead and faucet aerator measures are not installed unless an electric water heater is present and included a recommendation to correct the misclassification in the tracking data.
[56] The SWE reviewed this finding with Navigant and Navigant reported that it addresses this issue in the verified savings review and realization rate calculations.
[57] An example of this is one category of decorative globe bulbs with an indicated lumen value of 500, deemed at 60 watts per the TRM; however, an assortment of baseline wattage values were applied in the reported savings (12, 40, 60, 65, 75, 100, and 150 watts). As baseline wattage is not collected for replaced direct install bulbs, the SWE was unable to determine the basis of these values in the project file documentation or applying the TRM default.

- There were eight cases where the project files indicated that direct install measures took place but were not found in the tracking data.
- There were three project files that had inconsistent light bulb counts or wattages between the tracking data and the project files, though this only affected a small number of bulbs.
- The SWE observed that the equation used for the thermostatic showerhead used an incorrect TRM default value for the temperature out variable (101° F instead of 104° F).[58]
- Six of the sampled files did not include any reported savings for measures, just documentation that a baseload audit took place.

The SWE observed during the project file review that there are three different calculation methodologies for direct install Energy Star Lighting savings measures in use, differing by solution. The Whole Home Solution (WHS) collects data on the installed bulb wattage, type, and room location – which are all applied to the savings calculation, with a 100% ISR. The Low-Income Whole Home Solution (LIWHS) collects the same on-site data as the WHS; however, LIWHS applies the "efficient – unknown room" HOU (hours of use) default value instead of the room location HOU, in the savings calculation. The LIWHS solution also applies the TRM deemed 92% ISR. The Multifamily Targeted Sector Solution applies the "standard – unknown room" HOU for all rooms as well as the 92% ISR. The Multifamily Targeted Sector Solution does not collect information on the room type for directly installed lightbulbs, based on the project file documentation provided. Baseline wattage data from the removed bulbs are not collected by any of solutions.[59]

> **Recommendation:** Apply uniform calculation methodology for identical measures in different solutions. Apply a standard direct install ISR rate for all measures installed by on-site technicians. Apply uniform data collection principals, including capturing room-level data for the MF Target Solution. The SWE recommends that CSP's collect data on baseline wattage of replaced bulbs for direct install measures. This will lead to increased accuracy in reported and verified savings, while minimizing discrepancies between baseline wattages that were occasionally observed during the project file review.

The SWE recommends that Navigant clarify in future evaluation plans which open variables will be verified and which open variables will rely on TRM defaults, along with an explanation of why TRM defaults are used if EDC data gathering is available. The SWE notes that Navigant's EM&V plan for PECO (approved by the SWE) provides a summary for verifying as many open variables as possible during their savings verification activities, but does not specify the variables:

> "For partially deemed measures, evaluation activities include verification of measure installation, quantity, and the correct use of TRM protocols; verification of open variables, which may entail confirming nameplate data; facility staff interviews; or measurements of

[58] Navigant addresses this discrepancy in the verified savings review and realization rate calculations.
[59] Navigant reported to the SWE that this is primarily due to different CSP's implementing the different solutions that include directly installed lighting measures. Navigant also identified the inconsistent lighting calculation methodologies between solutions and provided their findings in the PY9 Final Report.

the variable(s). Evaluators will attempt to verify as many open values in the TRM algorithm as possible with the customer-specific or program-specific information gathered through evaluation efforts."

However, the SWE identified several cases in which EDC data gathering was possible but TRM defaults were used.[60] This is not to be confused for cases in which TRM defaults are used in the tracking data but updated with EDC-gathered data, as is the case for Appliance Recycling, during the verified savings calculations.

Recommendation: The SWE recommends that Navigant specify in its evaluation plans which open variables will be verified and which open variables will rely on TRM defaults, which will help clarify savings calculations and improve the efficiency of SWE reviews. Applying EDC collected data to the open variables will increase accuracy of the savings calculations. The SWE notes that the TRM recommends using EDC gathered data when available, and to use the TRM default value in cases that EDC data collection is not feasible. The SWE also recognizes that there are challenges/limitations to collecting information for all "open" variables.

The organization of the project file packages at times were not conducive for conducting project file reviews for specific solutions. There were quarterly uploads which included multiple solutions in one folder, causing the SWE to spend time determining which solution a project file belonged to. The SWE notes that this was more of an issue in the first three quarters of PY9 and was improved in the fourth quarter upload.

Recommendation: The project files are currently uploaded into folders by the implementation subcontractor that is responsible for a given solution. The SWE recommends that moving forward in PY10, that quarterly data submissions are uploaded in a structure that breaks it out by solution, rather than the implementation subcontractor.

B.3.2.2 Non-Residential

As part of its audit process, the SWE conducts a review of ex-ante savings. This review involves assessing specific project files for a sample of PECO's non-residential solutions in PY9. Project file documentation is provided each quarter of the program year by PECO, the program implementors, and the evaluation contractor, Navigant to the SWE. Project documentation provided typically includes program rebate applications and approvals, invoices for installed equipment, equipment specification or "cut" sheets, post-inspection forms, and calculation workbooks. The SWE reviews these documents for completeness and consistency. The SWE also compares the data points in the documentation against the program tracking database to ensure values such as savings, rebate amounts, installation, approval, and invoice dates align.

Table 93 presents a summary of SWE's non-residential project file reviews. Generally, the SWE found most of the project file packages for sampled projects to be complete. Most solutions provided a data key that allowed for easy identification of project file packages, especially for

[60] For example, number of Persons and the number of faucets/showerheads for the Whole Home Solution and "efficient – unknown room" HOU (hours of use) rather than the specific room in which direct install lighting is installed for Low-Income Whole Home Solution.

solutions that participate in both the residential and non-residential sectors. However, deficiencies were identified for certain program solutions due to either misaligned values between the quarterly program tracking data and project documentation or due to a lack of project documentation. Also note that very few solutions provided the TRM reference in the quarterly tracking data. This made TRM algorithms that were presented in both the tracking data and project files difficult to verify. Each solution is discussed in detail below.

Table 93: PECO PY9 Residential Project File Review Summary Checklist

Program	Solution	Number of files reviewed	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data?[1]
Small C&I	Equipment & Systems	4	✓	✓	✓	✓
Small C&I	New Construction	4	✓	✓	✓	✓
Small C&I	Whole Building	2	×	✓	✓	✓
Small C&I	Multifamily Targeted Segment	4	✓	×	✓	✓
Large C&I	Equipment & Systems	4	✓	✓	✓	✓
Large C&I	New Construction	4	✓	✓	✓	✓
Large C&I	Data Centers	4	✓	×	✓	✓
Large C&I	Multifamily Targeted Segment	4	✓	×	✓	✓

[1] Minor discrepancies were found and are detailed in the paragraphs below.

Equipment & Systems (E&S) Solution

The E&S solution incents a wide range of measures; however, the solution saw primarily lighting retrofits in PY9. The SWE completed reviews on a sample of eight projects across the Small and Large C&I programs. The eight projects were selected as a random sub-sample of each quarterly sample. Six of the eight samples were lighting retrofits, including screw-in and general service lighting, exterior lighting, and street lighting. The remaining two samples included a chiller optimization and a variable speed motor for a compressed air application.

The SWE found the project file packages for most of these projects to be very thorough. All project file packages contained enough information to understand the basic scope of work. Additionally, two projects' documentation was enhanced by the inclusion of standalone files that provided context for the projects and/or a summary of the scope of work. However, one project provided little context and the scope of the project could only be determined through the included calculator workbook.

Projects that relied on TRM algorithms generally included documentation that cited the input parameters used to calculate savings. One case was observed in which the tracker listed erroneous hours of use in the algorithm yet the project savings in the tracker were aligned correctly with the project documentation. In another instance for a project that provided very little documentation, the SWE was unable to determine from where the TRM algorithm parameters were sourced.

Two common deficiencies noted by the SWE while reviewing the project files included misaligned values, including dates, rebate value, or savings values between project documentation and the quarterly project tracker data. The SWE could not reconcile either the invoice or install dates for four projects nor the rebate value for two projects and the savings value for one project. One project provided a rebate approval date that predated the invoice dates from the quarterly tracking data and the actual project invoice. There was also a consistent lack of baseline data or documentation. Only two of the eight projects reviewed provided documentation on baseline conditions. While the SWE understands the difficulty in capturing baseline documentation from participants, especially in the case of lighting retrofits in which old equipment is typically disposed, assumptions and/or rationale for baseline conditions should be provided in project documentation.

New Construction Solution

The SWE reviewed eight projects from various non-residential segments covering multiple measure types within the New Construction solution. The SWE found the project files to be very comprehensive, including COMCheck forms, building plans, certificates of occupancy, invoices, measure spec sheets, and applications. Dates matched the tracking data except for the invoice date for three of the eight projects reviewed. Savings in the tracking data also aligned with the included calculator workbooks (primarily provided for lighting savings).

Due to the large amount of documentation, the project file packages would benefit from clearer explanation for which measures were rebated and the files that specifically apply to those rebated measures. Some files appeared superfluous or even sometimes erroneous (e.g., a COMCheck file for a grocery store was included a project file package for a school). The project file packages would greatly be improved with the inclusion of a brief project summary identifying relevant measures and documentation.

Whole Building Solution

The SWE's review of the sampled project files for the Whole Building solution found areas of the reporting that need improvement. No files were provided for the first quarter and while files were provided for the fourth quarter, the data key provided the measure number rather than the project number. While the project number could be identified through the tracking data, the actual project file package could not. Hence, project files for only the second and third quarters could be reviewed by the SWE.

The project files for the Whole Building Solution were aggregated into a single file comprised of the PECO Financial Summary, Construction Report, Safety Checklist, Construction Audit, Material Worksheet, and Disposal Report. Additional information that was sometimes provided included pre-installation photos and documentation of baseline conditions were provided along with the program invoice and spec sheets of installed retrofit equipment. This documentation was supplemented by calculation workbooks.

For the first of the reviewed projects, the SWE found the savings value between the documentation and tracking data to be different; however, the savings discrepancy was less than 1%. The second reviewed project provided two Financial Summaries in the project documentation. It is unclear why both summaries were provided, but the SWE believes one summary was a prior submittal that was later updated with new wattage values. This particular project also had erroneous entries in the Appendix C lighting calculator. Space types for refrigeration and freezers were included in the calculator yet the project files made no mention of retrofits to such spaces. The calculator ultimately reported savings that were two kilowatt-hours less than the value listed in the tracking data and the Financial Summary.

Multifamily Targeted Segment Solution

The Multifamily Targeted Segment project files consisted of the implementor's Efficiency Manager report with on-site notes. While the report matches the dates, savings, and rebates listed in the tracking data, the SWE found the reports to be very limited as only a small portion of total measures installed in the facility are listed in each Efficiency Manager report. Moreover, of the eight reports reviewed by the SWE, all measures detailed were installed in units within the facility and used residential TRM algorithms as opposed to measures installed in the common areas.

Unlike the other solutions' project documentation, the Multifamily Targeted Segment project files did not include invoices, spec sheets, or savings calculation workbooks. Moreover, no baseline data was provided.

Data Centers Solution

The SWE reviewed four of the five data center projects submitted in the quarterly samples. Each of these reviewed projects were custom and did not follow any specific TRM algorithm. Two of the four project file packages reviewed did include detailed calculation workbooks that provided clear baseline data and conditions. The scope for these two projects were clearly understood by the SWE. However, one of these projects did not have matching savings estimates between the calculation workbook and the tracking data. The tracking data savings value was 21% higher than the savings listed in the calculation workbook.

The remaining two data center project file packages did not provide any calculation workbooks nor was there any reported savings values listed in the project file package. Hence, the SWE

could not verify if the reported savings matched the value populated in the tracking data. The SWE was able to generally understand the scope of work based on the cut sheets provided for these two projects. Finally, three of the four projects reviewed did not have matching invoice dates and one did not have a matching rebate value between the tracking data and the project documentation.

During its file review, the SWE observed that several projects have misaligned values between the tracking data versus the project documentation. Most common was misaligned invoice dates some of which referenced different years. Installation dates, rebate values, and savings values were also observed to be misaligned for some projects.

> **Recommendation:** Identify key parameters, information, and data on submitted project documentation. This is already being performed on application approvals and invoices to identify updated or corrected rebate values and to identify the relevant materials listed on the invoice. Other key items, such as dates and savings values, should similarly be highlighted on project files.

Certain projects are complex and/or large and often contain project files, which may or may not be directly related to estimating program impacts. The SWE could much better navigate these file packages in cases where the implementer provided a brief project summary.

> **Recommendation:** The SWE recommends project file packages include a project summary that articulates the type of facility being upgraded, the quantity and type of measures installed, the pertinent dates and/or milestones of the project (install date, approval date, invoice date, etc.), project cost and rebate/incentive value, and reported savings. Additionally, the project summary should cite the documentation from which these data are sourced so the SWE can review the appropriate files in the package.

The SWE observed that very few of the project file packages reviewed contained any documentation of the baseline conditions. However, baseline values are assumed when estimating impacts with little to no explanation for how the assumptions were derived.

> **Recommendation:** The SWE recommends baseline data and documentation be included as part of the rebate application process. Having these data available will greatly assist evaluation efforts, strengthen input assumptions in the TRM, and ultimately make the reported savings more reliable. In cases where baseline data or documentation are not available, the program implementer should document its assumptions for selecting baseline conditions.

The content of the project file packages for each program solution varied significantly. While some solutions provided numerous documents, all of which are not pertinent, other solutions provided minimal content.

> **Recommendation:** Solutions should establish more consistent documentation and reporting criteria. Doing so will better ensure projects have the necessary data and information needed to complete a thorough evaluation.

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 the Residential 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.

The SWE found discrepancies in the application of TRM algorithms for the Multifamily Targeted Market Segment, Whole Home Solution, Low-Income Whole Home Solution, and the Residential Upstream Lighting Solution that impacted the verified savings reported in PECO's PY9 Annual Report. Overall, PECO's PY9 Annual Report underestimated verified savings by 2,132 MWh, or 0.55% of portfolio savings. The SWE observed that the evaluation for the New Construction Solution deviated from the TRM protocols as well. Table 56 provides a summary of the evaluation and M&V approaches used by PECO in their PY9 verified savings calculations. Table 94 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 the SWE adjusted verified savings in the PY9 Annual Report but that cumulatively all the discrepancies are less than 1% of portfolio savings and can be corrected in EDC reporting beginning in PY10.[61]

[61] 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 94: Residential Program Evaluation Activities (by Solution) – PECO

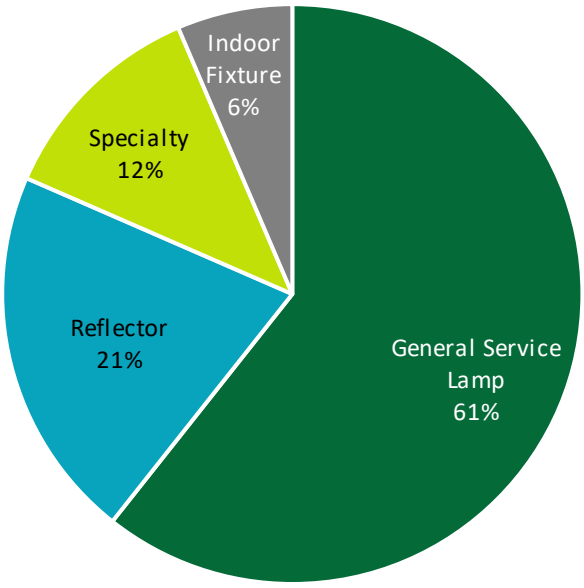
Solution	Surveys	Site Visits	Desk Review[a]	Billing Analysis	Applied PY8 RR
Lighting, Appliances and HVAC Solution	✓	--	✓	--	--
Appliance Recycling Solution	✓	--	✓	--	--
Whole Home Solution	✓	✓	--	--	--
New Construction Solution	--	--	✓	--	--
Multifamily Targeted Market Segment	✓	✓	✓	--	--
Behavioral solution	--	--	--	✓	--
LI – Whole Homes	✓	✓	--	--	--
LI – Lighting	--	--	✓	--	--

[a] The Desk Review Column includes database reviews, application reviews, and engineering desk reviews; or a combination of these activities.

B.4.1.1 Upstream Lighting & Cross-Sector Sales

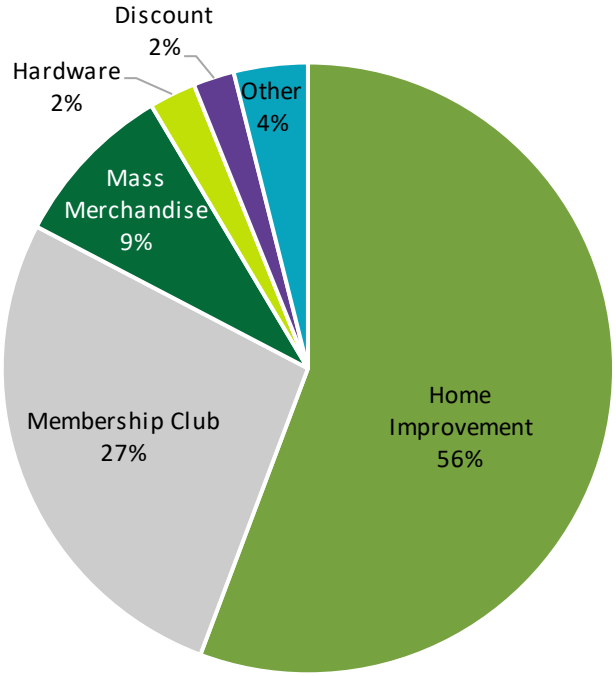
Customers purchased over 2.9 million efficient light bulbs and fixtures through PECO's PY9 upstream lighting program. Figure 38 displays the distribution of sales by product type. Over one-half (61%) of the products were general service lamps, while over one-fifth (21%) were reflectors.

Figure 38: PECO PY9 Upstream Lighting Sales by Product Type



Over four-fifths (83%) of PECO's PY9 upstream light bulbs and fixtures were sold through home improvement stores and membership clubs (Figure 39).

Figure 39: PECO PY9 Upstream Lighting Sales by Retail Channel



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 generally agrees with Navigant's verified gross savings for upstream lighting but has adjusted verified savings for the errors detailed below.

The SWE observed 912 unique lighting model numbers in the PY9 tracking system and was able to locate 903 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The nine models the SWE was not able to verify as ENERGY STAR certified represent less than 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 description, wattage, and/or lumens for 21 models, but it is unclear if these discrepancies are due to rounding, errors in the PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes.

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 five models. In these cases, the ENERGY STAR qualified products lists indicate that

these were EISA-exempt three-way bulbs, but Navigant utilized the EISA-compliant baseline. Overall, verified savings were overestimated by 260 MWh. The impact of the discrepancies the SWE identified on portfolio-level savings is minor, less than 0.1%.

Cross-Sector Sales

Navigant did not conduct cross-sector sales research in PY9. Navigant applied the PY8 cross-sector sales rates of 0.73% for standard LEDs and 2.0% for specialty LEDs. In both PY8 and PY9, Navigant applied the correct commercial coincidence factor and HOU for all building types except for one that is not listed in Table 3-5 of the TRM: “electrical contractor”.

Recommendations

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

- Utilize the EISA-exempt baseline wattage for three-way bulbs.

In addition, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- For cross-sector sales, utilize the HOU and coincidence factor for Miscellaneous/Other for building types not listed in Table 3-5, such as ‘electrical contractor.’

B.4.1.2 Residential Non-Lighting

The SWE’s review of verified savings for residential non-lighting and non-HER solutions found that, overall, the verified savings followed proper TRM protocols and that most of the verified savings are accurate. However, the SWE found discrepancies in the application of TRM algorithms for several solutions that resulted in underestimated verified savings of 2,132 MWh - or 0.55% of portfolio savings - in PECO’s PY9 Annual Report.

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, central A/C maintenance, ductless mini-split heat pumps, and ECM furnace fans. 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 included ENERGY STAR Air Purifiers, Clothes Washers, Dehumidifiers, and Refrigerators. The SWE determined that sample sizes were largely correct, savings were calculated in accordance with TRM protocols, and that realization rates were properly calculated and applied for the most part.

The SWE did find one error in verifying the savings for refrigerators. One (of nine) sampled refrigerators used in verification was found to have had its savings under-reported. When this was adjusted, the SWE calculated a revised realization rate of 1.06, compared to 1.0 calculated by the EDC evaluator, Navigant. With this new realization rate applied to the population savings, the

SWE determined that the refrigerator savings had been under-reported by 9,241 kWh. With this new realization rates, refrigerator kWh savings increase from 154,020 kWh to 163,261 kWh, while full LAH savings increase from 5,404,412 to 5,413,653 kWh. On the demand side, this correction increased demand reductions for refrigerator appliances (17.25 kW to 18.29 kW) and increased demand reductions for the entire program (2,126.03 kW to 2,127.07 kW).

Appliance Recycling Solution

The SWE audited verified gross savings for all measures covered under the Appliance Recycling Solution, including refrigerators, freezers, and room air conditioners. Overall, the audit showed that the proper TRM calculations and protocols were used, and verified savings were correct for all measures. For room air conditioner retirement, TRM default capacities based on location were used, as approved in the evaluation plan, but recorded capacities were also available in the data that could have been used to more accurately represent savings. Using default values over gathered capacity data, along with default (C)EER values, resulted in verified savings that were 18% higher than if gathered capacity data were used. The SWE also found that the sample sizes presented in the annual request data were much larger than the achieved sample size included in the PY9 annual report. The SWE confirmed with Navigant that the reported sample size was an error and that the achieved sample size matched that reported in the annual data request.

Whole Home Solution

The SWE audited the verified savings for all measures sampled in the Whole Home Solution evaluation. The SWE observed the interactive effects variable used an incorrect cell reference, which resulted in a discrepancy in verified energy and demand savings. The SWE also discovered a few of the sampled projects had verified savings discrepancies between the sampled sites calculation workbook and the savings rollup workbook. The SWE adjusted the solution-level savings to account for these discrepancies and determined the verified savings were over-reported by 157 MWh and demand savings were over-reported by 0.02 MW.

The SWE consulted with PECO's evaluator, Navigant, to address these discrepancies and other remaining questions which resulted from the audit. The primary question involved how the sample of on-site visits only verified a portion of the measures included in the reported savings, which Navigant was able to resolve. The SWE recommends verifying correct TRM variables, ensuring correct transcriptions between workbooks, and including notes to identify the source of hardcoded values. The SWE also recommends verifying all reported measures are installed during on-site visits and clearly note why a measure was unable to be verified.

New Home Solution

In accordance with the program's evaluation plan, the New Construction Solution was evaluated in PY9. The evaluation plan stated a full population review of REM/Rate files was to be conducted for PY9; however, a sample of 66 files were reviewed due to difficulties obtaining all the program participant files from the CSP. The SWE discovered that non-weather sensitive measures (lighting, appliances, and water heating) were not removed from the energy model savings results and were not recalculated using measure-level equations provided in the TRM for either reported savings or verified savings.

The SWE noted this issue based on the PY9 project file review and the verified savings review for the PY8 annual report. It should be noted that an evaluation of the New Construction Solution did not occur in PY8; however, the SWE recommended that the evaluation in PY9 remove the modeled non-weather sensitive measures and recalculate the savings per the TRM.

The SWE notes that the New Construction solution is the smallest program in PECO's energy-efficiency portfolio and only warranted a low-rigor evaluation.

Multifamily Targeted Market Segment

The Multifamily Targeted Market Segment provided low-flow faucet aerators; low-flow showerheads; ENERGY Star LED bulbs; and some additional measures, such as smart strips and insulation. The evaluator conducted site visits at a sample of projects with large savings to verify that installations took place and conducted engineering desk reviews for a sample of projects across all savings strata. The SWE determined the sample sizes and population sizes were correct.

The SWE found errors in the verified savings calculations of the sampled population that was used to determine the realization rate for the residential and C&I carveouts of the Multifamily Targeted Market Segment. Light bulbs that were directly installed included room-level data for each sampled project. The verified savings calculations weighted the quantity of bulbs installed in the room by the hours of use (HOU) indicated in the TRM. The SWE determined that most of the HOU used for each project did not match the TRM specifications and did not match the SWE's recreated weighted HOU calculations. This also had an impact on the coincidence factor variable used to calculate demand savings. The SWE informed Navigant of these calculation errors and Navigant responded by resubmitting corrected workbooks for the SWE to review.

The SWE recalculated the program savings after adjusting the HOU values. The revised savings resulted in an adjustment to the realization rate from 0.81 to 0.96, which increased the residential portion of program savings by 16% (from 2,828 MWh to 3,360 MWh). The verified demand savings were also impacted due to this error. The realization rate for demand savings adjusts from 0.72 to 0.90 after the correction and increased the residential portion of verified program demand savings by 19% (from 0.32 MW to 0.40 MWh).

Low-Income Whole Home Solution

The Low-Income Whole Home Solution (LI-WHS) 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. 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 minor errors in the calculations of the sampled population used to determine the realization rate for solution-level verified savings. These errors were limited to the calculation of both energy and demand savings for LI-WHS lighting, and demand savings for LI-WHS water

heaters. For lighting, the SWE found that the HOU used to determine kWh savings were incorrectly applied. The verified savings calculations used an HOU of 2.3 for all bulb types. Per the TRM, the HOU should be 3.0 when over 90% of the bulbs in the home are replaced, as should have been done in the solution. The TRM also gives a value of 12 for the HOU to be used for nightlights, but the verified savings calculations also used 2.3. For demand savings, the TRM CF value for night lights is 0, which was correctly applied, but the CF for all other bulbs is deemed 0.106. The verified savings calculations incorrectly used a value of 0.064 as the CF in calculating demand savings. These errors resulted in underreporting of verified energy (1,557 MWh) and demand savings for lighting and the LI-WHS solution by 0.2 MW.

The SWE also found an error in the calculation used to determine the demand savings for water heaters verified in the LI-WHS program. Due the formula being incorrectly applied, the demand savings from two verified water heaters were off by a large margin. Specifically, an incorrectly placed parenthesis resulted in an additional term being incorrectly included in the denominator. The space for the water heaters was also identified as unconditioned basement, but the formula used the conditioned space for the F_derate term in the equation. This resulted in a decrease of roughly 0.9 MW in the verified demand savings. The SWE recommends further vetting to ensure that TRM formulas are properly applied in PY10.

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 determined it is a reasonable approach.

B.4.1.3 Behavior

Approximately 20% of the PY9 verified gross energy savings listed in PECO's Annual Report came from Home Energy Reports issued to over 400,000 households. PECO was among the most HER-reliant EDC for portfolio savings in PY9 but did not claim HER energy savings towards its low-income compliance target. PECO's behavioral solution consists of the seven different waves, or cohorts, of homes summarized in Table 95. Home counts are rounded to the nearest thousand and represent the number of active households at the beginning of PY9.

Table 95: PECO HER Cohort Summary

Wave	First HER Mailing	Treatment Group Homes	Control Group Homes	Notes
Wave 1	August 2013	29,000	18,000	
Wave 2	March 2014	35,000	15,000	High usage homes
Wave 3	June 2015	61,000	18,000	
Wave 4	June 2016	201,000	18,000	
Wave 5 Electric	June 2017	32,000	13,000	
Wave 5 Dual Fuel	June 2017	18,000	7,000	
AC Saver	June 2016	38,000	33,000	All residential DR participants

The program ICSP Oracle implemented Waves 1-5 as randomized control trials where the eligible households were identified and then randomly assigned to either a treatment or control group. Wave 5, though randomized in the same manner as the previous waves, has been split into Electric Heat and Dual Fuel sub-cohorts. Following randomization, Navigant conducted statistical tests on participant billing data and confirmed that Wave 5's pre-treatment energy usage patterns were similar for the treatment and control group. After the randomization occurred, treatment and control group customers were split into the Electric and Dual Fuel groups. Splitting these groups provides further insight into the types of savings without affecting the overall MWh impact.

The AC Saver wave was not an RCT. This wave 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 experimental design for both the RCT and the AC Saver waves, regression-based HER savings estimates, and recipient household counts using data provided by Navigant. The SWE first used Navigant's data and regression model to confirm the savings estimates provided by Navigant. Second, the SWE independently constructed the cleaned data by following the procedures indicated by Navigant. This data was then used to estimate the savings, shown in Table 96, which matched Navigant's estimates. For comparison across waves, the average annual kWh savings per home and the average percent savings attributed to the behavioral program are provided. Average values in the Total row are calculated using a weighted average of the number of PY9 homes and the estimated impact of each wave.

Table 96: PY9 HER Energy Savings Before Dual Participation Adjustment

Wave	PY9 MWh	Average kWh per Home	Average Percent Savings
1	8,115	295	1.7%
2	15,975	467	1.9%
3	18,228	309	1.9%
4	30,158	155	1.3%
5 – Electric	4,108	142	1.1%
5 – Dual Fuel	1,741	104	0.9%
AC Saver	5,222	141	1.6%
Total	**83,548**	**210**	**1.5%**

Wave 5 Aggregate Impacts

Wave 5, unlike the previous waves, is split into separate cohorts of electrically heated and fossil fuel (Dual Fuel) heated households. HER mailings to the treatment group homes began in June 2017. To estimate impacts specifically for PY9, the data set was restricted to months in PY9 by using billing periods that ended between June 1, 2017 and May 31, 2018.

The regression model that Navigant utilized estimates the average daily savings during the PY9 period. Despite attrition in customer counts, PY9 impacts from Waves 1 through 4 and the AC Saver cohort increased from their respective PY8 levels. The Wave 5 cohorts showed the lowest annual savings estimates and percent impacts in PY9. The Dual Fuel program resulted in about 0.9% decrease in energy use and the Electric program showed a 1.1% decrease in usage between the treatment and control groups. The electric group saved more on both a relative and absolute basis, but the relative savings are very close. Savings are expected to grow with time as the treated customers internalize and implement savings strategies from the HER reports.

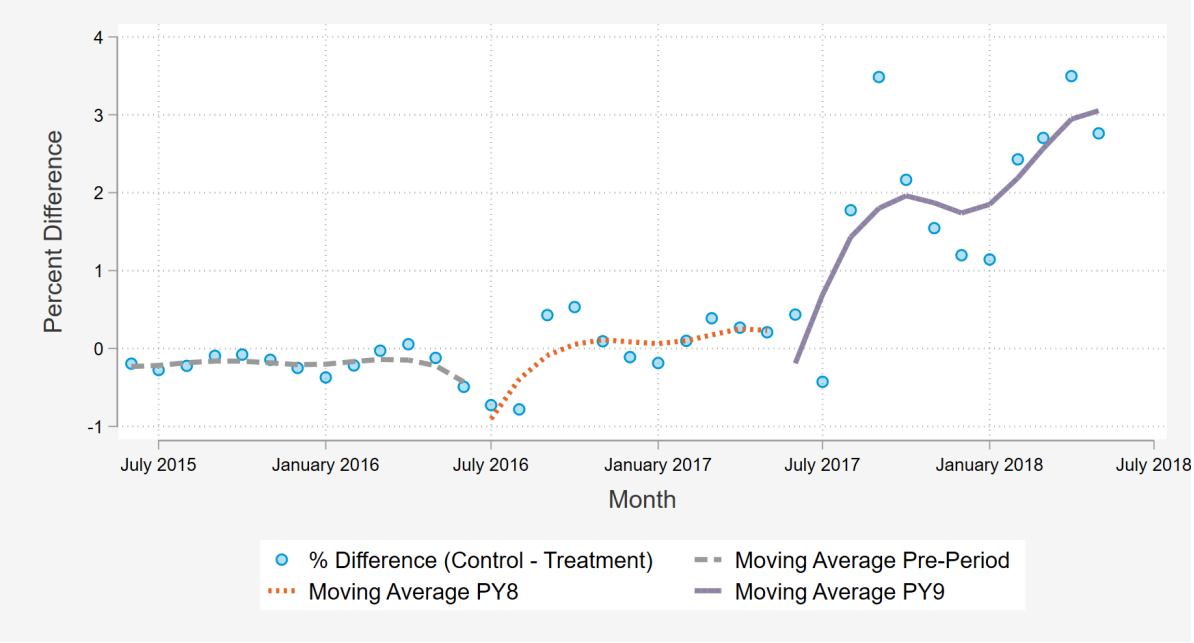
AC Saver Matched Control Group

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 1-5 because Navigant needed to create a control group via matching. They used Euclidian distance matching with replacement to select the PECO residential account that most closely resembled the energy usage of AC Saver participants from June 2015 through May 2016. The homes eligible for matching do not receive HERs from PECO. “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.

In PY8, the SWE’s audit uncovered a data management issue in the application of weights from the matching. This issue has been appropriately mitigated and the matching and regression processes for PY9 were sound. Navigant used a technique called frequency weighting in their model to account for the controls that are a best match for more than one treatment. For example, if a control group home was the best match for six treatment group homes, their billing data is weighted six times in the analysis model.

Figure 40 shows the monthly percent difference in average kWh usage between the treatment and matched control group prior to treatment and since the beginning of HER exposure. The matches were reasonably good. The treatment group used slightly more energy than the matched control group, on average, but the difference is less than 1% for most months of the pre-period. The treatment effect for this cohort is somewhat erratic by season with little or no savings in summer months and large savings in the winter and shoulder months. However, the average treatment effect over PY9 was 0.39 kWh per day with good statistical significance.

Figure 40: AC Saver Percent Impacts over Time



Dual Participation

In Table 96, calculated savings were 83,548 MWh. It is important to note that Home Energy Reports advertise other residential EE&C programs and measures, such as ENERGY STAR appliances, efficient lighting, HVAC, etc. If a household participates in one of those solutions, the savings from that participation is counted by the specific program but is also captured in the regression estimates for the HER analysis. To avoid double-counting, the HER savings are reduced to account for the incremental program participation observed in the treatment group compared to the control group. Participation is not tracked for upstream lighting, so PECO used the default reduction percentages for each wave, by age, to arrive at the gross verified savings of 78,396 MWh.

Peak Demand Impacts

Using the flat load shape assumption that assumes savings occur equally in each hour of the year, Navigant calculated gross verified demand savings of 8.95 MW for the Behavioral Solution.

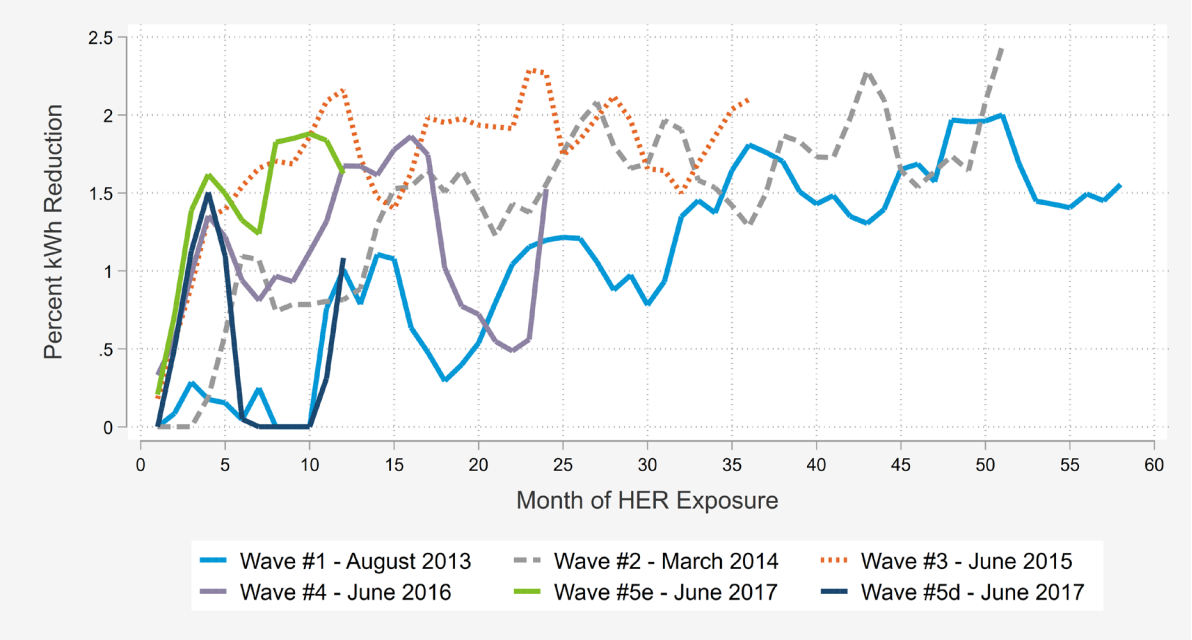
$$Verified\ MW\ Savings = \frac{78{,}396\ MWh}{8{,}760\ hours} = 8.95\ MW$$

The SWE agrees with the value.

Conclusion

Trends over time for each of the six RCT waves can be seen in Figure 41. Both new waves exhibit a sharp increase in the first three months, like Waves 3 and 4. Although the trends exhibit seasonal patterns and noise, the mature cohorts seem to stabilize between 1.5% and 2.0% savings. AC Saver, as shown in Figure 40, shows slow initial savings, but slightly higher impacts for the PY9 evaluation period relative to the RCT waves.

Figure 41: Percent Impacts Over Time



The SWE was able to independently replicate the energy and demand impacts provided by Navigant in the PY9 annual report to within 0.06%. This minor difference can be attributed differences in data cleaning procedures and logic for counting active participants.

B.4.2 Non-Residential Audit Activities

As noted in Section 3.1, PECO's non-residential portfolio consists of the Combined Heat and Power (CHP) program and five solutions within the Small C&I and Large C&I programs:

- Equipment & Systems
- Data Centers
- New Construction
- Whole House
- Multifamily

The SWE conducted various review and audit activities of the program solutions. These activities included a review of the evaluation efforts and an audit of the savings verification completed by PECO's evaluation contractor, Navigant Consulting (Navigant). Additionally, the SWE reviewed

project files used by PECO's program implementers to assess the reported savings. The remainder of this section presents the SWE's findings from these activities.

Navigant used multiple approaches to verify the gross impact estimates for each non-residential program. This section discusses the results of the SWE's review of Navigant's approach in applying various levels of rigor to assessing and estimating project impacts from their evaluation sample. The SWE completed this review based on evaluation sample population extracts provided by Navigant, which detailed how each sampled project was evaluated regarding evaluation activity and measurement and verification (M&V) approach. The purpose of this review is to affirm that the evaluator conducted the evaluation in compliance with the EM&V framework and followed the approved evaluation plan. Table 97 presents the list of evaluation activities and M&V approaches by project count.

Table 97: PECO Evaluation Activities by Project Count

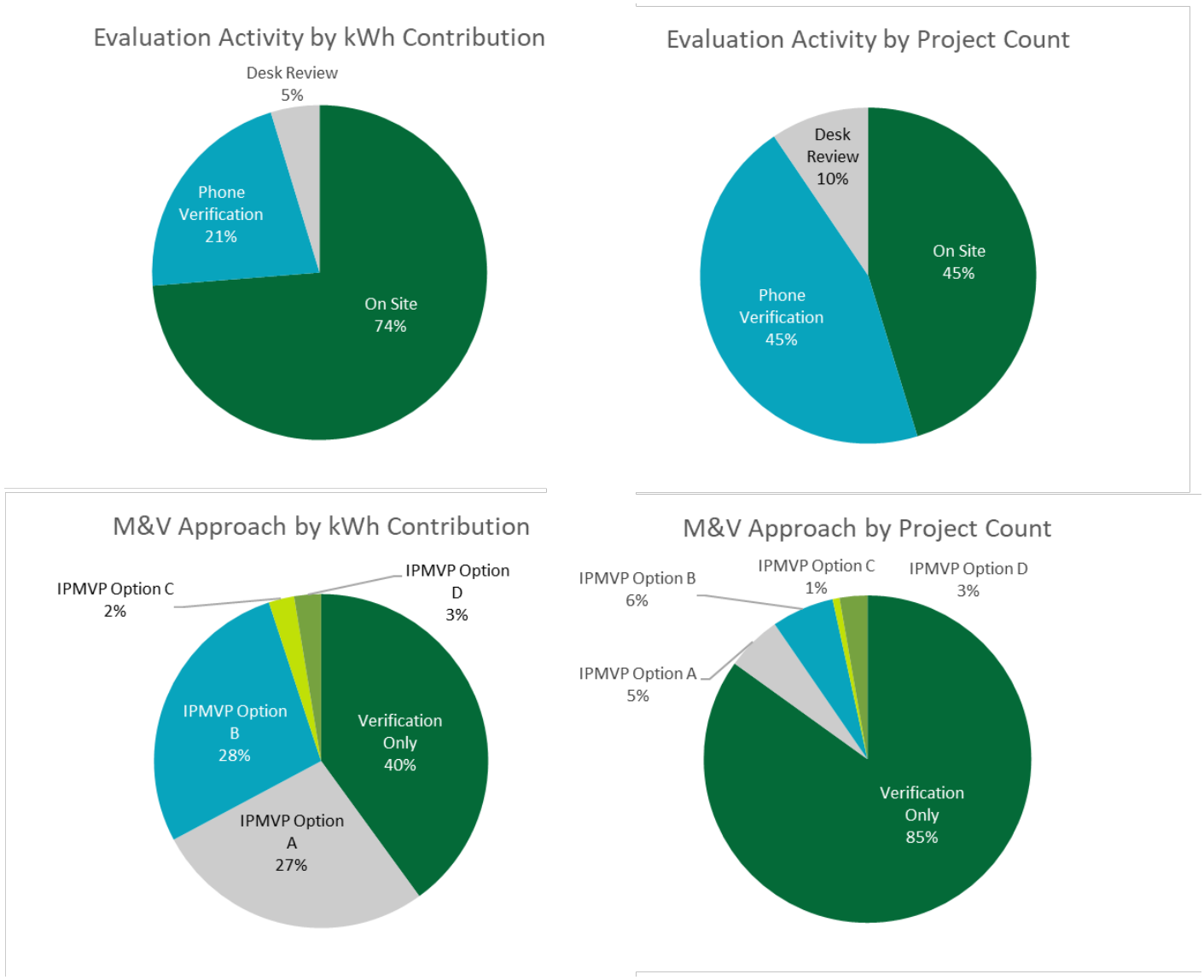
Program / Solution	Sample Quantity	RR–Energy	Desk Review Only	Phone Verification	On-Site Verification	IPMVP A	IPMVP B	IPMVP C	IPMVP D
Small C&I	**90**	**96%**	**6**	**48**	**34**	**2**	**-**	**-**	**-**
Equipment & Systems	41	98%	6	29	5	1	-	-	-
New Construction	1*	103%	-	-	-	1	-	-	-
Multifamily	14	62%	-	-	14	-	-	-	-
Whole Building	34	101%	-	19	15	-	-	-	-
Large C&I	**56**	**96%**	**7**	**17**	**11**	**7**	**9**	**1**	**4**
Equipment & Systems	35	96%	3	12	3	7	8	1	1
New Construction	11*	103%	3	5	-	-	-	-	3
Multifamily	7	89%	-	-	7	-	-	-	-
Data Centers	3	99%	1	-	1	-	1	-	-
Combined Heat & Power	**2**	**114%**	**-**	**-**	**-**	**-**	**2****	**-**	**-**
Total	**148**		**13**	**65**	**45**	**9**	**11**	**1**	**4**

*Represents PY9 sample of two-year combined PY8 and PY9 sample. Ex post verification for the two-year sample consisted of eight Small C&I New Construction project and 21 Large C&I New Construction projects.
**Metering conducted by participant; Navigant conducted a site verification visit and used the participant's metered data to complete the impact analysis.

Figure 42 provides a summary of the evaluation activities and M&V approaches utilized by Navigant for the PY9 verified savings calculations across the non-residential portfolio. Each figure reflects evaluation activities for all programs and solutions combined. Evaluation activities were roughly equal between site visits and phone verification and/or desk reviews. The site visits were heavily weighted to larger projects within the evaluation sample and accounted for almost three quarters of total reported savings. Navigant predominantly used verification only as its M&V approach; however, Navigant did target IPMVP M&V approaches for the larger projects and

verified over half of the reported project savings using metering methods. Similar to their approach used in PY8, Navigant reserved IPMVP Options A and B for primarily projects in the Large C&I Equipment & Systems Solution Program.

Figure 42: Summary of PECO's C&I Evaluation Activities



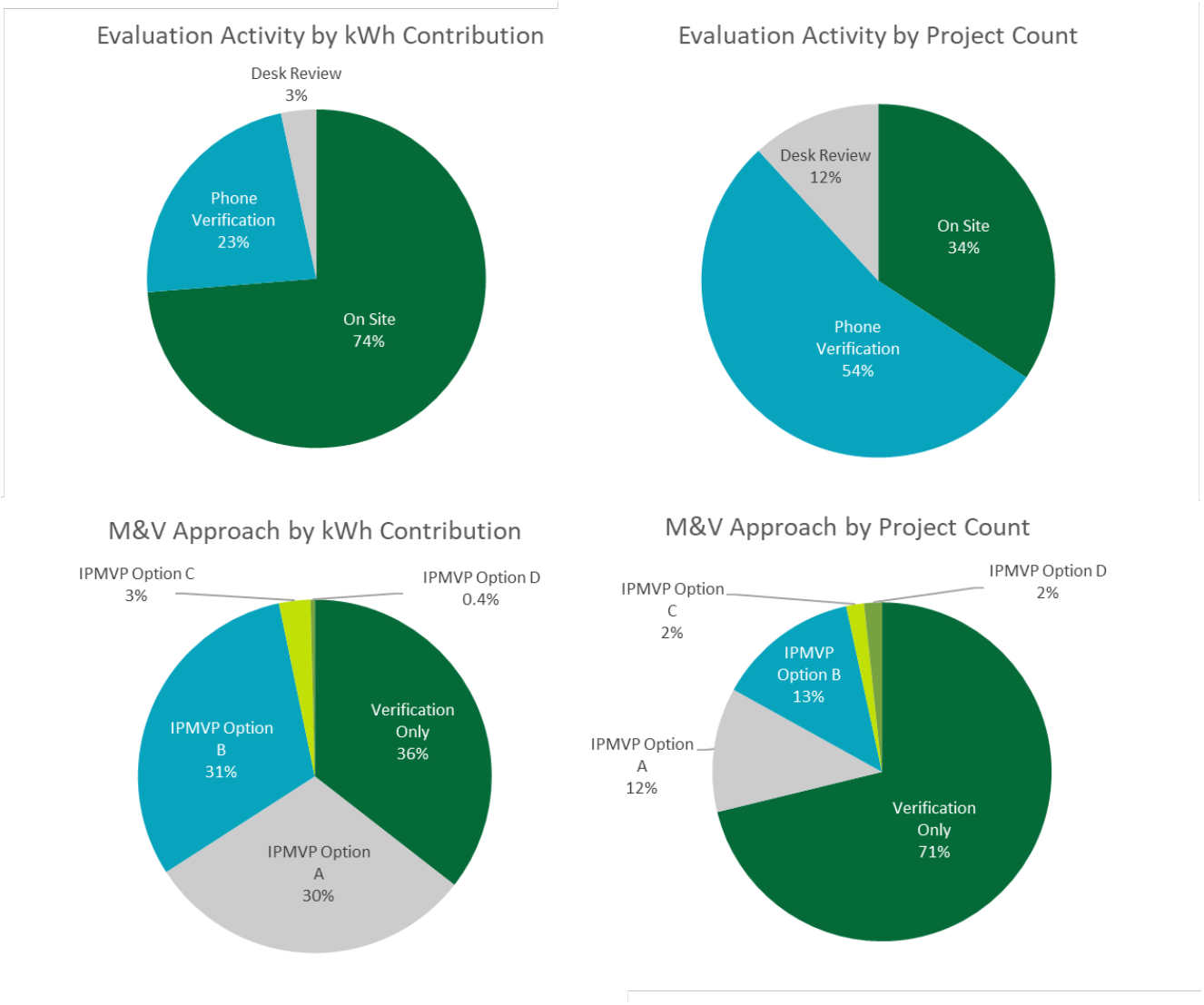
B.4.2.1 Equipment & Systems

The Equipment & Systems (E&S) solution comprised the vast majority of energy savings within the PECO non-residential portfolio accounting for over three quarters of the reported and verified savings. Navigant derived a sample of 76 projects from the Large and Small C&I programs and allocated to four strata: Very High Impact, High Impact, Medium Impact, and Small Impact. Navigant's evaluation strategy for these programs used IPMVP approaches as illustrated in Figure 43. Navigant evaluated approximately 14% of the program sample using IPMVP methods; this accounted for almost two thirds of program savings. Site visits accounted for approximately

one third of all evaluation activity while the balance was comprised of phone verification and desk reviews.

The majority of evaluated projects in Navigant's sample were lighting improvements. Per direction of the 2016 Pennsylvania TRM, any non-residential lighting retrofit that exceeds 750,000 kWh reported savings is required to be evaluated using on-site metering. Navigant's sample included 11 projects that met this threshold; however, for one site Navigant did not complete on-site metering and it is not clear if Navigant received any trend data from the customer to use in lieu of metering data.

Figure 43: Summary of PECO's E&S Evaluation Activities



As noted above, Navigant developed multiple strata defined by project savings in order to develop a sampling design for the E&S program. The strata categories included Very High Impact, High Impact, Medium Impact, and Small Impact projects. While the PECO evaluation report defines the savings boundary for each stratum, the SWE's review of Navigant's sampling files presents a

slight discrepancy in the defined savings boundaries for the Small C&I High Impact stratum and the Large C&I Medium stratum. Consequently, the SWE identified two samples in the Small C&I Medium stratum that should have been allocated to the Large stratum. Despite the erroneous stratum boundary identified in the Large C&I, the SWE did not find any misallocated samples.

Figure 44 and Figure 45 presents the M&V approach used by Navigant for each stratum based on project count and savings contribution, respectively. Navigant verified two thirds of reported savings using an IPMVP method. Navigant's general strategy to reserve more rigorous M&V methods for higher savings project reflects a Value of Information use of resources which is accepted by the EM&V framework. However, this is counter to Navigant's evaluation plan, which states that all High Impact sampled projects are to receive site visits and an IPMVP method is to be applied. This is reiterated in the PECO evaluation report, which claims all projects in the High Impact stratum received site visits (but the evaluation report does not specify if the site visits included metering or collected data to support an IPMVP-based analysis). Upon review of the evaluation sample population provided by Navigant, the SWE observed that just over half of the High Impact stratum sample received site visits while the balance received either phone verifications or desk reviews. Furthermore, the evaluation report asserts half of all Medium stratum samples received a site visit while the evaluation sample population only lists 20% of projects received a site visit as part of the verification activity.

Figure 44: PECO C&I Evaluation Activities Across Strata by Project Count

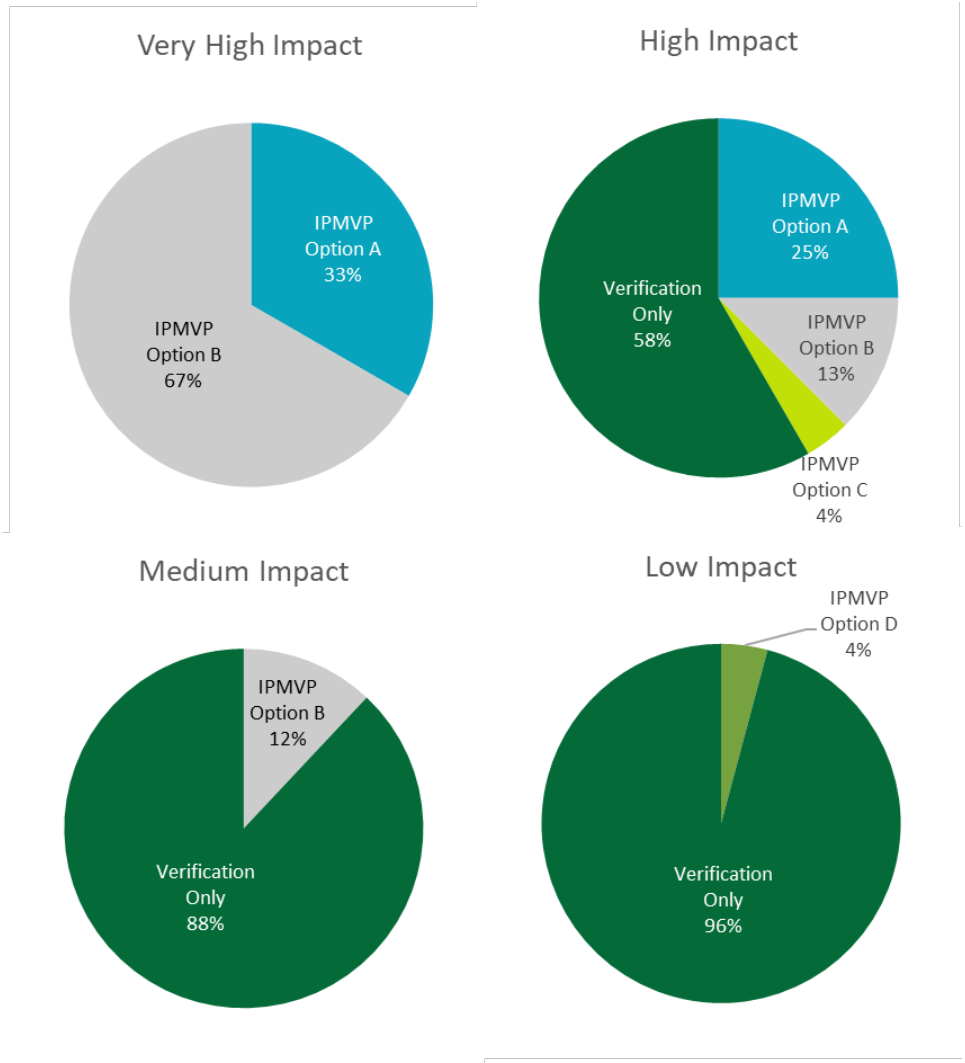
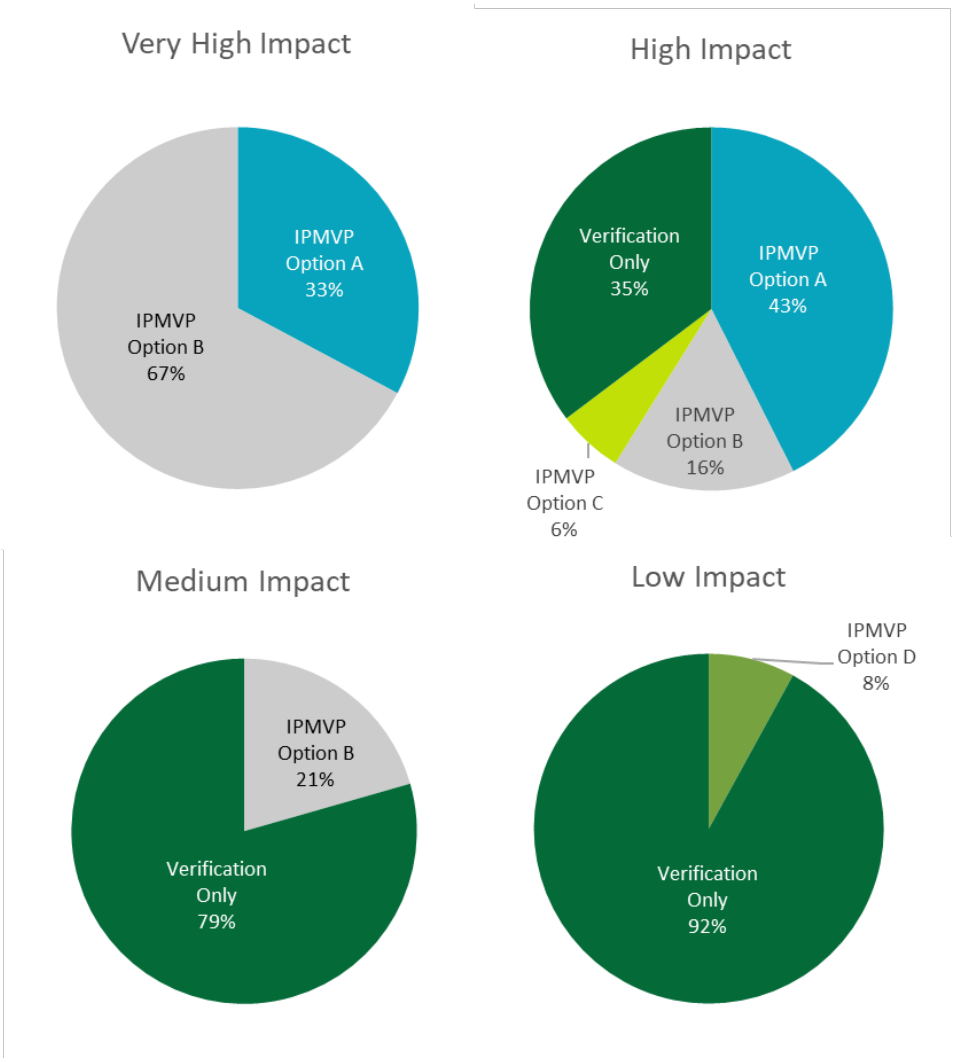


Figure 45: PECO C&I Evaluation Activities Across Strata by kWh Contribution

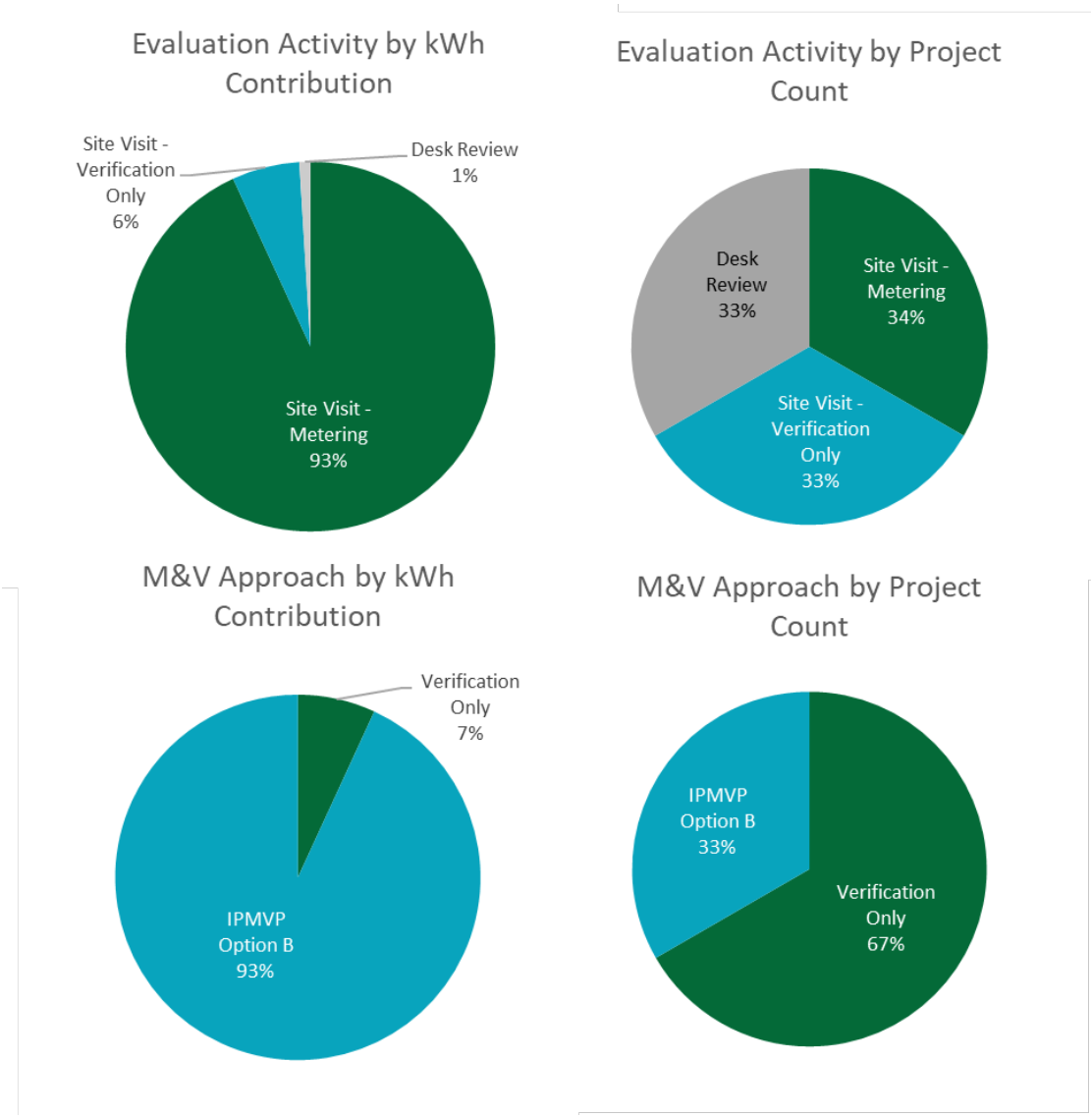


The targeted relative precision for the solution is 15% at the 85% confidence interval. Navigant met this goal for energy and demand verified savings in both the Small and Large C&I programs.

B.4.2.2 Data Centers

PECO's Data Center solution saw limited participation with just three customers enrolled during PY9. The program contributed less than 1% to PECO's non-residential portfolio reported savings. Navigant conducted a census review using various evaluation activities and methods per the evaluation plan. Each project was listed in PECO's Large C&I program; however, no strata were defined for the census. As illustrated in Figure 46, each project received a different evaluation activity – desk review, site visit with metering, and site visit with verification only. The largest project in the program (contributing 93% of reported savings) surpassed the TRM threshold of 250,000 kWh and therefore Navigant conducted on-site metering for this single project via IPMVP Option B. The remaining two projects received less rigor of on-site verification and desk review.

Figure 46: Summary of PECO's Data Center Evaluation Activities



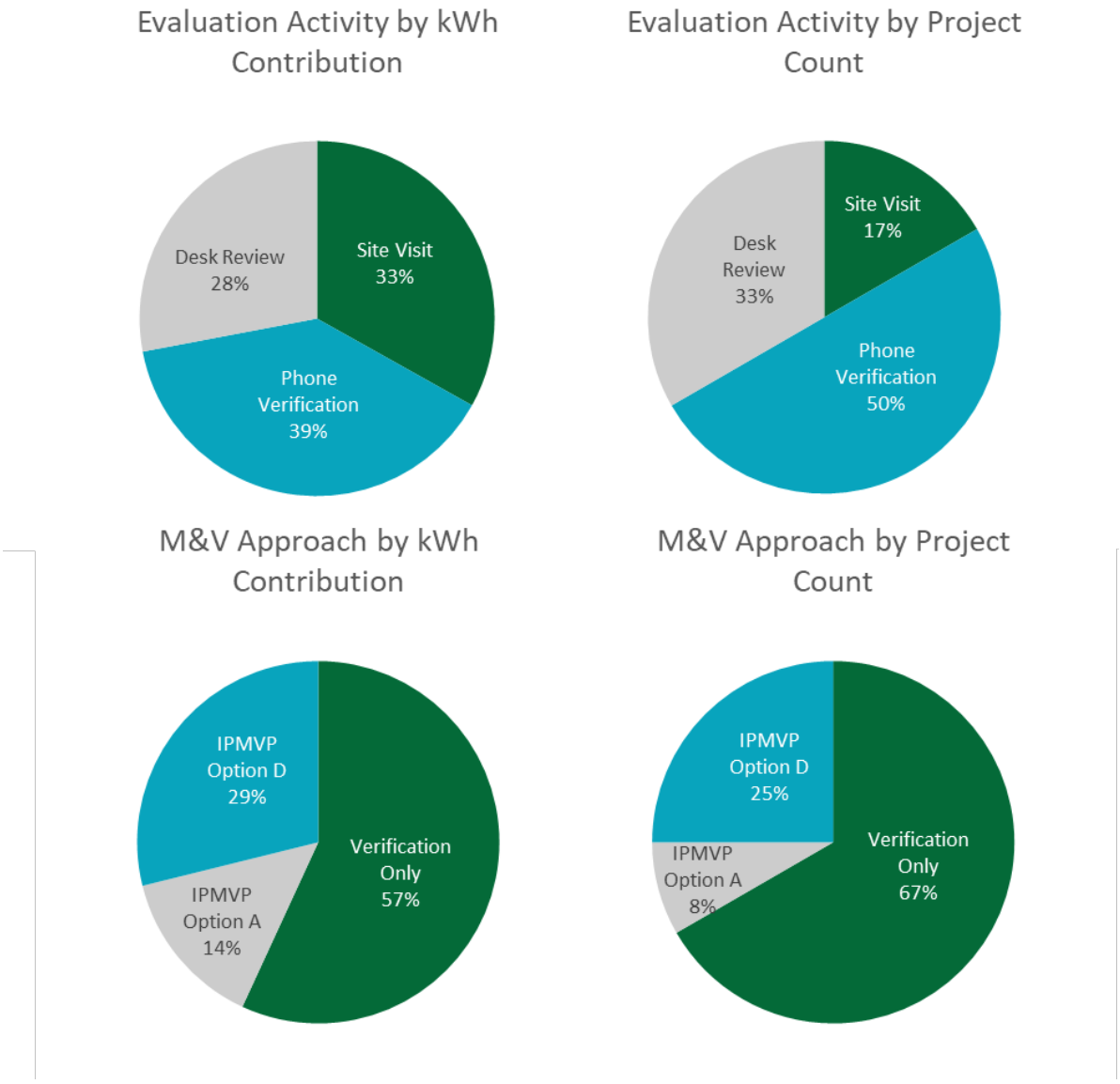
B.4.2.3 Non-Residential New Construction

The New Construction solution contributed approximately 10% of reported savings to PECO's non-residential portfolio. A two-year sample across PY8 and PY9 was developed by Navigant; however, the evaluation sample population extract only provided evaluation activity and M&V approach details for the PY9 portion of the sample. Therefore, the following discussion focuses on just the PY9 activity. Navigant derived its sample from the New Construction solution under both the Small and Large C&I programs and included 12 samples for PY9: 11 from the Large C&I program and one Small C&I program. These 12 projects were stratified into High Impact, Medium Impact, and Low Impact strata.

Figure 47 illustrates Navigant's PY9 sample evaluation activities and M&V approaches. Ultimately just two sites were visited (both projects were in the High Impact stratum) while the remaining projects received phone verifications and/or desk reviews. This is counter to the PY9 evaluation

report and the evaluation plan, which states that all projects in the High Impact stratum received site visits. Similarly, the PY9 evaluation report states about half of Medium strata projects received site visits but the evaluation population sample extract confirmed no Medium Impact stratum projects in the PY9 sample received a site visit. This lack of site visits with metering is concerning as the PY9 sample included five projects with reported savings above the TRM threshold of 250,000 kWh, which triggers required metering or trend data. However, Navigant only metered at two of these five sites. It is unclear if any trend data was provided for the remaining three projects as verification activity was described as phone verification or desk review.

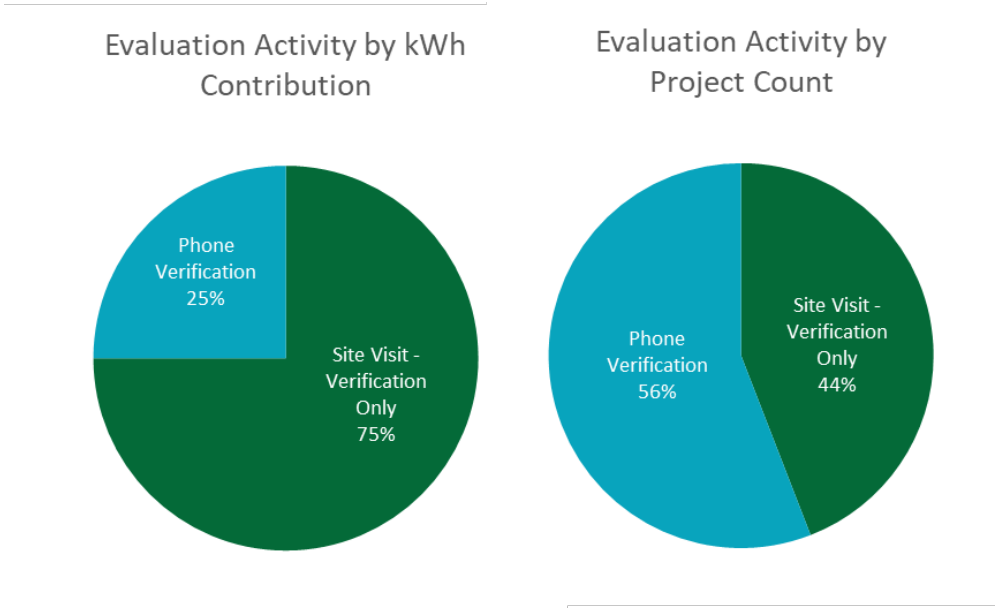
Figure 47: Summary of PECO's Non-Residential New Construction Evaluation Activities – PY9 sample



B.4.2.4 Non-Residential Whole Building

The Non-Residential Whole Building solution represented approximately 5% of PECO's non-residential portfolio reported savings. All projects were under the Small C&I program. Navigant identified a sample of 34 projects amongst two strata: 19 Small projects and 15 Medium projects. Figure 48 shows Navigant's evaluation activities were split between on-site verification and phone verification. Navigant conducted all site visits to the medium strata, which accounted for 75% of reported savings. No Whole Building project surpassed the TRM threshold of 250,000 kWh and therefore no on-site metering was required.

Figure 48: Summary of PECO's Non-Residential Whole Building Evaluation Activities



B.4.2.5 Non-Residential Multifamily

The Non-Residential Multifamily solution operates under both the Small and Large C&I programs but also heavily overlaps with the Residential program. The multifamily segment represented approximately 5% of PECO's non-residential portfolio.

Navigant completed its verification based on a sample of 21 projects: seven from the Large C&I program and 14 from the Small C&I program. The sample was stratified into Small and Multisector, and all samples, regardless of strata, received a site visit to complete verification only. No Multifamily project surpassed the TRM threshold of 250,000 kWh for non-lighting projects nor 750,000 kWh for lighting projects and therefore no on-site metering was required. The onsite verification confirmed installation of reported measures. Navigant used default TRM parameters, such as hours of use and interactive effects, to verify savings.

The Multifamily solution under the Small C&I program was the only solution that Navigant did not achieve the targeted relative precision of 15% at 85% confidence interval. The precision for verified energy and demand savings was 17.0% and 17.8%, respectively. The SWE did discover errors in the verified savings calculations primarily under the Residential portfolio; however, these

errors did not affect the total savings for the C&I programs. Discussion of these errors are presented under Appendix B.4.1.2.

B.4.2.6 Combined Heat and Power (CHP)

The Combined Heat and Power (CHP) program only completed two projects for PY9 and contributed just over 2% of the non-residential portfolio reported savings. Navigant evaluated both projects using trend data collected by the customer. As discussed below, the SWE completed audit reviews of each of these projects and found errors in the verified savings, which were subsequently corrected by Navigant prior to the report filing.

B.4.2.7 Verified Savings Reviews

As part of the audit process, the SWE audited verified savings for a sample of projects. The purpose of this activity is to review the evaluator's analysis methods applied to specific projects, ensure the approach is consistent with the EM&V framework and the analysis is free of errors or unsubstantiated assumptions. The SWE selected a subset of Navigant's samples to complete the verified savings audit. Upon completion of the audit process, the SWE relayed any concerns, recommendations, and/or updated savings value for incorporation in Navigant's PY9 evaluation.

The SWE selected 13 projects for its review. These projects were primarily from the Large C&I stratum and included both lighting and non-lighting retrofits. The two CHP projects implemented under PECO's CHP program were also reviewed. Two of the 13 projects were selected for a SWE ride-along in which a member of the SWE joined Navigant for the project site visit. The purpose of the ride-along is to observe the on-site evaluation practices. The two projects visited by the SWE included an HVAC project in which Variable Frequency Drive (VFD) controls were installed and a project involving a large lighting retrofit to LED technology. Based on the ride-alongs, the SWE had no further recommendations for site visit evaluation protocols.

The SWE completed a verified savings analysis on all 13 projects. In doing so, the SWE checked for accuracy of the calculations and the appropriateness of the evaluation method and level of rigor. Overall, the SWE found most reviewed projects were in accordance with the 2016 Pennsylvania TRM and/or followed industry best practices. When applicable, Navigant made appropriate updates to ex ante assumptions. The SWE found Navigant's Fulcrum reporting tool provided very thorough information that facilitated the review process. However, for some larger projects, the Fulcrum tool was cumbersome in presenting data and analysis. Analysis workbooks were well-organized and transparent. However, certain projects did lack supporting documentation such as ex ante conditions or primary data supporting key parameters.

The SWE identified three savings discrepancies for three of the reviewed projects. One discrepancy was based on a minor spreadsheet cell reference error, which resulted in a 5.4% overstatement of project energy savings (the affected energy savings related to heating, therefore demand savings were unaffected). This change was below the 1% portfolio impact threshold. The other two discrepancies were in reference to both CHP projects. One project analysis failed to incorporate all available trend data, incorrectly analyzed weather dependency, and used an erroneous peak demand definition. The correction of these errors resulted in an understatement of energy savings of 7.5% and demand savings of 6.8%. In the second CHP project, the analysis mischaracterized the system operation as a steady generation profile rather than a staged profile

and applied an erroneous peak demand definition. The correction of these errors resulted in an understatement of energy savings of 13.9% and demand savings of 5.5%. Navigant corrected these errors for both projects and updated the savings values prior to filing the evaluation report.

For any reviewed 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 102% and 101%, respectively. Table 98 provides an overview of the SWE project review for the verified savings audit of evaluated PECO projects.

Table 98: PECO Verified Savings Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
13	15,834,474	2,070	102%	101%

Overall, the SWE found Navigant 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 were generally provided. General recommendation for subsequent evaluation analysis is for Navigant to consistently provide documentation and/or files, including primary data, supporting key assumptions and parameters and to ensure analyses incorporate all relevant and appropriate data.

B.5 DEMAND RESPONSE

According to the Phase III Implementation Order, PECO's Phase III demand response (DR) compliance target is 161 MW. Note that compliance is determined based on the average MW performance across all DR event hours for the Phase and DR goals are assessed at the system level, meaning that line loss adjustments are applied to the load impacts measured at the customer meter. Additionally, the Implementation Order directs EDCs to obtain no less than 85% of the target in any single event. For PECO, this translates to a 137 MW minimum performance level for any given DR event. Decisions about which day DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. PECO called DR events on the three days those guidelines required.

In January 2018, the PECO team filed its first PY9 semi-annual report along with a standalone demand response evaluation report. After an initial review of the findings, the SWE and Navigant decided that the analysis needed to be modified and the results re-filed. In June 2018, PECO filed an amended PY9 DR report with the PUC along with an updated response to the SWE DR Data Request. This amended analysis is the focus of this memorandum. The performance estimates in PECO's PY9 Final Annual Report due November 15th were identical to the June 2018 amended PY9 DR filing.

PECO fell short of the 161 MW performance target for each of the three PY9 DR event days, but each day was above the 85% threshold of 137 MW. This section summarizes the SWE's audit

activities and offers some methodological recommendations that are intended to be prospective in nature as opposed to a suggestion to revise any PY9 calculations.

B.5.1 Residential DR Program

PECO's Residential DR program consists of direct load control switches installed on central air conditioners across over 60,000 residential households. Navigant utilized a "within-subjects" regression methodology to estimate savings. This approach involves creation of a mathematical model of metered hourly load as a function of various explanatory variables (hour of day, weather conditions). The model also includes a series of indicator variables equal to 1 for a specific DR event hour and zero otherwise. This series of indicator variables captures the difference in average household demand (kW) during each event hour relative to what the prediction would have been absent DR (e.g., if the indicator variable were equal to 0 instead of 1).

The SWE was able to reproduce perfectly the Navigant impact estimates for each of the twelve PY9 event hours. There were two methodological decisions the SWE recommends Navigant reconsider for PY10.

1. **Inclusion of Additional Non-Event Days** – the Navigant approach relied on using just three non-event weekdays from summer 2017 in the regression data set along with the three event days. These were the three hottest non-event days of the summer, so they are the most relevant days to include. However, three days provides a relatively thin amount of information to estimate the relationship between the load and the dependent variables. Technically, only two points are needed to fit a line – but more observations should improve the quality of the line. The slopes of the dependent variables are especially important when estimation is out-of-sample (i.e., the event days were all hotter than the non-event days). Navigant's PY10 evaluation plan calls for a comparison group analysis if data quality permits so this point may be irrelevant for PY10.
2. **Participant Counts** – the regression model returns the average kW savings per participating household. This gets multiplied by the number of participating households and escalated by the assumed line loss factor to calculate aggregate system-level performance in MW. The SWE was unable to replicate the Navigant participant count of 60,847 for the Residential DR program. Table 99 shows the number of accounts with load data by event date.

Table 99: Participating Households in the Estimation Dataset

Event Date	Count of Accounts with Interval Load Data
6/13/2017	59,622
7/20/2017	60,118
7/21/2017	60,118

In response to the SWE DR Data Request, the PECO/Navigant team provided a list of participating accounts with 60,846 unique residential customer IDs (one less than the claimed participant count). The participant list also included fields for "date added" and "date removed".

All participants were identified as added "Prior to DR Season". A total of 582 program participants were listed to have a removal date of 7/1/2017. All other removal dates were listed as "NA". It's unclear why impacts from these 582 households are included in the aggregate program performance estimates for the two July events if the load control equipment had been removed prior to the event. The SWE recommends Navigant explore these nuances with PECO and use event-specific counts in PY10. It's unlikely that 582 devices were removed in one day and none for the rest of the summer so a definition of what the "date removed" field means in practical terms is needed. Maybe the devices were removed during the month of June?

Normally the SWE would recommend the number of accounts with load data be used as the official count because it mirrors the basis for the per-account performance estimate. However, PECO had so many data quality issues in PY9 that the differences in Table 99 are unlikely to represent a perfect census of households. It is worth noting that the counts in Table 99 suggest a larger population in July while the participant list suggests a larger population in June. The participant count should be higher in June than July because customers can leave the program, but no new participants were added.

B.5.2 Large C&I DR Program

For PECO's PY9 Large C&I program, 261 individual customers were included in the data, but only 260 were analyzed because one individual did not have adequate load data for analysis. Table 100 shows the average estimated baseline load, DR performance, and percent reduction for PECO's PY9 Large C&I program. This information is separated into the five regression-based methods used for modeling and analysis (i.e., baselines). All the values in Table 100 have been scaled to the system level using a line loss factor of 1.0799.

Table 100: Customer Participation by Baseline

Baseline	Number of Customers	Mean Reference Load (MW)	Mean DR Performance (MW)	Mean Percent Reduction
Normal	100	12	2	17%
Decile All Hours	23	2	0	14%
Decile Prime Hours	7	46	10	23%
Quintile All Hours	71	88	22	25%
Quintile Prime Hours	59	292	82	28%
Missing	1	-	-	-
Total	**261**	**440**	**117**	**27%**

PECO's evaluation separates customers into five groups, each of which used the same regression model specification, but different techniques for data inclusion. For all baselines, the

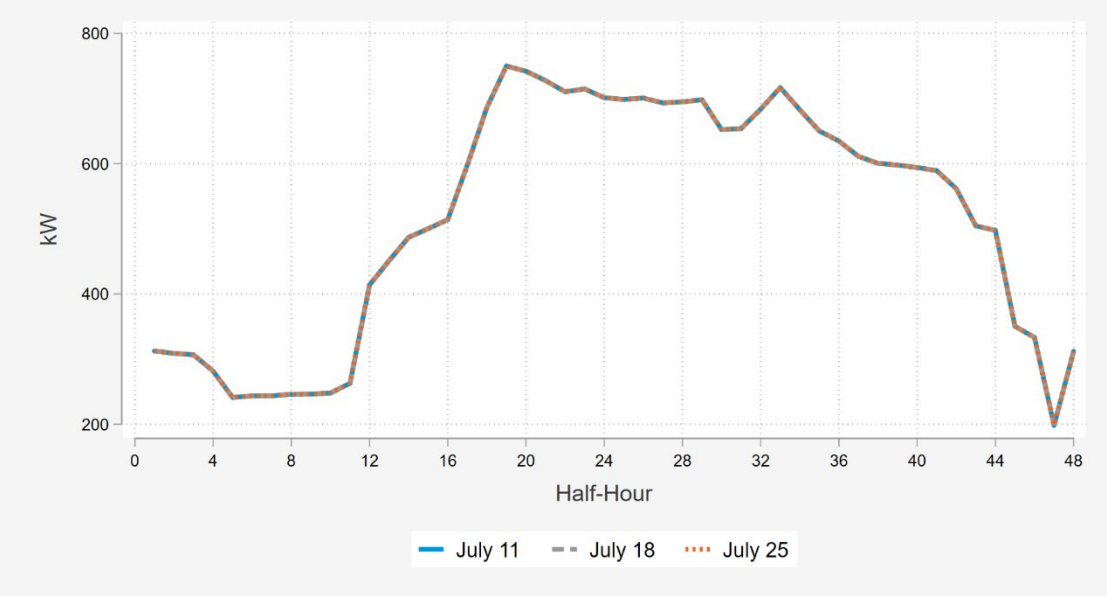
analysis focuses on non-holiday weekdays in June and July and excludes notification days. The steps used by the SWE to replicate the Navigant results are laid out below for each baseline.

- The “Normal” baseline includes no further restriction of the data. All non-event weekdays (with load data available) are included in the regression model.
- The “Decile All” baseline:
    1. Calculate each site’s total kWh usage for each non-event day
    2. Remove the lowest 10% of these days for each site
    3. Remove any days with less than 75% of the data for that day for each consumer
    4. Proceed as in the Normal baseline.
- The “Decile Prime” baseline hourly results have been replicated to within 30 kW or less.
    1. Remove any days with less than 75% of the data for the prime hours of 12 PM – 9 PM for each consumer.
    2. Calculate each site’s total kW used during the prime hours of each remaining non-event day
    3. Remove the lowest 10% of these days for each site
    4. Days removed in step one are included back into the data
    5. Using the data from the full day, proceed as in the Normal baseline.
- The “Quintile All” baseline:
    1. Remove any days with less than 75% of the data for that day for each consumer
    2. Calculate each site’s total kW used for each remaining non-event day
    3. Remove the lowest 20% of these days for each site
    4. Days removed in step two are included back into the data
    5. Proceed as in the Normal baseline.
- The “Quintile Prime” baseline:
    1. Remove any days with less than 75% of the data for the prime hours of 12 PM – 9 PM for each consumer
    2. Calculate each site’s total kW used during the prime hours of each remaining non-event day
    3. Remove the lowest 20% of these days for each site
    4. Using the data from the full day, proceed as in the Normal baseline.

While not all baselines were exactly reproduced, inconsistencies were noted during the SWE analysis. The ordering of the steps and the inclusion of specific data restrictions seems to differ between the baseline analyses – at least the SWE had to order the steps differently to reproduce the Navigant results. For example, dropping of days with less than 75% of the expected reads for a day happens after deciles are calculated in the “Decile All” analysis (step 3), but prior to the quintile calculations in the Quintile Prime analysis (step 1). Also, in the case of data collection, it is important to check for data quality. For example, some locations have identical half-hourly usage over multiple days. This can be seen in Figure 49, where a single customer’s half-hourly usage is shown for three days. Identical reads for each of the 48 thirty-minute intervals of the day for three consecutive Tuesdays is highly improbable and checks should be in place to understand

why this may occur in the data. We suspect it's some sort of imputation procedure for missing data.

Figure 49: Data Quality Issue Example



For the five baselines in the program population, the SWE was able to exactly reproduce results from three baselines; Normal, Decile, and Quintile Prime. These three baseline methods account for over 80% of the PY9 performance for the Large C&I DR program. The remaining two baselines have not been perfectly reproduced. Data quality issues lead to an inflated number of ties and the SWE was unable to perfectly reproduce the Navigant tie-breaking logic. We have no concerns about the filed numbers as the tie-breaking logic appears to be unbiased (i.e., sometimes the SWE's number is higher, and sometimes the Navigant number is higher). Decile Prime results have been calculated to within 30 kW for each date-hour of the events. While the SWE could not replicate the Navigant results for the Quintile baseline, SWE estimations were 4% higher than the Navigant findings.

Table 101 shows the Demand Response Savings as estimated by the SWE for each baseline type, date, and hour. The last column provides Navigant results for comparison. All values in Table 101 are presented at the meter level.

Table 101: SWE Estimates for Demand Response Savings (at Meter Level)

Date	Hour	Normal	Decile All	*Decile Prime	*Quintile All		Quintile Prime	SWE Total	NCI Total
13-Jun		15	7.79	0.82	0.13	22.80	77.78	109.33	107.97
		16	8.12	1.01	0.08	22.55	95.43	127.19	126.48
		17	7.17	0.74	-0.04	23.53	85.53	116.93	116.29
		18	5.71	-0.25	-0.05	19.11	62.65	87.16	87.10
20-Jul		15	10.93	2.32	0.46	23.85	71.44	109.00	107.71
		16	10.78	1.67	0.35	22.08	75.82	110.70	109.94
		17	10.67	1.86	0.33	21.97	73.96	108.79	108.13
		18	8.58	1.49	0.12	17.70	46.25	74.14	73.82
21-Jul		14	11.83	3.74	0.46	18.23	62.93	97.18	96.30
		15	12.38	3.31	0.52	22.87	94.73	133.81	132.46
		16	11.60	2.90	0.46	21.19	86.98	123.14	122.26
		17	10.96	2.72	0.46	20.59	81.40	116.13	115.29
PY9 Average			**9.71**	**1.86**	**0.27**	**21.37**	**76.24**	**109.46**	**108.65**

* PECO/Navigant reference loads were not perfectly duplicated.

B.6 NTG

B.6.1 Residential Programs

Navigant conducted primary NTG research using data from participant surveys for the Whole Home and Residential New Construction Solutions Programs. The NTG estimation method was consistent with SWE recommended practices and formulas. Spillover for the Whole Home Program was based on a subset of the survey sample because the spillover question battery did not collect data on counts of spillover measures. The SWE recommends stricter instrument review by both Navigant and the SWE to guarantee that all necessary spillover data is systematically collected in the future.

Navigant assigned an NTG of one to the Behavioral Solution, in accordance with the Evaluation Framework recommendations for RCT program designs.

Table 102: Summary of NTG Estimates for PECO Residential Program[1]

Approach	Solution or Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Lighting, Appliances & HVAC	0.55	0.04	0.49	--
PY8	Appliance Recycling	0.63	0.0	0.37	--
Estimated	Whole Home	0.15	0.03	0.89	145
Estimated	New Construction	0.13	0.0	0.87	--
PY8	Multifamily Targeted Market Segment	0.35	0.00	0.65	--
RCT	Behavioral	--	--	1.0	--

[1] Table values may not sum to one due to rounding.

B.6.2 Residential Low-Income EE Programs

Navigant did not conduct NTG evaluations for any components of the PY9 Residential Low-Income EE Program.

B.6.3 C&I EE Programs

The Small C&I EE Program and the Large C&I EE Program used in-person interviews and phone and online surveys to gather data for NTG estimates for all components of the Program. The exception is for Small and Large C&I Multifamily Targeted, which applied PY8 NTG values in PY9.

The SWE determined that Navigant utilized data collection, question bevies, and the common NTG formula recommended in the Phase III Evaluation Framework.

Table 103: Summary of NTG Estimates for PECO C&I EE Program

Approach	Solution or Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Small C&I Equipment and Systems	0.25	0.0	0.75	26
Estimated	Small C&I New Construction	0.73	0.0	0.27	5
Estimated	Small C&I Whole Building	0.09	0.07	0.98	42
PY8	Small C&I MF Targeted Market	0.35	0.0	0.65	--
Combination of Program component NTGs	Small C&I Program Total	0.26	0.01	0.75	71
Estimated	Large C&I Equipment and Systems	0.23	0.02	0.80	28
Estimated	Large C&I New Construction	0.59	0.0	0.41	5
PY8	Large C&I MF	0.35	0.0	0.65	--
Combination of Program component NTGs	Large C&I Program Total	0.25	0.02	0.77	33

B.7 TRC

Table 104 summarizes the results from the Total Resource Cost (TRC) test for PECO's PY9 individual programs and portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY9 annual report.

Table 104: Summary of PECO PY9 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	$78,465	$36,358	2.16	$42,464	$27,797	1.53
Low-Income EE	$11,233	$9,266	1.21	$11,233	$9,266	1.21
Small C&I EE	$18,333	$22,570	0.81	$13,764	$17,882	0.77
Large C&I EE	$35,945	$35,333	1.02	$27,346	$28,416	0.96
CHP	$1,962	$7,920	0.25	$1,746	$7,052	0.25
Residential DR	$3,000	$3,191	0.94	$3,000	$3,191	0.94
Small C&I DR	$0	$154	0.00	$0	$154	0.00
Large C&I DR	$10,959	$1,579	6.94	$10,959	$1,579	6.94
Portfolio Total[1]	**$159,898**	**$126,609**	**1.26**	**$110,513**	**$105,576**	**1.05**

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

Of PECO's eight energy-efficiency and demand response programs, four were determined cost-effective and four were not, based on the TRC test using gross verified savings. When using net verified savings, three programs were found to be cost-effective and five were non-cost-effective. The Large C&I EE Program was found cost-effective under gross-verified savings but non-cost-effective under net verified savings. PY9 TRC ratios improved for most programs from previous PY8 TRC ratios. Small C&I EE was the only energy-efficiency program that saw a decrease in the TRC ratio in PY9. PECO's definition of a *program* is very broad and comprises many types of individual program *solutions* that make it difficult to determine what components are reducing the TRC ratio. The break out of cost-effective and non-cost-effective energy-efficiency and demand response programs are listed below.

Gross Verified Savings

Cost-Effective Programs (TRC > 1):

- Residential Energy Efficiency (EE)
- Low-Income EE
- Large C&I EE
- Large C&I DR

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

- Residential DR
- Small C&I EE
- CHP
- Small C&I DR

B.7.1 Assumptions and Inputs

The PY9 TRC model was developed by Navigant using the Analytica software. However, due to how the Analytica model handles costs from fuel switching projects, the final TRC calculations were performed outside the model. Below is a summary of the assumptions and inputs that were verified by the SWE.

- The PY9 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 PY9 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 PY9 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 handled consistently with the 2016 TRC Order directive for Phase III. NTG ratios appear to be consistent with PECO's PY9 Annual Report.
- The PY9 TRC Model uses the Phase III approved avoided costs of energy and capacity. The SWE confirmed that the model selected the appropriate PY9 stream of avoided costs.
- The SWE confirmed that cost categories were handled correctly in the PY9 TRC model. However, similar to the PY8 TRC model, 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.
- The PY9 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 4.997 years for the Residential EE Program delivered through the Retail solution.
- The PY9 TRC model included benefits from fossil fuel and/or water savings. The SWE verified that the water savings were calculated in accordance to the *Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test*. For clothes washers PECO implemented a weighted average water savings of 2,303.6 gallons based on a Top-to-Front loading weight of 60-40.

B.7.2 Notes from the Review of the TRC Model

The PECO TRC model is performing most of the benefit-cost calculations in accordance with the 2016 TRC Order, although some inconsistencies were noted regarding the demand response calculations. The SWE recommends adjustments to the demand response calculations be made for PY10.

- PECO applied line loss assumptions to DR impacts that had already been grossed up for losses. This inflated TRC benefits by 7.99%. The SWE reduced the TRC benefits for DR programs by 7.99% to account for the inflated DR impacts. The updated TRC ratios for the DR programs are reported in Table 104.
- PECO calculated TRC benefits inconsistently with the 2016 TRC Order and applied avoided cost of distribution capacity benefits to all DR impacts, including the residential, commercial, and industrial sectors. The 2016 TRC Order "*proposed to not include industrial customers who are excluded from this benefits calculation because many of these large accounts receive service at high voltage and largely bypass the distribution system.*"

The SWE review of the PECO model found no obvious calculation errors related to the energy-efficiency programs; however, not all 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 documented in the model, including, the basis for determining incremental costs. The SWE recommends that adequate documentation outlining the origin of the incremental cost assumptions be provided for PY10.

B.8 PROCESS

B.8.1 Residential Energy-Efficiency Programs

For PY9, Navigant reported on process evaluations for three residential program solutions: The Appliances & HVAC component of the Lighting, Appliances, & HVAC Solution; Whole Home Solution; and New Construction Solution.[62]

For the process evaluations of these program solutions, Navigant reviewed program documents and data, interviewed utility and implementation staff, and surveyed participants or trade allies for a subset of solutions. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) varied among solutions, but generally included the effectiveness

[62]For the Residential Energy Efficiency Programs, Navigant did not conduct a full process evaluation for the Residential Lighting component of the Lighting, Appliances & HVAC Solution, the Residential Appliance Recycling Solution, the Residential Behavioral Solution, or the Multifamily Targeted Market in PY9, other than process interviews with program staff.

of program administration, implementation, and delivery; customer program awareness, satisfaction, participation, and challenges; and recommendations.

B.8.1.1 Appliances and HVAC Component of the Lighting, Appliances & HVAC Solution

Summary of the Process Evaluation Findings

Navigant employed several data-collection methods to gather information for the process evaluation. For non-lighting measures, Navigant conducted 12 telephone in-depth interviews with appliance and HVAC trade allies across the PECO service territory to better understand the downstream rebate component of the Appliances & HVAC Solution from the trade ally perspective. Navigant also reviewed the participation tracking databases and other program materials. There were no key process findings associated with this solution in PY9.

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. Navigant segmented the trade ally interview sample into three strata based on activity level with the program.

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.

B.8.1.2 Appliance Recycling Solution

No process evaluation was conducted in PY9 beyond interviews with program and implementation staff. Navigant will conduct a process evaluation in PY10.

B.8.1.3 Whole Home Solution

Summary of the Process Evaluation Findings

Navigant relied on several data sources to gather information for the process evaluation. It reviewed program materials, interviewed program manager and implementation staff, and conducted a participant survey of 144 customers. Navigant also reviewed the participation tracking databases and other program materials. Based on these data, two key process findings emerged.

Process key findings are as follows:

- Solution goals to convert in-home assessments and audits to major measure installations would require more promotional and customer facing program materials.

- Among participants, 90% indicated they are likely to recommend the PECO program to others. Participants primarily heard of the Whole Home Solution through bill inserts and word of mouth.

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. Navigant used a stratified random sampling approach for the participant phone survey, focusing on four strata: large, medium, small, and very small projects. 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 PY9 and prior program years. It would have been useful to know, for example, how the significant difference in sources of program awareness were assessed across program years. 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. Recommendations were clear and actionable and were supported by the findings.

B.8.1.4 New Construction Solution

Summary of the Process Evaluation Findings

Navigant relied on several data sources to gather information for the process evaluation. It reviewed program materials, interviewed program manager and implementation staff, and conducted an online survey of 12 builders. Navigant also reviewed the participation tracking databases and other program materials. Based on these data, two key process findings emerged.

Process key findings are as follows:

- Navigant surveyed participating builders about the New Home Rebates Program. Some responses indicated participants are less satisfied with marketing assistance and training opportunities because they are unaware that these services are offered through the program.
- The evaluation team analyzed open-ended survey responses describing reasons for lower participant builder satisfaction with the time it takes to receive a rebate. Over 33% of builders indicated that it takes about three to six months to receive a rebate.

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. Navigant conducted a census and did not stratify the builder population in any way.

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. Recommendations were clear and actionable and were supported by the findings.

B.8.1.5 Behavioral Solution

No process evaluation was conducted in PY9 beyond interviews with program and implementation staff. Navigant will conduct a process evaluation in PY10.

B.8.2 Multifamily Targeted Market Segment

No process evaluation was conducted in PY9 beyond interviews with program and implementation staff. Navigant will conduct a process evaluation in PY10.

B.8.3 Low-Income EE Program

B.8.3.1 Whole Home Solution

No process evaluation was conducted in PY9 beyond interviews with program and implementation staff. Navigant will conduct a process evaluation in PY10.

B.8.3.2 Lighting Solution

No process evaluation was conducted in PY9 beyond interviews with program and implementation staff.

B.8.4 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 or segment below:

- Equipment and Systems Solution
- New Construction Solution
- Whole Building Solution
- Behavioral Solution (not implemented in PY9)
- Multifamily Targeted Market Segment (no process evaluation in PY9)
- Data Centers Targeted Market Segment (no participation in PY9)

As the Behavioral Solution was not implemented in PY9, the Data Centers Targeted Market Segment had no participation in PY9, and a full process evaluation was not performed for the Multifamily Targeted Market Segment in PY9, the SWE does not present a review of these solutions or segments.[63]

For the process evaluations of these other program solutions, Navigant reviewed program documents and data, interviewed utility and implementation staff, and surveyed participants for a subset of solutions. 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.

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.8.4.1 Equipment and Systems Solution, New Construction Solution, Whole Building Solution, and Data Centers

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 for PY9 included participation data and materials review, in-depth interviews with the program and implementer staff, and participant surveys for the Equipment and Systems Solution (26 customers), the New Construction Solution (five customers), and the Whole Building Solution (42 customers). Based on these data, three key findings emerged:

- *Equipment and Systems, New Construction, and Data Centers:*[63] PECO has seen lower than planned participation numbers to date in the Equipment and Systems, New Construction, and Data Center segments. Results obtained from a C&I customer experience survey indicate that incentives are generally perceived as too low, although this is a common sentiment among utility customers in other jurisdictions as well. PECO has attempted to address customer satisfaction in this area by implementing an incentive adjustment for key lighting and custom measures aimed at improving savings generation.
- *Data Centers:* Most data center energy savings are derived from the load on the equipment (i.e., the greater the load, the larger the savings). This is potentially causing customers to delay program engagement until load is realized. In the Small C&I Program, there were no data center projects in either PY8 or PY9.
- *New Construction:* New Construction projects often involve significant planning and lead time, often resulting in longer-term commitments than retrofit projects. A majority of New Construction survey respondents – four out of seven – responded that their projects took more than two years from planning to completion. When asked when PECO could be most

[63] Two findings associated with the Small C&I Data Centers Targeted Market Segment are presented below despite their being no participation in this program in PY9.

influential in an organization's decision-making process, five out of six Small and Large C&I New Construction participants mentioned the planning phase or budgeting phase.

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. Navigant segmented the Equipment and Systems and Whole Building solutions customer samples into strata based on impact level with the program. It did not segment the New Construction customer solution sample in any way.

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 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.8.5 Large C&I EE Program

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

- Equipment and Systems Solution
- New Construction Solution
- Data Centers Targeted Market Segment (low participation in PY9)[64]
- Multifamily Targeted Market Segment (no process evaluation in PY9)

Since the Data Centers Targeted Market Segment had no participation in PY9, and since a full process evaluation was not performed for the Multifamily Targeted Market Segment in PY9, the PA SWE does not present a review of these segments.

For the process evaluations of the other program solutions, Navigant reviewed program documents and data, interviewed utility and implementation staff, and surveyed participants for a subset of solutions. 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.

[64] Navigant indicated that the Large C&I EE Program had three PY9 participants that were not interviewed because the population was too small to extrapolate meaningful information.

The 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 these two solutions combined.[65]

B.8.5.1 Equipment and Systems Solution, New Construction Solution, Data Centers

Summary of the Process Evaluation Findings

Data sources for the process evaluation of the Equipment and Systems Solution and the New Construction Solution included PY9 participation data and materials review, in-depth interviews with the program and implementer staff, and participant surveys for the Equipment and Systems Solution (28 customers) and the New Construction Solution (five customers). Based on these data, three key findings emerged:

- *Equipment and Systems, New Construction, and Data Centers:* As in the Small C&I Program, PECO has seen lower than planned participation numbers to date in the large Equipment and Systems, New Construction, and Data Center segments. Results obtained from a C&I customer experience survey indicate that incentives are generally perceived as too low, although this is a common sentiment among utility customers in general. PECO has attempted to address customer satisfaction in this area by implementing an incentive adjustment for key lighting and custom measures aimed at improving savings generation.
- *Data Centers:* Most data center energy savings are derived from the load on the equipment (i.e., the greater the load, the larger the savings). This is potentially causing customers to delay program engagement until load is realized. In the Large C&I Program, there were no data center projects in PY8 and only three in PY9.
- *New Construction:* New Construction projects often involve significant planning and lead time, often resulting in longer-term commitments than retrofit projects. Most New Construction survey respondents – four out of seven – responded that their projects took more than two years from planning to completion. When asked when PECO could be most influential in an organization's decision-making process, five out of six Small and Large C&I New Construction participants mentioned the planning or budgeting phases.

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection tasks requiring sampling, the SWE determined that the sampling approach for those tasks followed the approved sampling plans, and the report incorporated the required tables showing the sampling strategy. Navigant segmented the Equipment and Systems customer sample into three strata based on impact level with the program. Navigant conducted a census and did not segment the New Construction customer solution sample in any way.

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

[65] Two findings associated with the Large C&I Data Centers Targeted Market Segment are presented below despite their being very low participation in this program in PY9.

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 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.8.6 Combined Heat and Power Program

Process evaluations for the Combined Heat and Power Program in PY9 focused on research activities to support program administration and delivery to PECO customers.

Summary of the Process Evaluation Findings

The primary data sources for the process evaluation included market actor interviews and a review of economic factors. Based on these data, two key process findings emerged:

- Interviews with CHP market actors indicated a general lack of awareness of PECO's CHP program.
- Lack of developer interest in the program is reducing program participation. According to Navigant's market review, PECO's incentives are comparable to other programs within the region. However, some developers indicated that they feel PECO's incentives should be higher to move the market.

Summary of the Process Evaluation Audit

Due to low participation in the program, Navigant did not complete all the PY9 activities listed in the evaluation plan for this program. However, as indicated by Navigant within their final report, PECO authorized Navigant to conduct quick turnaround market research to understand the extent to which the current economic environment and program mechanics are affecting program participation. Navigant plans on conducting additional process evaluation work in PY10 to support and monitor performance of the program.

The SWE determined that the reporting mostly followed the SWE guidelines. The annual report included descriptions of the methods (though it could have been described in more detail), 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 findings, and recommendations, and to a lesser extent, the methods, which could have benefited from a more detailed description.

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.8.7 Demand Response Programs

The Demand Response Programs made up of three programs, shown below:

- Residential DR Program

- Small C&I DR Program
- Large C&I DR Program

For the process evaluations of these programs, Navigant reviewed program documents and data, interviewed utility and implementation staff, and surveyed participants. 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 program awareness, satisfaction, participation, and challenges; and recommendations.

B.8.7.1 Residential DR Program

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY9 participation data and materials review, a telephone survey of 183 program participants, and in-depth interviews with the program and implementer staff. Based on these data, two key process findings emerged:

- Some customers reported that they would like more information about the program
- Customers are interested in saving energy but have low awareness of other program offerings

Summary of the Process Evaluation Audit

Navigant completed all the PY9 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. The sample provided 90/10 confidence/precision.

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.8.7.2 Small C&I DR Program

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY9 participation data and materials review, a telephone survey of 51 program participants, and in-depth interviews with the program and implementer staff. Based on these data, two key process findings emerged:

- Some customers reported that they would like more information about the program
- Customers are interested in saving energy but have low awareness of other program offerings

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection task requiring sampling, total number of completes achieved was below the target sample and did not meet the confidence/precision target of 90/10. The report incorporated the required table showing the sampling strategy and described that the sampling approach did not lead to the targeted number of completes; it also indicates that it will seek to address this issue in future program years.

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.8.7.3 Large C&I DR Program

Summary of the Process Evaluation Findings

Data sources for the process evaluation included PY9 participation data and materials review, a telephone survey of seven customers representing 63 participating sites, and in-depth interviews with the program and implementer staff. Based on these data, one key process finding emerged:

- Customers reported lower satisfaction with incentive payments

Summary of the Process Evaluation Audit

Navigant completed all the PY9 activities listed in the evaluation plan.

For the data-collection task requiring sampling, the sampling approach could have been more clearly described, the report did not incorporate the required table showing the sampling strategy, and the confidence/precision was not discussed.

The SWE determined that the reporting mostly followed the SWE guidelines. The annual report included descriptions of the methods (though the sampling plan could have been more clearly described), 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 findings, and recommendations, and to a lesser extent, the methods, particularly related to sampling.

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.

Appendix C PPL Audit Detail

C.1 EM&V Plan Reviews

PPL's evaluation contractor, Cadmus, submitted redline versions for each program in PPL's Phase III EE&C plan with relatively minor adjustments to the evaluation approach. The SWE reviewed and approved the plans, generally with minor revisions.

In addition to reviewing PPL's revised evaluation plans, the SWE reviewed and approved a new survey instrument for PPL's Continuous Energy Improvement program.

C.2 Sample Design Review EM&V

A common technique to reduce the time and cost of verifying savings is to sample projects and then estimate total verified savings based on the sample. However, sampling introduces uncertainty into the calculation. The uncertainty is derived from the fact that the sample may not be representative of the entire population. Thus, the amount of uncertainty is based on the size of the sample and the correlation between reported and verified savings. The sampling error, or margin of error, is reported by the relative precision of verified savings at a given confidence level. For example, if an offering has verified savings of 1,000 MWh/year and a relative precision of ±10% at the 85% confidence level then there is an 85% chance that the true value of the savings is between 900 MWh/year and 1,100 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 15% at 85% confidence level for each "initiative." This constrains the sample design to ensure reliable estimates of verified savings. For Phase III of Act 129, the SWE established precision requirements at the initiative level instead of by program. As a result, PPL's Non-Residential Energy Efficiency program is divided into several components for evaluation purposes. As part of their evaluation activities for PPL, Cadmus developed samples to meet the 85/15 requirement for each program. Table 105 shows the relative precision of the verified energy savings by program.

Table 105: Relative Precision of PY9 Gross Verified Energy Savings Estimates for Programs with Sampling Error

Program/Initiative	Relative Precision at 85% Confidence Level (±)
Efficient Equipment (Lighting)	2.9%
Efficient Equipment (Equipment)	10.0%
Midstream Lighting	16.1%
Custom	7.8%
Efficient Lighting	4.3%
Energy Efficient Home	2.8%
Weatherization Relief Assistance Program	1.7%
Energy Efficiency Kits and Education	1.5%
Appliance Recycling	7.6%
Student Energy Efficient Education	1.0%

The relative precision values present in Table 105 represent sampling uncertainty for just PY9 verified savings with the exception of the Midstream Lighting program. Savings from Midstream Lighting were unverified in PY8 because the evaluation was still in progress, and as a result the PY9 report presented the PY8 and PY9 verified savings and relative precision values jointly.

The Midstream Lighting program was also the only program to exceed the allowable level of sampling uncertainty. Cadmus notes in the PPL PY9 Annual Report that this was the first time that any EDC offered a midstream option and despite implementing a conservative sample design, the high level of uncertainty around energy savings lead to a large relative precision value. Further, Cadmus noted in their report that the gross savings verification effort under-achieved sample targets in the larger strata, and error ratios were high across all strata due to duplicate and program ineligible jobs. In PY10, Cadmus plans to use an exploratory analysis to determine which variables are correlated with high/low realization rates and use a stratification method that includes those variables in order to achieve the 85/15 requirement. The gross verified energy savings estimates for all other programs were within the allowable levels of sampling error for PY9.

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' PY9 verification activities is discussed in detail in Appendix C.4.

The Home Energy Report, Demand Response, and Continuous Energy Improvement program evaluations do not rely on sampling. Instead, consumption data for a census of program participations is analyzed. The savings associated with Home Energy Education are verified using a regression model that estimates the program treatment effect using a treatment and control group to isolate program impacts from external noise. The Demand Response savings calculations were based on comparison to an estimated baseline for each customer and event

day. While there is no sampling error for these initiatives, there is estimation error because the modeling techniques used do not explain all the variation in the data set. In other words, because we are not able to observe participant consumption data in the absence of program a counterfactual is estimated to derive savings, but this estimate includes uncertainty.

The precision requirements for behavioral programs are unique, with the Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). That said, Cadmus reports the relative precision and given this is a higher bar to meet, the program achieves the Framework requirements. The relative precision for programs with estimation-based uncertainty are shown in Table 106. The Demand Response relative precision is based on demand savings as opposed to energy savings which were displayed for all other programs.

Table 106: Relative Precision of PY9 Gross Verified Savings Estimates for Programs with Estimation Error

Program/Initiative	Confidence Level	Relative Precision at Confidence Level (±)
Home Energy Education Program	85%	4.7%
Demand Response	90%	3.0%
Continuous Energy Improvement Program	85%	10.7%

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 PY9 Annual Report. Specifically, the values we examined are:

- Reported gross energy savings (MWh) for each program,
- Reported gross peak demand savings (MW) for each program,
- Participation counts for each program, and
- Incentive dollars for each program.

The SWE leveraged PPL's Q1-Q4 Appendix A tracking data to audit these values. Note that the Appendix A tracking data is a subset of the full tracking data set (which PPL Electric provides in Appendix Z of their quarterly data submissions). This subset is used in creating the statewide tracking database, as it is tailored to the SWE's PY9 quarterly data request. Any references to "tracking data" herein refer to tracking data in Appendix A, not the tracking data in Appendix Z. Also note that demand response (DR) or home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding PPL's Demand Response program can be found in Appendix C.5, and our findings regarding PPL's Home Energy Education program can be found in Appendix C.4.1.5.

Table 107 summarizes our findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the Annual Report and 'No' otherwise. For all programs, the tracking data supports the value shown in PPL Electric's Annual Report.

Table 107: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Recycling	13,454	13,454	Yes
Efficient Lighting	128,298	128,298	Yes
Energy Efficiency Kits and Education	12,205	12,205	Yes
Energy Efficient Home	21,705	21,705	Yes
Low-Income WRAP	17,530	17,530	Yes
Non-Residential Energy Efficiency	167,510	167,510	Yes
Student Energy Efficient Education	5,597	5,597	Yes
Portfolio Total	**366,299**	**366,299**	**Yes**

Table 108 summarizes the SWE's ex-ante findings regarding peak demand savings by program. Like with energy savings, demand savings in the Annual Report matched demand savings in the tracking data for every program.

Table 108: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Recycling	1.89	1.89	Yes
Efficient Lighting	18.01	18.01	Yes
Energy Efficiency Kits and Education	0.90	0.90	Yes
Energy Efficient Home	3.68	3.68	Yes
Low-Income WRAP	1.76	1.76	Yes
Non-Residential Energy Efficiency	22.22	22.22	Yes
Student Energy Efficient Education	0.56	0.56	Yes
Portfolio Total	**49.02**	**49.02**	**Yes**

Table 109 summarizes the SWE's findings regarding program participation. The SWE was able to replicate participation counts for all programs.

Table 109: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Recycling	12,852	12,852	Yes
Efficient Lighting	287,024	287,024	Yes
Energy Efficiency Kits and Education	13,406	13,406	Yes
Energy Efficient Home	33,334	33,334	Yes
Low-Income WRAP	12,242	12,242	Yes
Non-Residential Energy Efficiency	5,926	5,926	Yes
Student Energy Efficient Education	24,214	24,214	Yes
Portfolio Total	**388,998**	**388,998**	Yes

Finally, Table 110 summarizes the SWE's comparison of incentive dollars listed in program tracking data to the program totals in PPL's Annual Report. The Annual Report incentives and tracking data incentives are directionally similar (though unequal) within any given program. Also note that PPL Electric expressed to the SWE that the rebate amounts in the tracking data will generally never exactly equal the incentive dollars in their reports because the annual report values are pulled from a financial system as opposed to program tracking data.

Table 110: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Recycling	$363	$400	No
Efficient Lighting	$6,553	$6,597	No
Energy Efficiency Kits and Education	---		
Energy Efficient Home	$2,520	$2,824	No
Low-Income WRAP	---		
Non-Residential Energy Efficiency	$8,162	$9,456	No
Student Energy Efficient Education	---		
Portfolio Total	**$17,598**	**$19,277**	**No**

C.3.2 Project File Reviews

C.3.2.1 Residential

The SWE conducted a project file review for a sample of PPL's residential and low-income solutions in PY9 as part of the reported savings (i.e., ex-ante) review. The project file documentation was provided by PPL, the program implementors, and the evaluation contractor, Cadmus, in response to the SWE's standing quarterly data request. The project file packages

included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. The sampled project file packages included a majority of the documentation requested.

Table 111 presents a summary of SWE's residential project file reviews. As stated in the project file review section of the PY8 annual report, Cadmus continued to work with the SWE to clarify questions and processes, both general and specific, that resulted from the ex-ante review for PY9. Improvements were made to quarterly data submissions, such as providing a project file key, which allowed the SWE auditors to conduct thorough reviews of project file packages, TRM equations and values, and the tracking data.

Table 111: PPL PY9 Residential Project File Review Summary

Program	Solution	Number of files reviewed	Did EDC provide project files?	Are most of the requested files included?	Are projects easily located in the tracking data?	Does the data in the files match the tracking data?[1]
Appliance Recycling	n/a	30	✓	✓	✓	✓
Energy Efficient Homes	New Homes	30	✓	✓	✓	✗
Energy Efficient Homes	Audits and Energy-Savings Kits	20	✓	✓	✓	✓
Energy Efficient Homes	Weatherization	20	✓	✓	✓	✓
Energy Efficient Homes	Efficient Equipment	20	✓	✓	✓	✓
Energy Efficient Kits	n/a	10	✓	✓	✓	✓
Energy Efficient Lighting	n/a	10	✓	✓	✓	✓
Winter Relief Assistance	n/a	20	✓	✓	✓	✓

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

As outlined above, the requested number of project files and supporting details were submitted for the residential program. All the program measures used default or EDC collected data as outlined in the EM&V plan. Below is a summary of the project file reviews, including issues or discrepancies found between the project file packages and quarterly tracking data.

Energy Efficient Homes: New Homes Solution

The SWE located the New Homes Solution project files within the tracking database. Some discrepancies between the project files and tracking data were found. The SWE reviewed the discrepancies with PPLs' evaluator, Cadmus.

- Over half of the project files reviewed had supporting documentation in the form of REM/Rate files that indicated different kWh savings value compared to what was recorded in the tracking database. The SWE reviewed this discrepancy with PPL's evaluator, Cadmus, and Cadmus indicated that the ICSP calculates savings using the version of software the original REM/Rate file was developed with, which caused an inconsistency with savings calculated by the current version of the software. When New Homes reports are run for quarterly requests (at a later date), they are possibly running in a different version of the REM/Rate software, than what was previously used for savings.
- Two projects had home addresses that did not match between the project files and the tracking data. Cadmus found similar issues during their evaluation process and discussed it with CLEAResult. They concluded that in some cases, the address of where the payment

was sent is populating in the customer address fields instead of the site where the work was done. Cadmus stated that CLEAResult will be looking into this issue to resolve the mapping of the addresses.

- One project had supporting documentation indicating the home was ENERGY STAR® rated but was rebated $0.30 per kWh saved instead of $0.35 per kWh saved. Cadmus reached out about this issue to the ICSP. The ICSP stated that the home was submitted to the program as a $0.30 per kWh by the applicant because the builder usually does not build ENERGY STAR® homes. Miscommunication between the builder and the HERS rater caused the home to be submitted incorrectly.

Energy Efficient Homes: Audits and Energy Saving Kits

The Audits and Energy Savings Kits Solution project files were successfully located within the tracking database. Several project files did not include rebate forms due to online submittals or were missing data on product installations, preventing the SWE from verifying the accuracy of the information in the tracking data.

- Eleven of the projects reviewed by the SWE were online submittals that do not use rebate applications, so these projects did not contain Rebate Application Forms.
- When Rebate Application Forms were provided for in-home audits, most forms did not provide information for the energy-efficient measures installed because the kits are not direct installs. Instead, the measures in the kits are installed by the participants. Though tracking data indicating that at least one measure was installed during the audit, the SWE was not able to verify this through a review of the project files.

Cadmus verifies installation through participant surveys, not through records review, consistent with the program's delivery design. Cadmus verified that the kits are being delivered after the audit visit is complete and that there is no supplemental documentation that would indicate installations. During the impact evaluation, Cadmus applies ISRs calculated from participant surveys to the measure savings calculations.

Energy Efficient Homes: Weatherization

The Weatherization Solution project files were successfully located within the tracking database; however, four of the projects did not include a rebate application form because they were online submittals. In these instances, information was entered directly into the CLEAResult tracking database.

The SWE was unable to verify the accuracy of the tracking data for these four projects. For all the projects that did have the Rebate Application Form, all the information matched with the tracking database.

Energy Efficient Homes: Efficient Equipment

The SWE located the Efficient Equipment solution project files within the tracking database. There were no discrepancies between the tracking database and the project files reviewed.

Appliance Recycling Program

The SWE located the Appliance Recycling project files within the tracking database. There were no discrepancies between the tracking database and the project files reviewed.

Winter Relief Assistance Program

The SWE located the Winter Relief Assistance project files within the tracking database. There were no discrepancies between the tracking database and the project files reviewed.

C.3.2.2 Non-Residential

The SWE reviewed PPL's C&I projects for PY9 using the project documentation provided by the evaluation contractor in response to the SWE's standing quarterly data request. Except, for the midstream program, 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 112 presents an overview of the results of the SWE's C&I project file reviews.

Table 112: PPL PY9 C&I Project File Review Summary

Project Number	Program	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?
RBT-1200969	Custom	Agricultural Heat Mats	✓	✓	✓	✓	-	✓
RBT-1291835	Non-Res-DI	Exterior Ltg LED Downlights and Wall Packs	✓	✓	✓	✓	✓	-
RBT-1363545	Non-Res-Ltg	Office LED Linear and Spot Lighting	✓	✓	✓	✓	✓	-
RBT-1056331	EE Equipment	Refrigeration and Ice Machine Improvements	✓	×	✓	✓	✓	-
RBT-1210712	Custom	New Motor and VFD for Baghouse Fan	✓	✓	✓	✓	-	✓
RBT-1492647	Non-Res-DI	Exterior Ltg LED pole lighting and Wall Packs	✓	✓	✓	✓	✓	-
RBT-1313911	Non-Res-Ltg	Retail LED Ltg New Construction	✓	✓	✓	✓	✓	-
RBT-1474227	EE Equipment	VSD on Dairy Vacuum Pumps	✓	×	✓	✓	✓	-
RBT-1502582	Custom	VFD on Compressed Air Compressor	✓	✓	✓	✓	✓	✓

Project Number	Program	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?
RBT-1547128	Non-Res-DI	Industrial Facility LED and Controls Upgrade	✓	✓	✓	✓	✓	-
RBT-1402485	Non-Res-Ltg	Retail LED Wall Packs	✓	✓	✓	✓	✓	-
RBT-856943	EE Equipment	Refrigeration HE Evaporative Fan Motors	✓	×	✓	✓	✓	-
RBT-1447256	Custom	VFD on Compressed Air Compressor	✓	✓	✓	✓	-	✓
RBT-1607856	Non-Res-DI	Retail LED interior and exterior Lighting	✓	✓	✓	✓	✓	-
RBT-1763873	Non-Res-Ltg	Retail LED interior and exterior Lighting	✓	✓	✓	✓	✓	-
RBT-1539328	EE Equipment	VFD on HVAC Motors	✓	✓	✓	✓	✓	-
All	CEI	School Improvement Projects	✓	✓	✓	✓	-	✓

Within the review of the non-lighting energy-efficiency project files, it was noted on several occasions that the energy savings within the tracking did not exactly match the supporting project calculation spreadsheets. In all the reviewed cases, the difference was less than 1% and the project tracking database matched the TRM calculated value.

However, in the review of the Midstream Lighting program project files, the SWE was unable to provide a comprehensive audit of the supporting project files into the project tracking database. The SWE understands that the supporting documentation for a midstream program will be different and more limited as compared to a traditional downstream program. Midstream programs benefit by limiting the participation barriers by reducing activities required by the customer. The SWE found no cutsheet or supporting information of the energy-efficient equipment energy consumption data utilized in the estimates of energy savings. The SWE had challenges tracing a project invoice directly from a retailer through entry into the program database, because of inconsistent and incomplete use of project tracking identifier or invoice number.

Additionally, the SWE found inconsistent document completeness and approaches between the different lighting retailers. The SWE would expect the ICSP would have consistent MOUs and processes for program retailers.

It should also be noted that PPL's evaluation contractor had several recommendations in the PY9 process evaluation for the program and the ICSP to improve processes and project tracking.

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

The annual report states that the on-line tool development is underway and should be implemented within the Q1 of PY10. The SWE would request review of the tool to understand how some of this tool can provide address transparency.

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

The second recommendation is noted as under consideration. The SWE finds this to be a reasonable recommendation.

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

Table 113 provides a summary of the evaluation, measurement, and verification approaches used by Cadmus in their PY9 verified savings calculations. The SWE discovered only minor discrepancies during the audits of verified savings. Most notably, the SWE verified savings for the Efficient Lighting Program to be overstated by 282 MWh and adjusted verified savings in the PY9 Annual Report. Note that all discrepancies are much less than 1% of portfolio savings and should be corrected in EDC reporting beginning in PY10.

Table 113: Residential and Low-income Program Impact Evaluation Activities– PPL

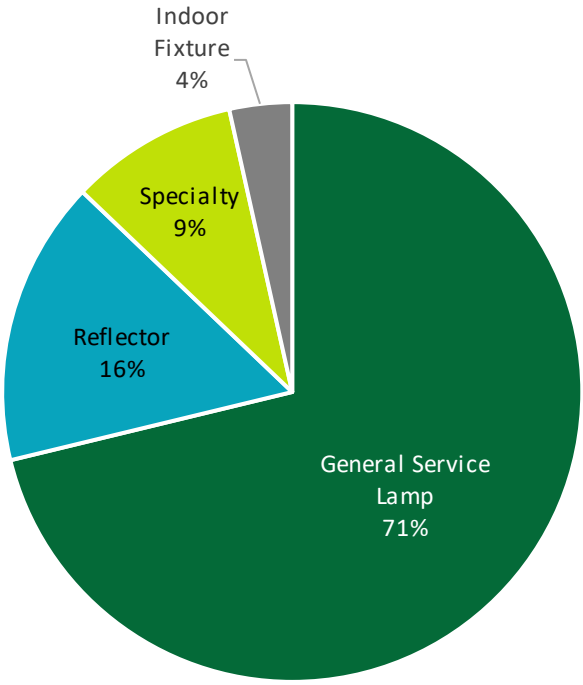
Program	Surveys	Site Visits	Desk Review [a]	Billing Analysis	PY8 Realization Rate
Efficient Lighting Program	✓	--	✓	--	--
Energy Efficient Home Program	✓	--	✓	--	--
Weatherization Relief Assistance Program	✓	--	✓	--	--
Energy Efficiency Kits and Education Program	✓	--	✓	--	--
Appliance Recycling Program	--	--	✓	--	--
Student Energy Efficient Education Program	✓	--	✓	--	--

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

C.4.1.1 Upstream Lighting & Cross-Sector Sales

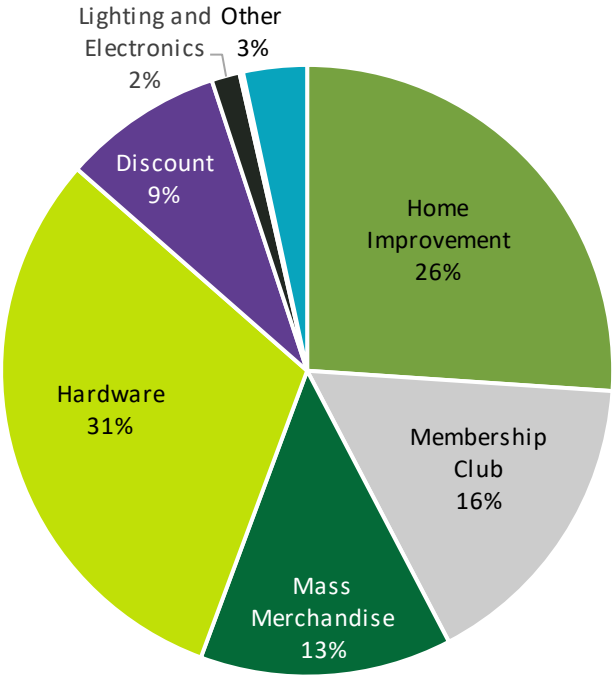
Customers purchased over 3.0 million efficient light bulbs through PPL's PY9 upstream lighting program. Figure 50 displays the distribution of sales by product type. Over two-thirds (71%) of the bulbs were general service lamps.

Figure 50: PPL PY9 Upstream Lighting Sales by Product Type



Almost one-third (31%) of PPL's PY9 upstream light bulbs were sold through hardware stores. About one-quarter (26%) were sold through home improvement stores (Figure 51).

Figure 51: PPL PY9 Upstream Lighting Sales by Retail Channel



C.4.1.2 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 generally agrees with Cadmus' verified gross savings for upstream lighting but has adjusted verified savings for the errors detailed below.

The SWE observed 703 unique lighting model numbers in the PY9 tracking system and was able to locate 699 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The four models the SWE was not able to verify as ENERGY STAR certified represent less than 0.1% 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 28 of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes.

The team confirmed that Cadmus used the appropriate algorithms, interactive effects, ISR, residential HOU, and residential coincidence factor to calculate kWh and kW savings. The team found that Cadmus assigned baseline wattages in accordance with TRM protocol *2.1.1* for all but 37 models. Bulbs with candelabra bases are EISA-exempt, but candelabra-shaped bulbs with medium screw bases are not. The EISA-exempt baseline wattage was erroneously applied to 33 models with medium screw-bases. In addition, the EISA-exempt baseline wattage was applied to two models that had incorrectly been categorized as EISA-exempt three-way bulbs. There was

also one instance in which the EISA-compliant wattage was applied to an EISA-exempt candelabra-based model, and another in which the EISA-compliant reflector wattage had been applied to an EISA-exempt BR30 reflector model. Overall, verified savings were overestimated by 282 MWh. The impact of the discrepancies the SWE identified on portfolio-level savings is minor, less than 0.1%.

C.4.1.3 Cross-Sector Sales

Cadmus did not conduct cross-sector sales research in PY9. Cadmus applied the PY8 cross-sector sales rate of 10% to PY9 sales.

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

- Verify the bulb type and bulb base of models in the program tracking data in order to assign baseline wattages in accordance with TRM protocol 2.1.1. Focus efforts on correctly classifying medium-based bulbs, candelabra-based bulbs, three-way bulbs, and reflectors.

In addition, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- 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.4.1.4 Residential Non-Lighting

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

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 a few minor discrepancies.

The SWE audit identified a couple of discrepancies in the savings calculations for the dehumidifier measure. The SWE identified a minor discrepancy for the dehumidifier reported savings calculations. An incorrect TRM L/kWhee was used for dehumidifiers with large capacities. The L/kWh default values used were from the 2016 ENERGY STAR Standards, but the TRM uses L/kWh default values from the 2012 ENERGY STAR Standards. Cadmus noticed this discrepancy and calculated the verified savings based on the 2012 ENERGY STAR standards.

The SWE noticed a discrepancy in the reported savings calculation for heat pump water heaters (HPWHs). An incorrect derating factor was applied to the reported savings calculations to some HPWHs located in unconditioned space. These systems were applied the derating factor associated with an installation in conditioned space. The error was the result of two separate

variables relating to the location of the water heater being confused. Cadmus identified the issue and corrected the derating factors for the verified savings. Cadmus and the SWE recommend combining these two variables in the future to limit confusion.

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 each component of the Low-Income WRAP Program for all stratum reported – baseline jobs, low-cost jobs, and full-cost jobs in single and multifamily homes. The SWE reviewed the TRM algorithms and protocols that went into the verified savings calculations for every measure included in the sample. Overall, the SWE concluded that TRM values and algorithms were followed and that survey responses from the sampled sites were applied in accordance with the approved EM&V plan. The SWE verified that population sizes, verified savings, and realization rates matched the savings values reported in the PY9 annual report.

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 PY9, kits included six LED bulbs, a night light, a tier 2 advanced power strip, 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 verified savings calculations for all measures included in the kits, reviewed both paper and telephone survey results, and determined realization rates were applied correctly. All measures applied the correct TRM-approved methods, sample sizes were correct, and the survey data was correctly incorporated.

Appliance Recycling

The Appliance Recycling program covers refrigerator, freezer, dehumidifier, and room air conditioner retirement. The SWE audited the verified savings for each of these measures using the annual request data and found that the correct TRM algorithms were followed and verified savings were correct for both room air conditioners and dehumidifiers. Slight discrepancies were found for some values used in savings calculations for refrigerators and freezers when comparing annual request data to the TRM and to the annual report, which caused what the SWE concluded to be 81 MWh of underreported savings. The SWE observed a difference in rounding for some variables in the annual request data, which caused a slight difference in savings (in the age coefficient used in freezer calculations), and the SWE calculated part-use factor used to adjust the per-unit savings for each refrigerator were slightly different from the weighted part-use factor the evaluator derived from survey data. Again, this may be due to rounding differences based on the formatting of the annual request data. It also appears that the evaluator calculated custom

heating and cooling degree days that do not match TRM values, and while not specifically against protocol, this also brought the savings down slightly relative to using TRM values.

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 determined the correct algorithms, sample sizes, and inputs were implemented in calculating energy savings in accordance with their approved EM&V plan.

C.4.1.5 Behavior

Roughly 8% of PPL's verified gross energy savings for PY9 were attributed to the Home Energy Education Program, which provided Home Energy Reports (HER) to around 162,000 residential and low-income households at some point in PY9. However, the verified savings analysis includes billing data from all homes that received Phase III HERs (approximately 206,000). Due to attrition, aggregated treatment days equate to 183,000 accounts with a full year of participation. The SWE reviewed Cadmus' methodology in detail and discovered two errors in the calculation of energy and demand savings. The corrected PY9 gross verified MWh and MW savings values for PPL's Home Energy Education offering are shown in Table 114. Table 114 shows the corrected savings totals in the format presented in the SWE report (uplift deducted from program total) as well as the Cadmus/PPL style, which reports the program savings and uplift separately.

Table 114: Corrected Savings Totals

Savings View	MWh	MW
PYVTD Gross/Net (SWE Report)	30,311	5.34
Cadmus Report Style (no Uplift)	36,232	6.11
Downstream Uplift	3,676	0.47
Upstream Uplift	941	0.16
LED mailing uplift adjustment	1,305	0.14
Total Uplift	5,921	0.77

Table 115 shows the average kWh savings and average percent savings per participant in PY9 by cohort. The reference load is the pre-treatment average annual usage. The savings from the Home Energy Education Program's Low-Income cohorts were not counted towards PPL's low-income compliance target for Phase III.

Table 115: Average PY9 kWh Savings per Participant

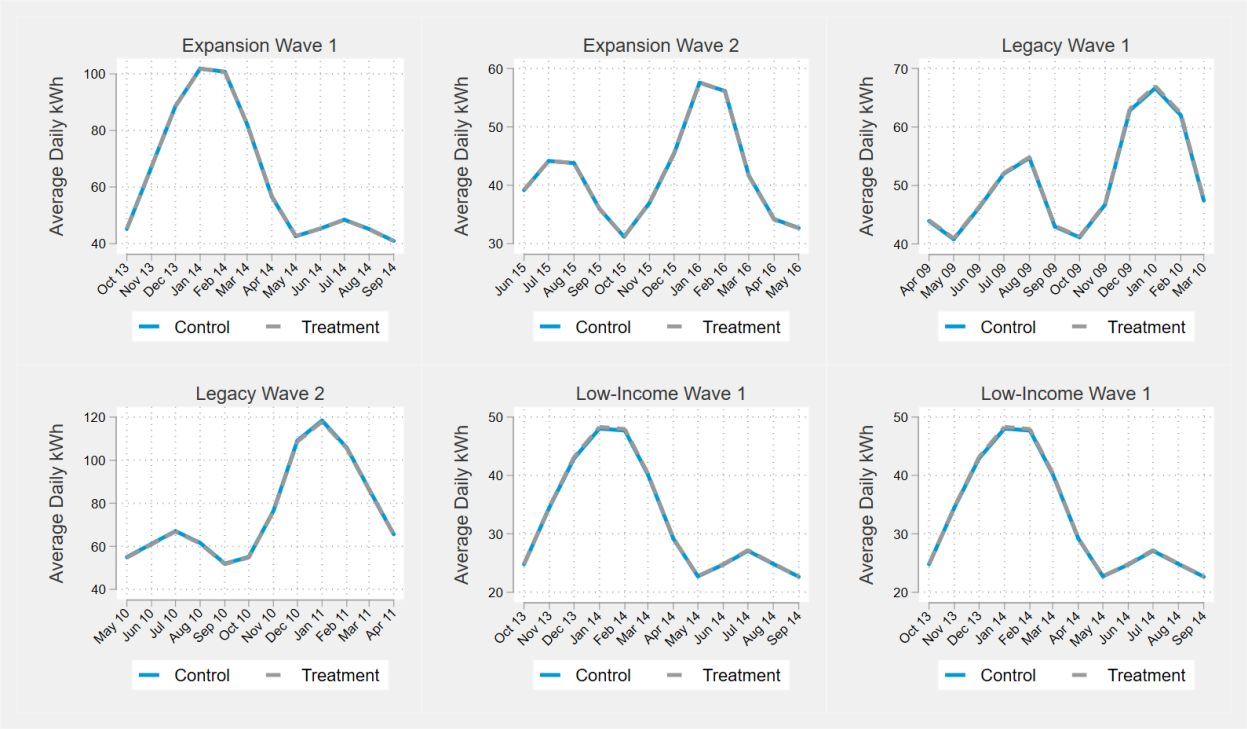
Cohort	Cohort Start Date	Reference Load (kWh)	Average PY9 Savings (kWh)	Average PY9 % Savings
Legacy Wave 1	April 2010	16,759	322	1.92%
Legacy Wave 2	June 2011	23,835	365	1.53%
Expansion Wave 1	October 2014	20,305	226	1.11%
Low-Income Wave 1	October 2014	10,495	91	0.87%
Low-Income Wave 2	June 2015	6,552	13	0.20%
Expansion Wave 2	June 2016	15,641	108	0.69%

The following sections describe the SWE's auditing efforts. The calculations herein are based on calendarized billing data and HER program tracking data provided to the SWE by Cadmus in response to the SWE Annual Data Request.

Group Equivalence

The Home Energy Education program uses a randomized control trial (RCT) design to enable estimates of savings post-implementation. In each cohort participants are randomly divided into treatment and control groups. Using large sample sizes and correctly implementing randomization the control and treatment groups should be statistically indistinguishable in their energy usage. Given group equivalence, the only plausible explanation for differences in energy consumption in the post treatment period is exposure to the HER. In the PY8 audit the SWE thoroughly investigated group equivalence using visual inspection and t-tests on pre-treatment consumption levels. The SWE re-ran the tests in PY9, but given no new cohorts were introduced since PY8 results were not expected to and did not change. There are no statistically significant differences in pre-period average daily kWh consumption between the treatment and control groups as visually depicted in Figure 52.

Figure 52: Pre-Period Group Equivalence



Data Checks

In creating valid HER impact estimates, data quality is essential to prevent erroneous or miscoded values from biasing results. The SWE checked billing data to ensure that the treatment variable was equal to 1 for any billing records after the month in which HER exposure began, and 0 otherwise. In addition, each account included in the analysis was examined to ensure that it contained the requisite number of pretreatment months. Less than 0.25% of accounts had less than 11 months of pre-treatment data. Finally, the SWE flagged and removed values that appeared erroneous (either implausibly high for a residential customer or zero across long periods of time). Only 0.18% of accounts had a data quality issue.

In calculating HER impacts, Cadmus employed a 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. The SWE examined how the three lagged seasonal variables were calculated. Following the recommendation in the PY8 audit, Cadmus adopted the preferred methodology of a days-per-month calculation, which avoids the error of averaging use in months with different numbers of days.

Impact Coefficients

The SWE was able to replicate the impact coefficients from the lagged seasonal model, which are displayed in Table 116. The SWE's regression estimates yielded larger standard errors than the Cadmus results, but the discrepancies did not affect the determination of energy savings or

statistical significance. There are separate coefficients for PY9a and PY9b for some waves because the ICSP's subcontractor did not send home energy reports to low-propensity customers until late April 2018, near the end of PY9. The effects of treatment are expected to differ before and after low-propensity customers received their first Phase III reports as more homes were actively exposed. To accurately measure the savings occurring before and after low-propensity customers received their first home energy reports, Cadmus included two program-year indicators for PY9:

- PY9a covers the period in PY9 in which only non-low-propensity customers received any home energy reports (June 2017 through April 2018)
- PY9b covers the period in PY9 in which all customers in these waves, including low-propensity customers, received a Phase III home energy report (May 2018)

This is like the methodology employed in PY8, in which the low-income wave customers did not receive their first reports until May 2017. The coefficients are interpreted such that an impact of –0.297 for Expansion Wave 2 means that average daily consumption in treatment group homes was 0.297 kWh less in PY9 than average daily consumption in control group homes, on average, after controlling for the effects of weather, time, and pre-period consumption patterns.

Table 116: PY9 Impact Coefficients

Wave	PY9a Impact Coefficient (kWh per Customer per Day)	PY9b Impact Coefficient (kWh per Customer per Day)
Legacy Wave 1	-0.906	-0.660
Legacy Wave 2	-1.039	-0.639
Expansion Wave 1	-0.640	-0.416
Low-Income Wave 1	-0.249	
Low-Income Wave 2	-0.036	
Expansion Wave 2	-0.297	

Annual Energy Savings

To calculate the incremental annual energy savings, the per customer average daily impacts of treatment must be multiplied by the number of treatment days. Total treatment days are composed of the treatment days per account and scaled by the number of active accounts. This methodology allows for the PY9a and 9b period savings to reflect just the treatment days in the portion of time those periods represent.

The SWE used data provided by Cadmus in response to the Annual Data Request to calculate the treatment days using the "min_datePY9" and "max_datePY9" variables, which record when treatment customers were first eligible to save towards PY9 and when they were no longer eligible, respectively. For homes that were active the entire program year, these values are equal to 6/1/2017 and 5/31/2018, respectively.

During the tabulation of treatment days, the SWE noticed that unique IDs were present in multiple HER cohorts in the customer tracking data. In an RCT, each account should generally only be in one cohort. Further investigation, and the footnote in Table C-1 from PPL's PY9 Annual Report, indicate that some accounts were in fact randomized into two waves (~ 1,250 homes). This issue did not extend into the billing data for coefficient estimation but did lead to some double counting of treatment days.

Cadmus verified that in their initial calculations they counted treatment days twice for some accounts included in multiple waves. They had assigned nonzero treatment days to 548 accounts that appeared in two waves when only savings attributable to the oldest wave should have been counted. Duplicate accounts that went inactive prior to PY9 or were assigned to a control group were not double-counted, which is why the count of affected customers (548) is lower than half the accounts randomized into two waves (675). Altogether, treatment days were overestimated by 169,458 in PY9a and 12,958 in PY9b. Table 117 shows the corrected number of treatment days for PY9a and PY9b periods following the SWE's audit.

Table 117: PY9 Treatment Days by Cohort

Wave	PY9a Treatment Days	PY9b Treatment Days
Legacy Wave 1	9,311,178	995,420
Legacy Wave 2	10,476,486	1,144,486
Expansion Wave 1	11,843,556	1,173,033
Low-Income Wave 1	16,521,576	685,212
Low-Income Wave 2	4,393,065	139,789
Expansion Wave 2	9,276,038	855,360
Total	**61,821,899**	**4,993,300**

The SWE used the corrected treatment days and impact coefficients to calculate annual energy savings by period for each cohort. Summing the savings from PY9a and PY9b yielded the total PY9 energy savings estimates. Table 118 shows the results. The equivalent accounts column is simply the number of treatment days divided by 365 and enables the generation of an average savings per customer.

Table 118: Annual MWh Savings by Cohort

Wave	PY9 Total Savings (MWh)	Equivalent Accounts	Avg. Account Savings (kWh)
Legacy Wave 1	9,092	28,237	322
Legacy Wave 2	11,615	31,838	365
Expansion Wave 1	8,067	35,662	226
Low-Income Wave 1	4,286	47,142	91
Low-Income Wave 2	164	12,419	13
Expansion Wave 2	3,008	27,757	108
Total	**36,233**	**183,055**	**198**

Demand Savings

As in PY8, Cadmus converted each wave's average energy savings into demand reductions using the evaluated PY4 ratio of peak demand reduction values to average per-customer energy savings per hour. In PY4 across Legacy Wave 1 and Legacy Wave 2, Cadmus estimated average per-customer demand reductions of 0.041 kW and 0.056 kW for each wave, or 193% and 108% of each wave's average per-customer energy savings per hour, respectively. Cadmus used the weighted average of these ratios (148%) to convert PY9 program energy savings into demand reductions.

In the SWE's audit of Cadmus results, we found that Cadmus had calculated separate MW savings for the PY9a and PY9b portions of the year. Rather than taking a weighted average of these demand savings, Cadmus summed the two values to get their PY9 total. The addition of demand savings in two different periods is incorrect and resulted in an overstated MW savings of approximately 5 MW. The SWE alerted Cadmus of the error and confirmed with them a new process, which converted from PY9 energy totals to average hourly savings directly before then scaling by 148%. The updated values are shown in Table 119.

Table 119: PY9 Demand Savings

Wave	Downstream and Upstream Uplift Adjusted PY9 Annual Savings (MWh/yr)	PY9 Savings per Treated Hour (MW)	Peak Demand Ratio Adjusted
Legacy Wave 1	8,132	0.93	1.37
Legacy Wave 2	10,372	1.18	1.75
Expansion Wave 1	7,777	0.89	1.31
Low-Income Wave 1	2,954	0.34	0.50
Low-Income Wave 2	22	0.00	0.00
Expansion Wave 2	2,357	0.27	0.40
Total	**31,615**	**3.61**	**5.34**

Mirroring energy savings, Cadmus subtracted upstream and downstream savings uplift from PPL's residential portfolio total (not the HER program total). This avoids double-counting and improves on their PY8 methodology, which failed to adjust for demand uplift. The uplift process is described in the following section.

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; however, the problem with double counting of treatment days detailed above required minor modifications to the uplift adjustments. The Evaluation Framework states that upstream adjustments should be made after downstream adjustments have been made. For each wave, Table 120 shows the downstream and upstream uplift savings. In total, Cadmus calculated 3,676 MWh and 941 MWh in downstream and upstream uplift savings, respectively. Additionally, Cadmus included a 1,305 MWh adjustment for LEDs that were installed in PY7. Combined, these adjustments total up to 5,921 MWh. Rather than subtracting this value from the Home Energy Education program total, Cadmus subtracts it from PPL's portfolio total. All SWE reporting deducts the uplift from the program total.

Table 120: Downstream and Upstream Uplift

Wave	PY9 Annual Savings (MWh/yr)	Downstream Uplift (MWh/yr)	Adjusted Annual Savings	Upstream Adjustment Factor	Upstream Uplift (MWh/yr)
Legacy Wave 1	9,092	708	8,384	3.00%	252
Legacy Wave 2	11,615	922	10,693	3.00%	321
Expansion Wave 1	8,067	49	8,018	3.00%	241
Low-Income Wave 1	4,286	1,241	3,045	3.00%	91
Low-Income Wave 2	164	142	23	2.25%	1
Expansion Wave 2	3,008	615	2,393	1.50%	36
Total	**36,232**	**3,676**	**32,556**		**941**

C.4.2 Non-Residential Audit Activities

Table 121 provides a summary of the evaluation activities and M&V approaches utilized by PPL's evaluation contractor in their PY9 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY9, PPL completed an extensive number of evaluated projects via site visits (217) and relied heavily on verification only as their primary M&V approach, utilizing IPMVP methods only for those projects in their Custom and CEI Programs.

Of particular note, PPL's evaluation contractor verified a small number of projects via telephone. However, these telephone verified projects had large energy savings and the evaluation contractor utilized post-retrofit measurement data collected by the ICSP, which is allowed by the Phase III TRM.

Figure 53: Summary of PPL's C&I Evaluation Activities

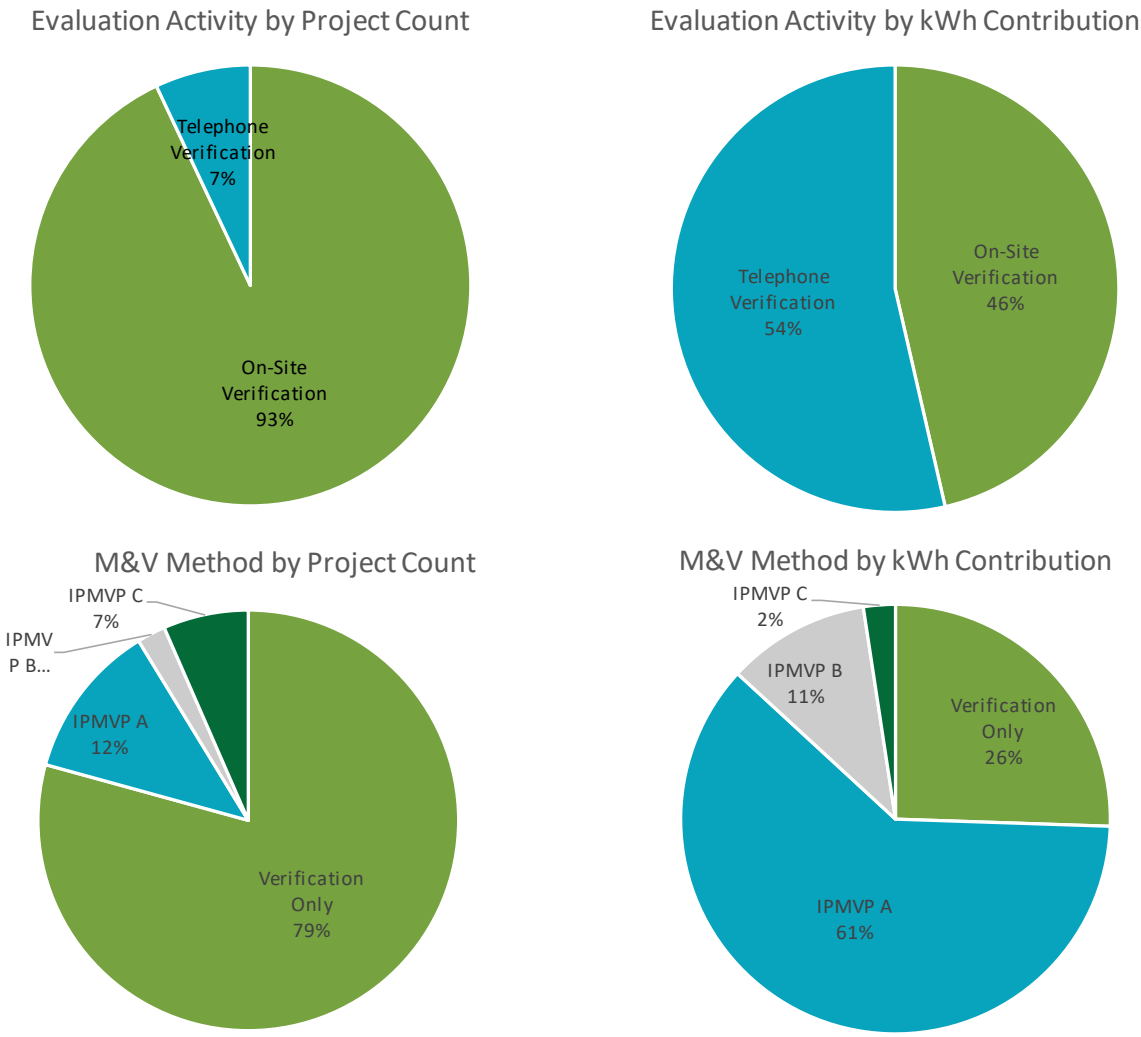


Table 121 provides a summary of the evaluation activities and M&V approaches PPL's evaluation contractor used across strata for all projects stratified by program.

Table 121: Summary of PPL's PY9 C&I Evaluation Activities by Program

Program / Strata	Sample Quantity	Phone Verification Only	On-Site Verification Only	IPMV P A	IPMV P B	IPMV P C
Custom Delivery Stream	**24**	**0**	**0**	**16**	**6**	**2**
Combined Heat and Power	1	0	0	0	1	0
Large	8	0	0	5	2	1
Small	15	0	0	11	3	1
EE Equipment Delivery Stream	**125**	**18**	**107**	**0**	**0**	**0**
Ltg Prescriptive	49	17	32	0[66]	0	0
Ltg Discount	50	0	50	0	0	0
Non-Lighting	26	1	25	0	0	0
Midstream Lighting	**110**	**0**	**110**	**0**	**0**	**0**
Continuous Energy Improvement	**16**	**0**	**0**	**0**	**0**	**16**
Total	**275**	**18**	**217**	**16**	**6**	**18**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation were aligned with the Evaluation Framework followed proper custom site-specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

C.4.2.1 Custom Delivery Stream

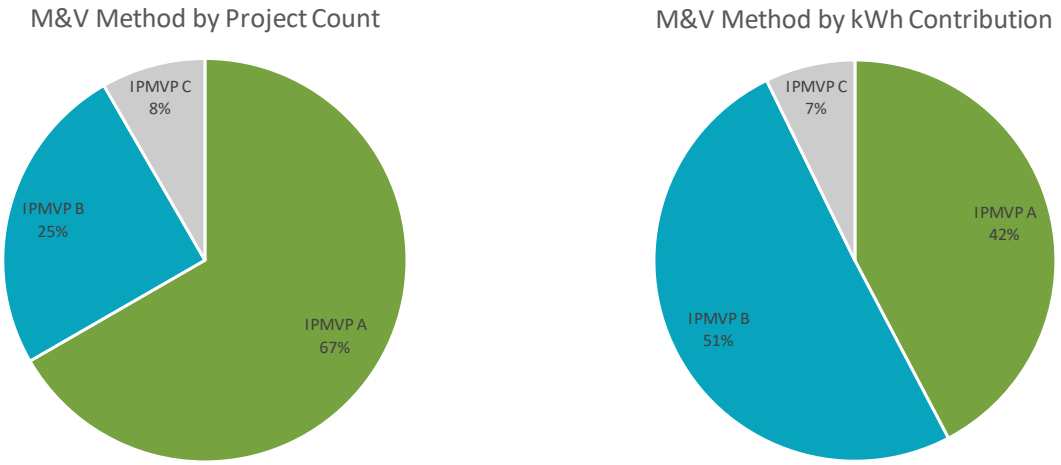
The SWE found that the evaluation contractor divided the evaluation sample into three strata: combined heat and power (CHP), large projects (larger than 500 MWh), and small projects (smaller than 500 MWh). The large project and CHP project verification strata are a census of the participation population (eight and one, respectively) with Cadmus conducting pre- and post-retrofit M&V so that TRM guidelines are met and the reported values are corrected to match evaluated results, so the realization rate for these strata is 100%. Cadmus targeted a confidence and precision outcome of 85%/20%, resulting in an achieved sample frame of 15.

Cadmus conducted on-site inspections for all evaluated sample projects utilizing measurement data for all verified results via IPMVP methods A, B, and C as shown in Figure 54. The CHP

[66] For 17 lighting projects with energy savings larger than 750,000 kWh, Cadmus utilized ICSP collected post-retrofit measurement data and only performed telephone verification for verified savings calculation. While this approach is permissible by the TRM and Evaluation Framework, for this summary, SWE is not characterizing this as IPMVP A method, because the data collection activities were not concurrent.

largest projects utilized calculation method IPMVP B as the prevalent option. The distribution of rigor across the 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 54: Summary of PPL's PY9 Custom Evaluation Activities



C.4.2.2 Prescriptive Energy Efficiency Delivery Stream

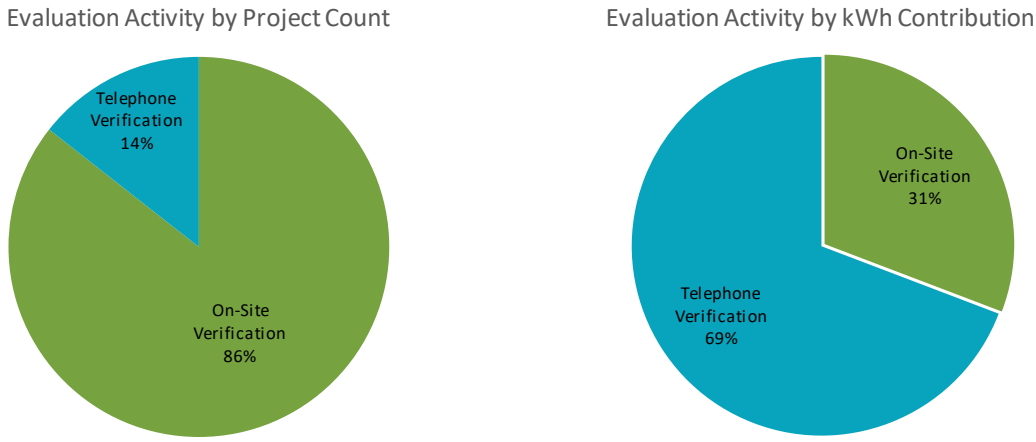
The evaluation contractor divided the evaluation sample for the Energy Efficiency Equipment program into three main strata: prescriptive lighting, discount lighting and non-lighting energy-efficiency equipment. For each of these strata, Cadmus established three to five sub-strata, as follows. Cadmus targeted 90/10 confidence/precision for the Energy Efficiency Equipment program overall. Cadmus targeted 90/10 confidence/precision for the prescriptive lighting and direct discount lighting strata, since they comprise that majority of program savings. Cadmus targeted 85/15 confidence/precision for the non-lighting strata.

- Prescriptive Lighting
  - Census (projects larger than 750 MWh)
  - Large
  - Medium
  - Small
- Discount Lighting
  - Large
  - Medium
  - Small
- Non-Lighting Equipment
  - HVAC
  - HVAC – Occupancy Sensors
  - Motors
  - Other
  - Refrigeration

For the two lighting strata, the sub-strata boundary adjusts every quarter of PY9 based on participation and the project energy savings in the that quarter. The distribution of rigor across these sample sub-strata is consistent 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.

As shown in Figure 55, PPL's evaluation contractor verified a small number of projects via telephone. These telephone verified projects had large energy savings and the evaluation contractor utilized post-retrofit measurement data collected by the ICSP, which is allowed by the Phase III TRM.

Figure 55: Summary of PPL's PY9 Energy-Efficiency Program Evaluation Activities



C.4.2.3 Midstream Lighting Program

In the SWE audit of the non-residential midstream lighting program, the SWE found that PPL's evaluation contractor executed with an appropriate measurement and verification approach across a generous sample of projects in PY8 and PY9. The midstream evaluation outcomes found a realization rate of 79% with a higher than expected uncertainty due to challenges with the baseline assumptions, differences in the business type affecting the hours of use, and in-service rate of installed lamps and fixtures.

Cadmus conducted 209 project evaluations across 88 site locations sampled from the midstream lighting program participants in PY8 and PY9 to verify savings across both program years. In PY9, Cadmus conducted 110 project evaluations across 37 sites to meet a target of 90/10 level of confidence/precision. The evaluation activity was a site verification and inspection for all sampled projects with no collected measurements. The PY8 and PY9 evaluation sample was segmented into five strata, as follows:

- Large (projects over 301 MWh)
- Large- Medium
- Medium-Small
- Small (projects less than 8 MWh)
- Convenience

The PY9 realization rate is 79% and utilized the 2016 TRM – Interim Measure Protocol: Lighting Improvements for Midstream Delivery Programs. Additionally, while the sample size was large, the precision target was not met with higher than expected variance in the outcomes, with a resulting precision of 16.1%. Contributing to lower realization rate and high variance are a number of factors, including incorrect baseline equipment, incorrect business type, and incorrect equipment counts.

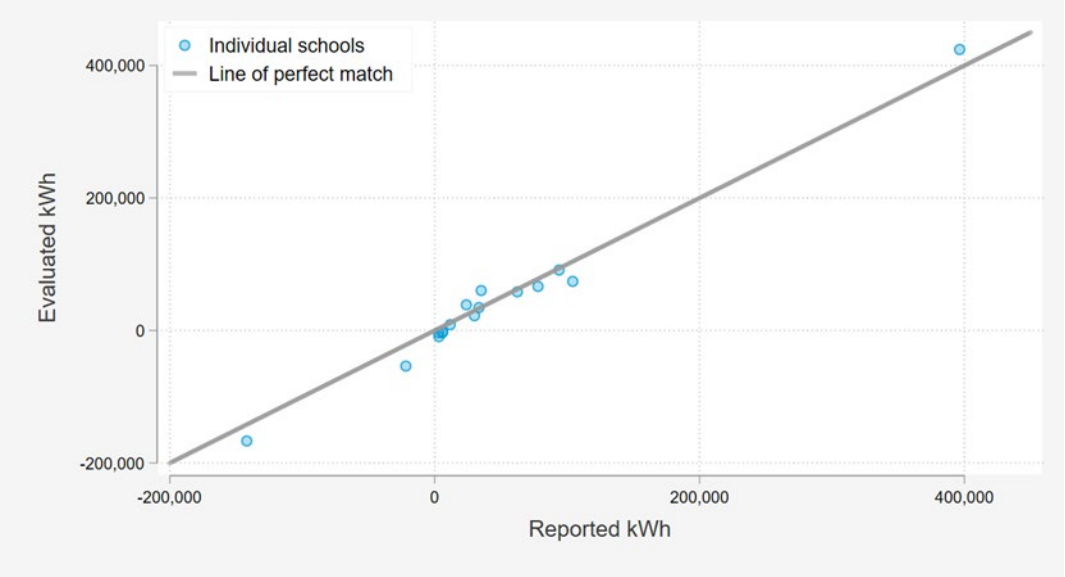
C.4.2.4 Continuous Energy Improvement Program

Cadmus evaluated Continuous Energy Improvement program energy savings for all 16 participating schools, within four school districts. They utilized an IPMVP option C billing analysis method to verify PY9 energy savings and estimated a 3.6% decrease in energy consumption. The SWE reviewed the methodology, analyzed the underlying interval data and conducted and independent replication of energy savings. The SWE found the verified savings approach to be reasonable.

Some of the key observations from our audit include the following:

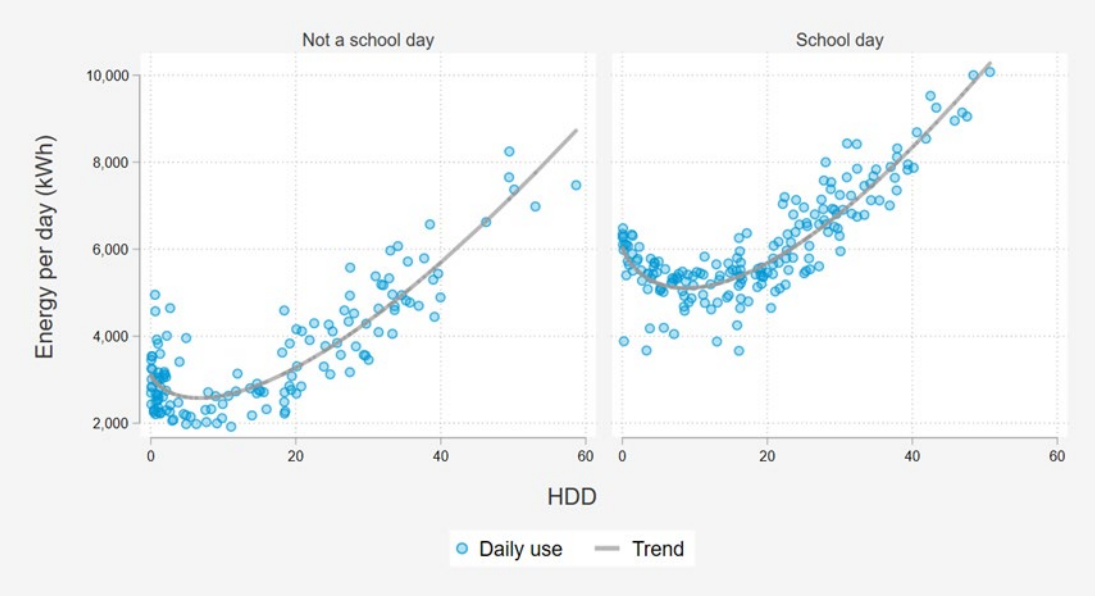
- The energy savings were very similar on a site-by-site level as the energy saving reported by the implementation CSP. The SWE independent replication also produced similar energy savings of 3.6%.

Figure 56: Scatterplot of Verified Savings vs. Reported Savings by School



- More than 50% of the savings came from one school and several schools had increased annual energy consumption.
- The schools analyzed have distinct energy use patterns as function of weather when they are and are not occupied, as illustrated in the below example.

Figure 57: Example of School with a Questionable Degree Day Base Selection



- A visual inspection of CDD and HDD included in the data provided indicates that additional refinement is needed in selecting the cutoff.
- The evaluation model included program participation, occupancy (school calendar), weather data, and hourly interval data. It was analyzed using a random forest regressor with gradient boosting. The machine learning technique is useful for accounting for non-linearities in energy use and factors, such as occupancy, that lead to inherently different energy patterns.
- The approach relies on a pre-post comparison without a control group. The approach inherently assumes there are no changes influencing energy use besides weather, occupancy, and the introduction of the energy-efficiency intervention.

C.4.2.5 Ride-Along Site Visits

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.

Table 122 provides an overview of the SWE milestones for the audit of PPL's site inspection efforts.

Table 122: PPL Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Energy Attainment Percentage
7	1,174,582	3	3	104%

Overall, the SWE agreed with the methods of calculation employed by PPL's evaluation contractor. 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 values were deemed inappropriate. The cumulative realization rate of the seven projects with ride-along audits was 78.6% of the reported energy savings. The SWE agreed with the evaluator's corrections, which largely corresponded to differences in lighting hours of use.

Table 123 provides an overview of the SWE milestones for the verified savings review of evaluated PPL projects conducted via desk review.

Table 123: PPL Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
2	185,243	9	73%	32%

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 projects. Overall, Cadmus estimated NTG following the recommended procedures outlined in the Phase III Evaluation Framework.

While not a large project, the SWE found an error in the calculations for Project RBT-1407808, which achieved energy savings for guest room occupancy sensor. However, the project attained approximately 10% of the reported energy savings – Cadmus gave the project a 63% realization rate and SWE gave the project an additional attainment percentage of 19% for energy savings and 0% for demand saving. Cadmus incorporated the SWE's feedback on the energy savings and demand reduction calculations for the project into the final verified savings, which are reflected in Cadmus' final RBT-1407808 site visit report and annual report. During Cadmus' visit, they observed that only the third-floor renovation has been completed and the second-floor renovation is still in progress. The first floor has not been started yet. The implementer reported the project as complete on 12/7/2017. Also, due to guest complaints and comfort issues, the customer had turned off the occupancy controls during the cooling season but intended to use setback during heating season (winter). The SWE found that the evaluator considered the in-service rate correctly; however, the SWE found that the evaluator had not considered the controls disablement correctly.

Per the in Sec. 3.3.3.1.2 of the Evaluation Framework for Pennsylvania Act 129 EE&C Programs, "If the evaluation contractor finds that a measure is operating, but in a manner that renders the TRM values not directly applicable, TRM deemed values should not be directly applied and the evaluation contractor must incorporate the noted differences in savings calculations. When possible, measure design intent (i.e., the designed measure function and use and its corresponding savings) should be established from program records and/or construction documents. If the TRM values were applied incorrectly, the evaluator should recalculate savings using the correct TRM values applicable to the measure."

C.5 DEMAND RESPONSE

PPL's Phase III demand response compliance target is 92 MW. DR goals are assessed at the system level, meaning that line loss adjustments are applied to the load impacts measured at the customer meter. In addition to the 92 MW target, which is an average of all Phase III DR events, EDCs are required to achieve at least 85% of their overall target in each event. For PPL, this translates to a 78.2 MW minimum performance level for any given DR event. Decisions about which day DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. PPL called DR events on the three days those guidelines required.

On January 15, 2018 the PPL/Cadmus team filed its first PY9 semi-annual report and a detailed DR evaluation report. These filings reported the PY9 verified gross impacts as calculated by Cadmus. The performance estimates in the PY9 Final Annual Report were unchanged from the original verified savings estimates. Table 124 summarizes the three PY9 DR events. PPL's gross verified performance was comfortably above the Phase III compliance target for each event.

Table 124: PY9 DR Impacts by Event

Event Date	Event Time	Average Performance (MW)	% of Phase III Target
June 13, 2017	2pm – 6pm	120.3	131%
July 20, 2017	2pm – 6pm	131.8	143%
July 21, 2017	2pm – 6pm	127.9	139%

The PPL/Cadmus team also submitted a response to the SWE DR data request. The data elements of this request included the following:

- A list of participating facilities and the reference load method used to estimate its gross verified performance
- For each event hour, a record of which facilities participated, their reference load, metered load, and verified DR impact
- For 20 sites selected by the SWE, the hourly load data and PJM participation records needed to replicate the Cadmus impact estimates
    - These 20 sites represented approximately 94% of the gross verified PY9 DR impacts.

The data request response and DR evaluation report formed the basis of the SWE audit activities. The SWE found the approaches implemented by Cadmus to be well-aligned with the Evaluation Framework and consistent with industry best-practice. The execution of the analysis was thorough and free of errors. The SWE agrees with the PY9 gross verified savings estimates and will recommend the Commission adopt them when assessing compliance with Phase III targets.

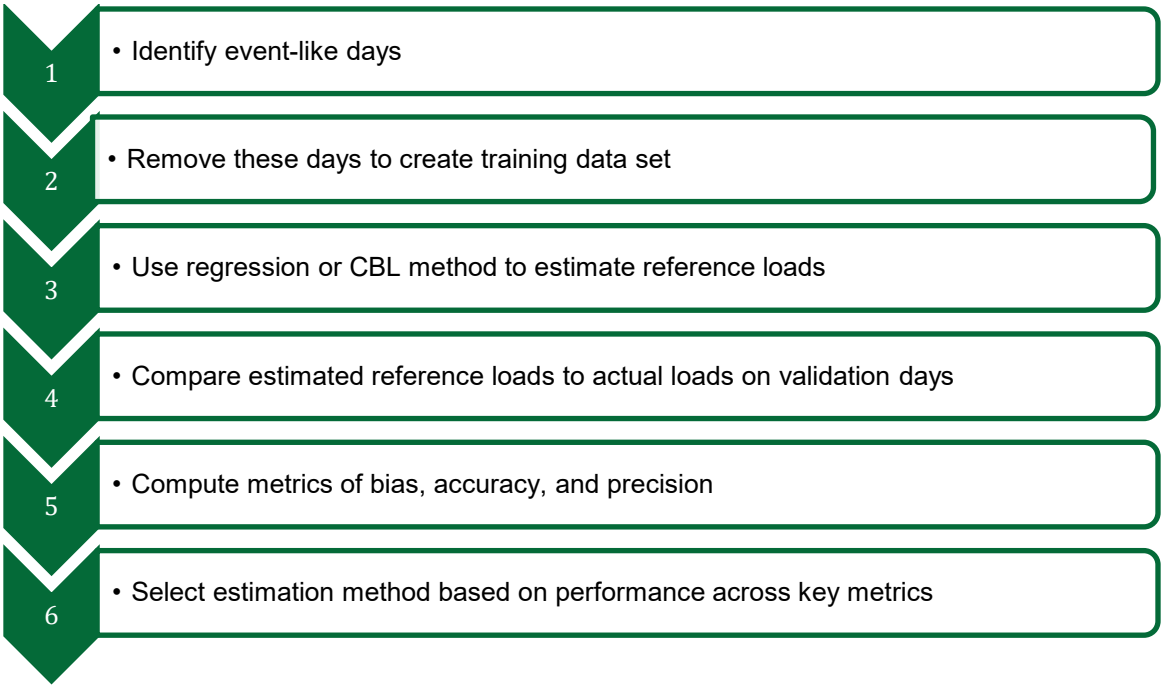
C.5.1 Replicate Program Totals

The first step in the SWE audit was to replicate the program performance totals from the site-level estimates. The DR Performance table was filtered to include only hours where sites were listed as participating and then the participating impacts were summed by date and hour. The SWE was not able to replicate the totals exactly because the data request did not ask for sector – which determines the line loss factor applied to a site's impact estimates. However, when the SWE used the Large C&I loss factor (1.042) for all participants the totals were only slightly lower than the report values. This makes sense because the Large C&I sector contributed the majority of the PY9 demand reduction. In the PY10 DR data request, the SWE will request sector (or LLF) for each participant.

C.5.2 Reference Load Selection

Early in 2017, Cadmus submitted a memo and supporting data to the SWE documenting the approach that was used to select sites-specific baselines. The approach was consistent with the process shown in Figure 58 – which is taken from the Evaluation Framework.

Figure 58: Baseline Selection Steps



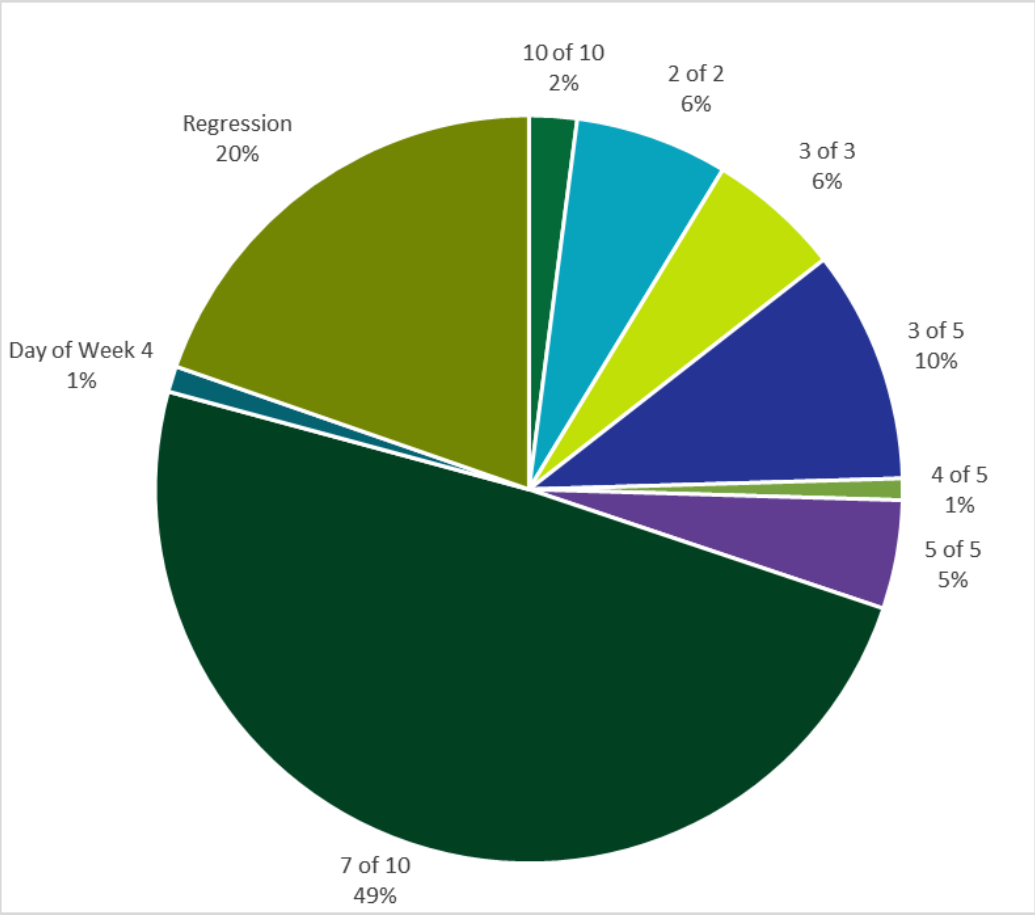
Cadmus tested, and ultimately used a variety of baseline methods in PY9. Table 125 shows the distribution of baseline approaches across the PY9 program population. Individual customer regression analysis was by far the most common approach (87% of sites).

Table 125: PY9 Baseline Frequency Table

Baseline	Number of Sites Used
10 of 10	1
2 of 2	3
3 of 3	1
3 of 5	1
4 of 5	1
5 of 5	1
7 of 10	3
Day of Week 4	1
Individual Customer Regression	81 (80 completed)

Figure 59 looks at the distribution of baseline methods by gross verified MW. While regression analysis was the most common approach, it only accounted for approximately 20% of the MW performance. Conversely, a high 7 of 10 baseline was selected for just three sites but accounted for almost half of the program impacts. This distribution makes sense because regression analysis tends to be well-suited for weather-dependent sites, and those sites are often smaller than the large industrial facilities with little or no weather-dependence.

Figure 59: Distribution of Gross Verified MW by Baseline



The SWE compared the baselines ultimately used to calculate gross verified PY9 impacts with the selections identified in February 2017 and found they were generally aligned. The ID variables used in the files were different (PPL account number vs. a Cadmus ID), so the comparison was based on customer name, which can be imperfect when organizations have multiple participating facilities.

It seems that the advance selections were used for most of the Large C&I sites, but not all. It's not clear why the methodology changed for some sites. Perhaps there was an adjustment in the scoring across accuracy or precision metrics, or maybe the exclusion of days prior to events altered the metric. Advance selection is a risk mitigation strategy and does not "lock" evaluators in to a specific approach. In fact, the SWE prefers Cadmus retain the flexibility to use its professional judgement to modify baseline selections based on observed load patterns as necessary.

C.5.3 Day-Matching Baselines

PPL is fortunate that three of the largest program participants have very predictable load patterns and reduce load completely when dispatched. Load impacts from this type of facility will be robust to baseline selection (e.g., most methods will return very similar answers). PPL has a lot of compliance risk tied to these three sites, so the certainty of an X-of-Y CBL is preferred, and there's really no loss of accuracy compared to regression because load patterns are so flat.

PPL's PY9 participant group also included some industrial plants with much less predictable load patterns that combined to account for approximately 25 MW of the PY9 gross verified performance. Volatile load patterns lead to much higher RMSE values and greater uncertainty in estimates of DR performance. These plants also tend drop less load (on a percent basis). From a compliance standpoint, these facilities present some additional risk for PPL. From an evaluation standpoint, they are more challenging for Cadmus because no baseline will be very accurate and verified impacts can vary widely across baselines.

There are few remedial measures for sites with erratic load patterns and high RMSE values. The Cadmus approach of advance baseline selection based on empirical metrics of accuracy and precision on placebo days is recommended for PY10 given the concentration of risk in these sites. Cadmus may choose to revisit the baseline selections using non-event days during summer 2017 or continue using the same baseline for PY10.

C.5.4 Regression Analysis

Cadmus used regression analysis for all Small C&I and GNE participants as well a few Large C&I sites where regression methods out-performed day-matching in out-of-sample testing. The SWE agrees with this approach as the Small C&I and GNE sites are typically more weather-dependent, which makes regression approaches more advantageous. Cadmus tested a variety of regression model specifications on each site and selected the model that predicted most accurately in out-of-sample testing. This is exactly the approach the SWE hoped to see from EDC evaluation contractors.

One other analysis decision Cadmus made that the SWE supports was the exclusion of the notification day from baseline calculations. We agree that the "day-ahead" event notification tends to influence participant loads (some up and some down) and the safest approach is to exclude these days from the analysis so as not to bias the calculations.

C.5.5 Independent Verification of Calculations

The SWE independently calculated reference loads and load impacts for each event hour for each of the 20 sites where hourly load data was requested. For 18 sites, the SWE estimates matched the Cadmus values exactly. Figure 60 contains scatter plots of the SWE and Cadmus reference loads for day-matching sites in the sample. The trends are perfect diagonal lines with slope = 1. The "25% rule" was only invoked twice in the analysis.

Figure 60: Reference Load Comparison for Day-Matching Sites

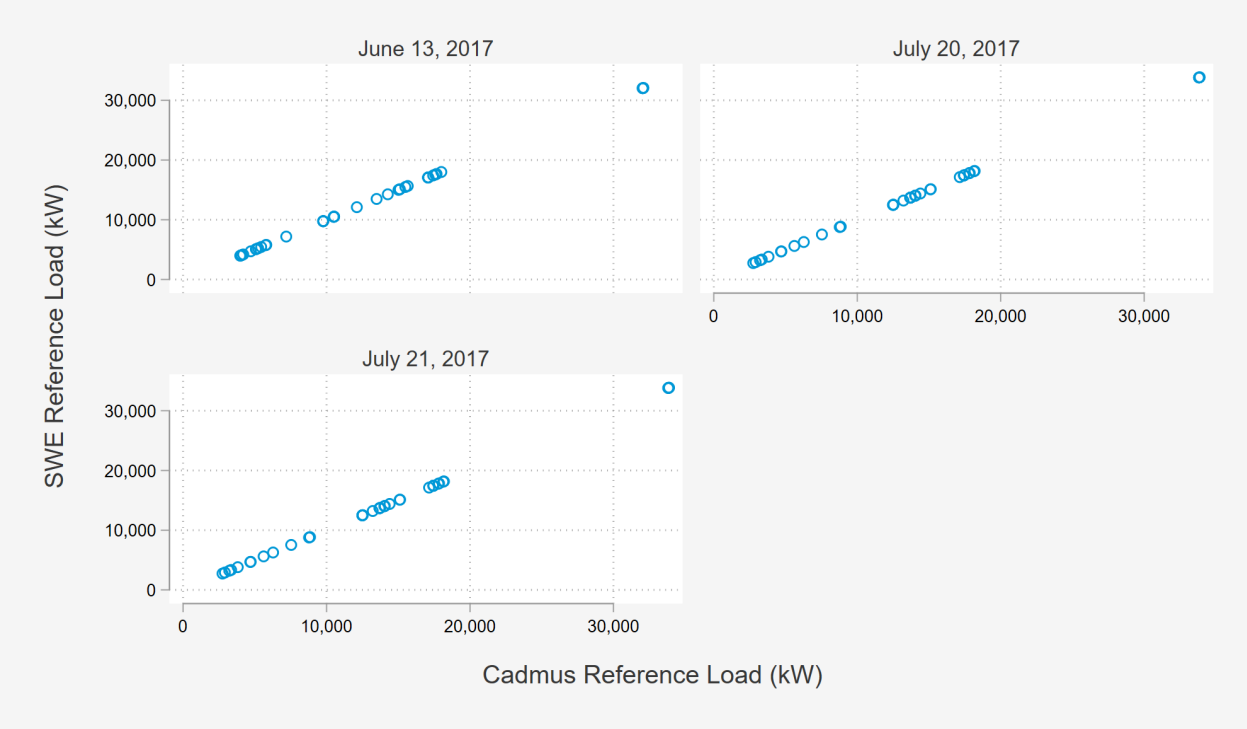


Table 126 compares the SWE load impact calculations with the Cadmus calculation for the nine sites in the SWE sample. The SWE used the same regression model specification and 30 non-event weekdays. The differences are tiny, but in each hour the SWE estimate is slightly above the Cadmus total.

Table 126: Impact Comparison – Regression Sites in SWE Sample

Date	Hour	SWE kW Estimate (at meter)	Cadmus Verified kW (at meter)	Sites Participating
6/13/2017	15	19,904	19,903	8
6/13/2017	16	21,137	21,128	9
6/13/2017	17	21,694	21,684	9
6/13/2017	18	22,250	22,243	9
7/20/2017	15	14,501	14,499	5
7/20/2017	16	15,095	15,087	5
7/20/2017	17	17,186	17,176	5
7/20/2017	18	16,764	16,758	5
7/21/2017	15	17,329	17,328	5
7/21/2017	16	17,181	17,174	5
7/21/2017	17	17,407	17,397	5
7/21/2017	18	15,912	15,906	5

The SWE isn't concerned about the small differences for these sites. The difference is likely due to the way different statistical packages handle the inclusion of categorical variables in the estimation procedure.

C.6 NTG

C.6.1 Residential Programs

Cadmus assigned a PY8 NTG value to two programs in PY9: The Appliance Recycling Program and the Efficient Lighting Program. Cadmus conducted a new evaluation with program participants' survey data and the common NTG formula to determine the NTG for the Efficient Equipment stratum of the Energy Efficient Home program. The updated stratum NTG was then combined with the other Energy Efficient Home stratum (PY8 NTG values weighted to PY9 program values).

Cadmus assigned an NTG of one to the Behavioral Solution, in accordance with the Evaluation Framework.

Table 127: Summary of NTG Estimates for PPL Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8 based on Demand Elasticity Model	Efficient Lighting	--	--	0.83	-
PY8	Appliance Recycling	--	--	0.66	--
PY8	Energy Efficient Home	0.32	0.07	0.75	--
RCT	Home Energy Education	0.0	0.0	1	--

C.6.2 Low-Income Residential Programs

Cadmus did not conduct NTG research for any low-income program during PY9.

Cadmus assigned an 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 an 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.6.3 C&I Programs

Cadmus utilized online and phone surveys to gather data for the PY9 Custom Program NTG analysis as well as the common method detailed in the Evaluation Framework.

Self-report surveys of Midstream Lighting Program were used to collect data for PY9 NTG estimation using the common method.

The Prescriptive Equipment stratum of the Efficient Equipment Program PY9 NTG evaluation was conducted based on eight surveys (2% of the total population). The SWE recommends increasing the sample size in future evaluations. The NTG for the Lighting stratum of the Efficient Equipment Program was based on self-report customer surveys and used a two-pronged approach for determining free-ridership and was applied to savings to yield a stratum NTG of 0.69. The Efficient Equipment Program stratum NTG values were weighted by savings, which was heavily influenced by lighting producing an overall program NTG of 0.69.

The SWE determined that Cadmus utilized data collection, question bevies, and the common NTG formula recommended in the Phase III Evaluation Framework.

Table 128: Summary of NTG Estimates for PPL C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Total Custom	0.27	0.0	0.73	25
Estimated	Midstream Lighting	0.15	0.0	0.85	27
Estimated	Efficient Equipment	0.44	0.0	0.56	8

C.7 TRC

Table 129 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.

The primary differences for the PY9 TRC from the previous program year are the inclusion of fossil fuel and water saving benefits under the Total NPV Lifetime Non-Electric Benefits and funding for demand response.

Table 129: Summary of PPL's PY9 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	5,618	2,032	2.76	5,618	2,032	2.76
Home Energy Education	1,466	1,623	0.90	1,466	1,623	0.90
Low-Income WRAP	6,472	9,371	0.69	6,472	9,371	0.69
Student Energy Efficient Education	2,230	1,103	2.02	2,230	1,103	2.02
Appliance Recycling	3,780	2,074	1.82	2,495	2,074	1.20
Custom	17,354	29,333	0.59	12,787	21,894	0.58
Efficient Equipment	83,590	43,240	1.93	59,124	31,481	1.88
Efficient Lighting	60,993	13,546	4.50	50,623	11,509	4.40
Energy Efficient Home	14,364	16,547	0.87	9,755	11,518	0.85
Demand Response	5,656	1,491		5,656	1,491	
Common Portfolio Costs		8,652			8,652	
Portfolio	**201,523**	**129,012**	**1.56**	**156,226**	**102,748**	**1.52**

Of PPL's nine (non-DR) programs, six are cost-effective by the TRC test and three are not.

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.7.1 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 multipliers (1.042 for industrial applications and 1.0875 otherwise) once revisions to the demand response calculations were applied. 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 Cadmus data request response did not include the TRC calculations for demand response programs. Once provided, the SWE discovered that incorrect MW performance totals were used, and line losses were applied to values that had already been escalated for losses. Cadmus should take care to avoid these disconnects between the DR impact evaluation and TRC calculations in PY10
- The TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. However, the monetization of water savings was not clearly calculated and avoided water costs were not transparent. The SWE recommends providing transparent water savings calculations in future program year reporting.
- The cost of kits was incorporated into the TRC as program delivery costs rather than incentives to participants. The SWE recommends treating the cost of kits as incentives to participants in future program year reporting.
- The Home Energy Education program included erroneously calculated MWh and MW values, which affected the benefits associated with that program. Additionally, the Home Energy Report program cost-effectiveness should include the deduction for uplift at the program level, rather than as a separate line item in the model.

The SWE noted a handful of minor issues in PY8 that PPL corrected for in PY9.

- In PY8, the reported benefits of the Home Energy Education program included a potential double counting of a portion of those benefits and were recommended to be removed from the TRC calculation. PPL included a line item in the PY9 TRC ratio calculation that corrects for the double counting from the Home Energy Education Program Energy Savings Uplift.
- In PY8, general service lamp pre-EISA savings were incorrectly included in the small C&I efficient lighting subprogram. The SWE recommended a change in which the pre-EISA general service lamp savings be correctly applied to the residential efficient lighting program. PPL applied this change to the PY9 TRC calculation.
- In PY8, the TRC model lacked documentation and transparency in the source data on which the calculations are based as well as the incremental cost basis for any measure.

PPL provided documentation on source data and incremental costs with their TRC model in PY9.

- In PY8, the SWE recommended lighting-related project lines that list "exit sign" in the descriptor be assigned a flat load shape. The PY9 TRC model made this correction.

C.8 PROCESS

C.8.1 Residential Programs

Cadmus reported on PY9 process evaluations for five 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 or a response to evolving evaluation needs. 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.8.1.1 Appliance Recycling Program

Summary of Process Evaluation Findings

In PY9, Cadmus conducted a process evaluation that included two interviews with PPL program managers, one interview with ICSP staff, and online participant surveys. According to the evaluation plan, non-participant surveys are scheduled for PY10. The process evaluation findings for PY9 are summarized below:

- Similar to findings from PY8, demographic data from the PY9 participant surveys indicate that the program is reaching older generations, but not as many younger customers. Only 17% of Appliance Recycling program participants were born in 1970 or after.
    - While the older demographics, who make up the majority of program participants, still rely heavily on bill inserts as the primary source of information about the Appliance

Recycling Program, there has been a marked shift toward online sources of data. In PY9, 30% of survey respondents born before 1970 and 47% of respondents born after 1970 reported learning about the program through an online source, an increase from PY8 of 5% and 13%, respectively.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, with one small addition: Cadmus interviewed PPL Electric Utilities and ICSP program managers to assess program changes between PY8 and PY9. Cadmus exceeded the target sample size of two programs and ICSP staff interviews by completing three interviews. All planned research activities for the process evaluation were performed. For participant surveys, Cadmus contacted the entire sample with the goal of targeting as many completes as possible, achieving a final sample size of 612.

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 drew directly from the process evaluation activities. There was one recommendation that followed from the process evaluation. The report also included a table with the recommendation, which is under consideration by PPL.

C.8.1.2 Energy Efficient Home Program

Summary of Process Evaluation Findings

In PY9, Cadmus conducted a process evaluation that included surveys with program participants, interviews with program staff and implementers, and a logic model review. The findings from the process evaluation are detailed below.

- Nine in ten (90%) of participants expressed satisfaction with the Energy Efficient Home Program. However, some participants – especially those in the equipment component – reported challenges with the application process. Many participants reported needing the contractor's assistance with the application and suggested making the application process simpler.

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 PY9 evaluation plan were completed. Cadmus noted one deviation from the evaluation plan; due to the small population size for weatherization participants, Cadmus completed only an online survey (rather than phone and online surveys). The planned sample size for program and ICSP staff was met; however, the target sample size of 195 telephone interviews for efficient equipment participants was not met; Cadmus completed 125 telephone interviews. 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. Although the methodology sections adequately explained the evaluation and included sampling and disposition information, it did not provide any explanation for why the evaluation was not able to achieve the target sample size for the participant 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 activities was clear. There was one recommendation that followed from the process evaluation; this recommendation is under consideration.

C.8.1.3 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, review of a logic model, and online and phone interviews with participants. All targeted sample sizes for interviews and surveys were met.

The results of the process evaluation are summarized below.

- The Phase III wave exhibited significantly higher satisfaction with the home energy reports than the Phase I and II waves. Phase I waves had the lowest proportion of satisfied respondents (55%), while the Phase III wave had the highest satisfaction (78%). Nearly two-thirds (65%) of Phase II respondents were satisfied.
- The home energy reports vendor redesigned the look and content of the reports. Compared to PY8, the PY9 reports contained less text and more images with clear call-to-action messages that also accounted for the customer's heating type.
- Overall, satisfaction with home energy reports decreased significantly since the previous evaluation. In PY8, 73% of participants reported satisfaction with the reports, compared to 65% in PY9.
- Dissatisfied respondents most often said they did not believe the home energy reports had accurate data (35%) and did not find the reports to be of value (19%). Respondents suggested improving the accuracy of the reports and offering participants something else besides a home energy report that would help them lower their bill.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, except for one deviation. No customer satisfaction surveys were planned for PY9; however, Cadmus conducted a customer satisfaction survey.

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; these recommendations are currently under consideration.

C.8.1.4 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, online focus groups with participating teachers, and interviews with non-participant teachers. The program has three cohorts: Bright Kids (2nd-3rd grades), Take Action (5th-7th grades), and Innovation (9th-12th grades). In PY9, the ICSP and the ICSP's subcontractor rolled out two pilots, which Cadmus evaluated as separate cohorts. The Take Action Pilot (5th-7th grades) provided a subset of classrooms with an application for tablets and smart phones to engage students and their parents with products in the energy-efficiency kit at home. The Innovation Pilot, for 9th-12th grade students, provided Tier 2 advanced power strips in place of Tier 1 smart strips for a subset of Innovation cohort classrooms. The findings of the process evaluation are summarized below.

- Some teachers in the Innovation cohort found the subject matter not sufficiently challenging for their students and suggested that the program could incorporate additional math exercises. Of all materials provided by the program, the energy usage meter they received in prior program years was reported to be most useful because it helped students better engage with energy-saving concepts.
- In PY9, students in this cohort indicated they were less satisfied than students in the Bright Kids or Take Actions cohort, which is consistent with the qualitative results of teachers in the Innovation cohort.[67] Nearly all teachers found the National Energy Foundation (NEF) presentation helpful because the presenters engaged the students. To make the classroom material more engaging, teaches requested additional interactive and digital elements, such as videos and games. In response, the program will roll out the Energy Sidekick app for all Take Action participants in PY10.
  - Some teachers requested additional instructions from PPL Electric Utilities on how to deliver the program. For PY10, the ICSP's subcontractor updated the installation videos provided to teachers by the program.
  - While two teachers whose students used the Energy Sidekick app thought it did a good job of helping students stay engaged with the program, students in the Take Action Pilot (where the app was debuted) indicated lower satisfaction than those in the Take Action cohort.
- Of all aspects of the program, students liked the energy-efficiency kits best. However, they were less likely to install the water-saving products, because some students and parents did not like them. To increase installation rates for these devices in PY9, the ICSP updated the presenter training and materials, and Cadmus did observe an increase in installation rates for showerheads in the Take Action cohort.
  - Teachers value the kits because the energy-savings products connect their students' home lives to what they learn in school, but some teachers do not have time to review the kits in their class. Most of the questions they get about kits regard the smart power

[67] The evaluation did not indicate if the difference was statistically significant.

strip, and in PY10 the ICSP's contractor has included additional information and instruction in the presentation on smart power strips.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, with one modification. In the PY9 plan, Cadmus proposed conducting three focus groups, one group for teachers representing each of the three student cohorts (Bright Kids, Take Action, and Innovation). However, PPL Electric Utilities identified non-participant research as important for understanding lower enrollment in PY9, and Cadmus conducted phone interviews with teachers who participated in PY8 but not in PY9. Due to budget constraints, Cadmus could not conduct these non-participant interviews and all three focus groups and prioritized the Take Action and Innovation cohorts because both are associated with higher savings, have a greater number of products, and have historically held more student engagement activities.

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 number of HEWs 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 were four recommendations that followed from the process evaluation, two of which were implemented and two of which are under consideration.

C.8.1.5 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 and a program database review. In consideration of the program's success, interviews with PPL staff focused on program progress and plans through PY10 and PY11. Cadmus noted that PPL sold fewer bulbs through do-it-yourself (i.e., home improvement) and club retailers and more bulbs through independent hardware franchisers in PY9 than in PY8. There were no key findings or recommendations related to the process evaluation.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan, with the exception of the planned logic model review. Cadmus did not conduct this activity review because the program did not change in PY9. There are limited process evaluation results presented in the report, but the tables that are included contained clear and sufficient detail.

C.8.2 Low-Income Programs

Cadmus reported on PY9 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; conducted benchmarking reviews, 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. The research issues addressed by the primary data-collection activities (in-depth interviews and surveys) varied among programs, but generally included 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 deviations in both programs that were requested by PPL or in response to changes in program circumstances. These will be covered in the program's process evaluation audit summary below. In the case of deviations from the evaluation plan, Cadmus provided satisfactory explanations.

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.8.2.1 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 satisfaction levels among program contractors and market actors (multifamily building property managers, manufactured home park property managers) were assessed through phone interviews. The evaluation also included a logic model review and a process flow map review. The findings of the process evaluation are summarized below.

- Participants were more satisfied with WRAP in PY9 (91%) than in PY8 (80%).[68] Concerns mentioned by respondents in the PY8 survey – issues with scheduling, expectations, and communication – were mentioned less frequently in PY9. WRAP achieved an excellent net promotor score of 70.
- Several program strategies in PY9, including more postcards sent to customers, diversified marketing methods, and accepting applications over the phone, increased leads.
- Most of the issues about scheduling reported in PY8 were addressed in PY9. Although communication improved substantially overall in PY9, a few participants reported concerns about products installed and follow-up visits.
- In PY9, 57% of WRAP participants reported acting on at least one energy-savings recommendation. This figure represented a substantial increase compared to PY8 (39%), but still falls below the desired impact. [69]
- Estimating energy education savings through participant telephone surveys has limitations; the phone survey respondent may not be the same person who directly

[68] The evaluation did not indicate if the difference was statistically significant.
[69] The evaluation did not indicate if the difference was statistically significant.

received the program intervention or may have trouble recalling the energy education recommendations they learned while on the phone.

- While complaints about Tier 2 advanced power strips decreased in PY9 from PY8, some program participants and contractors reported confusion about using the product correctly.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan, with one exception. Rather than conducting a single wave of phone surveys at the end of PY9, Cadmus conducted two waves of phone surveys with a sample of participants – one wave after the completion of PY9 Q2 (including Q1 and Q2) participants, and another after the completion of Q4 (including Q3 and Q4 participants). This change was implemented at the request of PPL in order to identify any possible differences in satisfaction, realization rates, or program success between the first and second halves of PY9.

Sample sizes in the final process evaluation matched the evaluation plan for interviews with EDC staff and market actors. 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 PY9 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. Cadmus provided three recommendations that followed from the process evaluation. Two recommendations are being considered, and one was implemented.

C.8.2.2 Energy Efficiency Kits and Education Program

Summary of Process Evaluation Findings

The process evaluation performed by Cadmus in PY9 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, Cadmus conducted a benchmarking review, analyzed the paper surveys included in the kits provided to participants, and conducted telephone surveys with a sample of kit recipients who did not return the paper survey. The process evaluation findings are summarized below.

- Responders and agency participants more frequently indicated they “strongly agreed” that they knew how to install all or most of the products in the kits compared to non-responders and participants who received their kits in the mail.[70]
- Compared to direct mail participants, agency participants more frequently responded “strongly agree” that they knew where to get information about the products in the kits. [71]

[70] The evaluation did not indicate if the difference was statistically significant.
[71] The evaluation did not indicate if the difference was statistically significant.

- Iowa's Energy Wise Program incorporates behavior change into its savings calculations, specifically temperature changes for water heating and space heating/cooling, changes in shower length, and unplugged electronics.
- The products in the Energy Efficiency Kits and Energy Program kits are generally consistent with the lighting and water products that benchmarked utilities have in their kits, except that PPL Electric Utilities' kit does not contain insulation products.
- The ICSP received reports from agencies that many customers were confused about how to install the advanced power strips. However, the ICSP is not including advanced power strips in the PY10 kits.
- Three of seven programs (PPL Electric Utilities, Focus on Energy, and Duquesne Light) included an advanced power strip in the program kits. Focus on Energy includes a Tier 1 smart strip in some of its kits. Duquesne Light also includes a power strip in its low-income kits but did not specify whether it was a Tier 1 or Tier 2 product.
- The direct mail channel delivered the vast majority of program kits in PY9 (81% of all kits distributed and not returned in PY9).
- According to the ICSP, nearly half of the participating agencies had not distributed as many kits as anticipated. PPL and the ICSPs believe that the agencies may have lacked staffing resources necessary to implement the program or may have been engaged in seasonal work.
- The ICSP reported that efforts to recruit additional agencies to the program in PY9 were unsuccessful because the ICSP did not find any agencies that covered underserved areas.
- Similar to the Energy Efficiency Kits and Education Program, Duquesne Light's Low-Income Energy Efficiency Program and Iowa's Energy Wise Program rely on agencies to distribute a significant number of kits. Neither program offers different kits by type of home water heating system.
- Focus on Energy's Simple Energy Education Program and PacifiCorp's Wattsmart Starter Kit program rely solely on the website and call centers to enroll participants and kits are distributed by mail. Both programs offer eight kit types, and several are specifically for water heating.

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. Cadmus did not conduct interviews with community-based organizations (CBOs) in PY9 because their responses to interview questions have remained consistent throughout the program. Secondly, Cadmus conducted follow-up telephone surveys with a sample of participants who responded to the paper kit survey to gather information about differences in in-service rates (ISR) between responders & non-responders. Cadmus met planned sample sizes for all research activities except telephone surveys for agency responders and were able to analyze 1,181 completed paper surveys returned by kit recipients. Cadmus did not meet

the target sample size of 70 for agency responders due to the low number of agency responders in the population; they reported achieving only 20 completed surveys after exhausting the sample frame.

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, in general, 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. The SWE notes that key findings from the benchmarking review presented alongside the recommendations may have benefited from additional context to increase clarity. Cadmus provided three recommendations that followed from the process evaluation. One recommendation was rejected, one was implemented, and one is under consideration.

C.8.3 Commercial and Industrial Programs

Cadmus reported on PY9 process evaluations for two non-residential programs: Demand Response Program and the Non-Residential Energy Efficiency Program, which has four distinct components: Efficient Equipment, Midstream Lighting, Custom, and Continuous Energy Improvement (CEI).

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 provided 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.8.3.1 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 results of the overall process evaluation are summarized below:

- Although 95% of survey participants were *very* or *somewhat satisfied* with the program overall, they were least satisfied with the ability to track rebates. Nine participants recommended improvements to the application.
    - Two of the three detractors (5% of respondents) said they were not given enough information to accurately complete the application, one respondent had difficultly managing the linked spreadsheets, and one had incorrect calculations that affected the project budget.
- PPL Electric Utilities' rebates were one of the most influential aspects of customers' decisions to install energy-efficient equipment. This was especially true of direct discount lighting participants. Additionally, five of seven contractors said PPL Electric Utilities' rebate programs were *very important* in their customers' decision to purchase more efficient equipment.
- Three of ten contractors said that before PPL Electric Utilities rebates were available, high efficiency equipment and lighting products were *sometimes* or *frequently* a selling point, compared to nine of ten contractors who said they were a selling point after rebates were available.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were mostly consistent with the Phase III Evaluation Plan. Cadmus noted one exception; they did not reach the targeted number of completed surveys in the equipment stratum due to low participation but achieved the overall target of 68 completed surveys by surpassing targets in other strata.

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 PY9 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 two recommendations that followed from the process evaluation, both of which are under consideration.

C.8.3.2 Midstream Lighting Program

Summary of Process Evaluation Results

The revised EE&C plan in October 2017 combined the Custom and Efficient Equipment programs into a single program called the Non-Residential Energy Efficiency program. For purposes of this evaluation, Cadmus treated each component of this program as individual program offerings and evaluated them separately in PY9. The process evaluation for the Midstream Lighting Program included interviews with PPL Electric Utilities Program and ICSP staff, end-user purchase, contractor purchasers, and end-user non-purchasers. Cadmus also conducted an end-user segmentation analysis, tracking data review, and logic model review. The findings of the process evaluation are summarized below.

- Overall, the Midstream Lighting component has been running effectively and saw a dramatic increase in reported sales from PY8 to PY9. The lighting delivery channel is used by a wide range of commercial customers. Satisfaction among program actors was high in PY9.
  - Distributors, in particular, were more satisfied with the diversity of eligible products in PY9 than reported in PY8.
- Although demand for efficient lighting (LED products, specifically) has been on the rise and represent the majority of participating distributors' lighting sales, both distributors and contractors reported that customers are cost-conscious and utility program incentives are very influential in maintaining sales of efficient products.
- Some distributors found it challenging to collect reliable information regarding the installation locations of all purchases, especially when contractors purchased the discounted products on behalf of the end-user. As a result, some distributors are concerned about the risk of not being reimbursed for instant discounts they advance on sales.
- Both distributors and customers said their program experience could be improved if they could access information about product eligibility and incentives online. They expressed frustration with current system wherein each distributor maintains a list of products they carry that qualify for incentives and must obtain pre-approval from the ICSP to add new products to their list.
  - Distributors also suggested that the program automatically include all ENERGY STAR- or DesignLights Consortium-certified products in defined categories, rather than requiring the ICSP's preapproval before the distributor can complete a discounted sale.
- Distributors and contractors play an important role in driving sales of efficient lighting by building on their relationship with customers. Specifically, they can influence customers' decisions to invest in upgrades, especially ENERGY STAR- or DesignLights Consortium-certified products.
  - Distributors use the Midstream Lighting instant discounts to drive sales of efficient products. However, awareness of the Midstream Lighting component is still relatively low among participants in other components of the Non-Residential Energy Efficiency Program.
- Distributors appreciate receiving time-limited sales performance incentives (SPIFFs), and a few reported that SPIFFs motivated staff to be more proactive in driving sales of program products. However, they agreed that SPIFFs had less influence on sales than did the instant discounts passed on to customers.
  - Distributors also preferred being made aware of SPIFFs in advance so they could prepare their sales staff; a timeline of 30 days was suggested.
- Some distributors said reconciling their internal bookkeeping was challenging because the ICSP's reimbursement checks did not include the distributors' invoice numbers.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan. 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. However, in two strata, participating distributors and end-user non-participants, Cadmus did not achieve the target sample sizes of 17 and 15, respectively, and did not provide an explanation for the shortfall.

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. One recommendation was accepted or implemented, and the other three are under consideration.

C.8.3.3 Continuous Energy Improvement

Summary of Process Evaluation Results

The CEI program, a component of the Non-Residential Energy Efficiency Program, began in Q4 of PY8, and PY9 was the first program year with savings. The process evaluation included interviews with PPL Electric Utilities Program and ICSP staff and school district energy managers. Cadmus also conducted a document and logic model review. The findings of the process evaluation are summarized below.

- According to energy managers, maintaining behavior-based changes can be challenging and often requires buy-in from principals and administrative staff as well as teachers and students. Student engagement in particular contributes to the success of Continuous Energy Improvement and is often more effective than directives from facility staff.
- Energy managers track their bills, but not all regularly check EnergyCenter for weather-adjusted savings reports. Feedback from energy managers indicates that being able to demonstrate monetary savings helps promote and maintain student, staff, and principal engagement with continuous energy improvement activities.
- Three of four energy managers were not aware of PPL Electric Utilities Student Energy Efficient Education Program, which offers classroom energy-efficiency education and energy-savings kits with products for students to install at home. One energy manager was aware that a teacher at the pilot school was in this program but was not directly involved with the other program.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan with one exception. Instead of conducting an online survey, Cadmus conducted telephone interviews with the energy managers at the four districts. Cadmus achieved the target sample size for both strata.

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 two recommendations that followed from the process evaluation; both are under consideration.

C.8.3.4 Custom Program

Summary of Process Evaluation Results

The revised EE&C plan in October 2017 combined the Custom and Efficient Equipment programs into a single program called the Non-Residential Energy Efficiency program. For purposes of this evaluation, Cadmus treated each component of this program as individual program offerings and evaluated them separately in PY9. The process evaluation for the Custom Program included interviews with PPL and ICSP program managers, a mix of phone and online participant surveys, and a logic model review. The findings of the process evaluation are summarized below.

- Although 96% of survey participants were *very* or *somewhat satisfied* with the program overall, they were least satisfied with the ability to track rebates. Satisfaction with this component decreased from 62% *very satisfied* in PY8 to 50% in PY9.
- Survey respondents reported that the two most influential items in their decision to complete the project were the contractor or vendor who designed the product (with a rating of 3.79 out of 5, where 5 is extremely influential) and PPL Electric Utilities' rebate (3.2 out of 5).
- Communication documentation showed that most customers learned about the program from PPL Electric Utilities staff (53%) or through contractors (29%).

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, including meeting specified sample size targets. Evaluation findings and a single recommendation were limited to results of the process evaluation. The recommendation is currently under consideration.

C.8.3.5 Demand Response Program

Summary of Process Evaluation Results

The ICSP enrolled and contracted with customers during PY8 and initiated events during the summer of PY9; this is the first program year the Demand Response Program was evaluated. Cadmus performed the process evaluation, which included interviews with PPL Electric Utilities and ICSP program managers, surveys with participants, and a logic model review. The findings of the process evaluation are summarized below.

- Participants were satisfied with the program overall. Of the ten respondents interviewed, six reported being *very satisfied* with the program and two said they were *somewhat satisfied*.
    - Interview respondents said the program is working as intended and that the notification timing is a main strength of the program. Respondents said the duration and frequency of events do not hinder their ability to participate.
- As of December 2017, participants had not yet received the incentive payment because the ICSP waits for the annual evaluation to determine verified peak reductions before processing incentive payments. Two interview respondents said the payment timing was

inadequate, particularly in comparison to the quarterly incentive payments they receive through PJM's program.

Summary of Process Evaluation Audit

The research activities performed under the process evaluation were consistent with the Phase III Evaluation Plan, with one deviation. In light of a smaller-than-expected sample frame, Cadmus altered the target number of completed participant interviews from 70 to ten and opted for telephone surveys rather than a mix of online and telephone surveys. Although Cadmus met the target of ten participant interviews, none of the top five participants (ranked by enrolled MW load reduction) agreed to an interview. Cadmus recognized that the representative enrolled MW of interview respondents was low – only 12.4% of the total enrolled MW in the program. One recommendation followed from the process evaluation and has been implemented.

Appendix D Duquesne Light Audit Detail

D.1 EM&V Plan Reviews

Duquesne Light's evaluation contractor, Navigant, submitted a redline version of their PY9 EM&V plan with relatively minor adjustments to the evaluation approach. In addition, Navigant submitted several memos providing more detail on their upstream lighting intercept survey analytical approach, and memos updating their sampling approach for PY9 and a second memo updating their sampling approach for the Duquesne Light Whole House Retrofit Program. The SWE reviewed and approved the plans and memos, generally with minor revisions.

In addition to reviewing Duquesne Light's revised evaluation and sampling plans, the SWE reviewed six survey instruments and one interview guide. Four of these instruments were for residential programs and three were for C&I programs.

D.2 Sample Design Review

Each program in Duquesne Light's portfolio is not evaluated in every program year. As approved by the SWE in the EM&V Plan, some programs rely on the verification results from a previous year's evaluations. Table 130 indicates the impact evaluation activity for a given program year. Cells with an X indicate a program was evaluated that year. A * indicates that program year results use values from the previous year's evaluation. A + indicates use of values from the previous year's evaluation but combined with the current year research results to produce values for the two-year period.

Table 130: Schedule of Impact Evaluation for Each Research Initiative

Program	PY8	PY9	PY10	PY11	PY12
REEP Rebate	*	X	*	X	*
REEP Kit	*	X	*	X	*
REEP Upstream Lighting	X	X	X	X	X
Residential Behavioral Savings	X	X	X	X	X
Whole House	X	X	*	X	*
Residential Appliance Recycling	X	*	*	X	*
Commercial/Express Efficiency	X	+	X	+	X
Industrial	+	X	+	X	+
Midstream Lighting	X	X	+	X	+
Small Commercial Direct Install	X	*			
Multifamily Housing Retrofit	X	*	*	X	*
Public Agency Partnership	X	+	X	+	X
Community Education	X	*	X	*	X

When conducting evaluations in multi-year periods there is inherent uncertainty in applying RRs from prior years to estimate current year verified savings. This uncertainty is not reflected in the uncertainty captured by the relative precision values detailed below.

During an evaluation, verified savings estimates rely on extrapolation from observations among a sample of projects to the population. There is a chance that the evaluation sample may not be representative of the program population as a whole. 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 1,000 MWh/year and relative precision of ± 15% at the 85% confidence level, we can infer an 85% chance that the true savings is between 850 MWh/year and 1,150 MWh/year.

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 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 affect Navigant evaluation because Duquesne Light's Phase III EE&C plan already defined programs narrowly into logical initiatives. Navigant's evaluation activities for Duquesne Light were 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) which were sampled separately, and the Low-Income Energy Efficiency Program was similarly composed of discrete initiatives (Whole house retrofit, behavioral, multifamily housing retrofits, and kits). Table 131 shows the relative precision at the 85% confidence level of the PY9 energy savings for each program.

Table 131: Relative Precision of PY9 Gross Verified Energy Savings Estimates by Initiative

Program / Initiative	Relative Precision at 85% Confidence Level (±)
Residential Energy Efficiency Program	4.1%
Residential Appliance Recycling*	2.0%
Whole House Retrofit Program	2.1%
Low-Income Energy Efficiency Program	6.8%
Commercial/Express Efficiency*	27.3%
Midstream Lighting	15.7%
Small Commercial Direct Install*	4.5%
Multifamily Housing Retrofit*	0.0%
Industrial+	5.6%
Public Agency Partnership*	4.7%
Community Education*	2.6%

**Denotes a program that Navigant did not evaluate in PY9 as part of a two-year evaluation plan approved by the PA SWE. PY9 values used verification results from PY8 and applied them to PY9 ex-ante numbers. The given values reflect the precision of the PY9 research, which for some programs will be combined with PY10 sample to produce two-year estimates.*
+Denotes a program that was not evaluated in PY8 as detailed in evaluation plan. PY9 report results and relative precision calculations are based on sampled sites from PY8 and PY9.

There are two program relative precision values that do not meet the 85/15 threshold. The first, Commercial/Express Efficiency was not evaluated in PY9. The high relative precision value is a result of standard and specialty LED lighting sample stratums in which cross sector sales from the REEP Upstream Lighting program to commercial customers are included in the CEP/EXP program group. These savings, which were included in verified but not reported values contribute to higher realization rate and have huge relative precision values. Removing these strata, which were not included in the reported savings, reduces the relative precision of the CEP/EXP program to 1.7%. The Midstream Lighting Program also failed to meet the threshold. Navigant stated in their PY9 report this was the result of differing customer-reported hours of use. Many customers installed bulbs in 24/7/365 areas leading to higher realization rates. They intend to remedy the issue in PY10 by adding a 24/7 hour of use option for reported savings. All other program values comply with the sampling uncertainty requirements.

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 PY9 verification activities is discussed in detail in Appendix D.4.

Not all programs rely on sampling to estimate verified savings. For the Residential Behavioral Savings program, the impact evaluation relies on a statistical billing analysis of all participants, so there is no uncertainty associated with sampling. The precision requirements for the behavioral

program are unique, with the Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). This requirement for program design is less stringent than the sampling requirement, described above, that programs annually achieve ±15% *relative* precision at the 85% confidence level. Standard precision requirements are not reasonable expectations for behavioral programs because the size of the average effect is typically much smaller, and all estimation error is captured as opposed to sampling error only. The SWE reviewed the design of Duquesne Light's behavioral program and found the treatment and control group sizes were adequate to achieve ±0.5 absolute precision at the 95% confidence level.

For the Large Curtailable Load program, demand response savings calculations are based on comparison to an estimated baseline a customer event-day. While there is no sampling error for these initiatives, there is estimation error because the regression models are unable to perfectly fit the data. The variation that is not captured by the model produces estimation uncertainty. The relative precision of the PY9 verified demand response MW savings from the Large Curtailable Load program was ±12% at the 90% confidence level.

D.3 Reported Gross Savings Audits

D.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Duquesne Light's PY9 Annual Report. Specifically, the values we examined are:

- Reported gross energy savings (MWh) for each program,
- Reported gross peak demand savings (MW) for each program,
- Participation for each program, and
- Incentive dollars for each program.

The SWE leveraged Duquesne Light's Q1-Q4 tracking data submissions 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 PY9 quarterly data request. Also note that demand response (DR) or home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding Duquesne Light's Demand Response program can be found in Appendix D.5, and our findings regarding Duquesne Light's Residential Behavioral Savings program (and the HER component of the Low-Income Energy Efficiency program) can be found in Appendix D.4.1.3.

Table 132 summarizes our ex-ante findings regarding energy savings. The 'Match' column contains 'Yes' if the tracking data supports the Annual Report and 'No' otherwise. Note that the Residential Appliance Recycling program is called 'RRP Refrigerator Recycling' in the tracking data. For each program, the SWE was able to replicate Duquesne Light's reported gross energy savings. The totals shown for the Low-Income Energy Efficiency Program (LIEEP) do not include the HER component.

Table 132: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Commercial Efficiency	8,653	8,653	Yes
Community Education	1,372	1,372	Yes
Express Efficiency	10,818	10,818	Yes
Industrial Efficiency	16,050	16,050	Yes
Large Midstream Lighting	1,159	1,159	Yes
Low-Income Energy Efficiency (LIEEP)	2,958	2,958	Yes*
Multifamily Housing Retrofit	107	107	Yes
Public Agency Partnership	5,599	5,599	Yes
REEP: Residential Energy Efficiency	33,028	33,028	Yes
Residential Appliance Recycling	2,703	2,703	Yes
Residential Whole House Retrofit	118	118	Yes
Small Commercial Direct Install	6,264	6,264	Yes
Small/Medium Midstream Lighting	1,329	1,329	Yes
Portfolio Total	**90,158**	**90,158**	**Yes***

*The LIEE program has an HER component not represented in this table.

Table 133 summarizes the SWE's findings regarding reported gross peak demand savings by program. For each program, we were able to replicate the values reported by Duquesne Light.

Table 133: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Commercial Efficiency	1.01	1.01	Yes
Community Education	0.18	0.18	Yes
Express Efficiency	1.73	1.73	Yes
Industrial Efficiency	1.17	1.17	Yes
Large Midstream Lighting	0.22	0.22	Yes
Low-Income Energy Efficiency	0.28	0.28	Yes*
Multifamily Housing Retrofit	0.01	0.01	Yes
Public Agency Partnership	0.65	0.65	Yes
REEP: Residential Energy Efficiency	3.63	3.63	Yes
Residential Appliance Recycling	0.30	0.30	Yes
Residential Whole House Retrofit	0.01	0.01	Yes
Small Commercial Direct Install	0.88	0.88	Yes
Small/Medium Midstream Lighting	0.23	0.23	Yes
Portfolio Total	**10.30**	**10.30**	**Yes***

*The LIEE program has an HER component not represented in this table.

Table 134 summarizes the SWE's ex-ante findings regarding program participation. For all programs except for the Residential Whole House Retrofit program, the SWE was able to replicate the participation count provided by Duquesne Light or calculate a directionally similar value. The tracking data cannot be used to duplicate participation for the Residential Whole House Retrofit program. In their Annual Report, Duquesne Light notes that their tracking data system aggregates activities for this program and does not track individual audits. In the response to the SWE's annual data request, Navigant provided supplemental documentation that illustrates the calculation of the reported participant counts for the Whole House Retrofit program.

Table 134: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Commercial Efficiency	49	49	Yes
Community Education	33	33	Yes
Express Efficiency	298	298	Yes
Industrial Efficiency	25	25	Yes
Large Midstream Lighting	158	157	No
Low-Income Energy Efficiency	5,369	5,725	No*
Multifamily Housing Retrofit	3	3	Yes
Public Agency Partnership	71	71	Yes
REEP: Residential Energy Efficiency	17,085	17,087	Yes
Residential Appliance Recycling	2,469	2,469	Yes
Residential Whole House Retrofit	274	--	--
Small Commercial Direct Install	94	94	Yes
Small/Medium Midstream Lighting	245	264	No
Portfolio Total	**26,173**	**26,275**	**No**

*The LIEE program has an HER component not represented in this table.

Finally, Table 135 summarizes the SWE's ex-ante findings regarding incentive dollars. The SWE was able to produce directionally similar (if not equal) incentives for each of Duquesne Light's programs. In total, the tracking data incentives exceed the Annual Report incentives by approximately $91,000. This difference exists because the Annual Report values are pulled from a financial system as opposed to program tracking data. For this reason, the SWE does not view the difference as an issue.

Table 135: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Commercial Efficiency	$453	$485	No
Community Education	$89	$106	No
Express Efficiency	$670	$618	No
Industrial Efficiency	$758	$758	Yes
Large Midstream Lighting	$118	$118	Yes
Low-Income Energy Efficiency	$0	$0	Yes
Multifamily Housing Retrofit	$17	$17	Yes
Public Agency Partnership	$236	$338	No
REEP: Residential Energy Efficiency	$1,145	$1,138	No
Residential Appliance Recycling	$93	$92	No
Residential Whole House Retrofit	$0	$0	Yes
Small Commercial Direct Install	$0	$0	Yes
Small/Medium Midstream Lighting	$104	$104	Yes
Portfolio Total	**$3,683**	**$3,774**	**No**

D.3.2 Project File Reviews

D.3.2.1 Residential

The SWE conducted a project file review for a sample of Duquesne Light's residential programs in PY9 as part of the reported savings (i.e., ex-ante) review. The project file documentation was provided by Duquesne Light, the program implementors, and the evaluation contractor, Navigant, in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, and post-inspection forms. The sampled project file packages included most of the documentation requested.

Table 136 presents a summary of SWE's residential project file reviews. Project files were found to match most of the tracking data, with some exceptions. The SWE also reviewed the sampled project files to verify that correct Pennsylvania TRM values and algorithms were applied to the reported savings. The evaluator, Navigant, was cooperative in working with the SWE on questions and comments as the ex-ante review took place and was able to clarify that all issues arising from this review were addressed during verified savings calculations.

Table 136: Duquesne Light PY9 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?[1]
Residential Energy Efficiency Program	Appliance Rebates	25	✓	✓	✓	✗
Residential Energy Efficiency Program	Efficiency Kits	30	✓	✓	✓	✓
Residential Energy Efficiency Program	Upstream Lighting	29	✓	✓	✓	✓
Residential Appliance Recycling	N/A	24	✓	✓	✓	✓
Residential Whole House Retrofit Program[2]	Direct Install	8	✓	✓	✓	✗

[1] It should be noted that while typically the data matches, there were minor discrepancies found and are detailed in the paragraphs below.
[2] This program began in Q3 of PY9.

As detailed above, the requested number of project files and supporting details were submitted for the residential program. Below is a summary of the discrepancies between the project file packages and quarterly tracking data found during the SWE's residential project file review.

Appliance Rebate Subprogram

The Appliance Rebate subprogram had several inconsistencies between the project file documentation and the tracking data.

- The installation date in the project files did not match the installation date in the tracking database for any of the reviewed projects.[72]
- Two cases for which the tracking data listed a higher SEER value than the model number in the project file documents indicated. The tracking database SEER value was used in the reported savings calculations, which overstates reported savings.
- The SWE observed a potential systemic issue with central air conditioner (CAC) measures and the tracking database. CAC system capacity (reported in tons) and SEER values that include a .5 decimal in the project file documentation is rounded up to a whole number. An example of this is: the project file documentation specifies a 2.5-ton system with an efficiency rating of 15.5 SEER, which the tracking database rounds up to reflect a capacity of a 3-ton system with an efficiency of 16 SEER. This was observed in all six cases that had systems with .5 specs. The reported savings calculations reflect the rounded values found in the tracking database, which results in an overstating of reported savings.

The SWE reviewed the discrepancies with Duquesne Light's evaluator, Navigant, and Navigant reported that they conduct participant surveys and a similar engineering desk review of project files for a sample of measures during their verified savings analysis. Adjustments are made to realization rates when issues, similar to those mentioned above, are found. Navigant also noted that adjustments related to SEER confirmation are to two decimal points to avoid overstating savings due to rounding.

Efficiency Kits Subprogram

The Efficiency Kit subprogram project files included invoices for kits purchased. The SWE verified that the total count of kits in the project file invoice documentation matched the counts in the tracking data. The SWE reviews the specs and savings calculations for kit packages during the verified savings review when that information is provided.

Upstream Lighting Subprogram

The Upstream Lighting subprogram project files included manufacturer invoices for the number of light bulbs purchased and subsequently rebated. The invoices were PDF files containing multiple manufacturer invoices compiled by billing date.

[72] Navigant clarified the SWE's observation and stated the installation date aligns with the project receipt date rather than the installation date of the measure.

- There were three manufacturer invoices that were not found in the tracking database. The invoices accounted for a total rebate amount of $43,641 and 7,597 packages of light bulbs.[73]
- Reported savings use a default value of 365 for the days variable, while the TRM states 365.25 days. This results in negligible differences between reported savings and the results of the SWE review (in this case, undercounting savings).

It should be noted that during the review, the SWE noticed a few light bulb models had wattage discrepancies between the manufacture invoice and the tracking database. Additional research was conducted on the light bulb discrepancies, and in all cases confirmed that the tracking database used the correct wattage value rather than the manufacture invoice.[74]

The SWE reviewed the lighting savings algorithm discrepancies with Navigant. Navigant reported that they conduct a similar calculation review for their verified savings analysis and adjust TRM values when incorrect values are identified, including the discrepancy mentioned above.

Appliance Recycling Program

For the Appliance Recycling program, a list of projects was provided in the quarterly tracking data upload. The list of projects included information such as age, cubic feet, configuration, etc. The projects were found in the residential downstream database and were applied a default savings value in the reported savings.

Whole Home Retrofit Program

The Whole Home Retrofit program began uploading project file packages starting Q3 of PY9. The project file packages included documentation for measures that were directly installed during the audit. The SWE was not able to verify the project file documentation for the individual audit files within the tracking database. Duquesne Light provided a key that links the individual project, to a larger project, which was found in the tracking database. The larger project's reported savings encompass directly installed measures from multiple audits (presumably) from the same building. The tracking database rolls the individual audit measure-level savings into the overall projects measure-level reported savings. It should be noted that there were single-family and multifamily designations in the key; however, the single-family projects were rolled up into a larger project savings in the tracking database.

The SWE confirmed with Navigant that details at the individual audit level are used to inform the verified savings in PY9. Navigant confirmed that the SWE would be provided these details, along with relevant verified savings analysis files, in the annual data request response.

The tracking database rounds 0.5 values for SEER and system capacity for central air conditioners up to the nearest whole number. This appears to be happening at a system level and causes reported savings to be consistently overreported.

[73] Navigant clarified that these invoices were unrelated to Duquesne's upstream lighting program and are not included in Duquesne's reported or verified savings.
[74] Model Numbers from the invoice and tracking data were used to verify wattage discrepancies using ENERGY STAR website and databases.

Recommendation: Update tracking database to include two decimal points to avoid rounding.

Appliance Recycling program includes data on age, cubic feet, manufacturer, and configuration in the tracking database. Recycled appliance savings are based on a deemed savings regression equation that incorporates TRM defaults and EDC gathered data for variables such as date of manufacture.

Recommendation: Provide the documentation on how this information is gathered (electronic or on-site forms).

Whole Home Retrofit Program is a direct install program that operates in multifamily and single-family dwellings. The project file documentation includes data for the directly installed measures for individual customers. The tracking data reports measure-level quantities and savings as a large project site. **The SWE is unable to verify how the directly installed measures identified in the project file packages are calculated, including the quantity, and is unable to check if proper TRM equations and variables are being considered in the reported savings.**

Recommendation: Provide project file documentation that allows the SWE to verify the individual customer savings. Include total project counts for measures installed at a large site if reported savings are not broken out by individual audit. It is also recommended that an equation field is included in the tracking database to allow the SWE to verify the correct application of the TRM equation and identify the variable sources (EDC gathered or default values) used for reported savings. The additional information will allow the SWE to conduct a more thorough review of project file packages and reported savings.

D.3.2.2 Non-residential

The SWE reviewed a sample of Duquesne Light's C&I projects for PY9 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. The SWE noted a handful of instances where the project documentation didn't fully match the calculation worksheets or where some project files were missing. Table 137 presents an overview of the results of the SWE's C&I project file reviews.

Table 137: Duquesne Light PY9 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?
1091520477.55.01	LED Lighting Retrofit	✓	✓	×	✓	✓	-
0409370000	Lighting Retrofit	✓	×	✓	✓	✓	-
6187820660.57.01	Lighting Retrofit	✓	✓	✓	✓	✓	-
5940950141.51.01	Custom, C&I, Interior Lighting	×	✓	×	✓	✓	✓
6951830706	LED Exterior Area Lighting LED Fixture	×	✓	×	×	✓	-
0796840283.58.01	VFD– HVAC Pump Motor	✓	✓	✓	✓	✓	-
0286600544.49.01	LED Lighting, ECM Motors, Anti-Sweat Heat Controls	✓	✓	✓	✓	✓	-
3334420000	LED Exterior Area Lighting LED Fixture	✓	✓	✓	✓	✓	-
3522460000	LED Exterior Area Lighting LED Fixture	✓	✓	✓	✓	✓	-
5036770000	LED Interior	✓	✓	✓	✓	✓	-
5147630000	LED Linear Replacement Lamp	✓	✓	✓	✓	✓	-

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?
1350110259.57.01	LED Interior	✓	✓	✓	✓	✓	-
1527040000	LED Interior Low/High-Bay Fixture	✓	✓	✓	✓	✓	-
0542330000	LED Linear Lamp and Exit Sign	✓	✓	✓	✓	✓	-
1341310516.60.02	VFD– HVAC Fan Motor	✓	✓	✓	✓	✓	-
8221130000	LED Bay Fixtures and Exit Signs	✓	✓	✓	✓	✓	-
9261830158	LED fixtures, lamps and occupancy sensors	✓	×	✓	✓	✓	-
9200560699	LED Lighting, ECM Motors, Anti-Sweat Heat Controls	✓	✓	✓	✓	✓	-
9899460990	LED Lighting, ECM Motors, Anti-Sweat Heat Controls	✓	✓	✓	✓	✓	-
4385270603	LED Lighting Retrofit	✓	✓	×	✓	✓	-

A review of the project files revealed only minimal issues affecting the SWE's ability to verify Duquesne Light's reported savings. The most prevalent issue identified was the scope of work not exactly matching between the invoice and the calculations for lighting projects; however, this could be due to additional lighting being purchased by the customer than what was incented through the program.

The SWE data requests for the PY9 Small, Medium and Large Midstream Lighting program were not clear, therefore the SWE did not have project documentation to review for this program. The SWE will work with Duquesne Light in PY10 to ensure that the necessary information is received to complete a comprehensive project file review. For PY9, the SWE did review program tracking records provided by Duquesne Light that listed all projects implemented in PY9 for the program along with details including project building type, installed product name and quantity and assumed baseline and measure wattage and hours of use. The SWE reviewed approximately 50 distinct line items across the Q1 through Q4 tracking spreadsheet. The review consisted of ensuring that the correct hours of use and coincidence factors were applied (based on reported building type) and that accurate baseline and installed measure wattage aligned with the TRM IMP Midstream lighting requirements. Lastly, the SWE attempted to replicate the reported energy savings for each reviewed project based on the information provided. In general, the SWE found that the reported HOU, baseline, and installed measure wattage aligned with the IMP. There were a handful of instances in the database where assumed baseline wattage was not provided, resulting in negative energy savings. At first attempt, the SWE was unable to replicate the reported energy savings values using the equation and assumptions listed in the IMP. However, the SWE was able to replicate the reported energy savings value when using an In-Service Rate (ISR) of 85% instead of the 98% value noted in the IMP. Navigant noted this same discrepancy in the evaluation report and noted it as one reason for the high realization rate for the program (although Navigant found that several of the sites visited actually had an ISR of 100%).

The SWE annual reports from PY6, PY7 and PY8 submit that the review of Duquesne Light project files was seamless, with only minimal inconsistencies. This trend continued through PY9; project documentation was generally well organized with necessary documentation provided in most cases.

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 Light's portfolio of residential programs consists of the following programs: Residential Energy Efficiency Program (REEP), Residential Appliance Recycling Program (RARP), Residential Behavioral Program, Residential Whole House Retrofit Program (WHRP), and the Low-Income Energy Efficiency Program (LIEEP). Note that the SWE reports the residential savings in the following three sections: upstream lighting, residential non-lighting, and behavior.

Table 138 provides a summary of the evaluation and M&V approaches used by Duquesne Light in their PY9 verified savings calculations. Note that the SWE adjusted verified savings in the PY9

Annual Report due to underestimated savings for the REEP Upstream Lighting program but that the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting beginning in PY10.[75]

Table 138: Residential Program Evaluation Activities – Duquesne Light Company

Program/ Subprogram	Surveys	Site Visits	Desk Review	Billing Analysis	Applied PY8 RR
REEP: Residential Energy Efficiency Rebate Program	✓	--	✓	--	--
REEP: EE Kits	✓	--	✓	--	--
REEP: Upstream Lighting	✓	--	✓	--	--
Residential Appliance Recycling[b]	--	--	✓	--	--
Residential Behavioral Savings			✓		
Residential Whole House Retrofit	✓	--	✓	--	--
Low-Income Energy Efficiency Program (LIEEP)	✓	--	✓	--	--

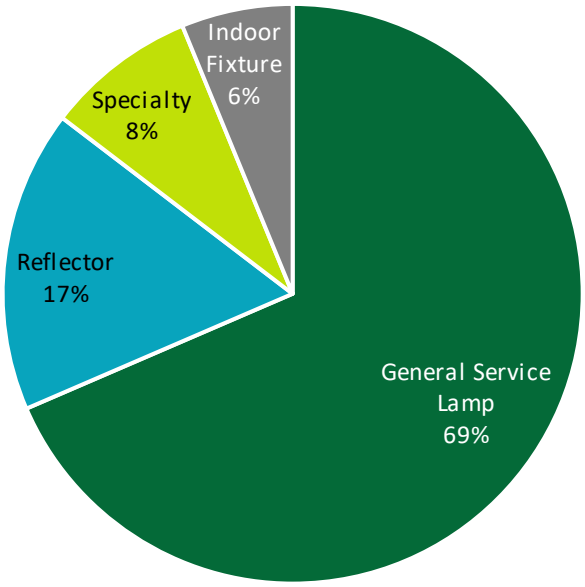
[a] The Desk Review column includes database reviews, application reviews, and/or engineering desk reviews.
[b] The Residential Appliance Recycling Program used survey results from PY8.

D.4.1.1 Upstream Lighting & Cross-Sector Sales

Customers purchased over 580 thousand efficient light bulbs and fixtures through Duquesne Light's upstream lighting program. Figure 61 displays the distribution of sales by product type. Over two-thirds (69%) of the products were general service lamps.

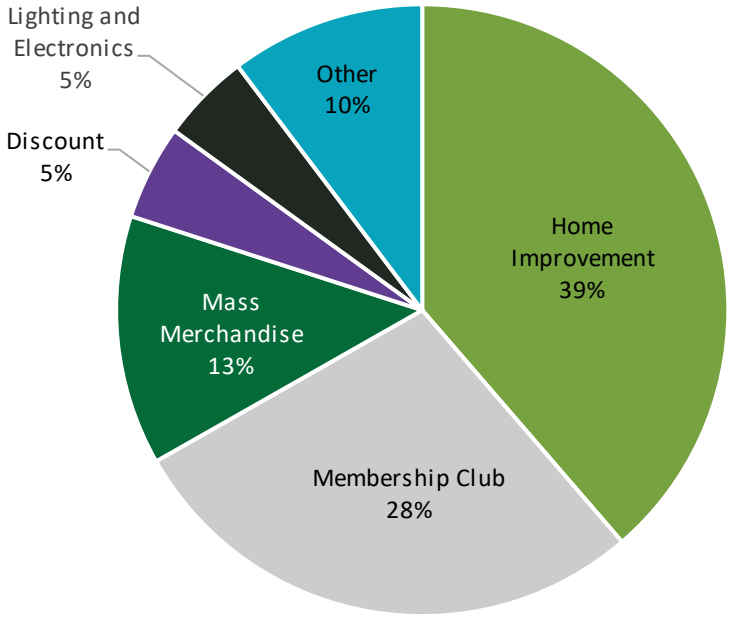
[75] The Phase III Evaluation Framework notes that for errors in the EDCs' Final Annual Reports that are greater than 1% of annual portfolio savings, the EDC should correct such errors and refile the Final Annual Report, but not refile their reports for errors that are less than 1% of annual portfolio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

Figure 61: Duquesne Light PY9 Upstream Lighting Sales by Product Type



Two-thirds (67%) of Duquesne Light's PY9 upstream light bulbs and fixtures were sold through home improvement stores and membership stores (Figure 62).

Figure 62: Duquesne Light PY9 Upstream Lighting Sales by Retail Channel



Audit Findings

The SWE reviewed the data in Duquesne Light'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 generally agrees with Navigant's verified gross savings for upstream lighting but has adjusted verified savings for the errors detailed below.

The SWE observed 402 unique lighting model numbers in the PY9 tracking system and was able to locate all 402 in the ENERGY STAR certified products lists for light bulbs and light fixtures. However, Navigant was not able to verify the ENERGY STAR status of 21 of the models. As a result, Navigant erroneously excluded savings from these 21 models from upstream lighting verified gross savings, resulting in verified savings being underestimated by 655 MWh.

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 five of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes.

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 a number of models that had been assigned an incorrect baseline wattage because the bulb type had been mischaracterized in the tracking data, described below. The SWE notes that it found the same mischaracterizations of candelabra-base and 3-way bulbs in PY8.

The SWE identified nine decorative models that are not exempt from EISA, but Navigant assigned the EISA-exempt baseline wattage. These nine decorative models had medium screw bases but were mischaracterized as candelabra-based 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 EISA-compliant baseline wattage. In addition, the team identified fourteen reflector models that were incorrectly coded as another type of reflector and were therefore assigned an incorrect baseline wattage. The team also identified two models for which Navigant assigned baseline watts of zero, and one model that had been assigned a baseline wattage that was not present in TRM protocol 2.1.1 nor was it equal to the manufacturer rated wattage equivalency. Some of these errors overestimate savings, while others underestimate savings. Overall, verified savings were underestimated by 655 MWh combined, the impact of all discrepancies the SWE identified on portfolio-level savings is relatively minor, less than 0.8%.

Cross-Sector Sales

In PY9, Navigant conducted a store-intercept survey to estimate the proportion of program bulbs installed in residential and non-residential sockets. The Navigant team interviewed 327 individuals in 12 stores; 210 of these individuals purchased program bulbs. Based on these surveys,

Navigant estimated that 3.5% of standard LEDs and 4.2% of specialty LEDs purchased were installed in non-residential locations. Navigant reported that the weighted average cross-sector sales rate for standard and specialty LEDs is 3.7%; however, 3.8% was calculated in the analysis file. The SWE verified that this was merely a typo and the verified lamp counts in table 133 of the PY9 annual report are correct. Lighting installed in non-residential locations was reassigned to the C&I Express Efficiency Program.

In the past, Navigant adjusted for variations between weekday and weekend sales. In PY4, the program estimated that 70% of lighting sales in a given week occurred on Saturday or Sunday. As part of retailer interviews conducted in PY9, retailers were asked to report their estimated sales split between weekends and weekdays. The only retailer able to provide this data indicated that weekend sales were 30%. Given this contradictory estimate, Navigant did not make any time-of-week adjustments for the PY9 estimates.

Recommendations

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

- Devote more time to verifying the ENERGY STAR status of program bulbs and fixtures in order to capture all program savings.
- Review the tracking data and correct any errors regarding bulb or base types in order to assign baseline wattages in accordance with TRM protocol 2.1.1. Focus efforts on correctly classifying medium-based bulbs, candelabra-based bulbs, three-way bulbs, and reflectors.

D.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 review includes descriptions of the measures within each program and evaluation activities that were reviewed. No discrepancies were observed.

Residential Energy Efficiency Program (REEP)

The SWE audited both components--rebates and energy-efficiency kits--of the Residential Energy Efficiency Program (REEP). 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 reviewed the rebate portion of the REEP program and found that the sample sizes and participation counts matched what is reported in the PY9 annual report. The SWE determined that TRM algorithms were followed correctly during the evaluator's review of the reported savings tracking data and confirmed that EDC gathered data was applied to open variables during the verified savings evaluation. The SWE determined the verified savings and realization rates for rebated measures were correct.

The kit portion of the REEP program was comprised of three energy-efficiency kits: The Apogee LED Kit – comprised of four 9 watt bulbs, two 11 watt bulbs, two 15 watt bulbs, and two LED nightlights; the four Bulb LED kit – comprised of two 9 watt bulbs, one 11 watt bulb, and one 15 watt bulb; and one-off single LED lamp giveaways. The kits evolved in PY9 to exclusively offer customers LED bulbs. In addition, smart power strips found in some kit varieties in PY8 were no longer included. The Apogee Kits were distributed to those who completed an online home energy audit and the four Bulb LED Kits were distributed through Duquesne Light's targeted community outreach programs.

The SWE was able to verify the sampled savings calculations, realization rates, and participation counts for the kit giveaways that were tracked at an individual level. However, there were give-away events that were tracked by the number of measures distributed rather than the participant who received the measure. The SWE was able to verify the savings based on the total reported quantity of measures given away during the events.

Residential Appliance Recycling Program

The Residential Appliance Recycling program covers the recycling of older model refrigerators and freezers. Following the approved PY9 Evaluation Plan, Navigant reviewed the program tracking data to verify measure eligibility and applied the PY8 realization rate. The SWE verified that the PY8 realization rate was correctly applied. However, the SWE also reviewed the verified savings for both measures by using the annual request data. While there was EDC gathered data available for measure size and configuration, this data was not used in savings calculations. In addition, the SWE found that the percentage of PY9 units manufactured prior to 1990 was different from the PY8 values used to calculate the PY8 realization rate that was applied in PY9. The percentage of freezers manufactured prior to 1990 was lower in PY9 (39% compared to 26% in PY8) but the percentage of refrigerators manufactured prior to 1990 was higher in PY9 (52% compared to 47% in PY8). These differences would have resulted in different verified savings values had they been applied. The SWE notes that the counts of recycled freezers and refrigerators are included in the process evaluation report but not in the impact portion of the report and recommends that Navigant report the counts in the impact portion of the report going forward. For PY10, the SWE recommends updating the percentage of units manufactured before 1990 and using the appliance characteristics collected by the ICSPs to provide a more accurate assessment of savings.

Residential Whole House Retrofit

The Residential Whole House Retrofit Program (WHRP) serves market rate and low-income residential customers, providing them with a low or no-cost energy audit and a range of directly installed energy saving measures. The SWE's review of WHRP found that proper TRM protocols were followed by the evaluator, and that the realization rates and verified savings are accurate. Many TRM default or deemed values were used for directly installed measures – the SWE recommends considering collecting data by the ICSP while on-site and using values from the equipment being installed to more accurately reflect savings.

Low-Income Energy Efficiency Program

Duquesne Light also offers kits to low-income customers and attributes savings to the LIEEP Program. The LIEEP program offered identical kits through the same channels as the REEP program. The SWE verified the sampled savings calculations, realization rates, and participation counts for the kit giveaways that were tracked at an individual level. There were certain give-away events that consisted of one-off lamp giveaways, which were tracked by the number of measures rather than the participant who received the measure. The SWE was able to verify the savings based on the reported total quantity of measures given away during the events.

The SWE audit of the low-income component of the Residential Whole House Retrofit program determined the sample sizes were correct, and savings were calculated in accordance with TRM protocols. Many TRM defaults were used for direct install measures – the SWE recommends the EDC consider working with its implementer to gather these values from the installed measures.

D.4.1.3 Behavior

Approximately 8% of Duquesne Light's verified gross energy savings for PY9 came from Home Energy Reports issued to around 75,000 residential and residential-low-income households. While Duquesne Light was among the least HER-reliant EDCs for portfolio energy savings in PY9, close to 40% of Duquesne Light's progress toward its low-income target in PY9 came from HERs. Duquesne Light's behavioral portfolio consists of the three different waves, or cohorts, of homes summarized in Table 139.

Table 139: Duquesne Light HER Cohort Summary

Wave	First HER Mailing	Treatment Group Homes	Control Group Homes
2012 Market Rate	July 2012[76]	15,000	40,000
2015 Market Rate	March 2015	45,000	16,000
2015 Low-Income	March 2015	15,000	7,000

The program ICSP Oracle implemented each of the three waves as randomized control trials where the eligible households were identified and then randomly assigned to either a treatment or control group. Following randomization, Navigant conducted statistical tests on the pre-treatment energy usage patterns to confirm they are similar for the treatment and control groups.

The SWE performed a detailed audit of the experimental design for the RCT cohorts, regression-based HER savings estimates, and recipient household counts using data provided by Navigant. The SWE first used Navigant's data and regression model to confirm the savings estimates provided by Navigant. Second, the SWE independently constructed the cleaned data by following the procedures indicated by Navigant. This data was then used to estimate the savings, shown in Table 140, which matched Navigant's estimates. It is important to keep in mind that these values still face further processing due to adjustment for dual participation in other programs and low-income reclassification, which are described in further detail below.

[76] The 2012 Market Rate cohort did not receive HERs from June 2013 to February 2015

Table 140 shows the aggregate PY9 MWh savings by wave. Aggregate and per home savings are lowest for the low-income cohort, but since they use less electricity on average, the percent savings is similar for each wave.

Table 140: PY9 HER Gross Energy Savings: Pre-Adjustments

Wave	PY9 MWh	Average kWh Savings per Home	Average % Savings
2012 Market Rate	2,093	142	1.2%
2015 Market Rate	5,485	127	1.4%
2015 Low-Income	1,358	104	1.2%
Total	**8,935**	**126**	**1.3%**

Data Management

Navigant's PY8 calendarization and handling of estimated meter reads was inconsistent with the behavioral protocol of the Evaluation Framework. The methodology used in PY9 was updated to align with the guidance in the Evaluation Framework and was free of errors. To ensure the PY9 data processing is sound, the SWE conducted an independent analysis following the data preparation procedures in the Evaluation Framework and the same regression model specification.

While the SWE has replicated the savings produced by Navigant, there are a few minor recommendations for improved data management in PY10. First, add a check to the data to prevent bill duration from exceeding the number of days since the prior bill. Occasionally, when estimated bills are issued, the duration between bills is not correct in the data. When combining these estimated bills with the non-estimated bills, the summed duration must be restricted to not exceed the difference in non-estimated bill dates. Second, some accounts have an inactive date that does not reflect the end of the billing history for that account. In the case where an account has multiple "inactive dates", the latter, or missing date, should be applied. The occurrence of multiple inactive dates for a customer reduced the number of accounts that could be used for analysis because the pre-period lag variable was removed for customers with "false" inactive dates prior to the evaluation period.

Regression Analysis

Duquesne Light uses a lagged dependent variable (LDV) model for impact analysis. In PY8, Navigant ran a separate model in the analysis from what was stated in the EM&V plan. Though both models were acceptable, consistency is required from planning through evaluation. PY9's EM&V plan description correctly matches the LDV regression methodology used in their analysis for the Annual Report.

Dual Participation

In Table 140, calculated savings were 8,935 MWh. It is important to note that Home Energy Reports advertise other residential EE&C programs and measures, such as ENERGY STAR appliances, efficient lighting, HVAC, etc. If a household participates in one of those programs, the savings from that participation is counted by the specific program but is also captured in the

regression estimates for the HER analysis. To avoid double-counting, the HER savings are reduced to account for the incremental program participation observed in the treatment group compared to the control group. Participation is not tracked for upstream lighting, so Duquesne Light used the default reduction percentages for each wave, by age, to arrive at the gross verified savings of 8,055 MWh.

Low-Income

In PY8, Duquesne Light re-allocated a subset of homes from the market rate cohort to low-income based on the results of the 2016 low-income status rescreening effort. This effort is not conducted yearly, so the PY9 evaluation maintains the classifications and savings re-distribution strategy from PY8. Since the homes have been randomized with their original cohorts, the regression analysis keeps the homes with the original group. Following regression analysis, savings are estimated by moving a portion of the market rate savings into the low-income results. For the 2012 and 2015 waves, 3.5% and 4.2% of the savings are removed, respectively, and added to the low-income savings. The adjusted savings are provided in Table 141.

Table 141: PY9 HER Gross and Net MWh Savings

Residential Sector Reporting Category	PY9 MWh
Market Rate	6,524
Low-Income	1,531
Total	**8,055**

Peak Demand Impacts

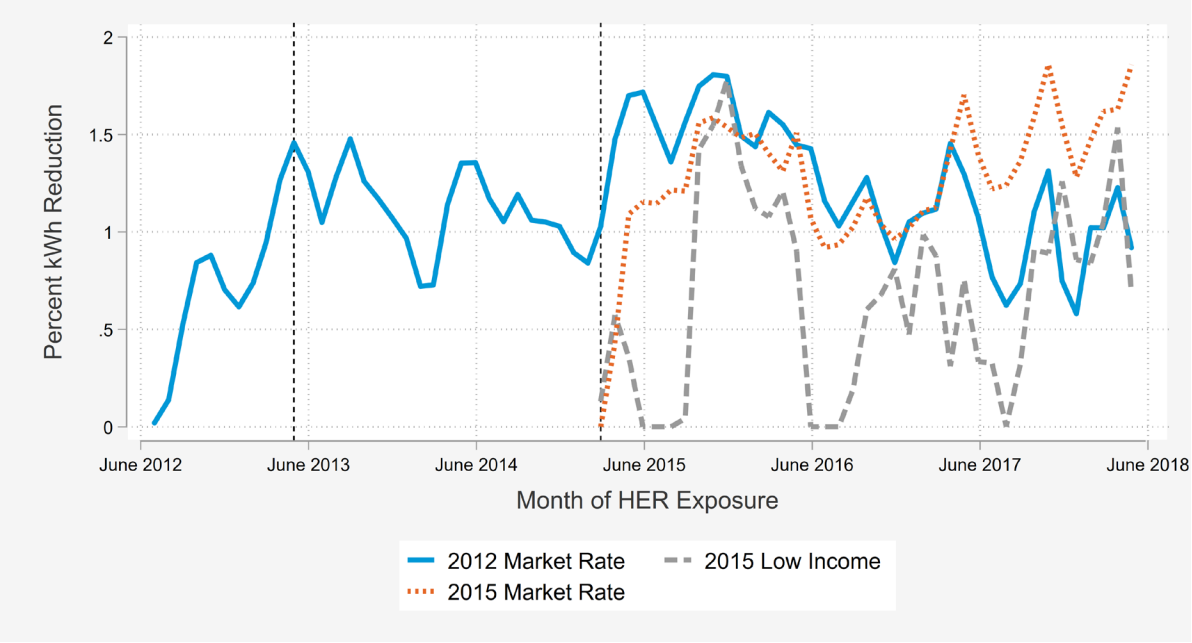
The behavioral protocol of the Evaluation Framework provided evaluation contractors several options for estimating peak demand savings for HER programs. Navigant utilized a flat load assumption, which assumes savings occur equally in each hour of the year. Gross verified demand savings are calculated as follows for the Behavioral solution:

$$Verified\ MW\ Savings = \frac{8{,}055\ MWh}{8{,}760\ hours} = 0.92\ MW$$

HER Savings Over Time

Trends over time for each of the three HER waves can be seen in Figure 63. Duquesne Light paused the distribution of HERs from May 2013 to March 2015 for the 2012 Market Rate cohort. Though there was no exposure during this time, the differences are still shown to represent the persisting impacts of the program. These dates are bound by dashed black lines in Figure 63. The graph shows the monthly, average percent difference in the kWh usage of the control and treatment groups in each of the three studies. The Market Rate waves steadily increase for their first year, then fluctuate around 1% to 1.5% savings. The Low-Income wave exhibits larger variance and occasionally dips to 0% difference in the control and treatment population. This statistical noise in the savings effect is expected with HER cohorts that have smaller treatment and control group sizes.

Figure 63: Percent Impacts Over Time



D.4.2 Non-Residential Audit Activities

Figure 64 provides a summary of the evaluation activities and M&V approaches utilized by Duquesne Light's evaluation contractor in their PY9 verified savings calculations. Navigant conducted site verification for the majority of the PY9 evaluation sample and for these site inspections, predominately conducted verification only based on project count, but predominately utilized IPMVP Option B when based on kWh contribution. The majority of verification only activities by project count were conducted for the Small/Medium and Large Midstream Lighting program because site verification was required for all sampled measures in this program by the SWE.

Figure 64: Summary of Duquesne Light's C&I Evaluation Activities

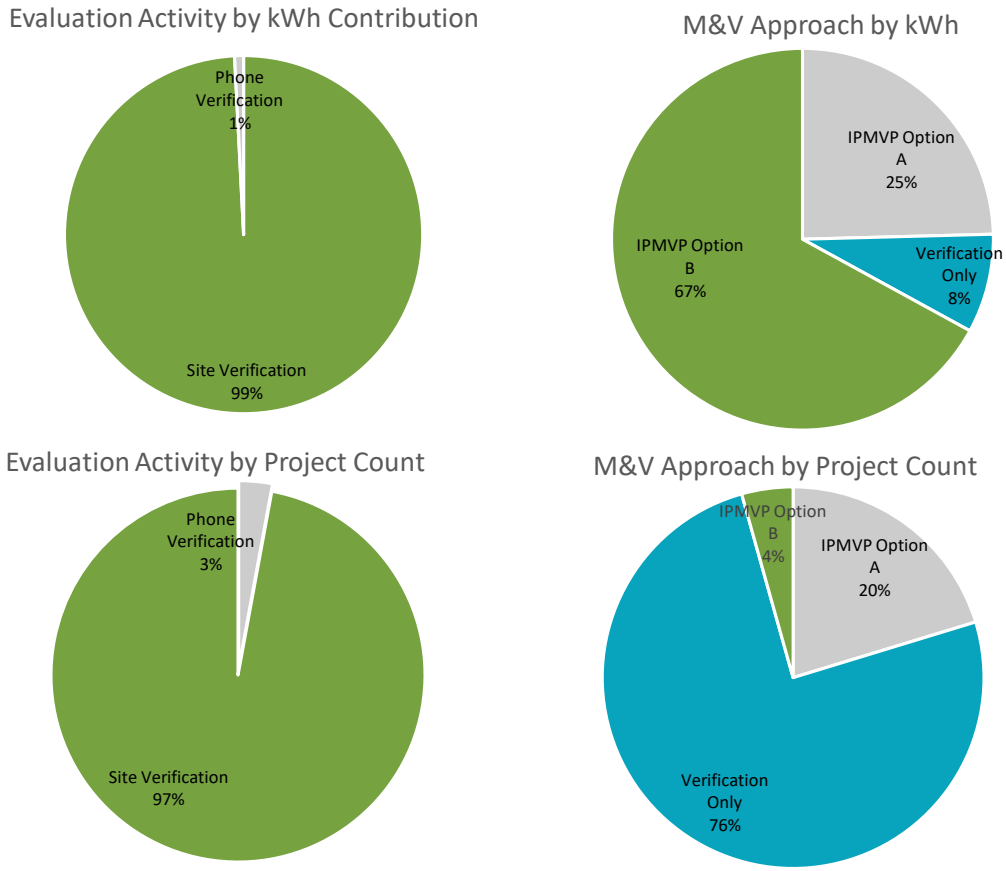


Table 142 outlines the evaluation activities by project count for each of Duquesne Light's non-residential programs, along with the evaluation realization rates. It should be noted that no evaluation activities were conducted for Commercial Efficiency/Express Efficiency, Small Commercial Direct Install, Multifamily House Retrofit, Public Agency Partnership, and Community Education programs and PY8 realization rates were applied for reporting purposes, per the Evaluation Plan.

Table 142: Duquesne Light Evaluation Activities by Project Count

Program / Strata	Sample Quantity	RR	Phone Verification Only	On-Site Verification Only	IPMVP A	IPMVP B	IPMVP C
Commercial Efficiency/Express Efficiency	**-**	**117%**	**-**	**-**	**-**	**-**	**-**
Small/Medium and Large Midstream Lighting	**43**	**168%**	**-**	**43**	**-**	**-**	**-**
SNUP-Small	9	115%	0	9	0	0	0
SNUP-Large	13	161%	0	13	0	0	0
LNUP-Small	11	325%	0	11	0	0	0
LNUP-Large	10	152%	0	10	0	0	0
Small Commercial Direct Install	**-**	**97%**	**-**				
Multifamily House Retrofit	**-**	**95%**	**-**				
Industrial	**26**	**100%**	**2**	**7**	**13**	**4**	**0**
Small	12	108%	2	6	4	0	0
Medium	11	113%	0	1	8	2	0
Large	3	98%	0	0	1	2	0
Public Agency Partnership	**-**	**101%**	**-**	**-**	**-**	**-**	**-**
Community Education	**-**	**104%**	**-**	**-**	**-**	**-**	**-**
Total	**69**		**2**	**50**	**13**	**4**	**0**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation were aligned with the Evaluation Framework, followed proper custom site specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following subsections outline the evaluation activities for each of Duquesne Light's non-residential programs in PY9.

D.4.2.1 Commercial Efficiency/Express Efficiency

Navigant did not evaluate the Commercial Efficiency or Express Efficiency program in PY9. Results from the verification activities conducted in PY8 were applied to the ex-ante savings, as per the evaluation plan. Verification activities conducted in PY8 resulted in a program-level realization rate of 117%.

D.4.2.2 Small/Medium and Large Midstream Non-Residential Lighting

Navigant divided the Small and Large programs into two strata each for sampling. Site visits were performed for all 43 sites sampled in PY9, as required by the SWE. All projects were less than the 750,000 kWh metering threshold, therefore all projects were verification only. Realization rates for the strata ranged from 115% to 325%, with an overall program-level realization of 173%. Navigant noted three main reasons for the high realization rate:

- In Service Rate (ISR): The ICSP for the program utilized an ISR of 85% for calculating reported energy savings. Navigant found ISR's closer to 100% for most of the sampled projects, although a few sampled sites had an ISR lower than 85%.
- Hours of Use (HOU): Navigant updated HOU based on customer-reported data and found that several of the sites installed lighting in areas with 24/7 operation, which results in an increase in energy savings and a high realization rate for these projects.
- Building Type: Navigant adjusted the building type for several of the projects where there were no set schedules and normal HOU verification was not possible, resulting in a changed HOU and CF for these projects and a high realization rate.

The SWE agrees with the adjustments made by Navigant and also noted the ICSP's use of a lower ISR in reported energy savings values during the project file review activities.

Navigant did not meet the 85/15 threshold for PY9. According to Navigant, this threshold was not met predominately because of varying customer-reported hours of use, which led to varying realization rates. Specifically, several sampled customers installed lighting in areas with 24/7 lighting hours of use, but because this operating schedule is not an option in the "building type" selection. Navigant stated that, in an effort to mitigate this issue in the future, an "24/7" HOU option will be added.

D.4.2.3 Small Commercial Direct Install

Navigant did not evaluate the Small Commercial Direct Install program in PY9. Results from the verification activities conducted in PY8 were applied to the ex-ante savings, as per the evaluation plan. Verification activities conducted in PY8 sampled across three strata and resulted in a program-level realization rate of 97%.

D.4.2.4 Multifamily House Retrofit

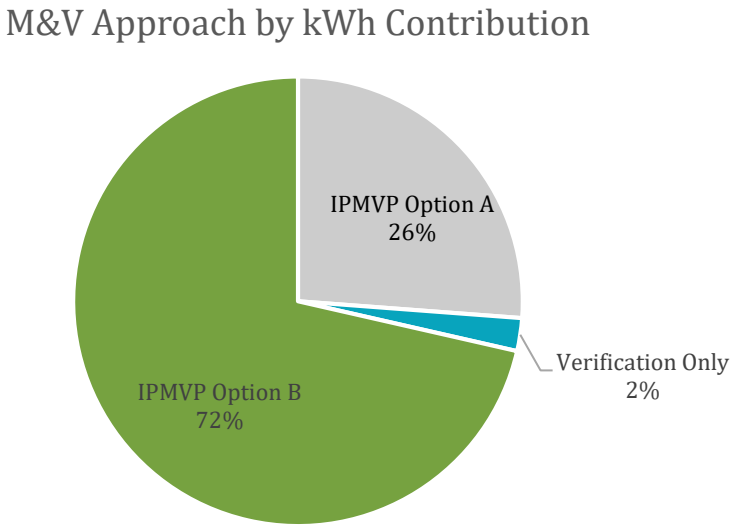
Navigant did not evaluate the Multifamily House Retrofit program in PY9. Results from the verification activities conducted in PY8 were applied to the ex-ante savings, as per the evaluation plan. Verification activities conducted in PY8 resulted in a program-level realization rate of 95%.

D.4.2.5 Industrial

Navigant divided the Industrial program into three strata for sampling; small, medium and large. Sampling was conducted at the measure level and measures from both PY8 and PY9 were included and combined into one realization, which is applied in PY9 and will be used for PY10 as well, per the Evaluation Plan. Verification activities were conducted for 26 measures. Site visits were performed for 24 of these 26 measures, accounting for 99% of the verified savings for the sample. Of these 24 site visits, nine were verification only, 13 were IPMVP Option A verification

and four were IPMVP Option B verification. Figure 65 shows the breakdown of M&V activities by kWh contribution.

Figure 65: Industrial Program M&V Approach by kWh Contribution



Three large projects dominated the savings for the Industrial program across PY8 and PY9. The two large projects that were implemented in PY9 accounted for approximately 63% of the overall PY9 program savings, according to Navigant's Annual Report. All three of these large projects were evaluated by Navigant for an overall strata realization rate of 97%. The three large projects accounted for approximately 83% of the kWh contribution of the sample. Verification activities resulted in a realization rate of 113% for the medium stratum and 108% for the small stratum. The realization rate for the Industrial program overall was found to be 100%.

Navigant did meet the 85/15 threshold for PY9, with a program-level relative precision of 5.6% at 90% confidence level. Navigant sampled 12 of the 200 implemented measures in the small stratum, with realization rates ranging from 53% to 128%, which may have led to the poor precision for this stratum (80.7%). Navigant did not note any reasons for the poor precision for the small stratum in their evaluation report.

D.4.2.6 Public Agency Partnership

Navigant did not evaluate the Public Agency Partnership program in PY9. Navigant did conduct 13 site visits and phone verifications during the PY9 evaluation period and the results for these site visits will be applied to the PY10 and PY11 ex ante values for the program. Results from the verification activities conducted in PY8 were applied to the ex-ante savings, as per the evaluation plan. Verification activities conducted in PY8, which included sampling across a large and small stratum, resulted in a program-level realization rate of 101%.

D.4.2.7 Community Education

Navigant did not evaluate the Community Education program in PY9. Results from the verification activities conducted in PY8 were applied to the ex-ante savings, as per the evaluation plan.

Verification activities conducted in PY8, which included sampling across a large and small stratum, resulted in a program-level realization rate of 104%.

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.4.2.8 Ride-Along Site Visits

Table 143 provides an overview of the SWE milestones for the audit of Duquesne Light's site inspection efforts.

Table 143: Duquesne Light Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)*	Field Engineers Observed	Measure Types Observed	Attainment Percentage
6	1,103,925	3	3	100%

*Savings reported by evaluation contractor.

The SWE conducted a total of six project reviews that included lighting, compressed air, and VFD measure types. The SWE generally agreed with the methodology and calculations submitted by Duquesne Light's evaluation contractors. Minor issues were noted with one project, leading to a change in verified savings for that project of approximately 3%. The change for this one project did not impact Duquesne Light's final realization rate for the strata of this project.

In general, the evaluation contractor's submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. Based on the minor issue with one Ride-Along Audit, the SWE makes the following recommendation for future sampling and site inspections:

- Navigant inform customers in the future of the sample size (i.e., number of light fixtures) that will need to be inspected so that they can make arrangements to have an appropriately equitable sample available for inspection.

D.4.2.9 Verified Savings Desk Reviews

Table 144 provides an overview of the SWE milestones for the verified savings review of evaluated Duquesne Light projects.

Table 144: Duquesne Light Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Measure Types Observed	kWh Attainment Percentage
8	13,261,617	3	101%

*Savings reported by evaluation contractor.

The SWE conducted a total of eight project reviews that included lighting, compressed air, and VFD measure types. Overall, the SWE found that Duquesne Light'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. Minor issues were noted with two projects, leading to a change in verified savings of 13% for one project and 3% for the other project.

In general, the evaluation contractor's submitted reports and calculations show evidence that the TRM and Evaluation Framework are followed appropriately. One larger project included in the verified savings desk review (1585540345.57.01) resulted in an attainment percentage close to 100%; however, several issues were identified during the review. The site savings was more than 750,000 kWh, therefore metering or trending was required for this site. However, the evaluator observed retrofit conditions and fixture quantity through on-site verification and conducted a survey with facility staff regarding the lighting operation but chose not to measure operating characteristics because they determined that this site was already metered during the M&V by the ICSP. Therefore, the evaluator instead leveraged the previous meter data to determine savings. The CSP project metering started on November 26, 2016 and the evaluator site inspection occurred on June 4, 2018, 18 months later with a follow-up four and a half months later. The evaluator noted discrepancies in the lighting operating characteristics during the evaluation period and also contacted the customer on 10/22/2018 to clarify the operating characteristics. It should be noted that the varying characterizations of lighting operating hours found by the evaluator could be accurate, because of the time difference in the data points. Regardless, based on the size of the project, the 18-month time lag between initial CSP metering and EM&V verification, and the potential discrepancy in the operating hours based from the facility manager interview, the SWE strongly encourages the evaluation team to conduct their unique measurement and verification activities in the future. The lighting schedule statements from the facility manager during the EM&V verification site introduce some uncertainty into the data utilized in the project analysis. Finally, the project analysis documentation does not include the measurement data from the CSP. If this data is to be utilized in future analysis, it needs to be included within the project documentation and analysis files.

Based on the identified issues and the overall verified savings desk review activities, the SWE makes the following recommendation for future evaluation activities:

- Navigant should conduct unique measurement and verification activities for projects that have a long lag time between the initial CSP metering and the EM&V verification, and in cases where large discrepancies are found, such as in operating hours.
- Navigant should review all trend data for reasonableness and the data should be adjusted if inconsistencies are observed.
- Navigant should check project submissions for consistency between the report and accompanying analysis workbooks.
- Navigant should submit complete project records to the SWE for review, such as original project documents that include ex ante savings calculation or equipment cut sheets, raw and prepared logger data, baseline conditions, detailed accounts of customer interviews, etc. (as applicable).
- Navigant should be wary of incorporating too many assumptions and factors into constructed baselines.

- Navigant should consider whether more simplistic usage of measured data could give a result that is easier to defend for some projects. Performing complicated and multi-step manipulations that are unnecessary introduces uncertainty and opportunity for errors.

D.5 DEMAND RESPONSE

Duquesne Light's Phase III demand response compliance target is 42 MW. DR goals are assessed at the system level, meaning that line loss adjustment factors are applied to the load impacts measured at the customer meter. In addition to the 42 MW target, which is an average of all Phase III DR events, EDCs are required to achieve at least 85% of their overall target in each event. For Duquesne Light, this translates to a 35.7 MW minimum performance level for any given DR event. Decisions about which days DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. Duquesne Light called DR events on the three days those guidelines required in PY9.

On January 15, 2018 the Duquesne Light/Navigant team filed its first PY9 semi-annual report, which included a summary of gross verified DR impacts. The Duquesne Light/Navigant team also submitted a response to the SWE DR data request. The data elements of this request included the following:

- A list of participating facilities and the reference load method used to estimate its gross verified performance
- For each event hour, a record of which facilities participated, their reference load, metered load, and verified DR impact
- For 11 sites selected by the SWE, the hourly load and weather data needed to replicate the Navigant impact estimates
    - These 11 sites represented approximately 84% of the gross verified PY9 DR impacts
- Two years of load and weather data used to calculate the Weather Sensitive Adjustment (WSA) slopes for sites that used a "high 4 of 5 with WSA" baseline method.

The data request response and semi-annual report formed the basis of the SWE audit activities – which are described in this section. The SWE audit uncovered several minor issues. Some of these issues required an update to the PY9 performance estimates. Others are prospective methodological recommendations. Issues are grouped in the following categories and each has a dedicated subsection of this memo.

- Data Management
- Application of Line Loss Factors
- Reference Load Selection

The SWE calculated PY9 performance totals based on an independent review. Table 145 shows the results. These updated verified savings were reflected in Duquesne Light's July 15, 2018 Preliminary Annual Report and November 15, 2018 Final Annual Report for PY9. The SWE's audit findings lowered Duquesne Light's P3TD demand response performance approximately 3.13 MW, from 62.18 MW to 59.06 MW. However, Duquesne Light is still comfortably above the

85% event-specific target for PY9 events and off to a strong start towards Phase III compliance target of averaging 42 MW across all DR events in the phase.

Table 145: PY9 DR Impacts by Event: SWE Calculations

Event Date	Event Time	Average Performance (MW)	% of Phase III Target
June 13, 2017	2pm – 6pm	61.99	148%
July 20, 2017	2pm – 6pm	63.81	152%
July 21, 2017	2pm – 6pm	51.38	122%

D.5.1 Data Management

The SWE PY9 demand response data request asked evaluation contractors to provide hourly load data for sampled sites for the full summer so that the SWE could independently replicate reference load calculations. When running some initial checks on the data, we noticed that for the last day in each month (6/30, 7/31, 8/31, 9/30), the data only included readings for hour ending 1:00 am (EDT). The other 23 reads were missing for all sites in the sample for each of the four days. Navigant reviewed the data provided by the ICSP and confirmed that this data was not provided to them. These were not unique weather days or part of the "4 of 5" window for any event day, so their exclusion from the analysis is of limited consequence. However, the SWE believes it is important to identify the root cause of the missing data and correct it prior to PY10. We also recommend Navigant include some additional reviews of data quality and completeness in their pre-analysis checklist.

One data management issue that did affect the PY9 estimates involved the calculation of the weather sensitive adjustment (WSA) for a large university. The premise of the "high 4 of 5 with WSA" baseline is as follows:

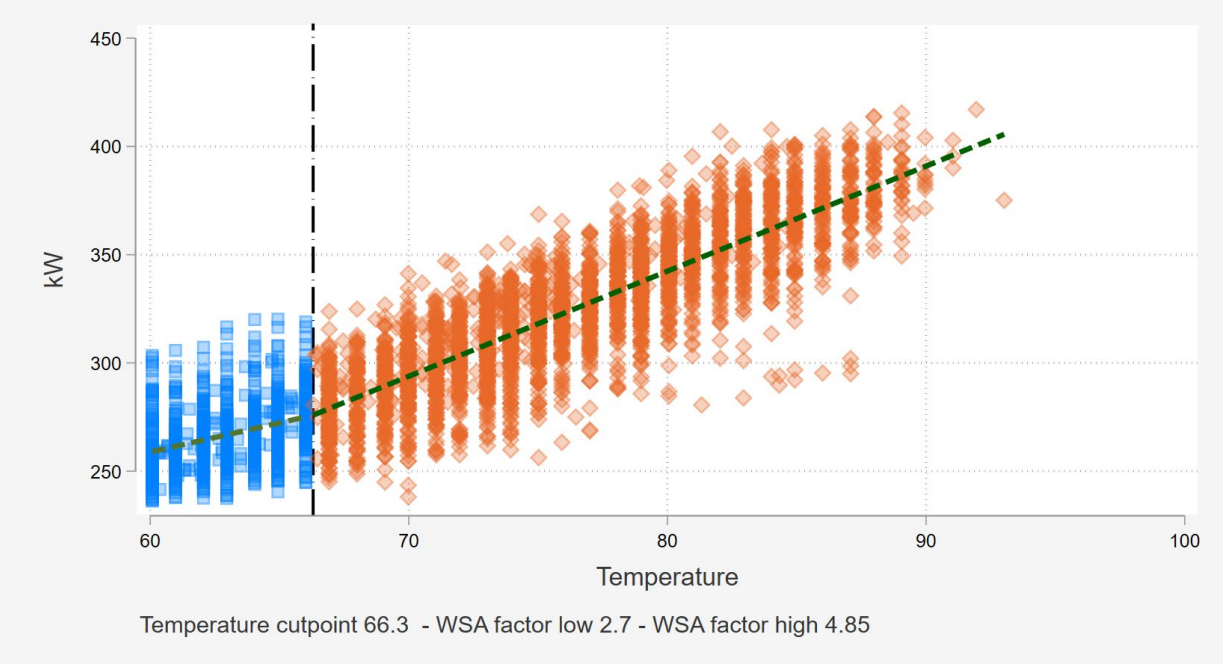
1. Identify the five most recent non-event weekdays prior to an event day
2. Select the four days with the highest loads during the event hours and average the hourly load and temperature
3. Compare the average temperature during the event hours for the baseline days and event day
4. Use a pre-determined load-temperature response to adjust the baseline up or down based on the temperature differential. If the event day is 3 degrees hotter than the average of the baseline days, the baseline will be adjusted upward by the WSA*3.

Figure 66 illustrates the calculation of the WSA for a sample customer. The WSA is a slope – or change in kW per one-degree change in temperature (F). Duquesne Light's ICSP chose to use a piecewise approach described in PJM's documentation[77] of the method to determine two

[77] https://www.pjm.com/-/media/markets-ops/demand-response/dsr-weather-sensitive-adjustment-using-wsa-factor-method.ashx?la=en

separate slopes for the temperature range from 60 to 95 degrees (F). The 'break point' from one slope to the other is determined mathematically and is different for each site.

Figure 66: Weather Sensitive Adjustment Example



The calculation of the WSA factors by the ICSP were robust and reasonable, but for one site two sets of meter reads were included for a portion of the historic load data leading to kW values that were approximately double what they should have been. As a result, the original WSA factors were overstated. Table 146 compares the WSA values before and after the data issue was fixed.

Table 146: Change in WSA Factors from Eliminating Duplicate Reads

Data Set	Break Point (F)	WSA Below Break	WSA Above Break
Original	84.366	251.61	567.27
Corrected	69.767	191.31	145.42

The site in question did not participate in the June 13th event so there was no impact on DR performance for that day. Table 147 shows the original and corrected DR performance estimates for the site. The SWE calculates a reduced DR performance of approximately 900 kW (after adding line losses) for the July 20th and July 21st event.

Table 147: Change in Verified Gross kW Impacts – University Site

Date	Hour	Original (kW)	Corrected (kW)	Change (kW)
7/20/2017	15	4,141	2,746	1,395
7/20/2017	16	3,602	2,243	1,359
7/20/2017	17	2,154	1,376	778
7/20/2017	18	815	889	(74)
7/21/2017	15	2,436	2,233	203
7/21/2017	16	3,023	2,128	895
7/21/2017	17	3,098	1,855	1,242
7/21/2017	18	3,346	1,963	1,383

Data management errors happen with this type of analysis. EDC evaluation contractors are tasked with developing independent estimates of EE and DR program performance so it's important that they validate the ICSP's procedures and calculations. If Navigant had reviewed the WSA basis data and calculations prior to utilizing the ICSP's WSA factors to calculate savings, this issue would have likely been identified and corrected prior to the PY9 semi-annual report.

D.5.2 Application of Line Loss Factors

Navigant used a line loss factor (LLF) of 6.9%, or 1.0741, to adjust DR performance estimates calculated at the meter to the system level for comparison with Act 129 targets. This value is consistent with the residential and commercial values of Table 1-4 of the 2016 PA Technical Reference Manual (reproduced in Table 148). Although the TRM gives a value of 1.0081 for the industrial sector, this value was not used in the PY9 DR evaluation for any sites.

Table 148: LLF by EDC and Sector

EDC	Residential LLF	Commercial LLF	Industrial LLF
Duquesne Light	1.0741	1.0741	1.0081
Met-Ed	1.0945	1.0720	1.0720
PECO	1.0799	1.0799	1.0799
Penelec	1.0945	1.0720	1.0720
Penn Power	1.0949	1.0545	1.0545
PPL	1.0875	1.0875	1.0420
West Penn Power	1.0943	1.0790	1.0790

The SWE reviewed the basis of the TRM line loss assumptions. The values were gathered by the Phase II SWE from EDCs in preparation for the Phase III EE and DR market potential studies. Duquesne Light indicated that the loss factor on the distribution system was 6.1% and the loss factor on the transmission system was 0.8%. For the residential and commercial sectors, the Phase II SWE assumed that customers are connected to the distribution network so the LLF is

the sum of the two (6.1% + 0.8% = 6.9%). For the industrial sector the Phase II SWE assumed that large industrials take service at primary voltage so are not a part of the distribution system. The DR potential study model assumed an LLF of 0.8% for the industrial sector and assigned no avoided cost of distribution capacity benefits to the kW reductions.

The SWE believes it is important that achievement of goals is measured using the same assumptions that were used in the goal-setting process, so we merged rate code information with the PY9 performance estimates to examine the distribution of impacts across rate classes. Table 149 shows the results of this exercise. Note that the values in Table 149 are based on results calculated with updated WSA factors for the site discussed in the previous section.

Table 149: PY9 Gross Verified kW Impacts by Date and Rate Code

Event Date	Rate Code	Rate Description	Verified kW (at Meter)	Count of Participating Sites
6/13/2017	GL-C	General Service Large Commercial	5,207.3	30
6/13/2017	GL-I	General Service Large Industrial	2,929.7	8
6/13/2017	GLH-C	General Service Large Heating Commercial	2,403.6	9
6/13/2017	GM>25	General Service Medium	829.5	12
6/13/2017	HVPS	High Voltage Power Service	39,224.4	2
6/13/2017	L-C	Large Power Service Commercial	3,763.3	2
6/13/2017	L-I	Large Power Service Industrial	5,761.2	3
7/20/2017	GL-C	General Service Large Commercial	5,116.1	31
7/20/2017	GL-I	General Service Large Industrial	2,663.4	7
7/20/2017	GLH-C	General Service Large Heating Commercial	3,052.7	9
7/20/2017	GM>25	General Service Medium	542.7	11
7/20/2017	HVPS	High Voltage Power Service	38,127.2	2
7/20/2017	L-C	Large Power Service Commercial	7,877.8	4
7/20/2017	L-I	Large Power Service Industrial	4,367.8	3
7/21/2017	GL-C	General Service Large Commercial	5,306.3	32
7/21/2017	GL-I	General Service Large Industrial	2,668.2	6
7/21/2017	GLH-C	General Service Large Heating Commercial	2,633.9	9
7/21/2017	GM>25	General Service Medium	527.8	13
7/21/2017	HVPS	High Voltage Power Service	35,610.6	1
7/21/2017	L-C	Large Power Service Commercial	3,268.5	4
7/21/2017	L-I	Large Power Service Industrial	5.1	3

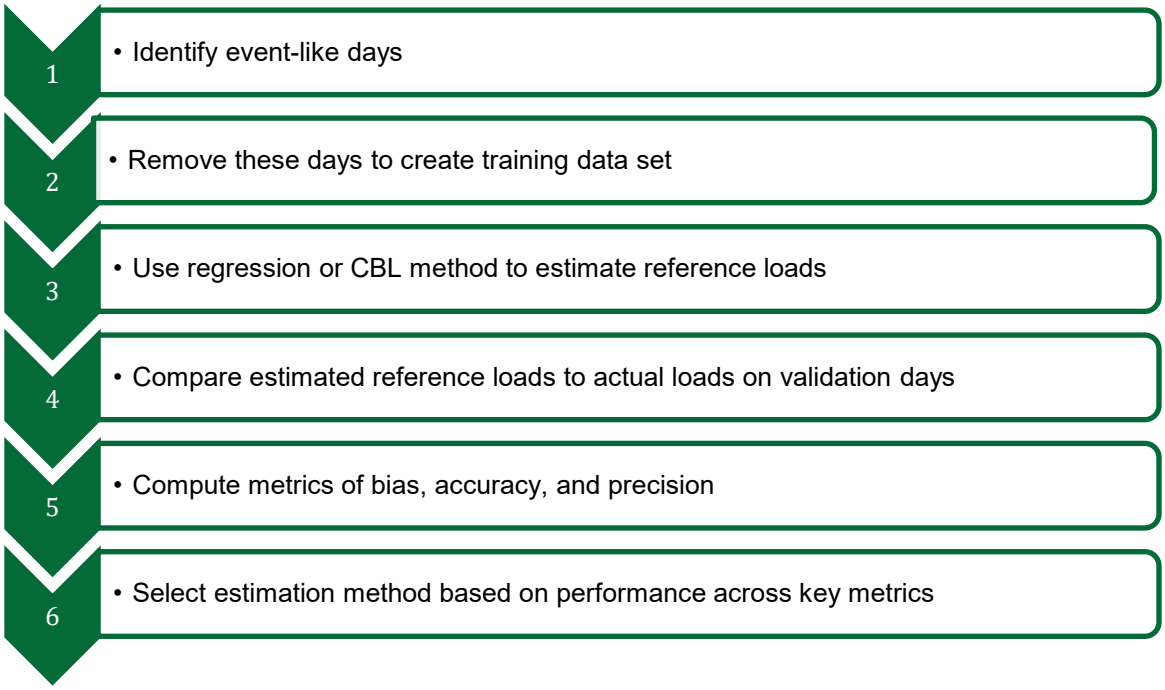
Based on the transmission vs. distribution loss assumptions that were the basis of the TRM line loss factors, we suggest DR impacts from the High Voltage Power Service (HVPS) be grossed up to the system level using a 1.0081 LLF. These sites take service at 69 kV or higher, so it follows that most of the losses from voltage step-downs would occur after the meter. While there were only two DR participants from this rate class, these two sites accounted for almost two-thirds of the PY9 DR reductions at the meter.

Applying the more conservative LLF to the HVPS sites reduces the DR performance for each event by approximately 2.5 MW. Table 145 showed the SWE and Duquesne Light's updated performance estimates for each DR event after making the changes discussed above to the WSA for the university and the LLF for large industrials.

D.5.3 Reference Load Selection

The approach Navigant used to determine reference loads for C&I DR participants was consistent with the process shown in Figure 67, which is taken from the Evaluation Framework. Navigant used summer 2016 data to perform out-of-sample testing on event-like days to select the more accurate method and used that method to calculate PY9 impacts.

Figure 67: Baseline Selection Steps



Navigant tested, and ultimately used, two different baseline methods in PY9. Table 150 shows the distribution of baseline approaches across the PY9 program population. Individual customer regression analysis and a "high 4 of 5 with WSA" CBL were each used for 37 sites, but the regression sites accounted for almost 80% of the DR impacts.

Table 150: PY9 Reference Load Frequency Table

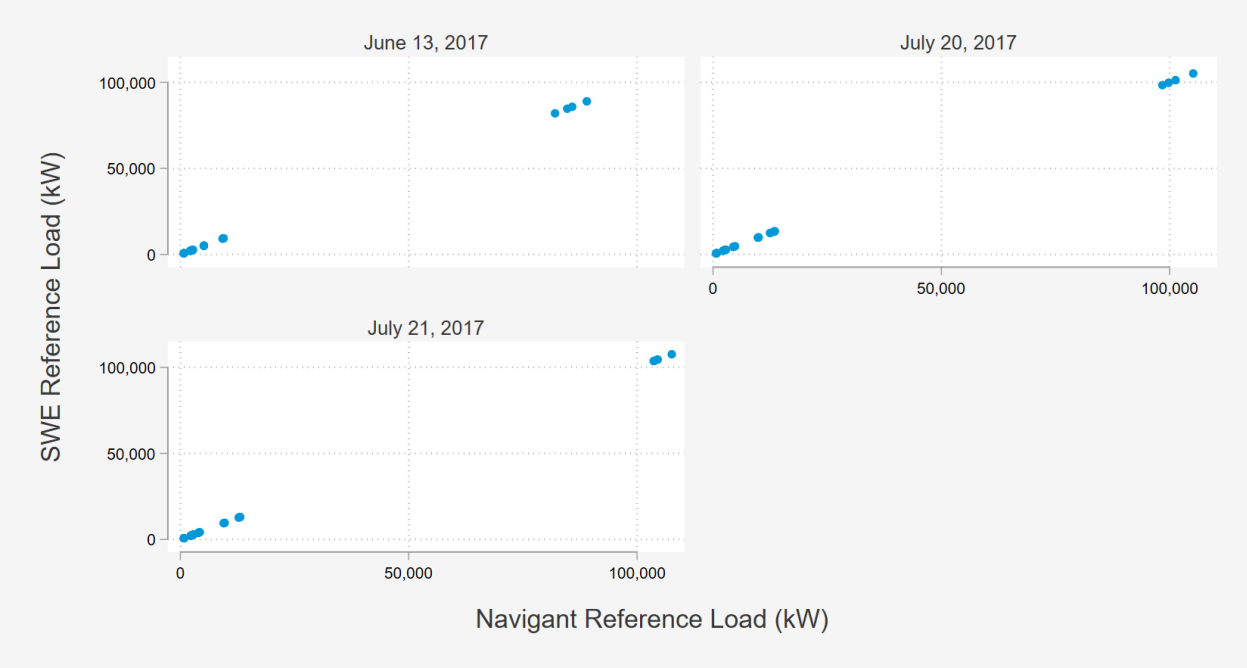
Baseline Method	Number of Sites Used	Share of DR Impacts (at Meter)
High 4 of 5 with WSA	37	20.3%
Individual Customer Regression	37	79.7%

In discussions with Navigant, the SWE suggested the inclusion of additional methods in the testing procedure. This recommendation has already been reflected in the PY10 evaluation plan for the Load Curtailable Load program, which includes plans to test over one hundred different reference load calculations for each participating customer.

D.5.4 Independent Verification of Calculations

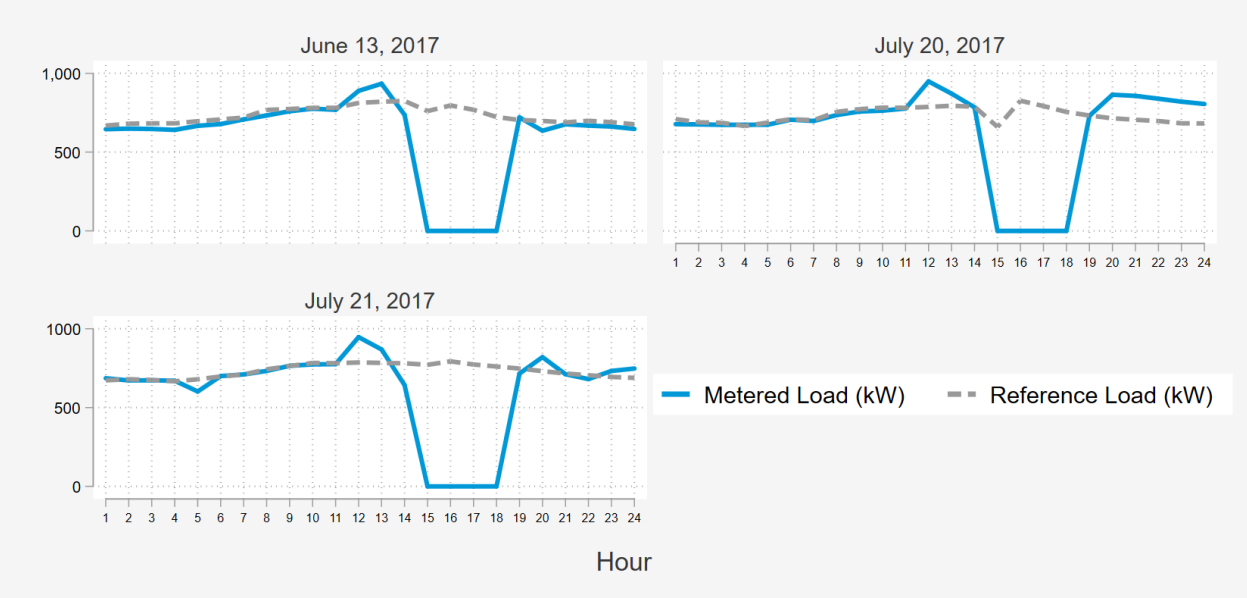
The SWE independently calculated reference loads and load impacts for each event hour for each of the eleven sites where hourly load data was requested. For ten of 11 sites, the SWE estimates matched the Navigant values exactly. The 11th site matched initially, until the issue with the WSA factors was uncovered and the slopes were updated. Once, Navigant recalculated baselines with the updated WSA factors, the estimates aligned again. Figure 68 contains scatter plots of the SWE and Navigant reference loads for the eight regression sites in the SWE sample. The trends are perfect diagonal lines with slope = 1.

Figure 68: Reference Load Comparison for Regression Sites



The SWE also examined the fit of the reference load for sampled sites. Figure 69 illustrates one of the more predictable sites with very clear event response on each of the three event days.

Figure 69: Site-Specific Reference Load by Event



Other sites have more uncertain baselines and load impact estimates. Figure 70 shows the same plot for the largest site in the Large Curtailable Load program. First, notice the difference in the scale of the y-axis. This site has metered load over 100 MW before and after the July event windows (hours 15 through 18).

Figure 70: Site-Specific Reference Load by Event

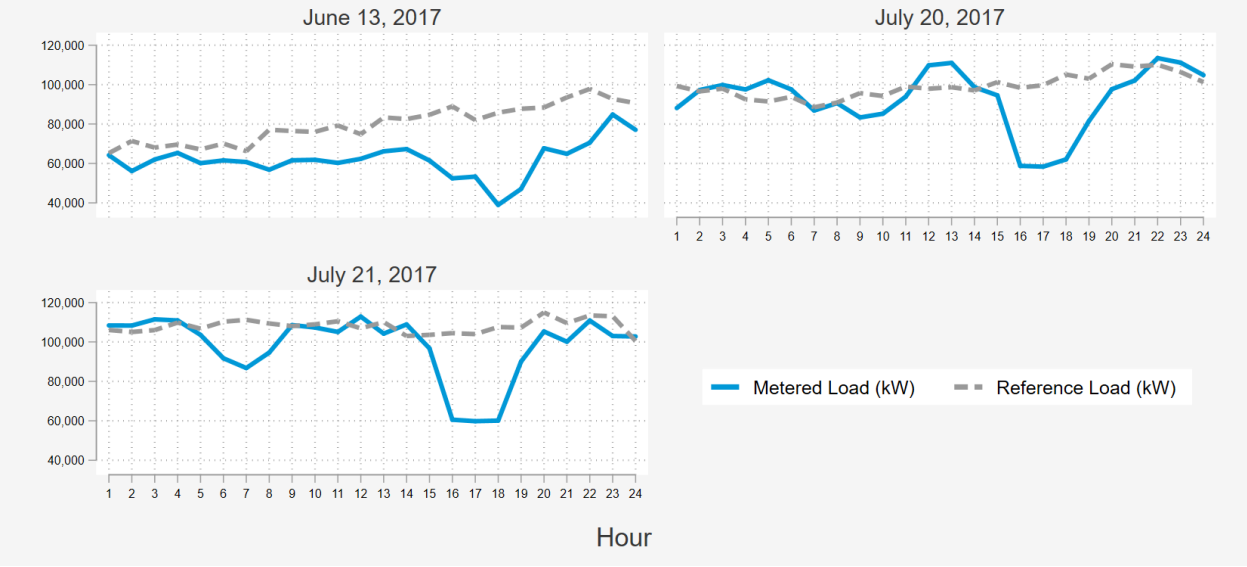
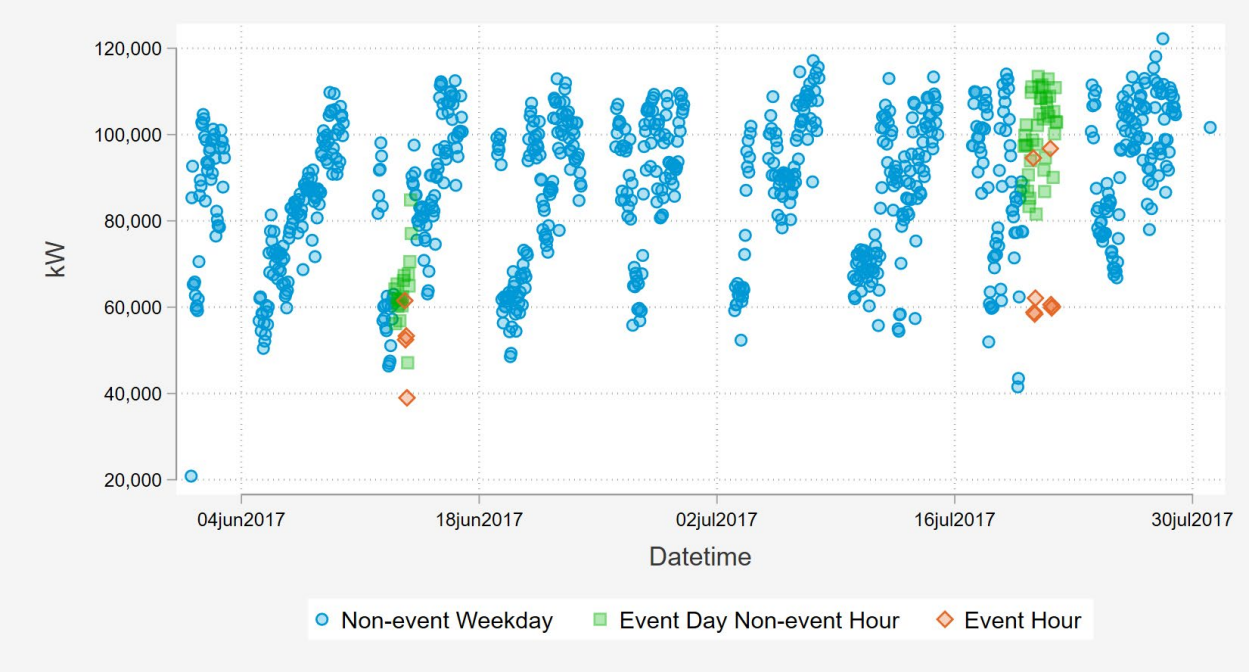


Figure 71 illustrates the challenges for this site by plotting the weekday loads for the site from June and July in a time-series. Loads routinely fluctuate from 60 MW to 110 MW and this introduces uncertainty into the estimates of DR performance.

Figure 71: June and July Load Time Series – Large Site



D.6 NTG

D.6.1 Residential Programs

Navigant estimated NTG for the Residential Energy Efficiency Program (REEP) for PY9 and applied PY8 NTG to the Residential Appliance Recycling Program. Navigant did not report an NTG for the Residential Whole House Retrofit program as they could not easily identify market rate participants.

Navigant estimated NTG for the Residential Energy Efficiency Program using the 2016 TRM, telephone participant surveys, and store intercept surveys. NTG was estimated for rebates, kits, standard LED, and specialty LED components of the program. Navigant took the average of the two participant and store intercept surveys to calculate free-ridership and used the participant survey to estimate spillover.

The Residential Home Energy Report Program claimed an 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.

The SWE determined that Navigant utilized data collection, question bevies, and the common NTG formula recommended in the Phase III Evaluation Framework.

Table 151: Summary of NTG Estimates for Duquesne Light Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Residential Appliance Recycling	0.59	0.06	0.47	--
RCT	Home Energy Report	0.0	0.0	1.0	--
Intercept Survey	REEP Rebates	0.62	0.08	0.45	73
Intercept Survey	REEP Kits	0.33	0.08	0.75	40
Intercept Survey	REEP Standard LED	0.66	0.09	0.43	416
Intercept Survey	REEP Specialty LED	0.65	0.09	0.43	239
Combination of program NTG values	Residential Energy Efficiency	0.60	0.08	0.49	768

D.6.2 Low-Income Residential Programs

Navigant did not gather data during PY9 to estimate Low-Income Energy Efficiency Program.

Navigant assumed that there was no free-ridership or spillover activity occurred among low-income participants and assumed an NTG of one for LIEEP Kits Program. The low-income home energy report was assigned an NTG of one, in accordance with the Evaluation Framework. The total LIEEP NTG was then calculated by averaging the LI kit and LIHERS NTG producing an overall NTG of one.

Table 152: Summary of NTG Estimates for Duquesne Light LIEEP

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY7	LIEEP Kits	0.0	0.0	1	--
RCT	LIEEP Home Energy Report	0.0	0.0	1	--
PY7 & RCT	LIEEP	0.0	0.0	1	--

D.6.3 C&I Programs

Navigant conducted NTG research in PY9 for the Commercial Efficiency Express Efficiency Program, Multifamily Housing Retrofit Program, Industrial Efficiency Program, Public Agency Partnership Program, and the Community Education Program following the recommended SWE framework. Navigant applied PY8 or PY6 NTG to the programs that did not conduct a PY9 NTG evaluation. The Multifamily Housing Retrofit Program NTG was estimated using 16 customer self-reports that included Public Agency Partnership and Community Education customer self-report data. The Industrial Efficiency Program NTG was calculated using six customer self-reports following the SWE framework. The Public Agency Partnership Program NTG relied on data gathered from customer self-reports though due to a low sample size within the program NTG results from the Multifamily Housing Retrofit and Commercial Efficiency Express Efficiency Program were combined with the self-report data. Net to Gross for the Community Education Program was evaluated using two customer self-reports, which were then combined with the

Multifamily Housing Retrofit and Public Agency Partnership Program NTG data to increase the sample size. The SWE recommends increasing sample sizes when possible even in the cases where a single digit sample is 30% of the population.

The SWE determined that Navigant utilized data collection, question bevies, decision trees, and the common NTG formula recommended in the Phase III Evaluation Framework.

Table 153: Summary of NTG Estimates for Duquesne Light C&I Programs

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Large Midstream Lighting	0.09	0.0	0.91	--
PY8	Medium Midstream Lighting	0.14	0.0	0.86	--
PY8	Small Midstream Lighting	0.29	0.0	0.88	--
PY8	Total Midstream Lighting	0.12	0	0.88	--
Estimated	Commercial Efficiency/ Express Efficiency	0.44	0.01	0.57	24
PY6	Small Commercial Direct Install	0.01	0.0	0.99	--
Estimated	Multifamily Housing Retrofit	0.55	0.0	0.45	16
Estimated	Industrial Efficiency	0.69	0.0	0.31	6
Estimated	Public Agency Partnership	0.55	0.0	0.45	16
Estimated	Community Education	0..55	0.0	0.45	16

D.7 TRC

Table 154 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Duquesne Light's PY9 individual programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY9 annual report.

Table 154: Summary of Duquesne Light's PY9 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	13,161	7,001	1.88	6,386	5,016	1.27
Residential Appliance Recycling	749	410	1.83	350	410	0.85
Residential Behavioral Savings	331	456	0.73	331	456	0.73
Residential Whole House Retrofit	55	236	0.23	55	236	0.23
Low-Income Energy Efficiency	1,152	1,238	0.93	1,152	1,238	0.93
Express Efficiency	8,256	1,682	4.91	4,582	1,482	3.09
Small/Medium Midstream Lighting	782	277	2.82	692	261	2.65
Small Commercial Direct Install	3,536	1,630	2.17	3,512	1,630	2.15
Multifamily Housing Retrofit	62	427	0.15	28	408	0.07
Commercial Efficiency	5,424	1,169	4.64	3,244	1,037	3.13
Large Midstream Lighting	1,011	606	1.67	895	589	1.52
Industrial Efficiency	9,499	2,113	4.5	2,907	1,314	2.21
Public Agency Partnership	3,371	1,254	2.69	1,534	894	1.71
Community Education	872	535	1.63	397	457	0.87
Large C&I Demand Response Curtailable	5,442	1,640	3.32	5,442	1,640	3.32
Portfolio Total	**53,703**	**20,675**	**2.60**	**31,507**	**17,067**	**1.85**

Of Duquesne Light's 15 energy-efficiency programs offered, 11 were found to be cost-effective and four were non-cost-effective when estimating the TRC using gross verified savings. Using net verified savings, nine programs were found to be cost-effective and six were non-cost-effective. The Residential Appliance Recycling and Community Education programs were cost-effective under gross verified savings, but non-cost-effective under net verified savings. The Large C&I Demand Response Curtailable program was a new program in PY9 and was found to be cost effective. 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
- Express Efficiency
- Small/Medium Midstream Lighting
- Small Commercial Direct Install

Net Verified Savings

Cost-Effective Programs (TRC > 1):

- REEP: Residential Energy Efficiency
- Express Efficiency
- Small/Medium Midstream Lighting
- Small Commercial Direct Install
- Commercial Efficiency

- Commercial Efficiency
- Large Midstream Lighting
- Industrial Efficiency
- Public Agency Partnership
- Community Education
- Large C&I Demand Response Curtailable

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

- Residential Behavioral Savings
- Residential Whole House Retrofit
- Low-Income Energy Efficiency
- Multifamily Housing Retrofit

- Large Midstream Lighting
- Industrial Efficiency
- Public Agency Partnership
- Large C&I Demand Response Curtailable

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

- Residential Appliance Recycling
- Residential Behavioral Savings
- Residential Whole House Retrofit
- Low-Income Energy Efficiency
- Multifamily Housing Retrofit
- Community Education

D.7.1 Notes from the TRC Model Review

- Duquesne Light 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.
- Water savings benefits were accounted for in the TRC model under Total NPV Lifetime Non-Electric Benefits. The SWE verified that the water savings were calculated in accordance to the Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test. The TRC model claimed 942.5 thousand gallons of water saved or approximately $142,000 in avoided costs.
- The SWE verified the measure-specific EULs. The team found that the EULs were consistent with the 2016 TRM. Duquesne Light accounts for the dual baselines for residential (CFLs and LEDs) and non-residential (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 SWE verified that the demand response program TRC ratio meets the 75% participant cost assumption where 75% of customer incentive payment is used as a proxy for participant cost.
- In PY8, the SWE recommended Duquesne Light's load profile engine be updated to be consistent with the 2016 TRM in PY9 reporting. The PY9 TRC model completed this update.

D.8 PROCESS

The Duquesne Light PY9 update to the Phase III 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 PY9.

D.8.1 Residential Programs

Duquesne Light operates five residential energy-efficiency programs: The Residential Energy Efficiency Program (REEP), the Residential Appliance Recycling Program (RARP), the Whole House Retrofit Program (WHRP, also known as the Whole Home Energy Audits Program, (WHEAP), the Home Energy Report Program, and the Low-Income Energy Efficiency Program (LIEEP).

For PY9, Navigant conducted process evaluation activities for four Duquesne Light residential programs: The Residential Energy Efficiency Program (REEP), the Home Energy Report Program, the Whole House Retrofit Program (WHRP), and the Low-Income Energy Efficiency Program (LIEEP).[78]

For the PY9 process evaluation of the above programs, Navigant conducted interviews with program managers and implementation contractors, reviewed program documentation and tracking databases, and conducted participant and general population surveys. In addition, for the WHRP program only, Navigant conducted in-depth interviews with a Conservation Service Provider (CSP).

For each program, the SWE provides a summary of the process evaluation findings and the SWE's audit of those findings. The PY9 report does not provide metrics on program participation, another important metric for evaluating participation and satisfaction across programs.

[78] For PY9, Navigant did not conduct process evaluation activities the Residential Appliance Recycling Program (RARP).

D.8.1.1 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 PY9 process evaluation activities for REEP addressed all three components of the program: Rebates, Kits, and Upstream Lighting components.

Navigant conducted a program theory and logic model review and noted that it remains unchanged in Phase III. The evaluation of the Rebates program component included an application file review to confirm the measure specifications and corresponding participating customer information for a sample of 97 measures. Navigant also requested the applications of the 75 random participants who participated in the PY9 phone survey 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. Navigant reported the following process-related findings:

1. *Program Awareness.* The majority of REEP Rebate survey respondents (67%) indicated that they look to the internet for information on energy-efficiency. Additionally, only a quarter of respondents stated that they look to Duquesne Light for information on energy-efficiency. DuquesneLight.com is the landing page for energy-efficiency programs. WattChoices.com is no longer active. Further investigations of this metric may find higher rates of respondents turning to Duquesne Light as they gain familiarity with the new website. Finally, 80% of respondents consider Duquesne Light a good resource for energy-efficiency information.
2. *Customer Satisfaction.* Overall satisfaction with the REEP Rebate component was high, with an average score of 8.6 on a 0-10 scale, with 10 meaning extremely satisfied. In addition, 92% rated their satisfaction higher than a six. When asked, customers tended to recommend larger rebates and better marketing for the program, and the recurring suggestion of improving the application process was also noticed in the verbatim responses. This suggestion made up 17% of all verbatim responses and 8% of all suggested recommendations.
3. *Customer Satisfaction.* Of the participants surveyed for the REEP Rebate component, 93% stated that they either had, or were likely to, recommend REEP Rebates to someone else within the next year. This further indicates a high level of satisfaction with REEP.

Customers received REEP kits as part of a self-paced online home audit and at community events. For PY9, Navigant completed telephone surveys with 75 kit participants (46 market rate and 29 low-income) to assess program awareness and satisfaction. Navigant reported the following findings:

1. *Satisfaction.* Overall satisfaction with REEP Kits is high, with an average score of 9.3 on a 0-10 point scale, with 10 meaning extremely satisfied. High scores were echoed between the market rate and low-income participants as well with 9.4 and 9.2, respectively. Of the participants surveyed, 99% gave a score of six or higher (100% for market rate and 96% for low-income). This was the first year that participants who received the Phase III kit, with LEDs instead of CFLs, were surveyed.
2. *Kit LEDs.* Navigant's participant survey found that among both market rate and low-income respondents an average of roughly six of eight bulbs per kit were either installed or stored for later installation. In other words, using the TRM's in-service rate (ISR) estimate and applying it to the LEDs both installed and in storage, Navigant concluded that, on average, 73% of LEDs within kits are eventually installed. Additionally, only 59% of respondents installed or planned to install all eight LEDs.

For the PY9 process evaluation of the Upstream Lighting component, Navigant conducted a general population survey of 1,119 individuals to assess the lighting market. Survey respondents who reported purchasing an ENERGY STAR LED within the past six months were assumed to be program participants. This survey resulted in the following findings:

1. *Survey Findings:* Navigant identified several other key findings from the in-store intercept and general population survey:
    - Awareness and use of LEDs is high and has increased in the past three years: only 5% of customers had not heard of LEDs. All customers who had heard of LEDs had at least a few installed (46% of survey customers had none installed in PY6).
    - Energy savings was the most commonly reported feature that respondents like about LEDs and the most commonly reported reason for purchasing LEDs as compared to other bulb types.
    - Many respondents, at the time of surveying, were not aware of the lifetime of an LED bulb, and after being informed by the interviewer, reported that they are more likely to purchase LEDs now that they understand LED lifetimes.
    - Understanding of color availability and energy consumption of LEDs has improved since PY6.
    - More than half (58%) of customers are aware of at least one Duquesne Light Energy Efficiency Program.
    - Customers are generally satisfied with Duquesne Light and with the Energy Efficiency programming that the utility offers.

Summary of Process Evaluation Audit

The process evaluation of REEP appears to have been generally consistent with the Phase III evaluation plan. For PY9, the evaluation planned for a documentation and database review, program theory and quality control review, program manager and implementer interviews, participating customer surveys, non-participant surveys, a recent lighting purchaser survey (upstream lighting), and an upstream lighting verification analysis. The report described results

from corresponding process evaluation activities that included an application file review, and an interview with the Duquesne Light Residential Coordinator.

Navigant provided a thorough explanation of the multi-step approach taken to verify applications and installed equipment for the document review task. For the Rebates and Kits components, Navigant conducted 75 telephone surveys each with program participants. For the Upstream Lighting component evaluation, Navigant also conducted interviews; this section of the report clearly documented the sampling process and steps of the evaluation. Navigant also conducted a general population survey with a sample size of 1,119. The target sample size indicated in the Upstream Lighting memo was 140 recent LED purchasers. Without a clear idea of the incidence rate, Navigant did not have an expectation for the number of completed surveys it needed to achieve this target. Over three-quarters (77%) of respondents have purchased LEDs, and over one-half (52%) had purchased an LED in the previous six months. Respondents who had purchased an LED in the past six months were assumed to be program participants.

Evaluation activities conformed with the evaluation plan for the three REEP components and methodology was generally well-documented. However, the SWE notes that the sampling plan and methodology could benefit from additional tables or figures that include total participation, sampling targets, and sample achieved. There were two recommendations that followed from the process evaluation; one was implemented and the other was rejected.

D.8.1.2 Residential Appliance Recycling Program (RARP)

Summary of Process Evaluation Audit

The Navigant report states that they did not conduct process evaluation activities for the Residential Appliance Recycling Program (RARP) in PY9.

D.8.1.3 Low-Income Energy Efficiency Program (LIEEP)

Summary of Process Evaluation Audit

The Navigant report states that they did not conduct process evaluation activities for the Low-Income Energy Efficiency Program (LIEEP) in PY9. In the evaluation plan, Navigant reports that "the schedule for conducting the evaluation of LIEEP is reflected in the schedule to conduct each of its component parts," the low-income components of the Whole House Retrofit Program (WHRP) and the Residential Behavioral Savings Program (HER). Energy savings from low-income participants in these programs contribute to LIEEP savings goals. The process evaluation activities related to LIEEP components are summarized in their market rate counterpart's report sections. Navigant notes that "the LIEEP surveys for low-income participants are generally similar to their market rate counterparts." There are no key findings specifically for the LIEEP program; however, there are some LIEEP-specific observations within the WHRP and HER process evaluation report sections.[79] The SWE notes that it would improve clarity to summarize these

[79] For example, in the WHRP process evaluation, Navigant observes: "In previous years, a few LIEEP WHRP respondents were dissatisfied with their replacement refrigerator they received at no charge from the program because the units were smaller than the ones they replaced. Navigant found that no one reported this being a problem this year."

survey results in the LIEEP section of the report, even if they are also mentioned in context alongside process findings for market rate survey respondents.

D.8.1.4 Home Energy Report Program

Summary of Process Evaluation Findings

Navigant's process evaluation activities for the Home Energy Report Program included telephone surveys with a total of 168 HER participants (88 low-income participants and 80 market rate participants). In the evaluation plan, Navigant targeted a sample size of 150 (75 low-income and 75 market rate customers) for the behavioral savings (HER) program; however, the evaluation team noted in the report that they did not achieve the targeted number of 240 completes (120 low-income and 120 market rate participants). The source of this discrepancy is unclear to the SWE. In the report, Navigant indicated a high "no contact" rate was the reason they failed to meet sampling targets, most likely due to high skepticism of phone solicitation scams among targeted customers. The "no contact" rate in PY9 was 16%, up from 14% in PY7; the evaluation team did not indicate if this was a significant difference. Navigant reported the following process-related findings:

1. *Participant Engagement.* Close to 30% of all participants noted receiving more than ten reports over the last year, and 18% recalled thoroughly reading at least three reports, with the number of reports read ranging from 21% (for market rate participants) to 16% (for low-income participants). Since PY7, participant awareness of Home Energy Reports has greatly increased; the majority of PY7 participants could not recall how many reports they had received at that time.
2. *Satisfaction.* The majority, 82%, of the HER participants are satisfied with their reports. The average satisfaction rating for the Home Energy Report was 8.4 out of a 1 to 10 scale, with 10 meaning extremely satisfied.
3. *Program Value.* Sixty-two percent of HER participants mentioned that home energy comparisons were the most valuable pieces of information provided to them in their reports. Forty-six percent and 44% of low-income and market rate respondents, respectively, said that the comparison of their home's current consumption to previous years was the most valuable information.
4. *Information on Behavior.* The majority of all treatment group participants reported taking some action to reduce their energy usage within the past year. Seventy-four percent of market rate participants and 66% of low-income participants purchased small energy-efficiency equipment, such as efficient light bulbs or power strips. Additionally, 72% of low-income participants stated that the Home Energy Reports influenced their actions to reduce energy.

Summary of Process Evaluation Audit

In the evaluation plan, Navigant indicated that a process evaluation for the Home Energy Report program would entail a review of program materials, interviews with two to four key program personnel at Duquesne Light and Oracle, creation of a program theory and logic model, and participant phone surveys. The audit team only observed findings from the participant survey in

the PY9 process evaluation. As mentioned previously, the target sample size for participant surveys in the evaluation plan was 150 (75 low-income and 75 market rate customers), but the report indicated Navigant fell short of the target of 240 participants. The source of this discrepancy from the sampling plan is unclear.

Findings from the participant survey were communicated in a clear manner with accompanying graphics; however, the audit team observed that context normally provided by program staff interviews and document review were noticeably absent. There was one recommendation that followed from the process evaluation; this recommendation is under consideration by Duquesne Light.

D.8.1.5 Whole House Retrofit Program (WHRP)

Summary of Process Evaluation Findings

The Whole House Retrofit Program (WHRP) is also known as the Home Energy Audits Program (WHEAP) in customer-facing materials. Because the program is referred to as WHRP throughout the PY9 report, the audit team will continue to refer to this program as WHRP throughout. For this process evaluation, Navigant conducted a review of program documentation, in-depth interviews with a WHRP Conservation Service Provider (CSP), logic model review, and telephone surveys with WHRP participants. Navigant reported the following process-related findings:

1. *Program Tracking Data:* Duquesne Light and the CSP track direct install measure details for each audit completed, and Navigant reviewed savings assumptions, algorithms, and reported installations. Navigant notes that program activities are not recorded at the audit or participant level within Duquesne Light's tracking database, PMRS. Instead, installation activities are combined, by measure type, at the invoice level. This differs from Phase II activities where PMRS reported each audit as a unique project and individual participants were readily identified.
2. *Income Status:* Several PY9 audits occurred in individually metered units within multifamily buildings, often originating from activities supporting the Multifamily Housing Retrofit (MFHR) program. Multifamily building landlords initially engaged with MFHR, but any activities completed for individually-metered dwellings happened through WHRP. In these instances, the income status of individual audit participants is not determined, but the building-level proportion of low-income-to-market rate residents is used to split all WHRP minor measure (e.g., direct install LEDs, smart power strips, etc.) savings associated with that building between the market rate and low-income components of WHRP (where the low-income savings are assigned to LIEEP and contribute to the low-income carve out). This same method is also used to determine the portion of MFHR savings that contribute to the low-income carveout. Low-income WHRP participants were the only recipients of the one major measure implemented in PY9, refrigerator recycling and replacement, and all savings from that measure are assigned to LIEEP and contribute to the low-income carveout.
3. Direct install LED lighting contributes the majority of program savings. The CSP's onsite auditors remove baseline lamps from the participant's home and replace them with LEDs. The LED details are captured within tracking data (i.e., 9, 11, or 15 watt), but the baseline

details are not. Instead, the program's reported savings rely on the TRM's deemed baseline for the given LED. However, the TRM allows for baselines to be based on actual bulbs replaced for direct install programs such as this.

4. The CSP's detailed program tracking data that Duquesne Light uses to report savings and Navigant uses to estimate verified savings excludes participant telephone numbers. Participant name, address, and account number are recorded.
5. *Program Overlap.* Of the 95 WHRP participants who were surveyed, 38 indicated that they participated in the REEP Kit program component in addition to the WHRP program. Participants can receive LEDs through the WHRP program, and therefore could either be receiving additional LEDs through the kits that may not be used, or the WHRP auditor may not be able to find sockets available for lighting retrofits because they already have LEDs from the kits installed. Although, Duquesne Light clarified that the kits offer a cross-marketing opportunity and provide a gateway that can lead participants to a WHRP audit.
6. *Satisfaction.* Satisfaction for WHRP is high across the board for the aspects asked about, with an average overall satisfaction score of 9.3 out of 10, in "overall experience with WHRP," with 10 meaning extremely satisfied. Of the participants surveyed, 96% gave a rating of six or higher.

Summary of Process Evaluation Audit

Navigant reported that there was a limited number of market rate participants (274) but did not specify the number of low-income participants or other population estimates. An updated sampling plan specified a total target sample size of 140 (70 for low-income and 70 for multifamily high-rise projects). In a table summarizing process evaluation research activities for PY9, Navigant indicated it completed surveys with a sample 95 participants but did not explain the discrepancy in the report. In the PY9 report, Navigant noted that Duquesne Light and Navigant simultaneously completed participant interviews with market rate and low-income WHRP participants using a sample that was stratified "based on how customers entered the program;" however, sample sizes or additional information was not provided. The SWE observes that sampling and reporting for the process evaluation was very opaque.

The evaluation plan specified that PY9 evaluation activities would include a program theory/quality control review, program manager and implementer interviews, participating customer surveys, and audit contractor interviews. Navigant noted it conducted a document review and in-depth interviews with Duquesne Lighting staff and "one of the CSPs" to compare the program in PY9 to earlier evaluations but did not specify methodology or number of interviews. Overall, a lack of a complete description of the methodology was an issue throughout the evaluation report for this program's process evaluation.

Addressing the in-depth interviews with the CSP's team of onsite auditors, Navigant explains that these interviews were not possible during PY9 and will be conducted in PY10. Duquesne Light issued a request for proposal (RFP) for WHRP implementation and the Navigant team was asked to delay interviews until a later date.

There were four recommendations that followed from the process evaluation; three recommendations are under consideration and one was rejected.

D.8.2 C&I Programs

Duquesne Light operated eight C&I energy-efficiency programs in PY9:[80]

- The Express Efficiency Program (EXP)
- The Commercial Efficiency Program (CEP)
- 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 (CEEEP)

In PY9, Navigant conducted process evaluations for six of the programs: Express Efficiency, Multifamily Housing, Commercial Efficiency, Industrial Efficiency, Public Agency, and Community Education.[81] Although net-to-gross and process evaluation research for SCDI was planned for PY9, the program was projected to reach its savings targets this year. As the program will not be offered moving forward, a process evaluation was deemed unnecessary.

Navigant attempted to complete surveys with all program participants in these six programs to assess program satisfaction; overall, there were 279 unique program participant decision makers (Table 155).[82] Despite combined email and phone outreach methods, Navigant achieved lower response rates (16%) in PY9 than in previous years.[83]

Table 155: C&I Evaluation Participant Survey Interview Targets and Sample Size

	Unique Decision Makers (Population Size)	Participant Survey (# of Completes)	Larger Saver Interviews (# of Completes)	Total Completes (Sample Size)
Express Efficiency	163	19	1	20
Commercial Efficiency	24	4	0	4
Industrial Efficiency	19	3	3	6
Community Education	19	2	0	2
Public Agency Partnership	52	10	3	13
MF Housing Retrofit	2	1	0	1

[80] 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).
[81] Process evaluation activities for Midstream Lighting were conducted in PY8 and will be conducted again in PY10.
[82] Some decision makers were associated with more than one project or program.
[83] Navigant noted that Duquesne Light's very limited non-residential customer base and repeat participation by some customers over time has likely reduced participant willingness to complete these surveys.

For each of these six programs, Navigant also conducted trade ally interviews, focusing on the participation process, benefits, and barriers of these programs from the prospective of a trade ally. Navigant collected a list of participating trade allies by reviewing C&I program applications from PY8 and PY9. Out of a total of 33 trade allies identified, Navigant completed interviews with eight of these individuals, representing all six programs. For CEEP, Navigant also completed interviews with school program participants who were involved with the program as a trainer for students or as an administrator for the program. Navigant followed the evaluation plan with one exception; they did not conduct in-depth interviews with program managers or implementation staff as planned. In PY8, Navigant conducted these interviews but did repeat this activity in PY9 because there were no significant program changes.

Throughout the report, Navigant did not present program-specific findings. For the net-to-gross analysis (discussed previously) in PY9, Navigant combined the GNI programs (CEEP, PAPP, and MFHR) NTG results and the Commercial sector programs (Express Efficiency and Commercial Efficiency) to get a more representative sample of the group. For the process evaluation, results from the participant survey and trade ally interviews were also presented together. The SWE observes that although all planned evaluation activities were completed, process evaluation plans for each program were presented separately in the planning document but conflated in the PY9 report, making it difficult to discern program-specific trends or findings. Key findings were not program specific and apply across all six programs evaluated:

- Program participants, trade allies, and CEEP participants were satisfied with the program. Specifically, program participants rated the program highly and stated they would recommend the program to others. Additionally, all participants viewed Duquesne Light either the same or more favorably after participating, reinforcing their contentment with the program overall. Trade allies also felt highly satisfied with Duquesne Light programs overall, rating satisfaction with support from Duquesne Light a 4.8 out of 5. Likewise, they rated the process to participate in the program a 4.9 on the same scale. CEEP participants felt highly satisfied based on their willingness to recommend the program to others in the future, despite the lack of measure installations that resulted from the program. In particular, CEEP participants gave positive comments on the materials provided by the program and appreciated the hands-on content.
- Bill/energy savings and rebates were reported as the top benefits to the program. However, participants also noted that burdensome paperwork, program complexity, and measures not qualifying for the program hinder the participation. Several trade allies also felt that Duquesne Light could further streamline its program requirements and reduce the amount of paperwork that needs to be submitted.
- Half of survey respondents stated they were unaware of any marketing materials, including the program website, brochure, and presentations, indicating a potential need for more education about available materials and services. Interviewed trade allies all reported that they recommend Duquesne Light's programs to customers. Interestingly, most trade allies do not leverage Duquesne Light marketing materials, citing difficulties in using the website and a lack of content for non-lighting measures. The lack of use of marketing materials by trade allies likely contributes to the lack of awareness of marketing materials amongst participants.

- Several surveyed participants requested the addition of new program offerings, including additional lighting options, drivers and motors, induction heaters, and more training. Many trade allies also made requests to add or adjust technologies offered through the program, especially for lighting measures.
- When asked to rank the ease and/or difficulty of making certain decisions related to participating, such as identifying opportunities, estimating cost savings, or deciding to install a measure, the factors which received the lowest rating (indicating they were elements participants found more difficult) were obtaining internal approval and estimating energy savings and costs.

Two CEEP-specific findings can be found in the program-specific section below. Evaluation activities specific to each program will be outlined briefly below. There were four general recommendations that followed from the process evaluation; all four are under consideration by Duquesne Light.

D.8.2.1 Express Efficiency Program

Summary of Process Evaluation Findings

Findings and survey results for all C&I programs evaluated in PY9 were presented together; there were no findings specific to the Express Efficiency Program to report.

Summary of Process Evaluation Audit

This program had 163 unique participants in PY9, and Navigant was able to contact 19 to complete a telephone survey. Navigant also conducted interviews with a total of eight individuals representing trade allies that participate in at least one of the C&I programs evaluated in PY9, including Express Efficiency.

D.8.2.2 Midstream Lighting Program

Summary of Process Evaluation Audit

No process evaluation for midstream lighting was scheduled for PY9; the next process evaluation is scheduled to occur in PY10. Although no evaluation was scheduled, the trade ally interview guide included questions about the Midstream Lighting program, since Duquesne Light staff expressed interest in learning more about trade ally interactions with the program. Three of the respondents, all lighting distributors, participated in this program. Although no key findings followed from these interviews, Navigant noted that while all the respondents would recommend this program to customers, they had mixed feedback regarding the participation process. Navigant suggested that Duquesne Light could consider evaluating the Midstream Lighting Program further to determine if there are ways to reduce and streamline paperwork.

D.8.2.3 Small Commercial

There was no process evaluation activity scheduled for the Small Commercial Program in PY9. The program was projected to meet its savings goals in PY9 and will be discontinued, so it was deemed unnecessary to conduct a process evaluation.

D.8.2.4 Multifamily Housing Retrofit Program

Summary of Process Evaluation Findings

Findings and survey results for all C&I programs evaluated in PY9 were presented together; there were no findings specific to the Multifamily Housing Retrofit Program to report.

Summary of Process Evaluation Audit

This program had two unique participants in PY9, and Navigant was able to contact one to complete a telephone survey. Navigant also conducted interviews with a total of eight individuals representing trade allies that participate in at least one of the C&I programs evaluated in PY9, including Multifamily Housing Retrofit.

D.8.2.5 Commercial Efficiency Program

Summary of Process Evaluation Findings

Findings and survey results for all C&I programs evaluated in PY9 were presented together; there were no findings specific to the Commercial Efficiency Program to report.

Summary of Process Evaluation Audit

The Commercial Efficiency Program had 24 participants in PY9; Navigant was able to reach four participants for a participant survey. Navigant also conducted interviews with a total of eight individuals representing trade allies that participate in at least one of the C&I programs evaluated in PY9, including Commercial Efficiency.

D.8.2.6 Industrial Efficiency Program

Summary of Process Evaluation Findings

Findings and survey results for all C&I programs evaluated in PY9 were presented together; there were no findings specific to the Industrial Efficiency Program to report.

Summary of Process Evaluation Audit

The Industrial Efficiency Program had 19 participants in PY9; Navigant was able to reach six participants for a survey. Navigant also conducted interviews with a total of eight individuals representing trade allies that participated in at least one of the C&I programs evaluated in PY9, including Industrial Efficiency.

D.8.2.7 Public Agency Partnership Program

Summary of Process Evaluation Findings

Findings and survey results for all C&I programs evaluated in PY9 were presented together; there were no findings specific to the Public Agency Partnership Program to report.

Summary of Process Evaluation Audit

The Public Agency Partnership Program had 52 unique participants in PY9; Navigant was able to reach 13 participants for a telephone survey. Navigant also conducted interviews with a total of eight individuals representing trade allies that participate in at least one of the C&I programs evaluated in PY9, including Public Agency Partnership.

D.8.2.8 Community Education Program

Summary of Process Evaluation Findings

Navigant conducted additional interviews with CEEP participants as part of the process evaluation, resulting in two CEEP-specific findings:

- When asked for constructive feedback on the CEEP materials, respondents had a variety of suggestions, mainly about amount of materials and content. In terms of amount, two of the participants felt that the amount of curriculum provided was overwhelming and requested training on the materials before they implemented them in class. With respect to content, one respondent thought the videos were too long, another requested that the program include additional interactive activities, and one other felt that the Excel sheet provided as part of the program was inappropriate for their students' age (because they did not know how to use it).
- CEEP interviewees, who were all teachers, noted that they did not have the authority to implement measures identified in the Conservation Action Plan. They said that principals and superintendents have this power and generally base their decisions on cost. For this reason, only two schools had implemented lighting measures, while the remaining three only made behavioral changes. Multiple respondents noted the difficulty in doing anything beyond these changes.

Summary of Process Evaluation Audit

The Community Education Program had 19 unique participants in PY9; Navigant was able to reach two participants for a telephone survey. Navigant also completed interviews with CEEP school program participants, defined as individuals who are an employee of the school that participated in PY8 or PY9. These individuals serve as a trainer for students or as an administrator for the program. Out of a total of nine CEEP school contacts provided by MCR, Navigant completed five interviews with teachers who had participated in CEEP. The program has three steps (present program materials, create and present a conservation action plan, and implement measures), and the interviews asked teachers about their experience with each element. Participants were also asked how they had heard about the program, their reasons for participating, benefits and barriers to participation, and recommendations on persuading other schools to participate in CEEP. There were two recommendations specific to this program that followed from the process evaluation; one was accepted, and one is under consideration by Duquesne Light.

Appendix E Met-Ed Audit Detail

E.1 EM&V Plan Reviews

FirstEnergy's evaluation contractor, ADM Associates, prepared a single, comprehensive evaluation plan for the four FirstEnergy EDCs that addressed evaluation activities for all of Phase III. In PY9 the ADM team submitted a sampling memo for the C&I DR program, which the SWE reviewed and approved with minor comments and suggestions.

In addition to reviewing FirstEnergy's sampling memo, the SWE reviewed two survey instruments, one for appliance retailers and one for the C&I DR program participants.

E.2 Sample Design Review

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

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 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 due program delivery channel or supported technology.

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than tariff-based program definitions, each of which would include the same mix of measures. This evaluation strategy also makes sample design more efficient because the same projects are more likely to share similar characteristics across rates classes (i.e., Small C&I, Large C&I, and Government) than a heterogeneous mixture of measures within a single class. For example, projects from Met-Ed's 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

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. Table 156 lists each initiative and the corresponding relative precision of the PY9 gross verified savings estimate for all initiatives that include sampling uncertainty.

Table 156: Relative Precision of Met-Ed PY9 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level (±)
Residential Appliance Turn-In (ATI)	6.2%
Low-Income ATI	9.0%
C&I ATI	10.9%
Res EE Kits	4.7%
Low-Income EE Kits	11.7%
Res Direct Install	13.1%
C&I Direct Install	N/A
Res Upstream Lighting	10.0%
Res Upstream Electronics	0.0%
Res HVAC	9.4%
Residential Appliances	13.7%
Low-Income Appliances	28.2%
Residential New Construction	7.0%
C&I Lighting	8.7%
C&I Custom	10.3%
C&I Prescriptive	0.0%

With the exception of the Low-Income Appliances Initiative, each of the sampling initiatives shown in Table 156 produced verified gross savings estimates of better than ±15% precision at the 85% confidence level. ADM notes that the relative precision for the LI Appliances Initiative was high due to realization rates far above 100% for clothes washers and heat pump water heaters. They attribute the large realization rates to conservative ex-ante values for those appliances. The C&I Direct Install program for Met-Ed did not receive a full evaluation in PY9 because only three projects were approved. All projects were selected for evaluation and were found to be lighting upgrades. The projects were evaluated according to the lighting evaluation protocol.

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 PY9 verification activities is discussed in detail in Appendix E.4.

The Behavioral Modification subprogram provides home energy reports to residential customers in the Met-Ed service territory. The subprogram is divided between market rate residential customers and Low-Income customers and each is administered as a randomized control trial (RCT). Participants are enrolled in experimental cohorts and a monthly billing analysis regression is the used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model is not able to fully capture the variation present in the data. Precision requirements for behavioral program are unique, with The Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). Table 157 shows the absolute precisions of the behavioral program components.

Table 157: Absolute Precisions of Met-Ed PY9 Behavioral Subprogram Gross Verified Energy Savings Estimates

Stratum	Absolute Precision at 95% Confidence Level (±)
Residential	0.12%
Low-Income	0.43%

Demand Response programs offered by the Met-Ed in PY9 include C&I Demand Response Program for both small and large customers. Starting in PY10 Met-Ed will also offer a Behavioral Demand Response Program to residential customers. Gross impact evaluations for the C&I Demand Response Programs do not rely on sampling but instead consist of establishing a customer baseline load (CBL) for each program participant. The relative precision of the PY9 DR impacts is ±8% at the 90% confidence level.

E.3 Reported Gross Savings Audits

E.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Met-Ed's PY9 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings (MWh) for each program;
- Reported gross peak demand savings (MW) for each program;
- Participation for each program; and
- Incentive dollars for each program.

The SWE leveraged Met-Ed'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 PY9 quarterly data request. Also note that demand response (DR) or home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding Met-Ed's C&I demand response programs

can be found in Appendix E.5, and our findings regarding the HER components of the Energy Efficient Homes and Low-Income Energy Efficiency programs can be found in Appendix E.4.1.3.

Table 158 summarizes our ex-ante findings regarding energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Met-Ed's PY9 Annual Report and 'No' otherwise. For each program, the SWE was able to replicate the values reported by Met-Ed.

Table 158: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	4,808	4,808	Yes
Energy Efficient Homes	21,006	21,007	Yes*
Energy Efficient Products	24,082	24,082	Yes
Low-Income Energy Efficiency	6,767	6,766	Yes*
C&I Energy Solutions for Business – Small	36,935	36,935	Yes
C&I Energy Solutions for Business – Large	31,334	31,334	Yes
Governmental & Institutional Tariff	619	619	Yes
Portfolio Total	**125,551**	**125,551**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 159 summarizes the SWE's ex-ante findings regarding peak demand savings. The SWE's records matched Met-Ed's reported peak demand savings for each program. Note that demand savings for the Governmental & Institutional Tariff program were non-zero but rounded down to 0.00 MW (0.0049).

Table 159: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.68	0.68	Yes
Energy Efficient Homes	4.69	4.69	Yes*
Energy Efficient Products	3.04	3.04	Yes
Low-Income Energy Efficiency	0.77	0.77	Yes*
C&I Energy Solutions for Business – Small	5.43	5.43	Yes
C&I Energy Solutions for Business – Large	4.69	4.69	Yes
Governmental & Institutional Tariff	0.00	0.00	Yes
Portfolio Total	**19.3**	**19.3**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 160 summarizes the SWE's ex-ante findings regarding program participation. For three programs, the SWE calculated exact matches. For two other programs, the SWE calculated participant counts that differed from Met-Ed's counts by fewer than six. For the two remaining programs, the SWE calculated directionally similar participant counts. Note that these two programs both have HER components – the counts for those components are not included. The values shown in the "Annual Report Participants" for those two programs represent the difference between the value for the full programs (inclusive of the HER components) and the maximum number of treatment group homes active in the HER program during PY9. The difference between the SWE and FirstEnergy participant counts for the Low-Income Energy Efficiency program is likely a function of the counting logic for accounts that participate more than once within a given program year.

Table 160: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	4,787	4,787	Yes
Energy Efficient Homes	64,360	61,888	No*
Energy Efficient Products	352,658	352,659	Yes
Low-Income Energy Efficiency	10,629	14,348	No*
C&I Energy Solutions for Business – Small	424	429	No
C&I Energy Solutions for Business – Large	207	208	No
Governmental & Institutional Tariff	57	57	Yes
Portfolio Total	**433,122**	**434,376**	**No**

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Finally, Table 161 summarizes the SWE's ex-ante findings regarding incentive dollars. The SWE was only able to replicate incentive dollars for one program – Appliance Turn-In. The SWE calculated directionally similar incentive dollars for five of the remaining programs. For these six programs, the totals are also directionally similar: $5,105,000 in the Annual Report and $5,100,000 in the tracking data.

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. The discrepancy between data sources ($2,913,000) is like the incentive amount that Met-Ed had earmarked for EE kits and audits in their PY9 EE&C plan ($2,845,000).

Table 161: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	$273	$273	Yes
Energy Efficient Homes	$3,293	$385	No
Energy Efficient Products	$1,698	$1,811	No
Low-Income Energy Efficiency	$133	$107	No
C&I Energy Solutions for Business – Small	$1,472	$1,356	No
C&I Energy Solutions for Business – Large	$1,497	$1,522	No
Governmental & Institutional Tariff	$32	$31	No
Portfolio Total	**$8,398**	**$5,485**	**No**

E.3.2 Project File Reviews

E.3.2.1 Residential

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of Met-Ed's residential project files for PY9 using the project file documentation provided by Met-Ed, the program implementors, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included a majority of the documentation requested. Initially, project file documentation was not provided for the Low-Income WARM program for quarters 3 and 4, but was later provided by ADM upon request.

Table 162 presents a summary of SWE's residential project file reviews. In addition to verifying that documentation was present and corresponded accurately with the quarterly tracking data, the SWE conducted a review of the sampled project files to verify that correct values and algorithms from the Pennsylvania TRM were applied to the reported savings. The evaluator, ADM, was very cooperative in working with the SWE on questions and comments during the project file reviews took place.

Table 162: Met-Ed PY9 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?[1]
Appliance Turn-In Program	Appliance Turn-In Program	28	✓	✓	✓	✓
Energy Efficient Homes Program	School Education	3	✓	✓	✓	✓
Energy Efficient Homes Program	EE Kits	3	✓	✓	✓	✓
Energy Efficient Homes Program	Audits	3	✓	✓	✓	✓
Energy Efficient Homes Program	New Homes	24	✓	✓	✓	✓
Energy Efficient Products Program	Appliances and Electronics	28	✓	✓	✓	✓
Energy Efficient Products Program	Lighting	24	✓	✓	✓	✓
Energy Efficient Products Program	HVAC	24	✓	✓	✓	✓
Low-Income Energy Efficiency Program	Weatherization	12	✓	✓	✓	✓

*The number of files reviewed reflects the total number for all First Energy EDCs.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews, including issues or discrepancies found between the project file packages and quarterly tracking data.

HVAC

The HVAC project files typically matched the quarterly tracking data; however, the SWE found one discrepancy in the heating and cooling capacity between the sampled project files and tracking data.

- For heat pump projects, the TRM requires separate inputs for heating and cooling capacity to calculate savings. In the tracking data, capacity was displayed as a singular 'tons' variable.[84]

The evaluator, ADM, worked with the SWE to clarify this discrepancy. Their approach is to use single point estimates for these values for the reported ex-ante savings, and to then pull the heating and cooling capacities directly from the AHRI database and other independent sources during the verified savings calculations.

Upstream Lighting

The Upstream Lighting files matched the tracking data; however, a discrepancy between the tracking data and the TRM equation was observed.

- In the TRM, the base wattage variable for specialty bulbs is dependent on bulb shape and lumen range; however, the tracking data did not break out bulb shape enough to make this determination.[85]

ADM again worked with the SWE to clarify this issue. This is corrected during the verified savings calculations, which are entirely independent from these ex-ante calculations. The model numbers are used to pull in all bulb information, including specific shape, from a compiled database, primarily using ENERGY STAR data.

Appliances

The Appliance files typically matched the tracking data, but the SWE had a question about the reported savings.

- Reported ex-ante savings were based on TRM defaults values despite the EDC collected data for those values being available.

ADM confirmed that defaults are used at the ex-ante level, but the model specific TRM values are used in verified savings calculations.

Low-Income WARM

Project files for the Low-Income WARM program typically matched the tracking data for Q1 and Q2. However, the SWE noticed that project files were not provided initially for Q3 and Q4.

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[84] For example, for a mini split project, the heating capacity might be 12k BTU, and the cooling capacity 9k BTU, but this would appear in a single 'tons' variable as 12k BTU in the tracking data. As noted, ADM reported that this is corrected in the verified savings calculations.

[85] For example, a specialty bulb at 500 lumens could have a base wattage of 40, 45, 60, or 65 depending on the shape, but there is no way to tell which value should be used without more specific shape categories being used. ADM confirmed that this is addressed in the verified savings calculations.

ADM was notified of this and quickly provided a sample of project files for these quarters, and no discrepancies were found.

E.3.2.2 Non-Residential

The SWE reviewed Met-Ed's C&I projects for PY9 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, equipment invoices, and equipment specification sheets. Most of the project file packages included all documentation requested. For lighting projects, Met-Ed's ICSP uses their own lighting calculator. For PY9, the inputs to the ICSP's lighting calculators were also transcribed into the Appendix C lighting calculator.

Project files were generally well organized, complete, and accurate. Table 163 presents an overview of the results of the SWE's C&I project file reviews.

Table 163: Met-Ed PY9 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?
FESPPS1534536493	Compressed Air	✓	✓	✓	✓	-	✓
FESPPS1534469397	Lighting	✓	✓	✓	✓	✓✓	-
FESPPS1534469395	Lighting	✓	✓	✗	✓	✗	-
FESPPS1534469340	Lighting	✗	✓	✓	✓	✓	-
FESPPS1535519067	PTHPs	✓	✓	✓	✓	✓	-
FESPPS1535822149	Lighting	✓	✓	✓	✓	✓	-
FESPPS1537129837	VFDs	✓	✓	✓	✓	-	✓
FESPPS1537731924	MZ Ductless HP	✓	✓	✓	✓	✓	-
FESPPS1537834392	Lighting	✓	✓	✓	✓	✓	-
FESPPS1537865815	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534536493	Compressed Air	✓	✓	✓	✓	-	✓

Specific issues noted during the project file review process are addressed individually by project below.

Two issues were noted for Project FESPPS1534469395. Energy savings calculations calculated savings for a lighting retrofit that included occupancy controls. However, the included invoice and spec sheet did not document the occupancy controls. Additionally, in the retrofit savings calculation, a coincidence factor of 0.57 was used for fixtures operating year-round (8,760 hours). This error resulted in a slight underestimate of demand savings.

Project FESPPS1534469340 was the only lighting project reviewed by the SWE for Met-Ed that did not include an Appendix C lighting calculator. However, the ICSP's calculator appeared to be following TRM methodology for the project.

The process by which the ICSP's calculators are transcribed into the Appendix C calculator preserves much of the Appendix C functionality but does overwrite some functions. Baseline fixture wattage lookups are preserved. Hours of operation, coincidence factors, and interactive factors are directly transcribed from the ICSP's calculator in a manner that overwrites the formulas built-in to the Appendix C calculator. For future years, the ICSP and the evaluator could consider improving the transcription process so that these parameters are calculated directly by the Appendix C calculator as intended.

Additionally, calculators submitted for prescriptive measures are locked. Worksheet and cell permissions could be modified to allow the SWE to view inputs and algorithms in the calculator. This would facilitate easier project reviews and evaluations in the future.

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'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 evaluation details differ or where the SWE audits determined that certain subprograms showed discrepancies not shared by others in a program). Note that the SWE reports 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 164 provides a summary of the evaluation and M&V approaches used by Met-Ed in their PY9 verified savings calculations. Note that the SWE adjusted verified savings in the PY9 Annual Report due to overestimated savings for the Upstream Lighting program but that the

discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting beginning in PY10.[86]

Table 164: Residential Program Evaluation Activities – Met-Ed

Program/ Subprogram	Surveys	Site Visits	Desk Review[a]	Billing Analysis	Applied PY8 RR
Appliance Turn-In					
Appliance Turn-In (LI & Non-LI)	✓	--	✓	--	--
EE Homes					
EE Kits	✓	--	✓	--	--
EE Kits- Low-Income	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	✓	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting					
Upstream Lighting	✓	--	✓	--	--
EE Products					
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Appliances- Low-Income	✓	--	✓	--	--
Low-Income WARM					
Low-Income WARM- Extra Measures	--	✓	✓	✓	--
Low-Income WARM- Multifamily	--	✓	✓	✓	--
Low-Income WARM- Plus	--	✓	✓	✓	--

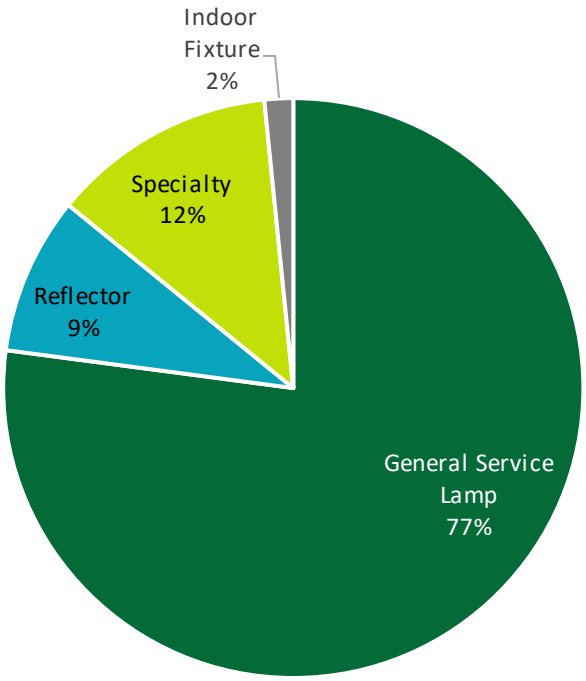
[a] The Desk Review column includes: database reviews, application reviews, and/or engineering desk reviews.

[86] 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.

E.4.1.1 Upstream Lighting & Cross-Sector Sales

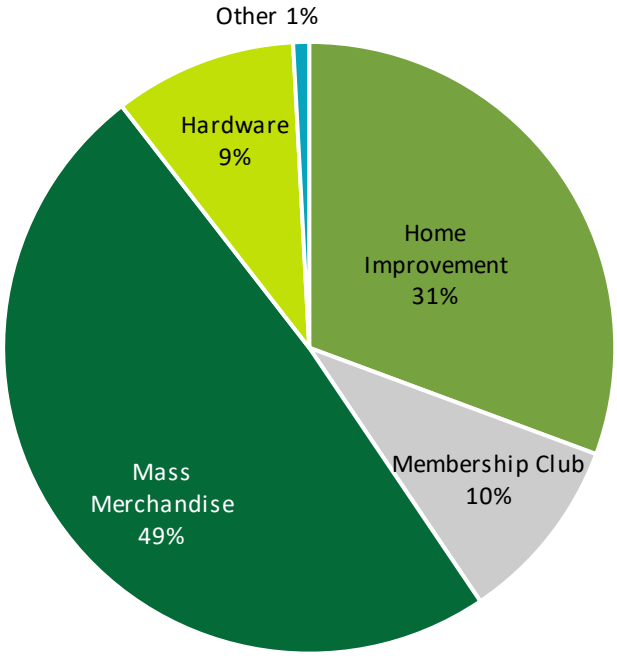
Customers purchased nearly 800 thousand efficient light bulbs and fixtures through Met-Ed's PY9 upstream lighting program. Figure 72 displays the distribution of sales by product type. Over three-quarters (77%) of the products were general service lamps.

Figure 72: Met-Ed PY9 Upstream Lighting Sales by Product Type



Most (80%) of Met-Ed's PY9 upstream light bulbs and fixtures were sold through home improvement and mass merchandise stores (Figure 73).

Figure 73: Met-Ed PY8 Upstream Lighting Sales by Retail Channel



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 generally agrees with ADM's verified gross savings for the Upstream Lighting Initiative but has adjusted verified savings for the errors detailed below.

The SWE observed 546 unique lighting model numbers in the PY9 tracking system and was able to locate 541 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The five models the SWE was not able to verify as ENERGY STAR certified represent 0.1% of both upstream 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 URLs ADM provided and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for two models, but it is unclear if these discrepancies are due to rounding, errors in the PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes. 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 one model, resulting in verified savings being overestimated by 55 MWh. The impact of all discrepancies the SWE identified on portfolio-level savings is minor, less than 0.1%.

Cross-Sector Sales

ADM did not conduct cross-sector sales research in PY9. ADM applied the PY8 cross-sector sales estimate of 8.3% to PY9 sales.

Recommendations

The SWE does not have any recommendations based on its review of the PY9 upstream lighting analysis. However, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- 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 minor issues that caused a negligible difference in savings, detailed below.

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 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 methodologies for ENERGY Star lighting and appliance measures to verify savings. The audit found that the new home sub-program was incorrectly applying 2016 TRM savings for ENERGY Star dishwashers, resulting in a negligible increase in savings.[87] The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

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.

Analysis files and data sets included in the gross impact data were reviewed for all HVAC, appliance, and consumer electronics measures included in the program. The SWE found that in all cases the correct TRM vales and algorithms were used, the verified savings were correct, and the savings and sample sizes included in the annual request data matched those reported in the PY9 annual report.

[87] ADM used a default energy savings of 29.4 kWh per year for non-electric (gas) water heating but the 2016 TRM default is 26.4 kWh (Table 2-90 of the 2016 TRM).

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.

Appliance Turn-In Program (Low-Income and Non-Low-Income)

The SWE performed audits on all measures included in the Appliance Turn-In Program, including dehumidifiers, refrigerators and freezers, and room air conditioners. Overall, the SWE concluded that the proper TRM algorithms and protocols were used, and that verified savings were correct. Sample sizes in the annual request data did not match the achieved sample sizes included in the annual report.

E.4.1.3 Behavior

Approximately 22% of Met-Ed's verified gross energy savings for PY9 came from Home Energy Reports issued to around 148,000 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 PY9. By cohort, Table 165 shows average kWh savings and average percent savings per participant in PY9. Note that the 'Average Number of Participants' column shows the average number of participants per month during PY9.

Table 165: Average PY9 kWh Savings per Participant

Sector	Cohort Start Date	Average Number of Participants	Average PY9 kWh Savings	Average PY9 % Savings
Low-income	July 2012	10,327	329	2.30%
Residential	July 2012	74,804	296	2.16%
Low-income	January 2014	2,251	335	1.99%
Residential	January 2014	49,422	181	1.34%
Residential	January 2015	11,403	258	1.95%

The following sections highlight some of the more important audit steps and findings: the calendarization of billing data, group equivalence, duplicating participant counts, the calculation of lag terms, missing eligibility filters, and energy and demand savings.

Calendarization

The first step the SWE took was to review ADM's calendarized data. "Calendarization" is a process that prorates billing data into a common calendar month basis shared by all accounts. Our review of the calendarized data had three primary components:

- Check the coding of the "pre" and "post" indicator variables;
- Confirm that the calendarized average daily usage values are correct; and
- Confirm that the lag terms (average usage in the pre-period, average summer usage in the pre-period, average winter usage in the pre-period) are correct.

Our team found no issues in the coding of the pre and post indicator variables. Table 166 shows summary statistics calculated for ADM's calendarized data and the SWE's calendarized data.[88] The distribution of average daily kWh is basically identical in the two data sets.

Table 166: Comparison of Calendarized Data

Variable	Mean	5th Percentile	25th Percentile	75th Percentile	95th Percentile
Average Daily kWh – ADM	38.44	15.61	24.25	46.83	79.11
Average Daily kWh – SWE	38.44	15.61	24.24	46.83	79.13

Regarding the lag terms, the SWE found that ADM's calculations were sound. ADM did not calculate summer or winter lag terms in cases where pre-period summer or winter data did not exist. Because we found no issues with ADM's calendarized data, the figures, tables, and summary statistics presented herein were created or calculated using ADM's calendarized data rather than our own.

Group Equivalence

After reviewing the calendarization, the SWE compared average daily consumption (kWh) between the treatment and control groups during the pre-treatment period. Table 167 shows the results for each cohort. Note that calendarized data was used to calculate the averages and any customer without at least 12 month of pre-treatment data was dropped. To avoid comparing averages calculated over different time spans (e.g., 14 months and 12 months), averages within each month were calculated before calculating overall averages for each customer. The 'P-value' column indicates the likelihood that the observed differences could happen by chance if the two experimental cells use the same amount of energy, on average. A p-value less than 0.05 indicates that the difference in average consumption between the two groups is statistically significant. No

[88] The table only summarizes records that were in both the ADM and SWE data sets. A small percentage of account/month combinations from the ADM data set were not in the SWE data set, but the majority of these were June 2018 records (PY10) that the SWE dropped.

cohorts were found to have statistically significant pre-treatment differences between the treatment and control groups.

Table 167: Group Equivalence in the Pre-Period

Sector	Cohort Start Date	Average Daily kWh – Control	Average Daily kWh – Treated	P-value
Low-income	July 2012	40.4	40.5	0.93
Residential	July 2012	39.5	39.4	0.84
Low-income	January 2014	47.7	48.6	0.08
Residential	January 2014	38.9	38.6	0.07
Residential	January 2015	37.7	37.7	0.94

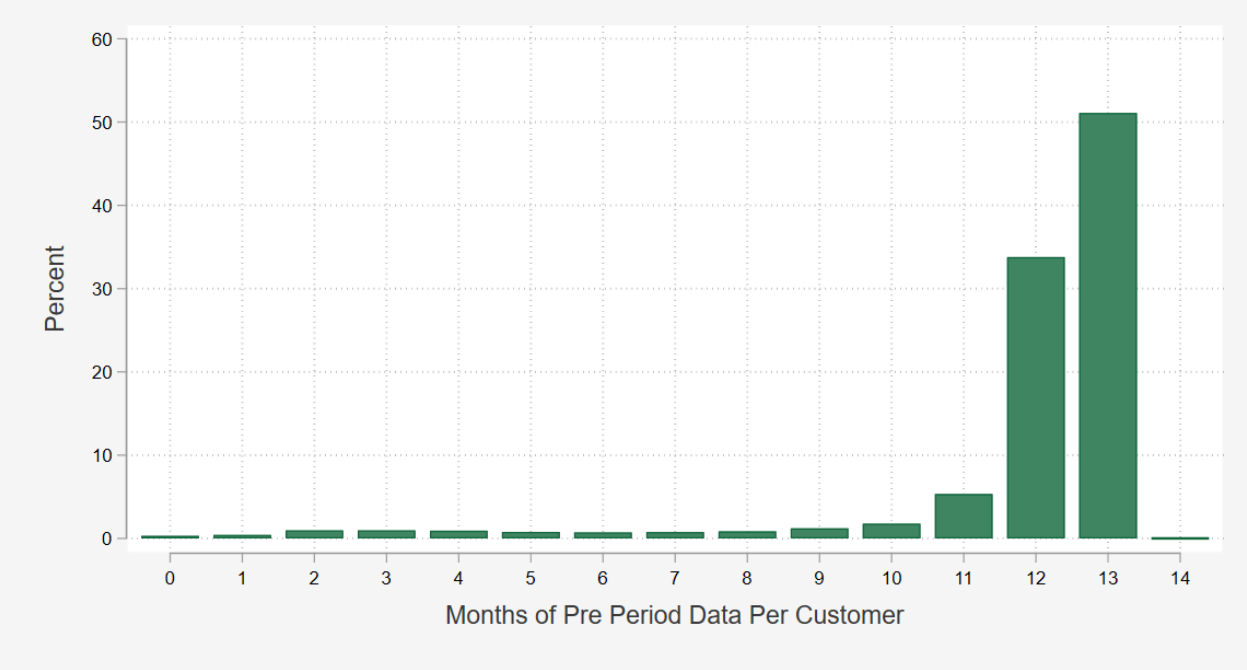
Participation Counts

The SWE leveraged the raw, un-calendarized billing data to audit participant counts. Because billing cycles can exceed 31 days in length (meaning bill dates can occasionally skip over a month), the SWE calculated the number of unique IDs beyond a certain bill date. As an illustrative example, suppose we wanted to compute the number of participants in Met-Ed's 2012 LI cohort for March of 2018. We removed any records with a billing end date prior to 3/1/2018, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that matched the reported counts.

Eligibility Filters

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 74 shows the distribution of the number of months of pre-period data per customer. Across all Met-Ed cohorts, 15.1% of homes had less than 12 months of pre-period data.

Figure 74: 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 12 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 (used in the lagged seasonal model specification) be calculated? For a given customer, suppose there is only one month of pre-period summer usage. Should the lagged summer variable (average daily consumption during summer months in the pre-period) be based on that lone summer month? Or should it be treated as a missing value?

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. For PY10, the SWE recommends Met-Ed investigate homes with less than 12 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 12 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: 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.)

Impact Coefficients and Energy Savings

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we ran the LS model without filtering out homes with less than 12 months of pre-period data. After replicating ADM's savings values, the SWE dropped any participant without at least 12 months of pre-period data and re-ran the LS model for each cohort. On average, the second method produced larger impacts (in magnitude). Impact 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 168 shows impact estimates for each cohort. Note that a different impact estimate was calculated for each month in PY9 – the estimates shown in the table reflect the averages of the PY9 monthly estimates. Using the first impact estimate as an example, the practical interpretation is as follows: treatment group homes in the low-income July 2012 cohort saved 0.88 kWh per day, on average, during PY9.

Table 168: Impact Coefficients

Sector	Cohort Start Date	Impact Estimate (kWh saved per home per day)	Impact Estimate – At least 12 Months of Pre
Low-income	July 2012	-0.88	-0.84
Residential	July 2012	-0.84	-0.84
Low-income	January 2014	-0.94	-1.07
Residential	January 2014	-0.51	-0.59
Residential	January 2015	-0.72	-0.92

Table 169 shows ADM's and the SWE's aggregate energy savings (MWh) for each cohort. On aggregate, the SWE estimate was approximately 2,085 MWh greater than the ADM estimate. The biggest differences were for the 2014 and 2015 residential cohorts – a gain of more than 2,000 MWh. As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework did not mandate that only accounts with at least 12 months of pre-period data could be used in a billing analysis.

Table 169: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	3,397	3,361	-36
Residential	July 2012	22,135	21,899	-236
Low-income	January 2014	753	853	100
Residential	January 2014	8,921	10,364	1,443
Residential	January 2015	2,941	3,756	815
Total		**38,148**	**40,233**	**2,085**

Demand Savings

As with energy savings, the SWE's audit of HER demand savings involved two primary steps. First, we replicated ADM's calculations, then we substituted our own regression coefficients (based on homes with at least 12 months of pre-period data) into ADM's calculations. The results, which mirrored the results for energy savings, are shown in Table 170. On aggregate, the SWE method returned an additional 0.25 MW in demand savings.

Table 170: Demand Savings Comparison

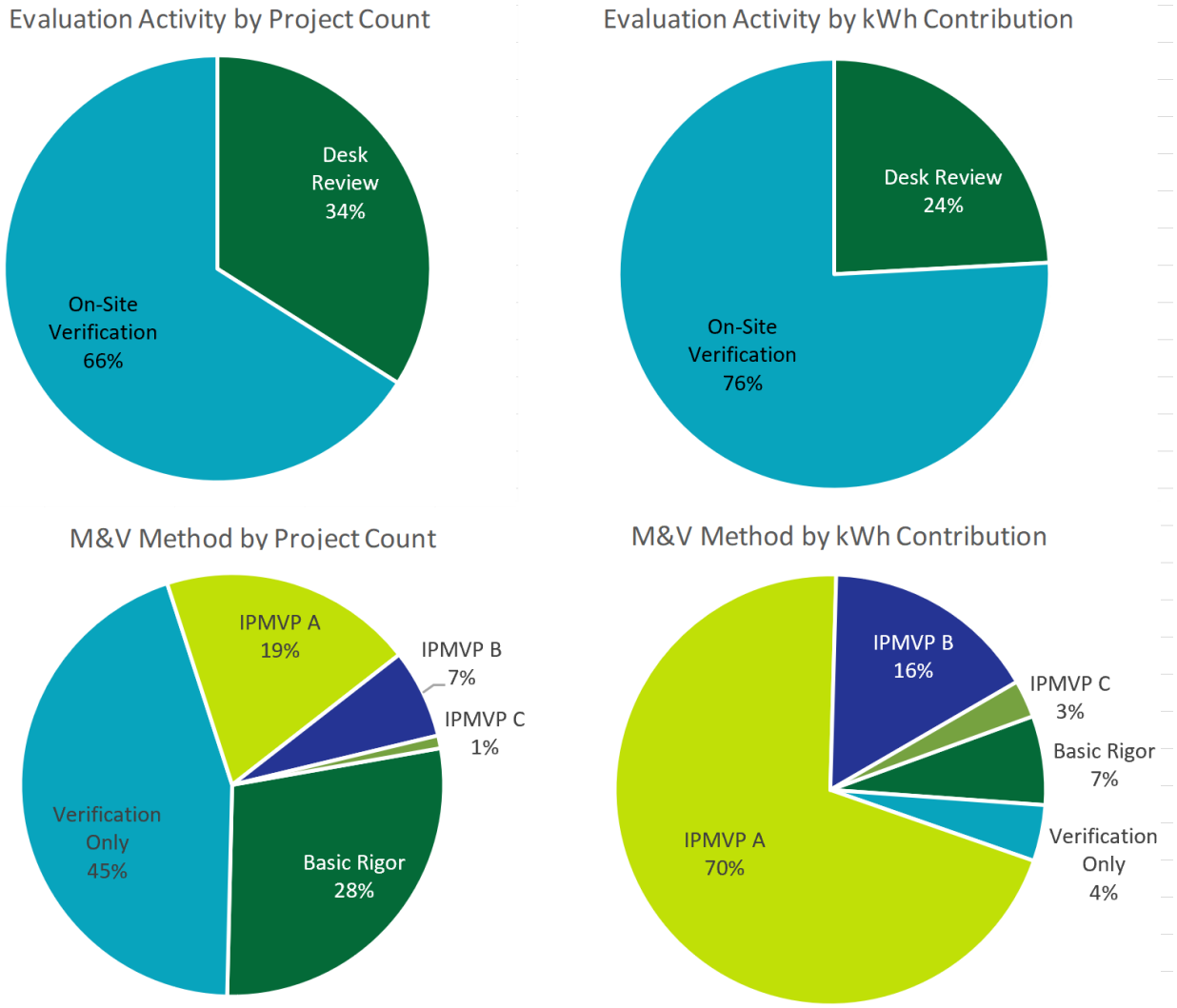
Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.38	0.38	-0.00
Residential	July 2012	2.49	2.46	-0.03
Low-income	January 2014	0.08	0.10	0.02
Residential	January 2014	1.02	1.19	0.16
Residential	January 2015	0.33	0.43	0.10
Total		**4.31**	**4.56**	**0.25**

In reviewing ADM's methodology, we noted one minor issue. This issue concerns Step 3 of their demand savings calculation, which posts that demand savings will be estimated as a function of three 8760 load shapes: heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not include the 'flat' end use. If the flat term had been included, total MW savings for Met-Ed would be 4.17 MW rather than 4.31 MW. For PY10, we would recommend either (1) updating the narrative in the annual report so that the flat end use is not included, or (2) updating the analysis to include the flat end use.

E.4.2 Non-Residential Audit Activities

Figure 75 provides a summary of the evaluation activities and M&V approaches utilized by Met-Ed's evaluation contractor in their PY9 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY9, Met-Ed's evaluation contractor completed site visits to 66% of projects, and these projects represented 76% of total evaluated energy savings. In total, 68 site visits were completed. IPMVP Option A was employed for the majority (70%) of total evaluated energy savings. Basic Rigor (desk review without a site visit) was employed for appliance recycling projects, a small selection of lighting projects, and one prescriptive project.

Figure 75: Summary of Met-Ed's C&I Evaluation Activities



Met-Ed's evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Met-Ed's C&I programs are assigned to one of five evaluation initiatives, as Met-Ed's programs target specific sectors of C&I customers but offerings are often identical across the programs. Table 171 provides a summary of the evaluation activities and M&V approaches Met-Ed's evaluation contractor used across strata for all projects by initiative.

Table 171: Summary of Met-Ed's PY9 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR	Basic Rigor	On-Site Verification Only	IPMVP A	IPMVP B	IPMVP C
Appliance Turn-In	**23**	**97%**	**23**	**0**	**0**	**0**	**0**
ApplianceRecycling-1	23	97%	23	0	0	0	0
Custom	**19**	**100%**	**0**	**11**	**0**	**7**	**1**
Custom-1	11	104%	0	11	0	0	0
Custom-2	3	84%	0	0	0	3	0
Custom-Certainty	5	100%	0	0	0	4	1
Direct Install	**3**	**95%**	**3**	**0**	**0**	**0**	**0**
Direct_Install-1	3	95%	3	0	0	0	0
Lighting	**30**	**102%**	**2**	**8**	**20**	**0**	**0**
Lighting-1	3	120%	0	2	1	0	0
Lighting-2	8	114%	0	3	5	0	0
Lighting-3	8	85%	1	3	4	0	0
Lighting-Certainty	11	102%	1	0	10	0	0
Prescriptive	**28**	**86%**	**1**	**27**	**0**	**0**	**0**
Prescriptive-1	26	95%	0	26	0	0	0
Prescriptive-2	2	77%	1	1	0	0	0
TOTAL	**103**		**29**	**46**	**20**	**7**	**1**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimations were aligned with the Evaluation Framework, followed proper custom site specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

E.4.2.1 Appliance Turn-In Initiative

The evaluation contractor conducted phone and online surveys to verify projects in this initiative. No site visits were conducted for these projects. Impacts were calculated using TRM calculations using project-specific data from the tracking system or verification surveys when available. TRM default values were used in absence of project-specific data.

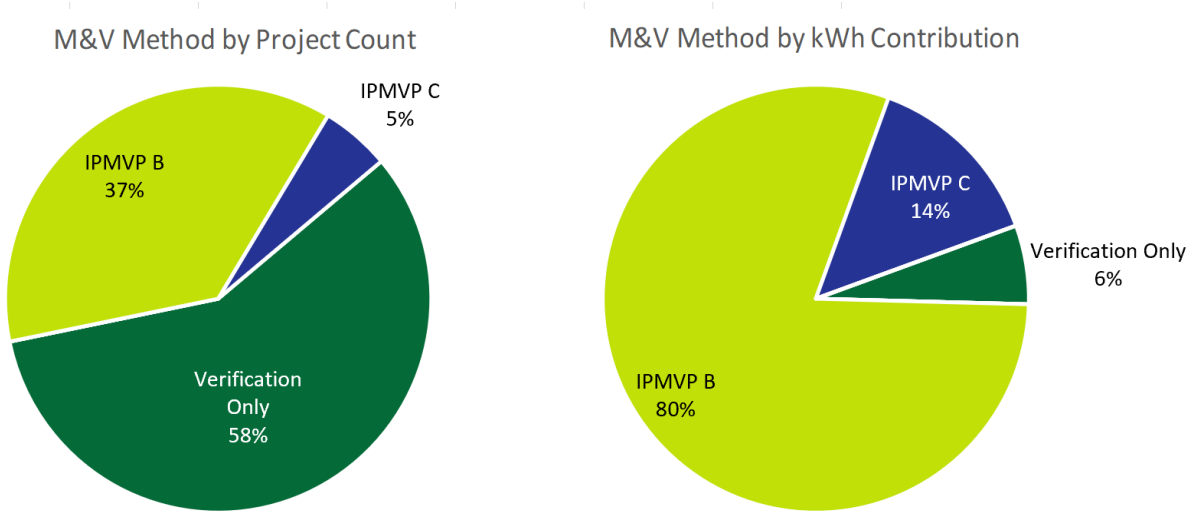
E.4.2.2 Custom Initiative

Evaluation activities for this initiative include site visits and/or IPMVP evaluation methods for all sampled projects. Site visits are always conducted unless the evaluation can be satisfactorily conducted remotely using data provided by the customer (EMS data, billing data, etc.). All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Met-Ed's evaluation contractor employed three strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 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. IPMVP Options B and C were employed to evaluate a combined 94% of the evaluated sample, as shown in Figure 76.

Figure 76: Summary of Met-Ed's C&I Custom Evaluation Activities



E.4.2.3 Direct Install Initiative

All projects in this initiative (three for Met-Ed) were included in the evaluation sample. Because all were found to be lighting upgrades, they were evaluated according to the protocol defined for the lighting initiative.

E.4.2.4 Lighting Initiative

Evaluation activities for this initiative include site visits for most projects and primary data collection of lighting hours of use for medium and high savings projects. TRM deemed hours of operation were applied for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Met-Ed's evaluation contractor employed four strata for projects in the Lighting initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

IPMVP Option A using standalone data loggers to measure lighting hours of use was employed for the large majority of projects evaluated in this initiative.

E.4.2.5 Prescriptive Initiative

Evaluation activities for this initiative include verification site visits for most projects and application of TRM-based savings calculation methodologies. All sampled projects undergo a full documentation review prior to site visits. This documentation review included identification of the appropriate TRM or IMP protocol and the defined key input parameters.

Met-Ed's evaluation contractor employed two strata for projects in the Prescriptive initiative, with the threshold set at 20 MWh of annual energy savings.

IPMVP-based methods were not employed for this initiative. All projects were evaluated using engineering algorithms following on-site verification visits in most cases.

E.4.2.6 Ride-Along Site Visits

Table 172 provides an overview of the SWE milestones for the audit of Met-Ed's site inspection efforts.

Table 172: Met-Ed Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Energy Attainment Percentage
3	909,159	2	5	100%

Overall, the SWE agreed with the methods of calculation employed by Met-Ed's evaluation contractor. 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 values were deemed inappropriate. The verified energy savings of the three projects with ride-along audits was 92% of the reported energy savings. The SWE agreed with the evaluator's corrections, which largely corresponded to differences in lighting hours of use.

E.4.2.7 Verified Savings Desk Reviews

Table 173 provides an overview of the SWE milestones for the verified savings review of evaluated Met-Ed projects via desk review.

Table 173: Met-Ed Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
5	1,149,331	145	103%	100%

Overall, the SWE found that Met-Ed's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods for custom measures. Of the five projects reviewed, the SWE recommended adjustments to energy savings for only one project. This project incorporated trend data collected from a period of less than five days, due to logger failure. The evaluation contractor's original savings calculation attempted to

extrapolate the trend data into an annual profile. Given the issues with the trend data, the SWE recommended discarding the trend data and moving to a TRM-based analysis. The resulting attainment percentage for this project was 167% for energy savings. The overall energy and demand savings attainment percentages of Met-Ed's reviewed projects were 103% and 100%, respectively.

E.5 DEMAND RESPONSE

According to the Phase III Implementation Order, Met-Ed's Phase III demand response (DR) compliance target is 49 MW. Note that compliance is determined based on the average MW performance across all DR event hours for the Phase and DR goals are assessed at the system level, meaning that line loss adjustments are applied to the load impacts measured at the customer meter. Additionally, the Implementation Order directs EDCs to obtain no less than 85% of the target in any single event. For Met-Ed, this translates to a 41.65 MW minimum performance level for any given DR event. Decisions about which day DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. Met-Ed called DR events on the three days those guidelines required.

On January 15, 2018 the Met-Ed/ADM team filed its first PY9 semi-annual report. This filing reported the PY9 verified gross impacts as calculated by ADM. The same impacts were claimed in the PY9 Final Annual Report. Table 174 shows Met-Ed's performance across the three events during the 2017 DR season. The average impact for each event exceeded 41.65 MW. After one summer, Met-Ed's P3TD average performance is slightly under the Phase III target, so PY10-PY12 performance will need to increase slightly to ensure compliance with the Phase III target.

Table 174: Met-Ed Event Performance

Date	Average Small C&I MW Impact	Average Large C&I MW Impact	Average Portfolio MW Impact	% of Phase III Target
6/13/2017	3.0 +/- 0.3	45.0 +/- 5.2	48.0 +/- 5.2	98%
7/20/2017	3.0 +/- 0.4	44.0 +/- 5.7	47.0 +/- 5.7	96%
7/21/2017	1.9 +/- 0.3	40.8 +/- 6.2	42.7 +/- 6.2	87%
Average			**45.9 +/- 3.6**	**94%**

The Met-Ed/ADM team also submitted a response to the SWE DR data request. The data elements of this request included ADM's R scripts as well as the following:

- A workbook illustrating how ADM calculated uncertainty bands (i.e., margin of error) for their X-of-Y CBLs.
- A data set that provided the top three CBLs for each participant and the relative root mean square error (RRMSE) for each CBL/participation combination.
- For each event hour, a record of which facilities participated, their reference load, metered load, and verified DR impact.

- For twelve sites selected by the SWE, the hourly load data needed to replicate the ADM impact estimates. Note that these twelve sites accounted for approximately 57% of Met-Ed's gross verified PY9 DR impacts. Also note that one of the other workbooks provided by ADM showed which days were ineligible baseline days due to PJM activity or plant shutdowns.
- Historical weather data that was used in creating weather sensitive adjustments, as well as a lookup that mapped each participant to a weather station.

The data request response and a series of follow-up emails formed the basis of the SWE audit activities – which are described in this section. The SWE found the approaches implemented by ADM to be well-aligned with the Evaluation Framework and consistent with industry best-practice. The execution of the analysis was thorough and free of errors. The SWE agrees with the PY9 gross verified savings estimates and will recommend the Commission adopt them when assessing compliance with Phase III targets.

E.5.1 Replicate Program Totals

Met-Ed's PY9 DR program had 106 participants – 69 categorized as Large C&I and 37 others categorized as Small C&I. ADM's verified gross peak demand savings generated by these sites are shown in Table 175. Note that these values are adjusted for line losses (by a multiplier of 1.072). For each DR event hour during the 2017 DR season, the SWE was provided with the metered load and CBL for each participant. Using this data, the SWE was able to replicate the PYVTD gross MW for both components of the C&I DR program.

Table 175: Met-Ed DR Savings

Program	PYVTD Gross MW	VTD Gross MW
C&I – Small	2.7	2.7
C&I – Large	43.3	43.3
Energy Efficient Homes (BDR)	N/A	N/A
Total	**45.9**	**45.9**

E.5.2 Reference Load Selection

ADM's CBL selection method was thoughtful and relied on non-event day testing. At a minimum, the following CBLs were considered for each participant:

- Linear modeling
- PJM high 4-of-5 with weather sensitive adjustment (WSA) and weekday specific options
- High 6-of-7 with WSA and weekday specific options
- 10-of-10 with WSA and weekday specific options
- 20-of-20 with WSA option

From the list above, the top three CBLs for each participant were selected. The basis for "top three" was the lowest relative root mean square error (RRMSE) on non-event, non-holiday, non-shutdown weekdays. On event days, a weighted average of these three CBL types was used in creating the actual CBL. The weights, in this case, were equivalent to the inverse squares of the RRMSEs. For a hypothetical event hour, Table 176 provides an illustration.

Table 176: CBL-of-CBLs Illustration

CBL Type	CBL	Non-Event Day RRMSE	Inverse Square of RRMSE	Weight
10-of-10	1,100	7.1%	198.37	35.7%
10-of-10 with WSA	1,200	7.2%	192.90	34.7%
20-of-20	1,300	7.8%	164.37	29.6%

Thus, the CBL-of-CBLs value would be: 1,100*0.357 + 1,200*0.347 + 1,300*0.296 = 1,193.90.

E.5.3 Weather Sensitive Adjustments (WSAs)

Several of the baseline types ADM considered involved a weather sensitive adjustment (which can be positive or negative). The WSA is a function of three terms: the temperature during the event hour, the average temperature during the same hour across days in the CBL lookback window, and the participant-specific WSA coefficient. Respectively, think of these components as X, Y, and Z. The WSA was then calculated as follows:

$$WSA = Z * (A - B)$$

Regarding the participant-specific WSA coefficient, this value was derived as follows:

- Map each participant to a weather station. Merge weather data in with load data.
- Drop any days outside of the DR season (June – September).
- Drop any holidays, event days, shutdown days, or weekends.
- Keep only event hours (hours ending 15-18).
- Calculate the average load and average temperature during the event window for each day in the data set. Drop any days where the average temperature during the event window is less than 75 degrees (F).
- Using the averages calculated in the previous step, run a simple linear regression model with load as the response variable and temperature as the explanatory variable.
- The regression coefficient for the temperature variable is the WSA coefficient.

E.5.4 Findings

For the twelve sites in our sample, the SWE was able to reproduce all inputs that feed into the savings – all WSA coefficients, all WSAs, all interim CBLs, and all CBL-of-CBLs. Table 177 provides a summary of the results.

Table 177: Met-Ed C&I DR Audit Summary

Group	Count	Gross MW Impact– ADM	Gross MW Impact– SWE	% of Total Savings
In SWE Sample	12	26.3	26.3	57.2%
Not in SWE Sample	94	19.7	---	42.8%
Total	**106**	**45.9**	**---**	**100%**

Figure 77 shows the load, CBL, and DR impacts (expressed as positive values) for one of Met-Ed's largest participants during the DR event on 7/21/2017, and Figure 78 shows the same values for another of Met-Ed's largest participants on the same date. In both cases, the load shed is obvious and the CBL-of-CBLs is very reasonable.

Figure 77: Load, CBL, and Impacts for a Large Industrial Participant

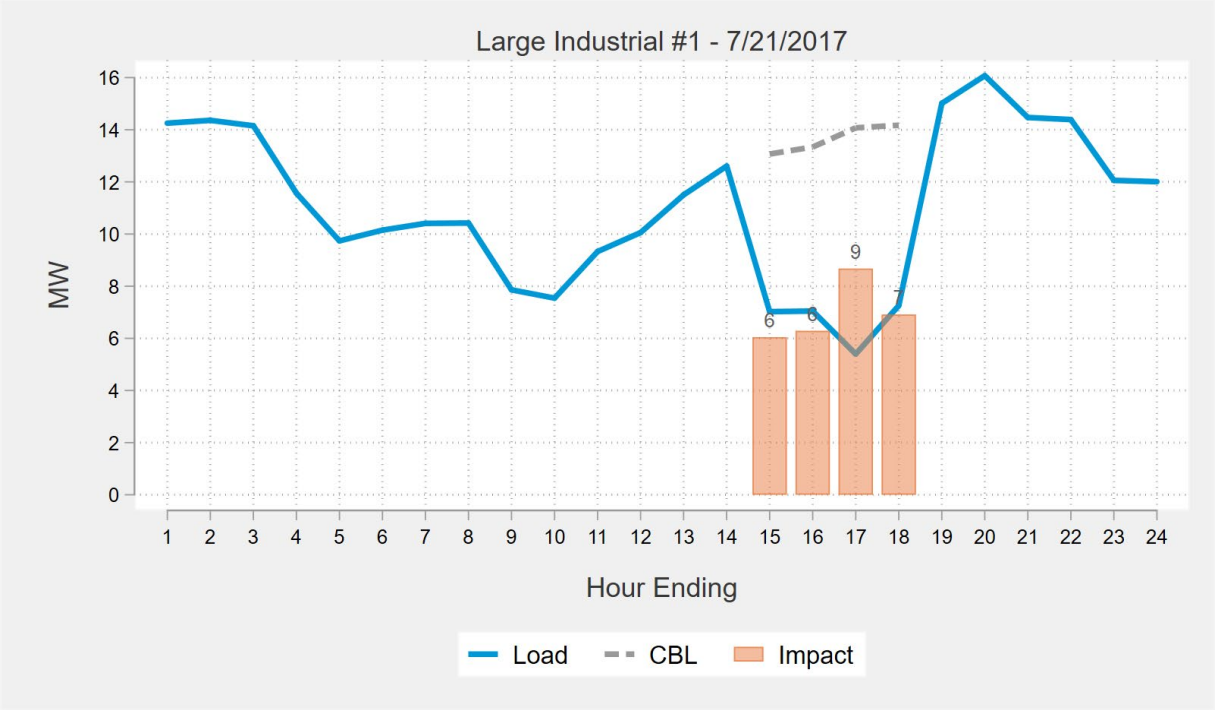
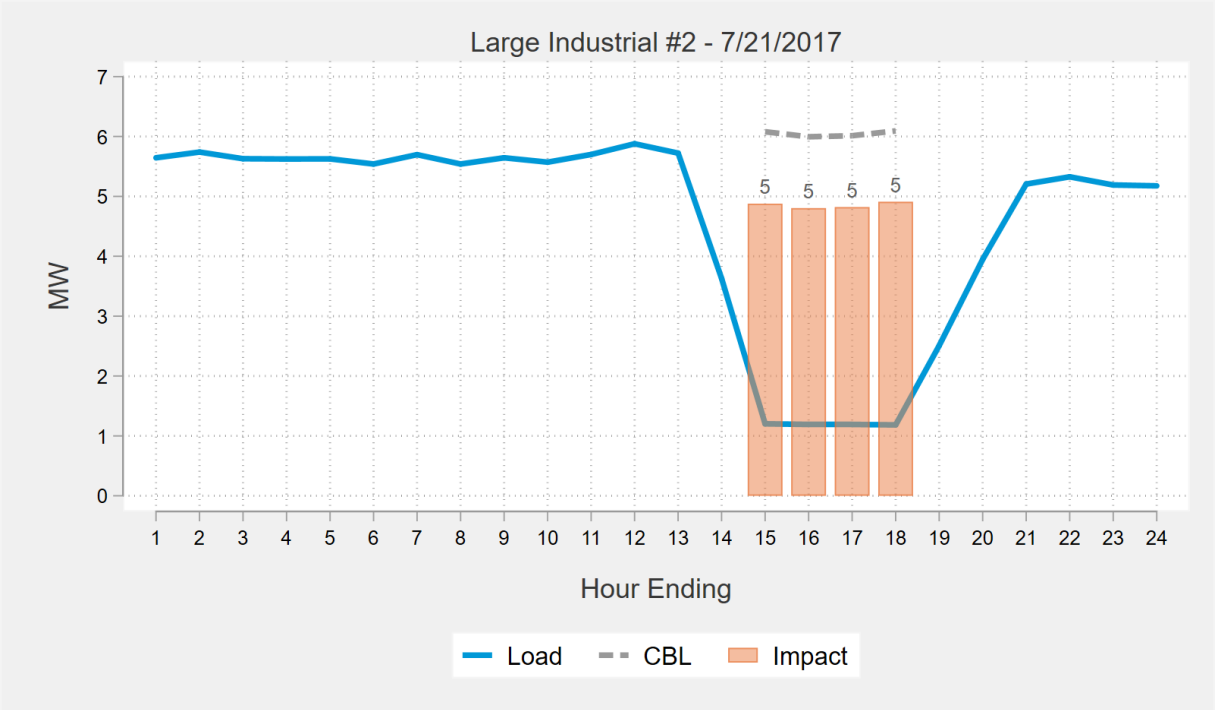


Figure 78: Load, CBL, and Impacts for Another Large Industrial Participant



E.6 NTG

E.6.1 Residential Programs

Tetra Tech estimated a PY9 NTG for the Appliance Turn-in Program and the New Homes Program. The Direct Install Program and the Energy Efficiency Kits Program NTG were drawn from the PY8 NTG evaluation.

For the Appliance Turn-In Program, Tetra Tech used primary data collection (participant surveys) to estimate NTG. NTG was estimated with the recommended UMP appliance recycling protocol. Tetra Tech measured free-ridership but not spillover due to program design and assigned the average NTG score for about 10% of the sample due to incomplete survey responses (for FE overall, specific imputation by EDC was not reported).

Tetra Tech assigned the HERs component of the program an 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.

AN NTG of 0.6 was applied to the New Homes components of the Program. Tetra-Tech conducted secondary NTG research across six similar programs offered in non-First Energy territories and applied the average of these programs NTG as the New Homes NTG.

For the Residential Energy Efficient Products Program, Tetra Tech applied the NTG from Phase II to all components of the program.

Table 178: Summary of NTG Estimates for Met-Ed Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.51	0.0	0.49	241
PY8	Upstream Lighting	--	--	0.37	--
PY8	EE Kits	--	--	0.82	--
RCT	Home Energy Reports	--	--	1	--
PY8	Direct Install	--	--	0.82	
Secondary Research	New Homes	--	--	0.60	--
PY8	Upstream Electronics	--	--	0.50	--
PY8	HVAC	--	--	0.45	--
PY8	Residential Appliances	--	--	0.52	--

E.6.2 Low-Income Residential Programs

Tetra Tech assigned LIEEP an NTG of 1, in keeping with the PY9 Evaluation Plan and SWE Phase III Evaluation Framework.

E.6.3 C&I Programs

Tetra Tech did not conduct NTG research in PY9 for Energy Solutions for Small Business Program or for the Energy Solutions for Large Business Program.

The estimated PY8 NTG was applied to the Small Business NTG for the Lighting, Custom, and Prescriptive components. The PY8 and PY9 NTG for these components differ slightly due to the differences in strata weighting between the two efforts.

Tetra Tech evaluated the Residential Appliance Program and estimated it's NTG for PY9 and applied the residential NTG to the small business component.

Tetra Tech was to evaluate the Small Business Direct Install NTG during PY9 but found that the Small Business Direct Install component was solely lighting retrofits. Tetra Tech then reasoned that the Small Business Lighting component NTG should be applied to Direct Install even though the Lighting NTG was based on the PY8 evaluation.

The Energy Solutions for Large Business Program NTG was evaluated in PY8 and these NTG values were then applied to the PY9 NTG. Values of NTG across programs for PY8 and PY9 vary slightly due to the difference in strata weighting in each effort.

Table 179: Summary of NTG Estimates for Met-Ed C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Small Energy Solutions for Business Lighting	--	--	0.63	--
PY8	Small Energy Solutions for Business Custom	--	--	0.39	--
PY8	Small Energy Solutions for Business Prescriptive	--	--	0.41	--
PY9 Residential NTG	Small Energy Solutions for Business Appliance Turn-In	--	--	0.49	--
PY8 ESB Lighting NTG	Small Energy Solutions for Business Direct Install	--	--	0.66	--
PY8	Small Energy Solutions for Business Total	--	--	0.65	--
PY8	Large Energy Solutions for Business Lighting	--	--	0.63	--
PY8	Large Energy Solutions for Business Custom	--	--	0.39	--
PY8	Large Energy Solutions for Business Prescriptive	--	--	0.41	--
PY8	Large Energy Solutions for Business Total	--	--	0.55	--

E.7 TRC

Table 180 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Met-Ed's PY9 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 PY9 annual report.

The primary differences for the PY9 TRC from the previous program year are the inclusion of fossil fuel and water saving benefits under the Total NPV Lifetime Non-Electric Benefits and two C&I demand response programs.

Table 180: Summary of Met-Ed's PY9 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	1,482	757	1.96	726	757	0.96
Energy Efficient Homes	15,060	7,272	2.07	12,423	6,816	1.82
Energy Efficient Products	13,480	8,002	1.69	5,128	3,819	1.34
Low-Income Energy Efficiency	2,582	3,568	0.72	2,582	3,568	0.72
C&I Energy Solutions for Business– Small	17,721	7,580	2.34	10,931	5,026	2.17
C&I Energy Solutions for Business– Large	14,990	8,304	1.81	8,356	4,699	1.78
Governmental & Institutional Tariff	228	163	1.40	144	127	1.13
C&I Demand Response Program – Small	226	91	2.47	226	91	2.47
C&I Demand Response Program – Large	3,675	1,192	3.08	3,675	1,192	3.08
Portfolio Total	**69,444**	**36,930**	**1.88**	**44,191**	**26,097**	**1.69**

Of Met-Ed's nine energy-efficiency programs offered, eight were found to be cost-effective and one was non-cost-effective when estimating the TRC using gross verified savings. Using net verified savings, seven programs were found to be cost-effective and two were non-cost-effective. The Appliance Turn-in program was cost-effective under gross verified savings, but non-cost-effective under net verified savings. The C&I Demand Response – Small and – Large programs were new programs in PY9 and were found to be cost effective. 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
- C&I Demand Response Program – 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
- Governmental & Institutional Tariff
- C&I Demand Response Program – Small

- C&I Demand Response Program–Large

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

- Low-Income Energy Efficiency

- C&I Demand Response Program–Large

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

- Appliance Turn-in
- Low-Income Energy Efficiency

E.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- Met-Ed's annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). First Energy applies a broader peak definition than the Act 129 peak hours defined in the 2016 TRM. The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions.
- 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 TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. The SWE verified that the savings were accounted for in accordance to the Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test. The TRC model claimed 66,547 thousand gallons of water saved or approximately $4,440,000 in avoided costs.

- 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 181 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 181: Met-Ed Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.88	1.69
Without Dual Baseline	2.05	1.78

- The SWE verified that the demand response program TRC ratio meets the 75% participant cost assumption where 75% of customer incentive payment is used as a proxy for participant cost.
- In PY8, the SWE recommended the Programmable Thermostat EUL be updated from 11 to 15 in PY9 reporting. The PY9 TRC model completed this update.

The SWE noted a minor issue pertaining to the implementation of the TRC model. The avoided cost of distribution capacity should not be applied to participants who take service at primary voltage. The SWE recommends breaking out transmission and distribution avoided costs and accounting for only generation capacity and transmission avoided costs when calculating large C&I demand response program benefits in future year reporting.

E.8 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, for PY9, the evaluation contractor conducted process evaluations for selected programs and program components. Most of the programs that did not receive a process evaluation for PY9 did get one in PY8. In addition to reporting PY9 process evaluation findings, the PY9 final report also incorporated the PY8 process evaluation results. This redundancy with the PY8 process evaluation report was unnecessary and slightly confusing. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractors submitted separate memos providing more detailed results of specific process evaluation tasks.

In response to SWE comments on the PY8 report, the PY9 report provided the percentage of satisfied or very satisfied participants for just the C&I Demand Response Program and just the

percentage “very satisfied” for the Residential Appliance Turn-in Program. While this is helpful, it would have been more useful to see the percentage of respondents selecting each point on the satisfaction scale, as was requested in the SWE’s comments on the PY8 report.

E.8.1 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

For PY9, the ADM/Tetra Tech team reported on process evaluation activities for three of these four residential programs: Residential Appliance Turn-In, Residential Energy Efficient Products, and Residential Home Performance.

The process evaluations of these programs appear to have been mostly consistent with the Phase III evaluation plan. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractors submitted separate memos providing more detailed results from individual process evaluation activities for the programs. For two of the three evaluated programs, the report or memos noted that the process evaluation also included interviews with program and implementation staff; however, they did not provide any further information on these interviews or associated findings.

E.8.1.1 Appliance Turn-In Program

Summary of Process Evaluation Findings

For PY9, the evaluation interviewed an unspecified number of program and implementer staff and surveyed 165 Met-Ed program participants, 177 Penelec, 110 Penn Power program participants, and 162 WPP program participants. The evaluation also included questions in a survey of 71 appliance retailers conducted for the Energy Efficient Products program. ADM/Tetra Tech reported the following key findings, which essentially paralleled those in the PY8 report:

1. As was the case in PY8, bill inserts continue to be the most common source of program information. Approximately 58% of respondents indicated bill inserts as a source of program information.
2. Program satisfaction remains high. About 75% of respondents reported they were “very satisfied” with program overall, with a mean score of 4.7 out of 5. This is the same mean rating as PY8. A follow-up question was asked of those reporting being dissatisfied with the program. Pick up delays, meaning the pick-up did not occur within the timeframe provided, and bad pick up experiences (e.g., damage to home, impolite staff) were the most frequently mentioned reasons for dissatisfaction.

Summary of Process Evaluation Audit

The process evaluation of the Appliance Turn-in Program appears to have been consistent with the Phase III evaluation plan. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractors submitted separate memos providing more detailed results from surveys of participants and appliance retailers. 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.

E.8.1.2 Energy Efficient Homes Program

Summary of Process Evaluation Findings

For PY9, ADM/Tetra Tech conducted process evaluations for one of five program components: New Homes.[89] For the New Homes program component, ADM/Tetra Tech completed a document review, in-depth interviews with program and implementation staff, and nine home builders and four HERS raters distributed across four First Energy EDCs. The evaluators reported the following key findings from the in-depth interviews with home builders and HERS raters:

1. Participating program builder overall mean satisfaction has increased this program year (score of 4.3, compared to 3.0 in Phase II) on a scale of 1 to 5, where 1 was "very dissatisfied" and 5 was "very satisfied". Raters also report very high satisfaction with the program overall with a mean score of 4.75 on a 1 to 5 scale, where 1 is "very dissatisfied" and 5 is "very satisfied". Raters' satisfaction with PSD, remains very high, as it has been in previous years' evaluations.
2. Builders reported key PY9 program changes improved their program participation experience. For example, nearly all builders are working with their raters in some way to submit program paperwork, thereby reducing a program barrier reported by interviewees in our Phase II evaluation. Participating raters also indicated the PY9 program changes have improved their participation experience. For example, raters report that taking ownership of the program paperwork experience (instead of the responsibility being with the builders, as it was in previous years) has provided an opportunity to show additional program value to the builders. In turn, the builders allocating a portion of their program incentive to their raters in exchange for this service has increased the rater satisfaction within this program.
3. Only one of nine builders interviewed for PY9 reported seeking ENERGY STAR® certifications in the new homes they built for the program, and nearly all noted creating their own energy-efficiency equipment packages or marketing messages for the program. All participating builders interviewed in the Phase II evaluation reported they observed the

[89] The program components for which process evaluation were not conducted in PY9 are: Energy Efficiency Kits, Home Energy Reports, Residential Direct Install, and Behavioral Demand Response. Process evaluations of Energy Efficiency Kits (EE Kits) and Home Energy Reports were conducted in PY8. The PY9 report also notes that "Tetra Tech is presently conducting a process evaluation of this program. The process evaluation results and recommendations will be included in the PY10 report."

value of the ENERGY STAR® New Home Certification was declining in the market; many reported creating their own Energy Efficiency packages at that time.

4. Builders who are aware of the PSD-offered communication tools are highly satisfied with the services. However, awareness of some program tools was low – such as the program website, the COMPASS reservation system, or the builder dashboard – and these are not utilized by most builders interviewed for this evaluation.

Summary of Process Evaluation Audit

The process evaluation of the New Homes component of the Energy Efficient Homes Program appears to have been consistent with the Phase III evaluation plan. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractors submitted a separate memo providing more detailed results from in-depth interviews with home builders and HERS raters. 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.

E.8.1.3 Energy Efficient Products Program

Summary of Process Evaluation Findings

For PY9, ADM/Tetra Tech conducted process evaluation activities for one of four program components: Appliances.[90] For the Appliances program component, the evaluation conducted a survey of participating appliance retailers. The evaluators reported the following key findings from the survey of retailers:

1. Retailer satisfaction with the program is high (63% gave the overall program a rating of very or extremely satisfied). When asked what the EDC or Honeywell could do to improve the program, they mentioned that additional hand-outs with information about energy-saving benefits could help them promote program-eligible products to customers.
2. Retailers were asked to rate their level of satisfaction with various program aspects. These included the appliances eligible for rebates, the rebate amounts, the materials they have received, and support from the EDC or Honeywell. The lowest satisfaction ratings given were for the support received from the EDC or from Honeywell (33% said they were somewhat satisfied9 and 4% said they were not at all satisfied). The reasons provided were because they felt there was not enough personal interaction; stating either there has been no contact, or the materials were dropped off but there were no discussions.
3. Based on their interaction with customers, retailers report that energy-efficiency or ENERGY STAR® rating is the main factor when purchasing an appliance only 20% of the time (23% and 21%, respectively). Price was the biggest factor in customers' decision-making (65%), followed by size (35%), and aesthetics (25%).

[90] For PY8, the evaluation included process evaluations of the Appliances, HVAC, and Upstream Lighting program components. The PY9 report notes that "Process and Net Impact evaluation is planned for the fourth program element – Upstream Electronics, in PY10.:

4. Retailer awareness of the additional rebates available for income qualified customers is low (10%).

Summary of Process Evaluation Audit

The process evaluation of the Energy Efficient Products Program appears to have been generally consistent with the Phase III evaluation plan. However, the plan also calls for interviews with non-participating trade allies. It is not clear if or when this will be done. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractors submitted a separate memo providing more detailed results from the survey of appliance retailers.

PY9 process evaluation activities were not conducted for Upstream Lighting, Upstream Electronics, and HVAC program components. Note that it is possible that surveyed appliance retailers also sold program-qualified HVAC units. However, the memo describing the survey results provided no indication that they did. Additionally, in a discussion of the evaluation of the Upstream Lighting program component, the previous report for PY8 observed that the "evaluation planned additional activities to inform the process evaluation, including a survey of participating retailers and a shelf-stocking study. These activities are ongoing, and the results will be included in the PY9 annual report." There was no mention at all of these activities in the PY9 report.

E.8.1.4 Low-Income Program

The ADM/Tetra Tech report states that they conducted a process evaluation in PY8, indicating that there was no process evaluation for PY9.

E.8.2 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 PY9, The ADM/Tetra Tech team reported on process evaluations for two C&I programs: Demand Response-Small and Demand Response-Large.

E.8.2.1 Energy Solutions for Business – Small, Energy Solutions for Business – Large, Government and Institutional

A process evaluation was not conducted for PY9. In PY8, ADM/Tetra Tech conducted combined process evaluations for the Large C&I, Small C&I, and Government and Institutional programs.

E.8.2.2 C&I Demand Response Program – Small, C&I Demand Response Program – Large

Summary of Process Evaluation Findings

ADM/Tetra Tech conducted a combined process evaluation for the Large and Small C&I Demand Response programs given the similarities in program delivery. The process evaluation included a

program documentation and tracking data review, in-depth interviews with program and implementation staff, participation in an implementer marketing and outreach webinar, and a survey of 25 participating customers. The evaluators reported the following key process evaluation findings from the survey of customers:

1. Event performance for each EDC and ICSP in 2017 relied heavily on a few major customers causing unpredictable performance relative to expectations. For Met-Ed, one major customer subscribed to the program with 6 MW but did not participate in any events citing production needs were a priority over demand response. West Penn Power had a major customer who contributed negatively to event results. Conversely, two large Penn Power customers were responsible for the EDC exceeding its program goals throughout 2017; if these two customers do not regularly participate in events or reduce energy demands only modestly, then the EDC is likely to fall short of its targets. The ICSPs reported during our interviews that they have heard feedback from customers that production requirements have been a larger priority and are one of the challenges for the programs to meet targets. This should be a topic of further exploration among participants in the PY10 evaluation.
2. Despite some performance uncertainty on the program side, customers did not report change in perception of the Companies through the participant survey. Customers maintained a high opinion of the Companies after their participation in the program, and a few indicated their views had improved. No customers reported negative opinions of the Companies as a result of the program.
3. The most common source of program confusion for respondents centered around their incentive agreement with the ICSPs. While customers generally reported they knew incentives were available for program participation, four of 25 customers rated their incentive agreement “somewhat difficult” to understand.
4. Some customers recall participating in more Act 129 C&I DR events than were initiated. Nine of 25 customers recalled more than three events occurring over the course of the summer when just three Act 129 events occurred. There could be several reasons for the mistaken recall – including PJM DR program events or test events being confused for Act 129 events. However, this misperception could decrease a customer’s willingness to participate in future events.
5. Some customers recall participating in more Act 129 C&I DR events than were initiated. Nine of 25 customers recalled more than three events occurring over the course of the summer when just three Act 129 events occurred. There could be several reasons for the mistaken recall – including PJM DR program events or test events being confused for Act 129 events. However, this misperception could decrease a customer’s willingness to participate in future events.

Summary of Process Evaluation Audit

The process evaluation of the Large and Small C&I Demand Response programs appears to have gone above and beyond the research design in the Phase III evaluation plan. The plan called for a survey of participants and the evaluation did that. The evaluation additionally did a

documentation and tracking data review, IDIs with program and CSP staff, and participated in one of the CSP's marketing outreach webinars. Although the process evaluation sections in the PY9 final annual report include limited information, the evaluation contractor submitted a separate memo providing more detailed results from the survey of participants. The report and memo provided sample information for the participant survey but did not identify the number of staff or contractors interviewed. The report also did not provide any detail on the other research activities conducted.

Appendix F Penelec Audit Detail

F.1 EM&V Plan Reviews

FirstEnergy's evaluation contractor, ADM Associates, prepared a single, comprehensive evaluation plan for the four FirstEnergy EDCs that addressed evaluation activities for all of Phase III. In PY9 the ADM team submitted a sampling memo for the C&I DR program, which the SWE reviewed and approved with minor comments and suggestions.

In addition to reviewing FirstEnergy's sampling memo, the SWE reviewed two survey instruments, one for appliance retailers and one for the C&I DR program participants.

F.2 Sample Design Review

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

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 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 due program delivery channel or supported technology.

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than tariff-based program definitions, each of which would include the same mix of measures. This evaluation strategy also makes sample design more efficient because the same projects are more likely to share similar characteristics across rates classes (i.e., Small C&I, Large C&I, and Government) than a heterogeneous mixture of measures within a single class. For example, projects from Penelec's 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

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. Table 182 lists each initiative and the corresponding relative precision of the PY9 gross verified savings estimate for all initiatives that include sampling uncertainty.

Table 182: Relative Precision of Penelec PY9 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level (±)
Residential Appliance Turn-In (ATI)	5.9%
Low-Income ATI	9.8%
C&I ATI	11.0%
Res EE Kits	4.5%
Low-Income EE Kits	12.2%
Res Direct Install	13.7%
Low-Income Direct Install	10.6%
C&I Direct Install	N/A
Res Upstream Lighting	10.0%
Res Upstream Electronics	0.0%
Res HVAC	16.4%
Residential Appliances	14.1%
Low-Income Appliances	30.1%
Residential New Construction	12.0%
C&I Lighting	8.3%
C&I Custom	9.3%
C&I Prescriptive	6.0%

With the exception of the Residential HVAC and Low-Income Appliances Initiative, each of the sampling initiatives shown in Table 182 produced verified gross savings estimates that met the requirement of ±15% precision at the 85% confidence level. ADM did not provide an explanation for the failure of the Residential HVAC initiative. They did note that the relative precision for the LI Appliances Initiative was high due to realization rates far above 100% for clothes washers and heat pump water heaters. They attribute the large realization rates to conservative ex-ante values for those appliances. The C&I Direct Install program for Penelec did not receive a full evaluation in PY9 because only one project was approved. This project was selected for evaluation and was found to be a lighting upgrade. This project was evaluated according to the lighting evaluation protocol.

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 PY9 verification activities is discussed in detail in Appendix F.4.

The Behavioral Modification subprogram provides home energy reports to residential customers in the Penelec service territory. The subprogram is divided between standard residential customers and Low-Income customers and each is administered as a randomized control trial (RCT). Participants are enrolled in experimental cohorts and a monthly billing analysis regression is the used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model is not able to fully capture the variation present in the data. Precision requirements for behavioral program are unique, with The Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). Table 183 shows the absolute precisions of the behavioral program components.

Table 183: Absolute Precisions of Penelec PY9 Behavioral Subprogram Gross Verified Energy Savings Estimates

Stratum	Absolute Precision at 95% Confidence Level (±)
Residential	0.13%
Low-Income	0.39%

F.3 Reported Gross Savings Audits

F.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penelec's PY9 Annual Report. Specifically, the values we examined are as follows:

- Reported gross energy savings (MWh) for each program;
- Reported gross peak demand savings (MW) for each program;
- Participation for each program; and
- Incentive dollars for each program.

The SWE leveraged Penelec'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 PY9 quarterly data request. Also note that home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding the HER components of Penelec's Energy Efficient Homes and Low-Income Energy Efficiency programs can be found in Appendix F.4.1.3.

Table 184 summarizes the SWE's ex-ante findings regarding reported gross energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Penelec's PY9 Annual Report and 'No' otherwise. For each program, the SWE was able to replicate the values reported by Penelec.

Table 184: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	4,565	4,565	Yes
Energy Efficient Homes	18,708	18,708	Yes*
Energy Efficient Products	27,048	27,048	Yes
Low-Income Energy Efficiency	7,336	7,335	Yes*
C&I Energy Solutions for Business – Small	28,898	28,898	Yes
C&I Energy Solutions for Business – Large	45,092	45,092	Yes
Governmental & Institutional Tariff	1,152	1,152	Yes
Portfolio Total	**132,799**	**132,798**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 187 summarizes the SWE's findings regarding peak demand savings by program. The SWE's records matched Penelec's reported peak demand savings for each program.

Table 185: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.61	0.61	Yes
Energy Efficient Homes	1.89	1.89	Yes*
Energy Efficient Products	3.07	3.07	Yes
Low-Income Energy Efficiency	0.76	0.76	Yes*
C&I Energy Solutions for Business – Small	4.11	4.11	Yes
C&I Energy Solutions for Business – Large	5.78	5.78	Yes
Governmental & Institutional Tariff	0.02	0.02	Yes
Portfolio Total	**16.24**	**16.24**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 186 summarizes the SWE's findings regarding program participation. For three programs, the SWE calculated exact matches. For two other programs, the SWE calculated participant counts that differed from Penelec's counts by fewer than three.

For the two remaining programs, the SWE calculated directionally similar participant counts. Note that these two programs both have HER components – the counts for those components are not included. The values shown in the "Annual Report Participants" for those two programs represent

the difference between the value for the full programs (inclusive of the HER components) and the maximum number of treatment group homes active in the HER program during PY9. The difference between the SWE and FirstEnergy participant counts for the Low-Income Energy Efficiency program is likely a function of the counting logic for accounts that participate more than once within a given program year.

Table 186: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	4,155	4,155	Yes
Energy Efficient Homes	52,460	54,708	*No
Energy Efficient Products	307,249	307,249	Yes
Low-Income Energy Efficiency	13,683	14,583	*No
C&I Energy Solutions for Business – Small	741	743	No
C&I Energy Solutions for Business – Large	176	177	No
Governmental & Institutional Tariff	307	307	Yes
Portfolio Total	**378,771**	**381,922**	**No**

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Finally, Table 187 summarizes the SWE's ex-ante findings regarding incentive dollars. The SWE was able to exactly replicate incentive dollars for two programs – Appliance Turn-in and Governmental & Institutional Tariff. For four of the remaining five programs, the SWE calculated directionally similar incentive dollars via the tracking data. For the six programs noted in this paragraph, the portfolio totals are very similar – $5,631,000 in the Annual Report and $5,662,000 in the tracking data.

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 difference between incentives in the quarterly tracking data and incentives in the Annual Report for these two programs is largely attributable to EE kits. The discrepancy between data sources ($2,489,000) is similar to the incentive amount that Penelec had earmarked for kits in their PY9 EE&C plan ($2,652,000).

Table 187: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	$234	$234	Yes
Energy Efficient Homes	$2,601	$81	No
Energy Efficient Products	$1,499	$1,602	No
Low-Income Energy Efficiency	$86	$82	No
C&I Energy Solutions for Business – Small	$1,557	$1,472	No
C&I Energy Solutions for Business – Large	$2,198	$2,215	No
Governmental & Institutional Tariff	$57	$57	Yes
Portfolio Total	**$8,232**	**$5,743**	**No**

F.3.2 Project File Reviews

F.3.2.1 Residential

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of Penelec's residential project files for PY9 using the project file documentation provided by Penelec, the program implementors, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included a majority of the documentation requested. Initially, project file documentation was not provided for the Low-Income WARM program for quarters 3 and 4 but was later provided by ADM upon request.

Table 188 presents a summary of SWE's residential project file reviews. In addition to verifying that documentation was present and corresponded accurately with the quarterly tracking data, the SWE conducted a review of the sampled project files to verify that correct values and algorithms from the Pennsylvania TRM were applied to the reported savings. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place and was able to clarify that all issues arising from this review were addressed during verified savings calculations.

Table 188: Penelec PY9 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?[1]
Appliance Turn-in Program	Appliance Turn-in Program	28	✓	✓	✓	✓
Energy Efficient Homes Program	School Education	3	✓	✓	✓	✓
Energy Efficient Homes Program	EE Kits	3	✓	✓	✓	✓
Energy Efficient Homes Program	Audits	3	✓	✓	✓	✓
Energy Efficient Homes Program	New Homes	24	✓	✓	✓	✓
Energy Efficient Products Program	Appliances and Electronics	28	✓	✓	✓	✓
Energy Efficient Products Program	Lighting	24	✓	✓	✓	✓
Energy Efficient Products Program	HVAC	24	✓	✓	✓	✓
Low-Income Energy Efficiency Program	Weatherization	12	✓	✓	✓	✓

*The number of files reviewed reflects the total number for all First Energy EDCs.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews, including issues or discrepancies found between the project file packages and quarterly tracking data.

HVAC

The HVAC project files typically matched the quarterly tracking data; however, the SWE found one discrepancy in the heating and cooling capacity between the sampled project files and tracking data.

- For heat pump projects, the TRM requires separate inputs for heating and cooling capacity to calculate savings. In the tracking data, capacity was displayed as a singular 'tons' variable.[91]

The evaluator, ADM, worked with the SWE to clarify this discrepancy. Their approach is to use single point estimates for these values for the reported ex-ante savings, and to then pull the heating and cooling capacities directly from the AHRI database and other independent sources during the verified savings calculations.

Upstream Lighting

The Upstream Lighting files matched the tracking data; however, a discrepancy between the tracking data and the TRM equation was observed.

- In the TRM, the base wattage variable for specialty bulbs is dependent on bulb shape and lumen range; however, the tracking data did not break out bulb shape enough to make this determination.[92]

ADM again worked with the SWE to clarify this issue. This is corrected during the verified savings calculations, which are entirely independent from these ex-ante calculations. The model numbers are used to pull in all bulb information, including specific shape, from a compiled database, primarily using ENERGY STAR data.

Appliances

The Appliance files typically matched the tracking data, but the SWE had a question about the reported savings.

- Reported ex-ante savings were based on TRM defaults values despite the EDC collected data for those values being available.

ADM confirmed that defaults are used at the ex-ante level, but the model specific TRM values are used in verified savings calculations.

Low-Income WARM

Project files for the Low-Income WARM program typically matched the tracking data for Q1 and Q2. However, the SWE noticed that project files were not provided initially for Q3 and Q4.

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[91] For example, for a mini split project, the heating capacity might be 12k BTU, and the cooling capacity 9k BTU, but this would appear in a single 'tons' variable as 12k BTU in the tracking data. As noted, ADM reported that this is corrected in the verified savings calculations.

[92] For example, a specialty bulb at 500 lumens could have a base wattage of 40, 45, 60, or 65 depending on the shape, but there is no way to tell which value should be used without more specific shape categories being used. ADM confirmed that this is addressed in the verified savings calculations.

ADM was notified of this and quickly provided a sample of project files for these quarters, and no discrepancies were found.

F.3.2.2 Non-Residential

The SWE reviewed Penelec's C&I projects for PY9 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, equipment invoices, and equipment specification sheets. Most of the project file packages included all documentation requested. For lighting projects, Penelec's ICSP uses their own lighting calculator. In PY9, the inputs to the ICSP's lighting calculators were also transcribed into the Appendix C lighting calculator.

Project files were generally well organized, complete, and accurate. Table 189 presents an overview of the results of the SWE's C&I project file reviews.

Table 189: Penelec PY9 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?
FESPPS1534469336	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534469390	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534484342	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1535238026	Lighting	✓	✓	✓	✓	-	✓
FESPPS1535822176	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534806573	HVAC Equipment	✓	✓	✓	✓	-	✓
FESPPS1537455080	Lighting Controls	✓	✓	✓	✓	-	✓
FESPPS1537130515	HVAC Equipment	✓	✓	✓	✓	-	✗
FESPPS1537959304	Lighting	✓	✓	✓	✓	✓	✓
FESPPS1537865755	MZ Ductless Mini Splits	✓	✓	✓	✓	✓	✓
FESPPS1537827300	Street Lighting	✗	✓	✓	✓	✓	-

Specific issues noted during the project file review process are addressed individually by project below.

The two reviewed street lighting projects, FESPPS1534484342 and FESPPS1537827300, did not include an Appendix C lighting calculator. However, the ICSP's calculator appeared to be following TRM methodology for the project.

The energy savings for Project FESPPS1537130515, a heat recovery project, were generated using an energy model. The model is not included or documented, so the savings methodology cannot be audited. Energy modeling efforts should be thoroughly described to preserve transparency in savings calculations.

The process by which the ICSP's calculators are transcribed into the Appendix C calculator preserves much of the Appendix C functionality but does overwrite some functions. Baseline fixture wattage lookups are preserved. Hours of operation, coincidence factors, and interactive factors are directly transcribed from the ICSP's calculator in a manner that overwrites the formulas built-in to the Appendix C calculator. For future years, the ICSP and the evaluator could consider improving the transcription process so that these parameters are calculated directly by the Appendix C calculator as intended.

Additionally, calculators submitted for prescriptive measures are locked. Worksheet and cell permissions could be modified to allow the SWE to view inputs and algorithms in the calculator. This would facilitate more thorough project reviews and evaluations in the future.

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 Penelec portfolio of residential programs. Penelec'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 evaluation details differ or where the SWE audits determined that certain subprograms showed discrepancies not shared by others in a program). Note that the SWE reports residential savings in 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 190 provides a summary of the evaluation and M&V approaches used by Penelec in their PY9 verified savings calculations. Note that the SWE adjusted verified savings in the PY9 Annual Report due to overestimated savings for the Upstream Lighting program but that

the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting beginning in PY10.[93]

Table 190: Residential Program Evaluation Activities – Penelec

Program/ Subprogram	Surveys	Site Visits	Desk Review[a]	Billing Analysis	Applied PY8 RR
Appliance Turn-In					
Appliance Turn-in (LI & Non-LI)	✓	--	✓	--	--
EE Homes					
EE Kits	✓	--	✓	--	--
EE Kits- Low-Income	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	✓	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting					
Upstream Lighting	✓	--	✓	--	--
EE Products					
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Appliances- Low-Income	✓	--	✓	--	--
Low-Income WARM					
Low-Income WARM- Extra Measures	--	✓	✓	✓	--
Low-Income WARM- Multifamily	--	✓	✓	✓	--
Low-Income WARM- Plus	--	✓	✓	✓	--

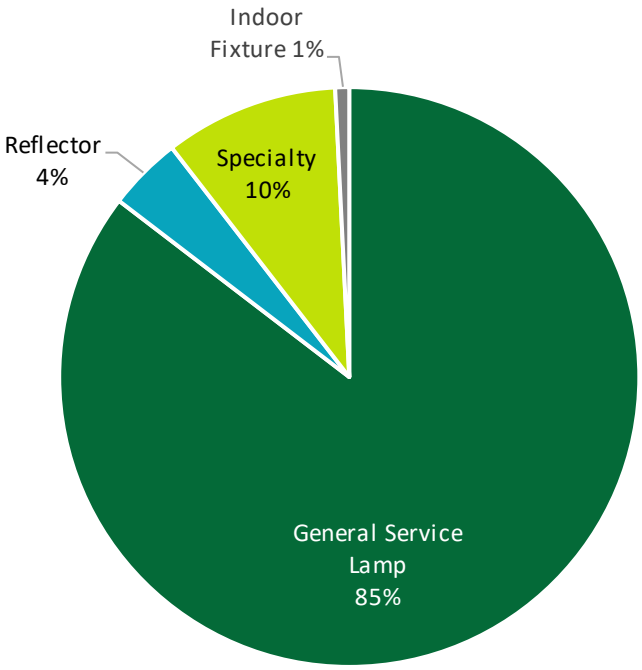
[a] The Desk Review column includes: database reviews, application reviews, and/or engineering desk reviews.

[93] 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.

F.4.1.1 Upstream Lighting & Cross-Sector Sales

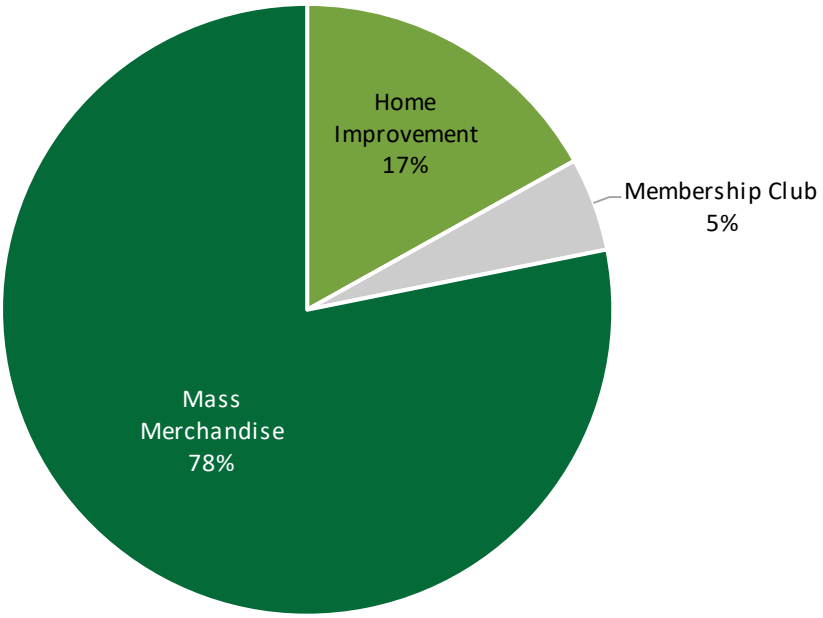
Customers purchased over 820 thousand efficient light bulbs and fixtures through Penelec's upstream lighting program. Figure 79 displays the distribution of sales by product type. Most (85%) of the products were general service lamps.

Figure 79: Penelec PY9 Upstream Lighting Sales by Product Type



Over three-quarters (78%) of Penelec's PY9 upstream light bulbs and fixtures were sold through mass merchandise stores (Figure 80).

Figure 80: Penelec PY9 Upstream Lighting Sales by Retail Channel



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 generally agrees with ADM's verified gross savings for the Upstream Lighting Initiative but has adjusted verified savings for the errors detailed below.

The SWE observed 474 unique lighting model numbers in the PY9 tracking system and was able to locate 469 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The five models the SWE was not able to verify as ENERGY STAR certified represent 0.1% 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 URLs ADM provided 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 PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes. 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 one model, resulting in verified savings being overestimated by 67 MWh. The impact of all discrepancies the SWE identified on portfolio-level savings is minor, less than 0.1%.

Cross-Sector Sales

ADM did not conduct cross-sector sales research in PY9. ADM applied the PY8 cross-sector sales estimate of 8.3% to PY9 sales.

Recommendations

The SWE does not have any recommendations based on its review of the PY9 upstream lighting analysis. However, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- 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 minor issues that caused a negligible difference in savings, detailed below.

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 F.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 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 dishwashers, resulting in a negligible increase in savings.[94] The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

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 F.4.1.1 of this appendix.

Analysis files and data sets included in the gross impact data were reviewed for all HVAC, appliance, and consumer electronics measures included in the program. The SWE found that in all cases the correct TRM vales and algorithms were used, the verified savings were correct, and

[94] ADM used a default energy savings of 29.4 kWh per year for non-electric (gas) water heating but the 2016 TRM default is 26.4 kWh (Table 2-90 of the 2016 TRM).

the savings and sample sizes included in the annual request data matched those reported in the PY9 annual report.

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.

Appliance Turn-In Program (Low-Income and Non-Low-Income)

The SWE performed audits on all measures included in the Appliance Turn-In Program, including dehumidifiers, refrigerators and freezers, and room air conditioners. Overall, the SWE concluded that the proper TRM algorithms and protocols were used, and that verified savings were correct. Sample sizes in the annual request data did not match the achieved sample sizes included in the annual report.

F.4.1.3 Behavior

Approximately 14% of Penelec's verified gross energy savings for PY9 came from Home Energy Reports issued to around 157,000 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 PY9. By cohort, Table 191 shows average kWh savings and average percent savings per participant in PY9. Note that the 'Number of Participants' column shows the average number of participants during PY9.

Table 191: Average PY9 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY9 kWh Savings	Average PY9 % Savings
Low-income	July 2012	6,494	236	1.84%
Residential	July 2012	48,387	211	1.71%
Low-income	January 2014	1,650	218	1.68%
Residential	January 2014	63,687	111	1.25%
Low-income	December 2014	8,948	54	0.73%
Residential	December 2014	27,714	75	1.10%

The following sections highlight some of the more important audit steps and findings: the calendarization of billing data, group equivalence, duplicating participant counts, the calculation of lag terms, missing eligibility filters, and energy and demand savings.

Calendarization

The first step the SWE took was to review ADM's calendarized data. "Calendarization" is a process that prorates billing data into a common calendar month basis shared by all accounts. Our review of the calendarized data had three primary components:

- Check the coding of the "pre" and "post" indicator variables;
- Confirm that the calendarized average daily usage values are correct; and
- Confirm that the lag terms (average usage in the pre-period, average summer usage in the pre-period, average winter usage in the pre-period) are correct.

Our team found no issues in the coding of the pre and post indicator variables. Table 192 shows summary statistics calculated for ADM's calendarized data and the SWE's calendarized data.[95] The distribution of average daily kWh is basically identical in the two data sets.

Table 192: Comparison of Calendarized Data

Variable	Mean	5th Percentile	25th Percentile	75th Percentile	95th Percentile
Average Daily kWh – ADM	29.13	10.27	17.24	35.81	62.52
Average Daily kWh – SWE	29.13	10.27	17.24	35.81	62.53

Regarding the lag terms, the SWE found that ADM's calculations were sound. ADM did not calculate summer or winter lag terms in cases where pre-period summer or winter data did not exist. Because we found no issues with ADM's calendarized data, the figures, tables, and summary statistics presented herein were created or calculated using ADM's calendarized data rather than our own.

Group Equivalence

After reviewing the calendarization, the SWE compared average daily consumption (kWh) between the treatment and control groups during the pre-treatment period. Table 193 shows the results for each cohort. Note that calendarized data was used to calculate the averages and any customer without at least 12 month of pre-treatment data was dropped. To avoid comparing averages calculated over different time spans (e.g., 14 months and 12 months), averages within each month were calculated before calculating overall averages for each customer. The 'P-value' column indicates the likelihood that the observed differences could happen by chance if the two experimental cells use the same amount of energy, on average. A p-value less than 0.05 indicates that the difference in average consumption between the two groups is statistically significant.

[95] The table only summarizes records that were in both the ADM and SWE data sets. A small percentage of account/month combinations from the ADM data set were not in the SWE data set, but the majority of these were June 2018 records (PY10) that the SWE dropped.

One cohort was found to have statistically significant pre-treatment differences between the treatment and control groups – the Low-income July 2012 cohort. That said, the SWE believes that the model being used to estimate savings (lagged seasonal) accounts for this difference.

Table 193: Group Equivalence in the Pre-Period

Sector	Cohort Start Date	Average Daily kWh – Control	Average Daily kWh – Treated	P-value
Low-income	July 2012	37.2	37.8	0.02
Residential	July 2012	37.1	36.9	0.09
Low-income	January 2014	40.2	40.3	0.86
Residential	January 2014	25.6	25.6	0.95
Low-income	December 2014	20.4	20.7	0.09
Residential	December 2014	19.0	18.7	0.18

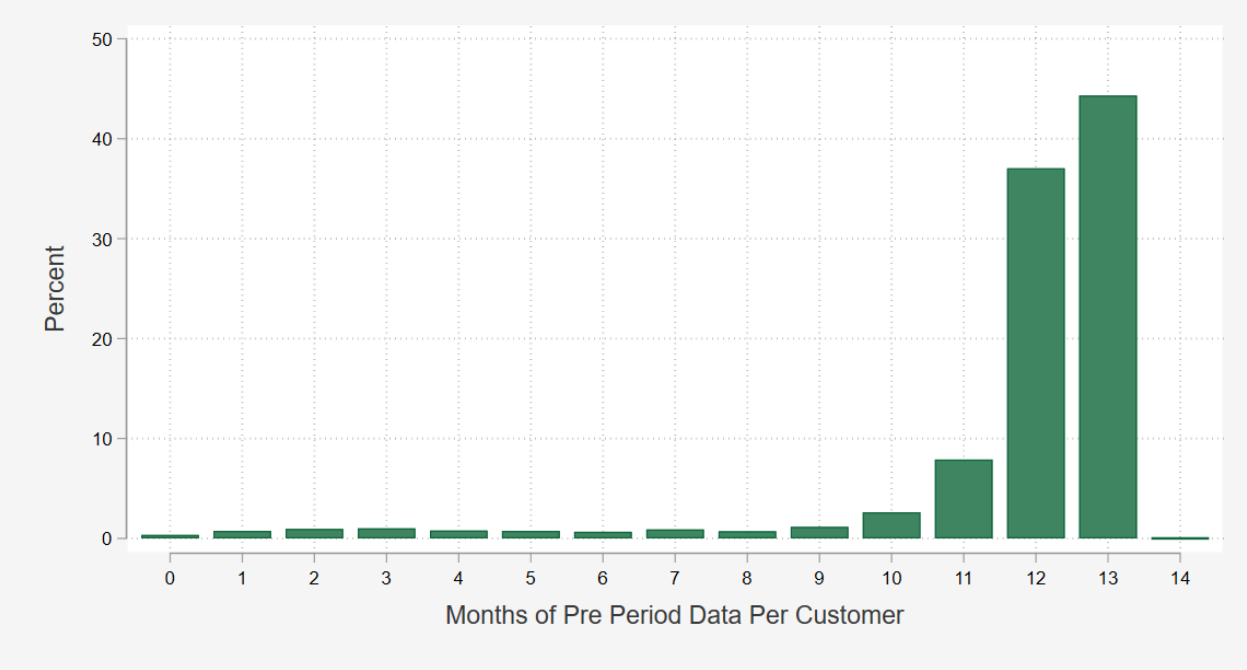
Participation Counts

The SWE leveraged the raw, un-calendarized billing data to audit participant counts. Because billing cycles can exceed 31 days in length (meaning bill dates can occasionally skip over a month), the SWE calculated the number of unique IDs beyond a certain bill date. As an illustrative example, suppose we wanted to compute the number of participants in Penelec's 2012 LI cohort for March of 2018. We removed any records with a billing end date prior to 3/1/2018, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that matched the reported counts.

Eligibility Filters

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 81 shows the distribution of the number of months of pre-period data per customer. Across all Penelec cohorts, 18.6% of homes had less than 12 months of pre-period data.

Figure 81: 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 12 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 (used in the lagged seasonal model specification) be calculated? For a given customer, suppose there is only one month of pre-period summer usage. Should the lagged summer variable (average daily consumption during summer months in the pre-period) be based on that lone summer month? Or should it be treated as a missing value?

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. For PY10, the SWE recommends Penelec investigate homes with less than 12 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 12 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: 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.)

Impact Coefficient and Energy Savings

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we ran the LS model without filtering out homes with less than 12 months of pre-period data. Next, the SWE dropped any participant without at least 12 months of pre-period data and re-ran the LS model for each cohort. On average, the second method produced larger impacts (in magnitude). Impact 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 194 shows impact estimates for each cohort. Note that a different impact estimate was calculated for each month in PY9 – the estimates shown in the table reflect the averages of the PY9 monthly estimates (weighted by month duration). Using the first impact estimate as an example, the practical interpretation is as follows: treatment group homes in the low-income July 2012 cohort saved 0.33 kWh per day, on average, during PY9.

Table 194: Impact Coefficients

Sector	Cohort Start Date	Impact Estimate (kWh saved per home per day)	Impact Estimate – At least 12 Months of Pre
Low-income	July 2012	-0.33	-0.36
Residential	July 2012	-0.64	-0.63
Low-income	January 2014	-0.63	-0.36
Residential	January 2014	-0.31	-0.35
Low-income	December 2014	-0.15	-0.21
Residential	December 2014	-0.21	-0.20

Table 195 shows ADM's and the SWE's aggregate energy savings (MWh) for each cohort. On aggregate, the SWE estimate was approximately 533 MWh greater than the ADM estimate. This increase was largely buoyed by the residential January 2014 cohort, which saw an increase of 783 MWh. As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework did not mandate that only accounts with at least 12 months of pre-period data could be used in a billing analysis.

Table 195: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	1,531	1,511	-19
Residential	July 2012	10,214	10,085	-130
Low-income	January 2014	359	202	-157
Residential	January 2014	7,043	7,826	783
Low-income	December 2014	480	668	187
Residential	December 2014	2,089	1,957	-132

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Total		**21,716**	**22,249**	**533**

Demand Savings

As with energy savings, the SWE's audit of HER demand savings involved two primary steps. First, we replicated ADM's calculations, then we substituted our own regression coefficients (based on homes with at least 12 months of pre-period data) into ADM's calculations. The results, which mirrored the results for energy savings, are shown in Table 196. On aggregate, the SWE method returned an additional 0.06 MW in demand savings.

Table 196: Demand Savings Comparison

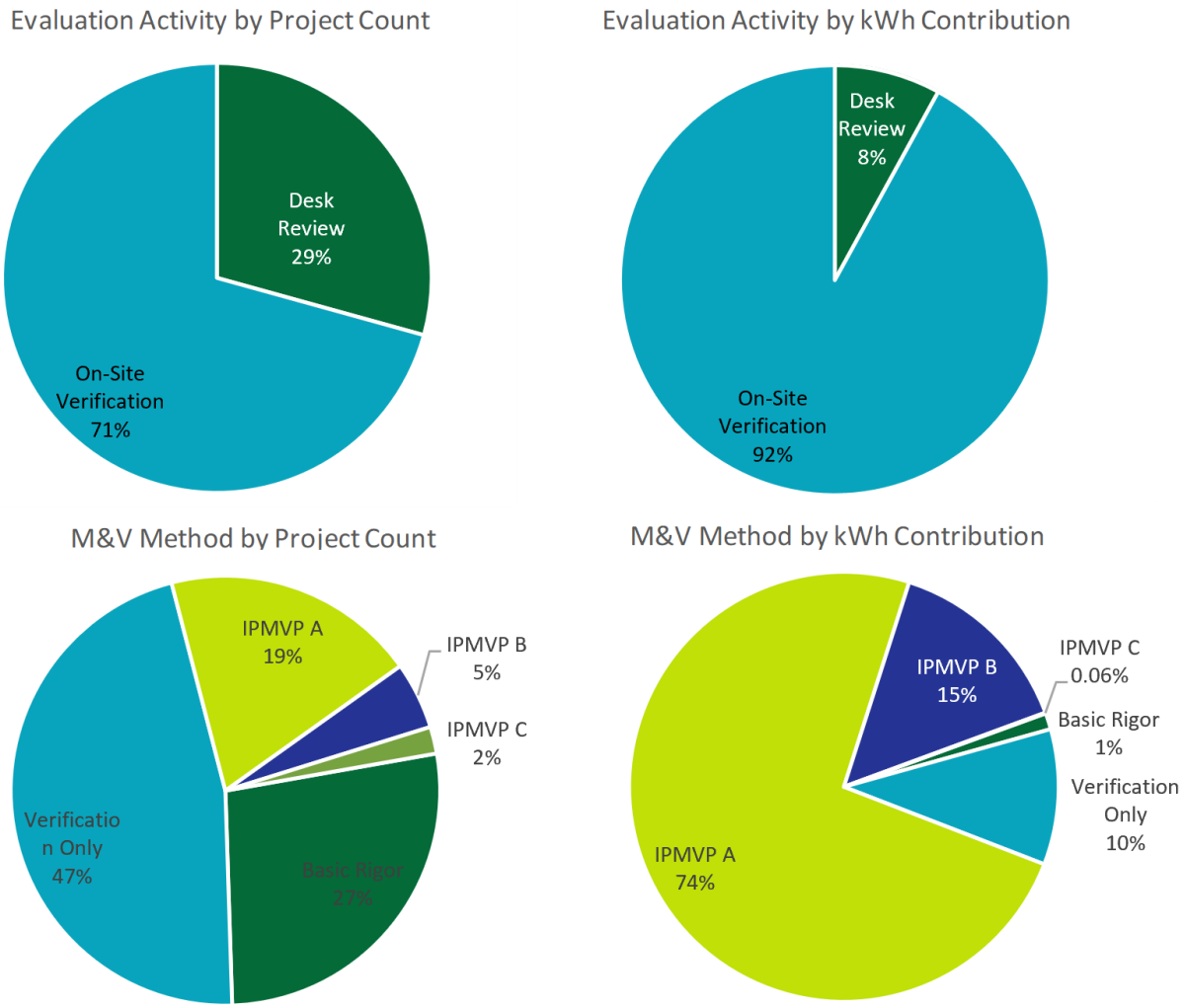
Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.17	0.17	-0.00
Residential	July 2012	1.14	1.13	-0.01
Low-income	January 2014	0.04	0.02	-0.02
Residential	January 2014	0.79	0.88	0.09
Low-income	December 2014	0.05	0.08	0.02
Residential	December 2014	0.24	0.23	-0.02
Total		**2.44**	**2.50**	**0.06**

In reviewing ADM's methodology, we noted one minor issue. This issue concerns Step 3 of their demand savings calculation, which posts that demand savings will be estimated as a function of three 8760 load shapes: heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not include the 'flat' end use. If the flat term had been included, total MW savings for Penelec would be 1.92 MW rather than 2.44 MW. For PY10, we would recommend either (1) updating the narrative in the annual report so that the flat end use is not included, or (2) updating the analysis to include the flat end use.

F.4.2 Non-Residential Audit Activities

Figure 82 provides a summary of the evaluation activities and M&V approaches utilized by Penelec's evaluation contractor in their PY9 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY9, Penelec's evaluation contractor completed site visits to 71% of projects, and these projects represented 92% of total evaluated energy savings. A total of 70 site visits were conducted. IPMVP Option A was employed for the majority (74%) of total evaluated energy savings. Basic Rigor (desk review without a site visit) was employed for appliance recycling projects and small selection of lighting projects.

Figure 82: Summary of Penelec's C&I Evaluation Activities



Penelec's evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Penelec's C&I programs are assigned to one of five evaluation initiatives, as Penelec's programs target specific sectors of C&I customers but offerings are often identical

across the programs. Table 197 provides a summary of the evaluation activities and M&V approaches Penelec's evaluation contractor used across strata for all projects by initiative.

Table 197: Summary of Penelec's PY9 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR	Basic Rigor	On-Site Verification Only	IPMVP A	IPMVP B	IPMVP C
Appliance Turn-In	**22**	**93%**	**22**	**0**	**0**	**0**	**0**
Appliance Recycling-1	22	93%	22	0	0	0	0
Custom	**18**	**94%**	**0**	**11**	**0**	**5**	**2**
Custom-1	11	74%	0	8	0	1	2
Custom-2	5	128%	0	3	0	2	0
Custom-Certainty	2	100%	0	0	0	2	0
Direct Install	**1**	**94%**	**1**	**0**	**0**	**0**	**0**
Direct_Install-1	1	94%	1	0	0	0	0
Lighting	**28**	**86%**	**4**	**5**	**19**	**0**	**0**
Lighting-1	5	100%	3	2	0	0	0
Lighting-2	9	78%	0	2	7	0	0
Lighting-3	8	74%	1	1	6	0	0
Lighting-Certainty	6	102%	0	0	6	0	0
Prescriptive	**30**	**101%**	**0**	**30**	**0**	**0**	**0**
Prescriptive-1	27	115%	0	27	0	0	0
Prescriptive-2	3	95%	0	3	0	0	0
TOTAL	**99**		**27**	**46**	**19**	**5**	**2**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation were aligned with the Evaluation Framework, followed proper custom site specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

F.4.2.1 Appliance Turn-In Initiative

The evaluation contractor conducted phone and online surveys to verify projects in this initiative. No site visits were conducted for these projects. Impacts were calculated using TRM calculations using project-specific data from the tracking system or verification surveys when available. TRM default values were used in absence of project-specific data.

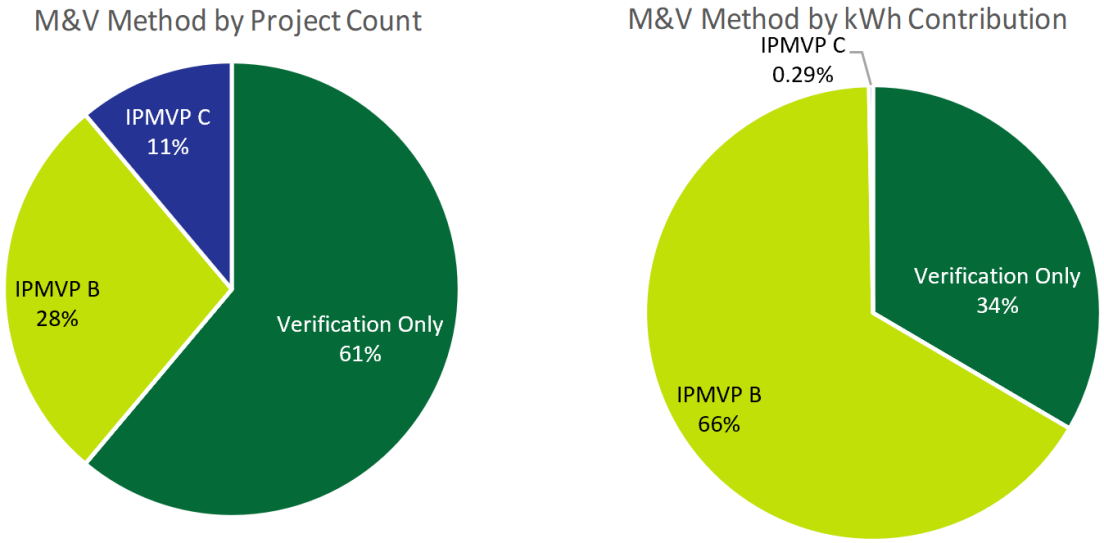
F.4.2.2 Custom Initiative

Evaluation activities for this initiative include site visits and/or IPMVP evaluation methods for all sampled projects. Site visits are always conducted unless the evaluation can be satisfactorily conducted remotely using data provided by the customer (EMS data, billing data, etc.). All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penelec's evaluation contractor employed three strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 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. IPMVP Options B and C were employed to evaluate a combined 67% of the evaluated sample, as shown in Figure 83.

Figure 83: Summary of Penelec's C&I Custom Evaluation Activities



F.4.2.3 Direct Install Initiative

All projects in this initiative (only one for Penelec) were included in the evaluation sample. The project was a lighting upgrade and therefore evaluated according to the protocol defined for the lighting initiative.

F.4.2.4 Lighting Initiative

Evaluation activities for this initiative include site visits for most projects and primary data collection of lighting hours of use for medium and high savings projects. TRM deemed hours of operation were applied for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penelec's evaluation contractor employed four strata for projects in the Lighting initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

IPMVP Option A using standalone data loggers to measure lighting hours of use was employed for the large majority of projects evaluated in this initiative.

F.4.2.5 Prescriptive Initiative

Evaluation activities for this initiative include verification site visits for most projects and application of TRM-based savings calculation methodologies. All sampled projects undergo a full documentation review prior to site visits. This documentation review included identification of the appropriate TRM or IMP protocol and the defined key input parameters.

Penelec's evaluation contractor employed two strata for projects in the Prescriptive initiative, with the threshold set at 20 MWh of annual energy savings.

IPMVP-based methods were not employed for this initiative. All projects were evaluated using engineering algorithms following on-site verification visits in most cases.

F.4.2.6 Ride-Along Site Visits

Table 198 provides an overview of the SWE milestones for the audit of Penelec's site inspection efforts.

Table 198: Penelec Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Energy Attainment Percentage
1	76,084	1	1	100%

Only one ride-along site visit was conducted for Penelec. The SWE agreed with the methodology and calculations completed by Penelec's evaluation contractors.

F.4.2.7 Verified Savings Desk Reviews

Table 199 provides an overview of the SWE milestones for the verified savings review of evaluated Penelec projects.

Table 199: Penelec Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
5	11,517,876	1,296	100%	100%

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. Among the five projects reviewed, the SWE found no basis for recommending adjustments to energy or demand savings.

F.5 Demand Response

Penelec does not have a demand response target for Phase III of Act 129.

F.6 NTG

F.6.1 Residential Programs

Tetra Tech estimated a PY9 NTG for the Appliance Turn-in Program and the New Homes Program. The Direct Install Program and the Energy Efficiency Kits Program NTG were drawn from the PY8 NTG evaluation.

For the Appliance Turn-in Program, Tetra Tech used primary data collection (participant surveys) to estimate NTG. NTG was estimated with the recommended UMP appliance recycling protocol. Tetra Tech measured free-ridership but not spillover due to program design and assigned the average NTG score for about 10% of the sample due to incomplete survey responses (for FE overall, specific imputation by EDC was not reported).

Tetra Tech assigned the HERs component of the program an 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.

An NTG of 0.6 was applied to the New Homes components of the Program. Tetra-Tech conducted secondary NTG research across six similar programs offered in non-First Energy territories and applied the average of these programs NTG as the New Homes NTG.

For the Residential Energy Efficient Products Program, Tetra Tech applied the NTG from Phase II to all components of the program.

Table 200: Summary of NTG Estimates for Penelec Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.55	0.0	0.45	264
PY8	Upstream Lighting	--	--	0.34	--
PY8	EE Kits	--	--	0.82	--
RCT	Home Energy Reports	0	0	1	--
PY8	Direct Install	--	--	0.82	--
Secondary Research	New Homes	--	--	0.60	--
PY8	Upstream Electronics	--	--	0.50	--
PY8	HVAC	--	--	0.52	--
PY8	Residential Appliances	--	--	0.48	--

F.6.2 Low-income Residential Programs

Tetra Tech assigned LIEEP an NTG of 1, in keeping with the PY9 Evaluation Plan and SWE Phase III Evaluation Framework.

F.6.3 C&I Programs

Tetra Tech did not conduct NTG research in PY9 for Energy Solutions for Small Business Program or for the Energy Solutions for Large Business Program.

The estimated PY8 NTG was applied to the Small Business NTG for the Lighting, Custom, and Prescriptive components. The PY8 and PY9 NTG for these components differ slightly due to the differences in strata weighting between the two efforts.

Tetra Tech evaluated the Residential Appliance Program and estimated it's NTG for PY9 and applied the residential NTG to the small business component.

Tetra Tech was to evaluate the Small Business Direct Install NTG during PY9 but found that the Small Business Direct Install component was solely lighting retrofits. Tetra Tech then reasoned that the Small Business Lighting component NTG should be applied to Direct Install even though the Lighting NTG was based on the PY8 evaluation.

The Energy Solutions for Large Business Program NTG was evaluated in PY8 and these NTG values were then applied to the PY9 NTG. Values of NTG across programs for PY8 and PY9 vary slightly due to the difference in strata weighting in each effort.

Table 201: Summary of NTG Estimates for Penelec C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Small Energy Solutions for Business Lighting	--	--	0.84	--
PY8	Small Energy Solutions for Business Custom	--	--	0.52	--
PY8	Small Energy Solutions for Business Prescriptive	--	--	0.43	--
PY9 Residential NTG	Small Energy Solutions for Business Appliance Turn-In	--	--	0.45	--
PY8 ESB Lighting NTG	Small Energy Solutions for Business Direct Install	--	--	0.85	--
PY8	Small Energy Solutions for Business Total	--	--	0.79	--
PY8	Large Energy Solutions for Business Lighting	--	--	0.84	--
PY8	Large Energy Solutions for Business Custom	--	--	0.52	--
PY8	Large Energy Solutions for Business Prescriptive	--	--	0.43	--
PY8	Large Energy Solutions for Business Total	--	--	0.78	--

F.7 TRC

Table 202 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penelec's PY9 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 PY9 annual report.

The primary difference for the PY9 TRC from the previous program year is the inclusion of fossil fuel and water saving benefits under the Total NPV Lifetime Non-Electric Benefits.

Table 202: Summary of Penelec's PY9 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	$1,323	$687	1.93	$596	$687	0.87
Energy Efficient Homes	$11,431	$6,111	1.87	$9,622	$5,811	1.66
Energy Efficient Products	$12,914	$6,270	2.06	$4,518	$2,965	1.52
Low-Income Energy Efficiency	$2,559	$3,441	0.74	$2,559	$3,441	0.74
C&I Energy Solutions for Business– Small	$11,350	$10,905	1.04	$9,046	$9,016	1.00
C&I Energy Solutions for Business– Large	$17,244	$16,456	1.05	$13,530	$13,359	1.01
Governmental & Institutional Tariff	$348	$517	0.67	$291	$451	0.64
Portfolio Total	**$57,169**	**$44,386**	**1.29**	**$40,160**	**$35,729**	**1.12**

Of Penelec's seven energy-efficiency programs offered, five were found to be cost-effective and two were non-cost-effective. Using net verified savings, four were found to be cost-effective and three were non-cost-effective. 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. 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

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

- Low-income Energy Efficiency
- Governmental & Institutional Tariff

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):

- Appliance Turn-in
- Low-income Energy Efficiency
- Governmental & Institutional Tariff

F.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- Penelec's annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). First Energy applies a broader peak definition than Act 129 peak hours defined in the 2016 TRM. The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions.
- 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 TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. The SWE verified that the savings were accounted for in accordance to the Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test. The TRC model claimed 58,973 thousand gallons of water saved or approximately $3,900,000 in avoided costs.
- 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 203 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 203: Penelec Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.29	1.12
Without Dual Baseline	1.42	1.18

- In PY8, the SWE recommended the Programmable Thermostat EUL be updated from 11 to 15 in PY9 reporting. The PY9 TRC model completed this update.

F.8 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

FirstEnergy's evaluation contractor, ADM Associates, prepared a single, comprehensive evaluation plan for the four FirstEnergy EDCs that addressed evaluation activities for all of Phase III. In PY9 the ADM team submitted a sampling memo for the C&I DR program, which the SWE reviewed and approved with minor comments and suggestions.

In addition to reviewing FirstEnergy's sampling memo, the SWE reviewed two survey instruments, one for appliance retailers and one for the C&I DR program participants.

G.2 Sample Design Review

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

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 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 due program delivery channel or supported technology.

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than tariff-based program definitions, each of which would include the same mix of measures. This evaluation strategy also makes sample design more efficient because the same projects are more likely to share similar characteristics across rates classes (i.e., Small C&I, Large C&I, and Government) than a heterogeneous mixture of measures within a single class. For example, projects from Penn Power's 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 (No projects approved in PY9)

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. Table 204 lists each initiative and the corresponding relative precision of the PY9 gross verified savings estimate for all initiatives that include sampling uncertainty.

Table 204: Relative Precision of Penn Power PY9 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level (±)
Residential Appliance Turn-In (ATI)	6.8%
Low-Income ATI	10.5%
C&I ATI	11.6%
Res EE Kits	4.9%
Low-Income EE Kits	11.2%
Res Direct Install	11.7%
Low-Income Direct Install	9.7%
Res Upstream Lighting	10.0%
Res Upstream Electronics	0.0%
Res HVAC	10.1%
Residential Appliances	10.9%
Low-Income Appliances	41.8%
Residential New Construction	7.0%
C&I Lighting	11.2%
C&I Custom	7.9%
C&I Prescriptive	0.0%

With the exception of the Low-Income Appliances Initiative, each of the sampling initiatives shown in Table 204 produced verified gross savings estimates of better than ±15% precision at the 85% confidence level. ADM notes that the relative precision for the LI Appliances Initiative was high due to realization rates far above 100% for clothes washers and heat pump water heaters. They attribute the large realization rates to conservative ex-ante values for those appliances.

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 PY9 verification activities is discussed in detail in Appendix G.4.

The Behavioral Modification subprogram provides home energy reports to residential customers in the Penn Power service territory. The subprogram is divided between standard residential customers and Low-Income customers and each is administered as a randomized control trial (RCT). Participants are enrolled in experimental cohorts and a monthly billing analysis regression

is the used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model is not able to fully capture the variation present in the data. Precision requirements for behavioral program are unique, with The Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). Table 205 shows the absolute precisions of the behavioral program components.

Table 205: Absolute Precisions of Penn Power PY9 Behavioral Subprogram Gross Verified Energy Savings Estimates

Stratum	Absolute Precision at 95% Confidence Level (±)
Residential	0.21%
Low-Income	0.66%

Demand Response programs offered by the Penn Power in PY9 include the Behavioral Demand Response targeted at residential customers and the Demand Response Program for both small and large C&I customers. Penn Power is the first of the FirstEnergy EDCs to offer the Behavioral Demand Response Program. It is evaluated using similar methodology to the Behavioral Program, but with hourly data. The gross verified DR savings from that program in PY9 have a relative precision of ±13% at the 90% confidence level. The gross impact evaluations for the C&I Demand Response Programs also do not rely on sampling but instead rely on establishing a customer baseline load (CBL) for each program participant. The relative precision of the PY9 verified DR savings was ±58% at the 90% confidence level for the Penn Power non-residential DR programs.

G.3 Reported Gross Savings Audits

G.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in Penn Power's PY9 Annual Report. Specifically, the values we examined are:

- Reported gross energy savings (MWh) for each program;
- Reported gross peak demand savings (MW) for each program;
- Participation for each program; and
- Incentive dollars for each program.

The SWE leveraged Penn Power'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 PY9 quarterly data request. Also note that demand response (DR) or home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding Penn Power's demand response programs can be found in Appendix G.5, and our findings regarding the HER components of the

Energy Efficient Homes and Low-Income Energy Efficiency programs can be found in Appendix G.4.1.3.

Table 206 summarizes our ex-ante findings regarding energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values shown in Penn Power's PY9 Annual Report and 'No' otherwise. For each program, the SWE was able to replicate the values provided by Penn Power.

Table 206: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	1,695	1,695	Yes
Energy Efficient Homes	5,916	5,915	Yes*
Energy Efficient Products	10,250	10,250	Yes
Low-Income Energy Efficiency	747	748	Yes*
C&I Energy Solutions for Business – Small	13,729	13,729	Yes
C&I Energy Solutions for Business – Large	11,449	11,449	Yes
Governmental & Institutional Tariff	605	605	Yes
Portfolio Total	**44,391**	**44,391**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 207 summarizes the SWE's ex-ante findings regarding peak demand savings by program. The SWE's records matched Penn Power's reported peak demand savings for each program.

Table 207: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.22	0.22	Yes
Energy Efficient Homes	1.93	1.93	Yes*
Energy Efficient Products	1.24	1.24	Yes
Low-Income Energy Efficiency	0.29	0.29	Yes*
C&I Energy Solutions for Business – Small	1.93	1.93	Yes
C&I Energy Solutions for Business – Large	1.34	1.34	Yes
Governmental & Institutional Tariff	0.00	0.00	Yes
Portfolio Total	**6.95**	**6.95**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 208 summarizes the SWE's ex-ante findings regarding program participation. The SWE was able to replicate participant counts for four of the seven programs. For one other, the difference between the SWE's count and Penn Power's count was just one.

For the two remaining programs, the SWE calculated directionally similar participant counts. Note that these two programs both have HER components – the counts for those programs are not included. The values shown in the "Annual Report Participants" for those two programs represent the difference between the value for the full programs (inclusive of the HER components) and the maximum number of treatment group homes active in the HER program during PY9. The difference between the SWE and FirstEnergy participant counts for the Low-Income Energy Efficiency program is likely a function of the counting logic for accounts that participate more than once within a given program year.

Table 208: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	1,528	1,528	Yes
Energy Efficient Homes	16,345	16,640	No*
Energy Efficient Products	100,510	100,511	No
Low-Income Energy Efficiency	4,605	4,728	No*
C&I Energy Solutions for Business – Small	351	351	Yes
C&I Energy Solutions for Business – Large	49	49	Yes
Governmental & Institutional Tariff	81	81	Yes
Portfolio Total	**123,469**	**123,888**	**No**

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Finally, Table 209 summarizes the SWE's ex-ante findings regarding incentive dollars. The SWE was able to calculate directionally similar (but not equal) incentive dollars for each program except for EE Homes. For the EE Homes program, the two data sources differ by over $750,000. The SWE believes this difference can, in part, be explained by EE&C kits. The incentive amount that Penn Power has earmarked for EE kits and audits in their PY9 EE&C plan is $595,176. Ignoring this program, the portfolio totals for the two data sources match – $1,938,000 in the tracking data and $1,938,000 in the Annual Report.

Table 209: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	$86	$85	No
Energy Efficient Homes	$1,033	$279	No
Energy Efficient Products	$518	$550	No
Low-Income Energy Efficiency	$51	$50	No
C&I Energy Solutions for Business – Small	$736	$691	No
C&I Energy Solutions for Business – Large	$510	$527	No
Governmental & Institutional Tariff	$37	$35	No
Portfolio Total	**$2,971**	**$2,217**	**No**

G.3.2 Project File Reviews

G.3.2.1 Residential

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of Penn Power's residential project files for PY9 using the project file documentation provided by Penn Power, the program implementors, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included a majority of the documentation requested. Initially, project file documentation was not provided for the Low-Income WARM program for quarters 3 and 4 but was later provided by ADM upon request.

Table 210 presents a summary of SWE's residential project file reviews. In addition to verifying that documentation was present and corresponded accurately with the quarterly tracking data, the SWE conducted a review of the sampled project files to verify that correct values and algorithms from the Pennsylvania TRM were applied to the reported savings. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place and was able to clarify that all issues arising from this review were addressed during verified savings calculations.

Table 210: Penn Power PY9 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?[1]
Appliance Turn-in Program	Appliance Turn-in Program	28	✓	✓	✓	✓
Energy Efficient Homes Program	School Education	3	✓	✓	✓	✓
Energy Efficient Homes Program	EE Kits	3	✓	✓	✓	✓
Energy Efficient Homes Program	Audits	3	✓	✓	✓	✓
Energy Efficient Homes Program	New Homes	24	✓	✓	✓	✓
Energy Efficient Products Program	Appliances and Electronics	28	✓	✓	✓	✓
Energy Efficient Products Program	Lighting	24	✓	✓	✓	✓
Energy Efficient Products Program	HVAC	24	✓	✓	✓	✓
Low-Income Energy Efficiency Program	Weatherization	12	✓	✓	✓	✓

*The number of files reviewed reflects the total number for all First Energy EDCs.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews, including issues or discrepancies found between the project file packages and quarterly tracking data.

HVAC

The HVAC project files typically matched the quarterly tracking data; however, the SWE found one discrepancy in the heating and cooling capacity between the sampled project files and tracking data.

- For heat pump projects, the TRM requires separate inputs for heating and cooling capacity to calculate savings. In the tracking data, capacity was displayed as a singular 'tons' variable.[96]

The evaluator, ADM, worked with the SWE to clarify this discrepancy. Their approach is to use single point estimates for these values for the reported ex-ante savings, and to then pull the heating and cooling capacities directly from the AHRI database and other independent sources during the verified savings calculations.

Upstream Lighting

The Upstream Lighting files matched the tracking data; however, a discrepancy between the tracking data and the TRM equation was observed.

- In the TRM, the base wattage variable for specialty bulbs is dependent on bulb shape and lumen range; however, the tracking data did not break out bulb shape enough to make this determination.[97]

ADM again worked with the SWE to clarify this issue. This is corrected during the verified savings calculations, which are entirely independent from these ex-ante calculations. The model numbers are used to pull in all bulb information, including specific shape, from a compiled database, primarily using ENERGY STAR data.

Appliances

The Appliance files typically matched the tracking data, but the SWE had a question about the reported savings.

- Reported ex-ante savings were based on TRM defaults values despite the EDC collected data for those values being available.

ADM confirmed that defaults are used at the ex-ante level, but the model specific TRM values are used in verified savings calculations.

Low-Income WARM

Project files for the Low-Income WARM program typically matched the tracking data for Q1 and Q2. However, the SWE noticed that project files were not provided initially for Q3 and Q4.

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[96] For example, for a mini split project, the heating capacity might be 12k BTU, and the cooling capacity 9k BTU, but this would appear in a single 'tons' variable as 12k BTU in the tracking data. As noted, ADM reported that this is corrected in the verified savings calculations.

[97] For example, a specialty bulb at 500 lumens could have a base wattage of 40, 45, 60, or 65 depending on the shape, but there is no way to tell which value should be used without more specific shape categories being used. ADM confirmed that this is addressed in the verified savings calculations.

ADM was notified of this and quickly provided a sample of project files for these quarters, and no discrepancies were found.

G.3.2.2 Non-Residential

The SWE reviewed Penn Power's C&I projects for PY9 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, equipment invoices, and equipment specification sheets. Most of the project file packages included all documentation requested. For lighting projects, Penn Power's ICSP uses their own lighting calculator. In PY9, the inputs to the ICSP's lighting calculators were also transcribed into the Appendix C lighting calculator.

Project files were generally well organized, complete, and accurate. Table 211 presents an overview of the results of the SWE's C&I project file reviews.

Table 211: Penn Power PY9 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?
FESPPS1534469396	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534444774	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534469350	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1535822180	HVAC Equipment	✓	✓	✓	✓	-	✓
FESPPS1535238032	Lighting	✓	✓	✓	✓	-	✓
FESPPS1537455060	Compressed Air	✓	✓	✓	✓	-	✓
FESPPS1537455156	HVAC Equipment	✓	✓	✓	✓	-	✗
FESPPS1536742534	Kitchen Equipment	✗	✓	✓	✗	✗	-
FESPPS1537865764	HVAC Equipment	✓	✓	✓	✓	✓	-
FESPPS1537975336	Lighting	✓	✓	✓	✓	✗	-
FESPPS1537716264	Street Lighting	✗	✓	✓	✓	✓	-

Specific issues noted during the project file review process are addressed individually by project below.

The two reviewed street lighting projects, FESPPS1534469350 and FESPPS1537716264, as well as lighting project FESPPS1534444774 did not include an Appendix C lighting calculator. However, the ICSP's calculator appeared to be following TRM methodology for the project.

Project FESPPS1536742534 included savings for hot food holding cabinets and a high efficiency commercial refrigerator. No savings calculation was submitted for the hot food holding cabinet. Additionally, the high efficiency commercial refrigerator calculation used the PY8 baseline, whereas the TRM specifies a higher baseline for projects in PY9 and later.

The energy savings for Project FESPPS1537455156, a heat recovery project, were generated using an energy model. The model was not included or documented, so the savings methodology cannot be audited. Energy modeling efforts should be thoroughly described to preserve transparency in savings calculations.

The process by which the ICSP's calculators are transcribed into the Appendix C calculator preserves much of the Appendix C functionality but does overwrite some functions. Baseline fixture wattage lookups are preserved. Hours of operation, coincidence factors, and interactive factors are directly transcribed from the ICSP's calculator in a manner that overwrites the formulas built-in to the Appendix C calculator. In the case of Project FESPPS1537975336, the transcription process resulted in a coincidence factor less than 1 being used for fixtures that operated year-round (8,760), which resulted in demand savings being underestimated. For future years, the ICSP and the evaluator should consider improving the transcription process so that these parameters are calculated directly by the Appendix C calculator as intended.

Additionally, calculators submitted for prescriptive measures are locked. Worksheet and cell permissions could be modified to allow the SWE to view inputs and algorithms in the calculator. This would facilitate more thorough project reviews and evaluations in the future.

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 Penn Power portfolio of residential programs. Penn 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 evaluation details differ or where the SWE audits determined that certain subprograms showed discrepancies not shared by others in a program). Note that the SWE reports residential savings in 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 212 provides a summary of the evaluation and M&V approaches used by Penn

Power in their PY9 verified savings calculations. Note that all the discrepancies are much less than 1% of portfolio savings and can be corrected beginning in PY10.[98]

Table 212: Residential Program Evaluation Activities – Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review[a]	Billing Analysis	Applied PY8 RR
Appliance Turn-In					
Appliance Turn-in (LI & Non-LI)	✓	--	✓	--	--
EE Homes					
EE Kits	✓	--	✓	--	--
EE Kits- Low-Income	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	✓	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting					
Upstream Lighting	✓	--	✓	--	--
EE Products					
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Appliances- Low-Income	✓	--	✓	--	--
Low-Income WARM					
Low-Income WARM- Extra Measures	--	✓	✓	✓	--
Low-Income WARM- Multifamily	--	✓	✓	✓	--
Low-Income WARM- Plus	--	✓	✓	✓	--

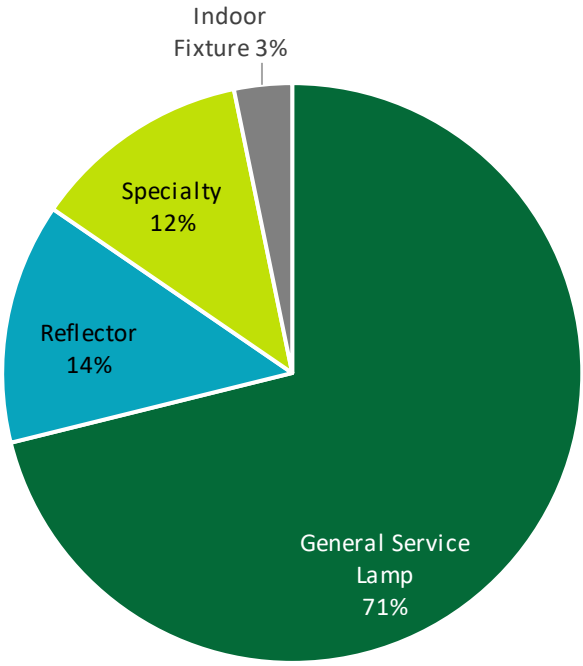
[a] The Desk Review column includes: database reviews, application reviews, and/or engineering desk reviews.

[98] 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.

G.4.1.1 Upstream Lighting & Cross-Sector Sales

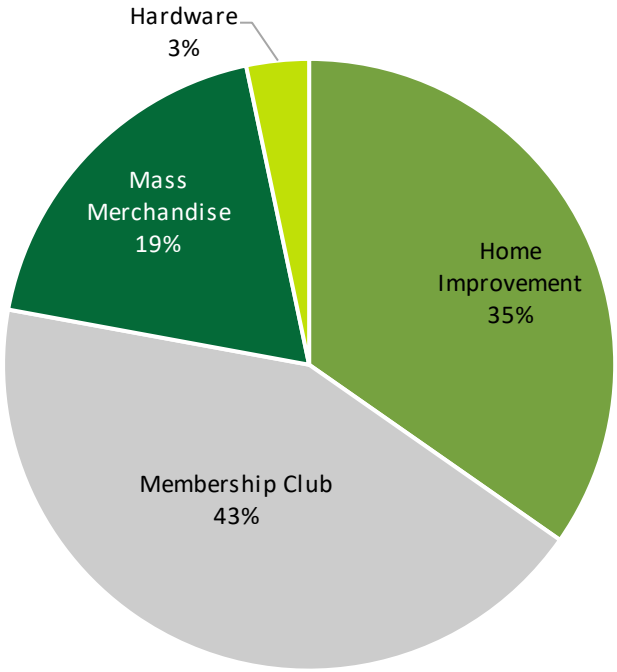
Customers purchased over 300 thousand efficient light bulbs and fixtures through Penn Power's PY9 upstream lighting program. Figure 84 displays the distribution of sales by product type. Over two-thirds (71%) of the products were general service lamps.

Figure 84: Penn Power PY9 Upstream Lighting Sales by Product Type



Over three-quarters (78%) of Penn Power's PY9 upstream light bulbs and fixtures were sold through membership clubs and home improvement stores (Figure 85).

Figure 85: Penn Power PY9 Upstream Lighting Sales by Retail Channel



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 385 unique lighting model numbers in the PY9 tracking system and was able to locate 383 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The two models the SWE was not able to verify as ENERGY STAR certified represent 0.1% 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 URLs ADM provided and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for 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 in accordance with TRM protocol *2.1.1* for all but one model.

Cross-Sector Sales

ADM did not conduct cross-sector sales research in PY9. ADM applied the PY8 cross-sector sales estimate of 8.3% to PY9 sales.

Recommendations

The SWE does not have any recommendations based on its review of the PY9 upstream lighting analysis. However, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- 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 minor issues that caused a negligible difference in savings, detailed below.

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 G.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 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 dishwashers, resulting in a negligible increase in savings.[99] The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

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 G.4.1.1 of this appendix.

Analysis files and data sets included in the gross impact data were reviewed for all HVAC, appliance, and consumer electronics measures included in the program. The SWE found that in all cases the correct TRM vales and algorithms were used, the verified savings were correct, and the savings and sample sizes included in the annual request data matched those reported in the PY9 annual report.

[99] ADM used a default energy savings of 29.4 kWh per year for non-electric (gas) water heating but the 2016 TRM default is 26.4 kWh (Table 2-90 of the 2016 TRM).

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.

Appliance Turn-In Program (Low-Income and Non-Low-Income)

The SWE performed audits on all measures included in the Appliance Turn-In Program, including dehumidifiers, refrigerators and freezers, and room air conditioners. Overall, the SWE concluded that the proper TRM algorithms and protocols were used, and that verified savings were correct. Sample sizes in the annual request data did not match the achieved sample sizes included in the annual report.

G.4.1.3 Behavior

Approximately 12% of Penn Power's verified gross energy savings for PY9 came from Home Energy Reports issued to around 27,000 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 PY9. By cohort, Table 213 shows average kWh savings and average percent savings per participant in PY9. Note that the 'Number of Participants' column shows the average number of participants during PY9.

Table 213: Average PY9 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY9 kWh Savings	Average PY9 % Savings
Low-income	July 2012	2,111	223	1.82%
Residential	July 2012	17,357	206	1.73%
Low-income	January 2014	834	373	2.15%
Residential	January 2014	7,100	385	2.18%

The following sections highlight some of the more important audit steps and findings: the calendarization of billing data, group equivalence, duplicating participant counts, the calculation of lag terms, missing eligibility filters, and energy and demand savings.

Calendarization

The first step the SWE took was to review ADM's calendarized data. "Calendarization" is a process that prorates billing data into a common calendar month basis shared by all accounts. Our review of the calendarized data had three primary components:

- Check the coding of the "pre" and "post" indicator variables;
- Confirm that the calendarized average daily usage values are correct; and
- Confirm that the lag terms (average usage in the pre-period, average summer usage in the pre-period, average winter usage in the pre-period) are correct.

Our team found no issues in the coding of the pre and post indicator variables. Table 214 shows summary statistics calculated for ADM's calendarized data and the SWE's calendarized data.[100] The distribution of average daily kWh is basically identical in the two data sets.

Table 214: Comparison of Calendarized Data

Variable	Mean	5th Percentile	25th Percentile	75th Percentile	95th Percentile
Average Daily kWh – ADM	38.12	15.05	23.40	45.87	81.95
Average Daily kWh – SWE	38.12	15.05	23.40	45.87	81.95

Regarding the lag terms, the SWE found that ADM's calculations were sound. ADM did not calculate summer or winter lag terms in cases where pre-period summer or winter data did not exist. Because we found no issues with ADM's calendarized data, the figures, tables, and summary statistics presented herein were created or calculated using ADM's calendarized data rather than our own.

Group Equivalence

After reviewing the calendarization, the SWE compared average daily consumption (kWh) between the treatment and control groups during the pre-treatment period. Table 215 shows the results for each cohort. Note that calendarized data was used to calculate the averages and any customer without at least 12 month of pre-treatment data was dropped. To avoid comparing averages calculated over different time spans (e.g., 14 months and 12 months), averages within each month were calculated before calculating overall averages for each customer. The 'P-value' column indicates the likelihood that the observed differences could happen by chance if the two experimental cells use the same amount of energy, on average. A p-value less than 0.05 indicates that the difference in average consumption between the two groups is statistically significant.

One cohort was found to have statistically significant pre-treatment differences between the treatment and control groups – the Low-income January 2014 cohort. That said, the SWE believes that the model being used to estimate savings (lagged seasonal) accounts for this difference.

[100] The table only summarizes records that were in both the ADM and SWE data sets. A small percentage of account/month combinations from the ADM data set were not in the SWE data set, but the majority of these were June 2018 records (PY10) that the SWE dropped.

Table 215: Group Equivalence in the Pre-Period

Sector	Cohort Start Date	Average Daily kWh – Control	Average Daily kWh – Treated	P-value
Low-income	July 2012	35.5	35.6	0.72
Residential	July 2012	35.6	35.5	0.29
Low-income	January 2014	52.3	49.8	0.01
Residential	January 2014	50.1	50.0	0.74

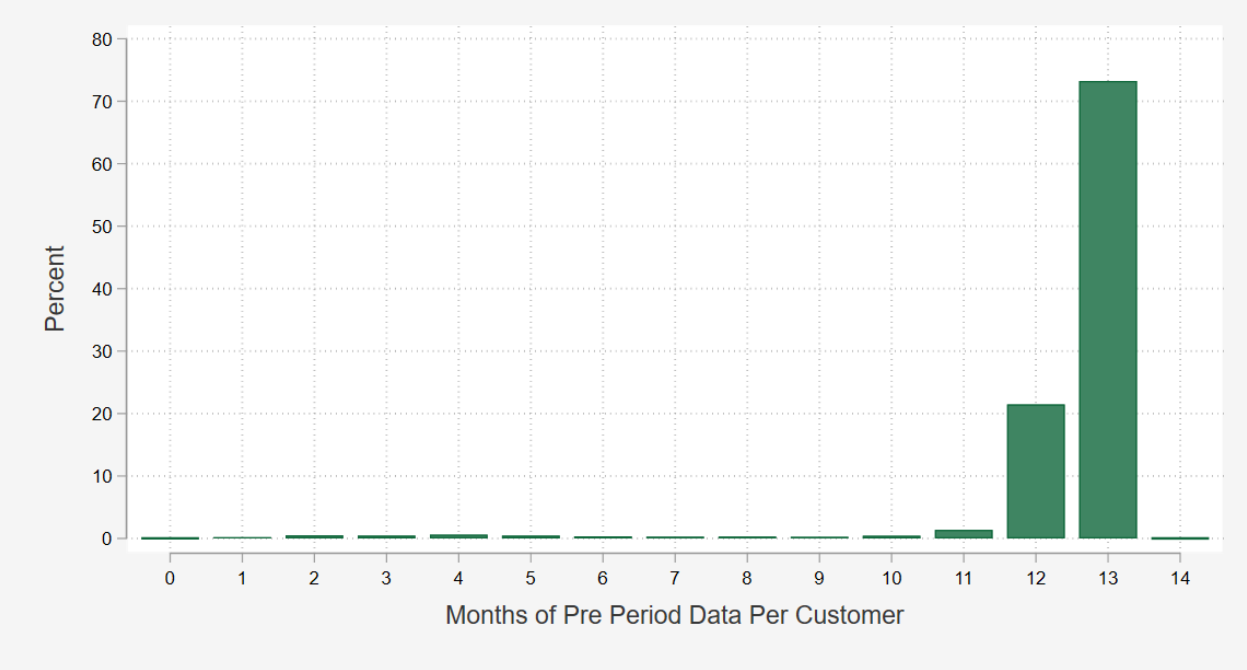
Participation Counts

The SWE leveraged the raw, un-calendarized billing data to audit participant counts. Because billing cycles can exceed 31 days in length (meaning bill dates can occasionally skip over a month), the SWE calculated the number of unique IDs beyond a certain bill date. As an illustrative example, suppose we wanted to compute the number of participants in Penn Power's 2012 LI cohort for March of 2018. We removed any records with a billing end date prior to 3/1/2018, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that matched the reported counts.

Eligibility Filters

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 86 shows the distribution of the number of months of pre-period data per customer. Across all Penn Power cohorts, 5.3% of homes had less than 12 months of pre-period data. Note that this percentage is much lower than the percentages for the other FirstEnergy companies.

Figure 86: 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 12 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 (used in the lagged seasonal model specification) be calculated? For a given customer, suppose there is only one month of pre-period summer usage. Should the lagged summer variable (average daily consumption during summer months in the pre-period) be based on that lone summer month? Or should it be treated as a missing value?

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. For PY10, the SWE recommends Penn Power investigate homes with less than 12 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 12 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: 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.)

Impact Coefficients and Energy Savings

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we ran the LS model without filtering out homes with less than 12 months of pre-period data. Next, the SWE dropped any participant without at least 12 months of pre-period data and re-ran the LS model for each cohort. On average, the second method produced smaller impacts (in magnitude). Impact 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 216 shows impact estimates for each cohort. Note that a different impact estimate was calculated for each month in PY9 – the estimates shown in the table reflect the averages of the PY9 monthly estimates (weighted by month duration). Using the first impact estimate as an example, the practical interpretation is as follows: treatment group homes in the low-income July 2012 cohort saved 0.15 kWh per day, on average, during PY9.

Table 216: Impact Coefficients

Sector	Cohort Start Date	Impact Estimate (kWh saved per home per day)	Impact Estimate – At least 12 Months of Pre
Low-income	July 2012	-0.15	-0.08
Residential	July 2012	-0.64	-0.20
Low-income	January 2014	-1.06	-1.34
Residential	January 2014	-1.08	-1.22

Table 217 shows ADM's and the SWE's aggregate energy savings (MWh) for each cohort. On aggregate, the SWE estimate was approximately 325 MWh greater than the ADM estimate. The largest difference was in the residential January 2014 cohort, where the SWE's aggregate savings estimate was 350 MWh greater than ADM's estimate. As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework did not mandate that only accounts with at least 12 months of pre-period data could be used in a billing analysis.

Table 217: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	July 2012	470	458	–12
Residential	July 2012	3,569	3,475	–95
Low-income	January 2014	311	394	82
Residential	January 2014	2,735	3,084	350
Total		**7,085**	**7,410**	**325**

Demand Savings

As with energy savings, the SWE's audit of HER demand savings involved two primary steps. First, we replicated ADM's calculations, then we substituted our own regression coefficients (based on homes with at least 12 months of pre-period data) into ADM's calculations. The results, which mirrored the results for energy savings, are shown in Table 218. On aggregate, the SWE method returned an additional 0.04 MW in demand savings.

Table 218: Demand Savings Comparison

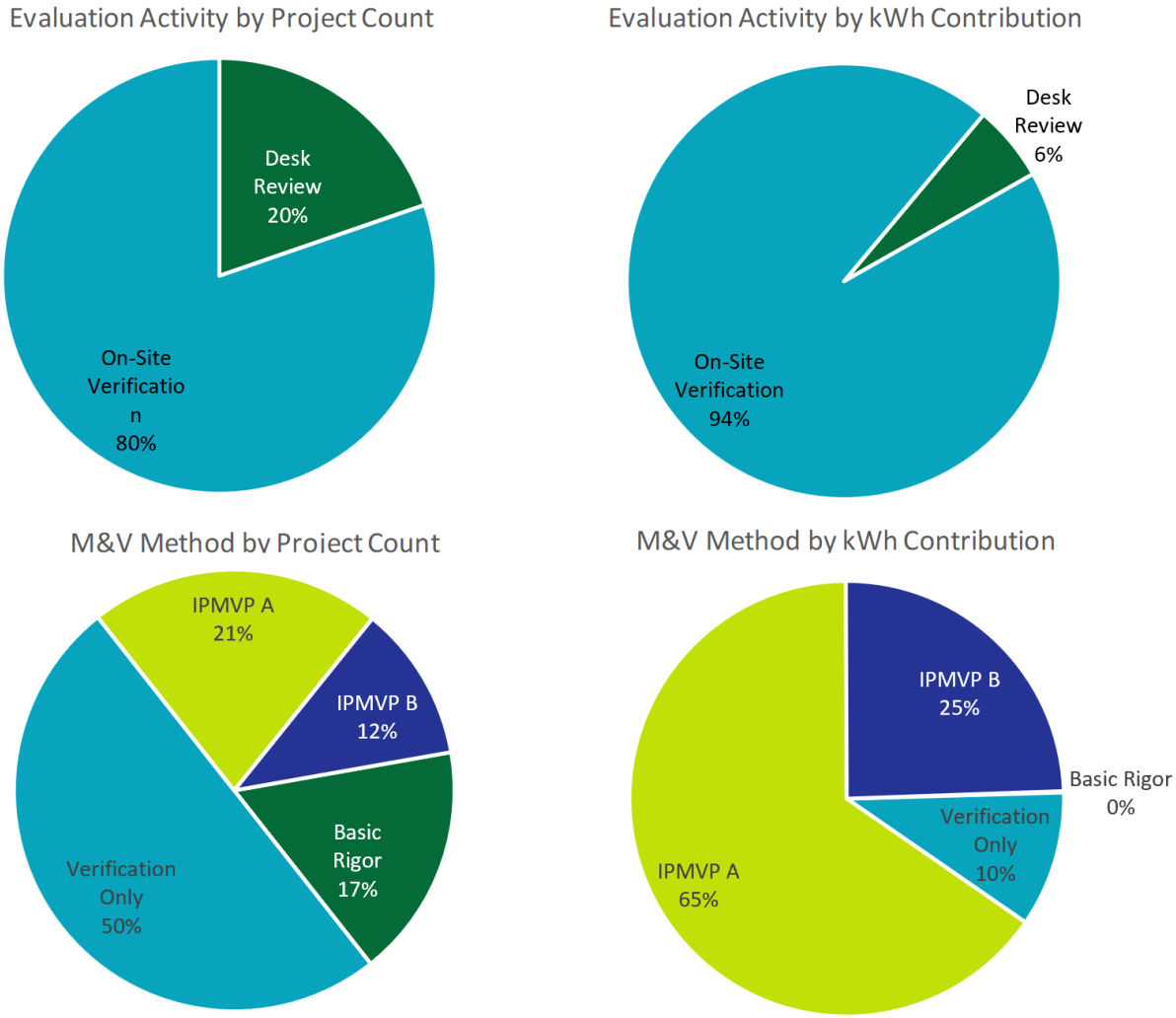
Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	July 2012	0.05	0.05	-0.00
Residential	July 2012	0.40	0.39	-0.01
Low-income	January 2014	0.04	0.04	0.01
Residential	January 2014	0.31	0.35	0.04
Total		**0.80**	**0.84**	**0.04**

In reviewing ADM's methodology, we noted one minor issue. This issue concerns Step 3 of their demand savings calculation, which posts that demand savings will be estimated as a function of three 8760 load shapes: heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not include the 'flat' end use. If the flat term had been included, total MW savings for Penn Power would be 0.47 MW rather than 0.80 MW. For PY10, we would recommend either (1) updating the narrative in the annual report so that the flat end use is not included, or (2) updating the analysis to include the flat end use.

G.4.2 Non-Residential Audit Activities

Figure 87 provides a summary of the evaluation activities and M&V approaches utilized by Penn Power's evaluation contractor in their PY9 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY9, Penn Power's evaluation contractor completed site visits to 80% of projects, and these projects represented 94% of total evaluated energy savings. A total of 57 site visits were conducted. IPMVP Option A was employed for the majority (65%) of total evaluated energy savings. Basic Rigor (desk review without a site visit) was employed for appliance recycling projects, a small selection of lighting projects, and one prescriptive project.

Figure 87: Summary of Penn Power's C&I Evaluation Activities



Penn Power's evaluation contractor conducted sampling within defined evaluation initiatives. Measures across Penn Power's C&I programs are assigned to one of five evaluation initiatives, as Penn Power's programs target specific sectors of C&I customers but offerings are often identical across the programs. Table 219 provides a summary of the evaluation activities and M&V approaches Penn Power's evaluation contractor used across strata for all projects by initiative.

Table 219: Summary of Penn Power's PY9 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR	Basic Rigor	On-Site Verification Only	IPMVP A	IPMVP B	IPMVP C
Appliance Turn-in	**11**	**77%**	**11**	**0**	**0**	**0**	**0**
Appliance Recycling-1	11	77%	11	0	0	0	0
Custom	**17**	**98%**	**0**	**9**	**0**	**8**	**0**
Custom-1	11	97%	0	9	0	2	0
Custom-2	5	100 %	0	0	0	5	0
Custom-Certainty	1	100 %	0	0	0	1	0
Lighting	**25**	**99%**	**0**	**9**	**15**	**0**	**1**
Lighting-1	6	101 %	0	6	0	0	0
Lighting-2	9	104 %	0	2	7	0	0
Lighting-3	7	89%	0	1	5	0	1
Lighting-Certainty	3	99%	0	0	3	0	0
Prescriptive	**18**	**197 %**	**1**	**17**	**0**	**0**	**0**
Prescriptive-1	17	259 %	1	16	0	0	0
Prescriptive-2	1	37%	0	1	0	0	0
TOTAL	**71**		**12**	**35**	**15**	**8**	**1**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation were aligned with the Evaluation Framework, followed proper custom site specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

G.4.2.1 Appliance Turn-In Initiative

The evaluation contractor conducted phone and online surveys to verify projects in this initiative. No site visits were conducted for these projects. Impacts were calculated using TRM calculations using project-specific data from the tracking system or verification surveys when available. TRM default values were used in absence of project-specific data.

G.4.2.2 Custom Initiative

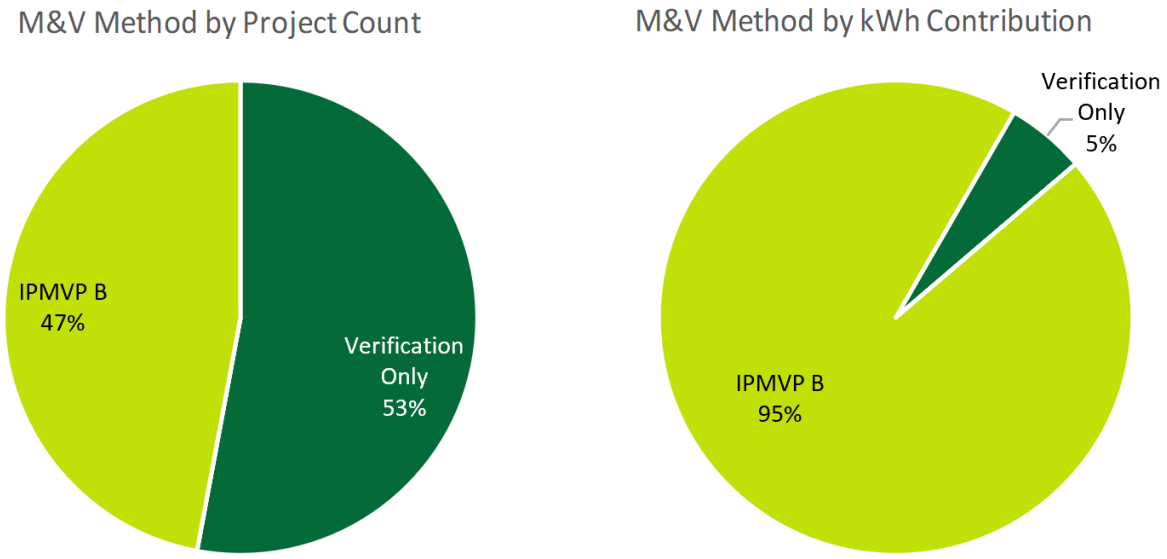
Evaluation activities for this initiative include site visits and/or IPMVP evaluation methods for all sampled projects. Site visits are always conducted unless the evaluation can be satisfactorily conducted remotely using data provided by the customer (EMS data, billing data, etc.). All

sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penn Power's evaluation contractor employed three strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 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. IPMVP Options B was employed to evaluate 95% of the evaluated sample, as shown in Figure 88.

Figure 88: Summary of Penn Power's C&I Custom Evaluation Activities



G.4.2.3 Direct Install Initiative

Penn Power had no participating projects in this initiative in PY9.

G.4.2.4 Lighting Initiative

Evaluation activities for this initiative include site visits for most projects and primary data collection of lighting hours of use for medium and high savings projects. TRM deemed hours of operation were applied for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

Penn Power's evaluation contractor employed four strata for projects in the Lighting initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

IPMVP Option A using standalone data loggers to measure lighting hours of use was employed for the large majority of projects evaluated in this initiative.

G.4.2.5 Prescriptive Initiative

Evaluation activities for this initiative include verification site visits for most projects and application of TRM-based savings calculation methodologies. All sampled projects undergo a full documentation review prior to site visits. This documentation review included identification of the appropriate TRM or IMP protocol and the defined key input parameters.

Penn Power's evaluation contractor employed two strata for projects in the Prescriptive initiative, with the threshold set at 20 MWh of annual energy savings.

IPMVP-based methods were not employed for this initiative. All projects were evaluated using engineering algorithms following on-site verification visits in most cases.

G.4.2.6 Ride-Along Site Visits

Table 220 provides an overview of the SWE milestones for the audit of Penn Power's site inspection efforts.

Table 220: Penn Power Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
9	2,974,346	2	8	100%

Overall, the SWE agreed with the methods of calculation employed by Penn Power's evaluation contractor. 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. The verified energy savings of the nine projects with ride-along audits was 97% of the reported energy savings. The SWE agreed with the evaluator's corrections.

G.4.2.7 Verified Savings Desk Reviews

Table 221 provides an overview of the SWE milestones for the verified savings review of evaluated Penn Power projects.

Table 221: Penn Power Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
2	222,491	39	100%	100%

Overall, the SWE found that Penn Power's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. The SWE asserts that ADM conducted appropriate M&V efforts, and that sufficient documentation supporting savings analyses was provided. Among both projects reviewed, the SWE found no basis for recommending adjustments to energy or demand savings.

G.5 DEMAND RESPONSE

In PY9, Penn Power had active DR programs in both the residential and C&I customer classes. On the C&I side, there were nine participants – six categorized as large C&I sites and three categorized as small C&I sites. The residential Behavioral Demand Response (BDR) component had approximately 30,000 homes in the treatment group, though this number declined throughout the summer. According to the Phase III Implementation Order, Penn Power's Phase III demand response (DR) compliance target is 17 MW. Note that compliance is determined based on the average MW performance across all DR event hours in the Phase and DR goals are assessed at the system level, meaning that line loss adjustments are applied to the load impacts measured at the customer meter. Additionally, the Implementation Order directs EDCs to obtain no less than 85% of the target in any single event. For Penn Power, this translates to a 14.45 MW minimum performance level for any given DR event. Decisions about which day DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. Penn Power called DR events on the three days those guidelines required.

On January 15, 2018 the Penn Power/ADM team filed its first PY9 semi-annual report. This filing contained the PY9 verified gross impacts as calculated by ADM. The DR performance estimates were unchanged in the PY9 Semi-Annual and Final Annual Reports. Table 222 shows Penn Power's performance across the three events during the 2017 DR season. Penn Power's PY9 average performance (33.5 MW) was comfortably above its Phase III target. Regarding the per-event target of 14.45 MW, the average impact for each of the three DR events exceeded this value. The large uncertainty bands for the large C&I sites (and portfolio total) were largely attributable to large customers with volatile loads.

Table 222: Penn Power Performance by Event

Date	Average Small C&I MW Impact	Average Large C&I MW Impact	Average Residential MW Impact	Average Portfolio MW Impact	% of Phase III Target
6/13/2017	0.1 +/- 0.1	48.7 +/- 24.2	2.0 +/- 0.6	50.8 +/- 24.2	299%
7/20/2017	0.2 +/- 0.2	26.4 +/- 24.3	2.5 +/- 0.6	29.2 +/- 24.3	172%
7/21/2017	0.3 +/- 0.3	18.1 +/- 24.1	2.0 +/- 0.6	20.4 +/- 24.1	120%
Average				**33.5 +/- 18.1**	**197%**

The Penn Power/ADM team also submitted a response to the SWE DR data request. The elements of this request included R scripts used in developing ADM's C&I and residential impact estimates, as well as the following:

- A workbook describing how ADM calculated uncertainty bands (i.e., margin of error) for their X-of-Y CBLs

- A data set that provided the top three CBLs for each participant and the relative root mean square error (RRMSE) for each CBL/participation combination
- For each event hour, a record of which facilities participated, their reference load, metered load, and verified DR impact
- For five sites selected by the SWE, the hourly load data needed to replicate the ADM impact estimates. Note that these five sites accounted for approximately 99.7% of Penn Power's gross verified PY9 C&I DR impacts (not inclusive of residential DR). Also note that one of the other workbooks provided by ADM showed which days were ineligible baseline days due to PJM activity or plant shutdowns
- Historical weather data that was used in creating weather sensitive adjustments, as well as a lookup that mapped each participant to a weather station
- Hourly load and weather data for approximately ~50,000 residential accounts (~30,000 treatment group accounts and ~20,000 control group accounts)
- A map that indicated which residential accounts belonged to which experimental cell

The data request response and a few follow-up emails formed the basis of the SWE audit activities – which are described in this memo. The SWE found the approaches implemented by ADM to be well-aligned with the Evaluation Framework and consistent with industry best-practice. The execution of the analysis was thorough and free of errors. The SWE agrees with the PY9 gross verified savings estimates and will recommend the Commission adopt them when assessing compliance with Phase III targets.

G.5.1 Replicate Program Totals

Penn Power's C&I DR program had nine participants and nearly all the demand savings produced by this program came from the six Large C&I participants. ADM's verified gross peak demand savings, by program, are shown in Table 223. Note that the C&I values are adjusted for line losses (by a multiplier of 1.0545). For each DR event hour during the 2017 DR season, the SWE was provided with the metered load and CBL for each participant. Using this data, the SWE was able to replicate the PYVTD gross MW for both components of the C&I DR program. Table 223 also shows ADM's verified gross peak demand savings for the residential DR component (adjusted for line losses by a multiplier of 1.0949).

Table 223: Penn Power DR Savings

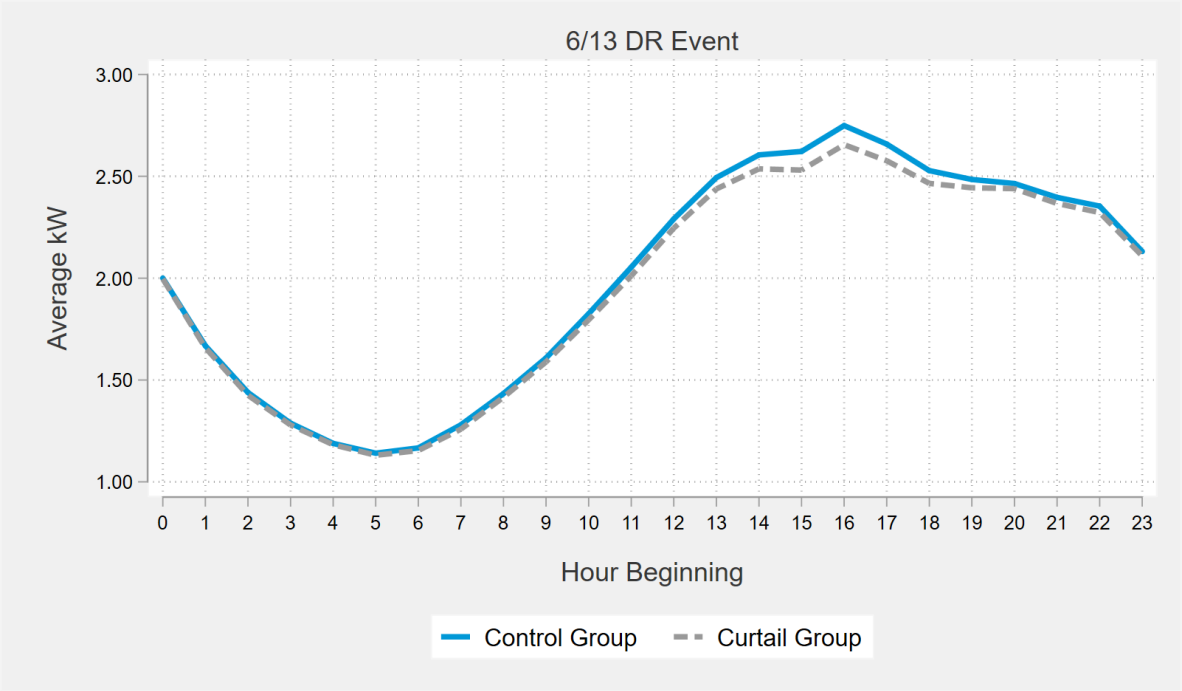
Program	PYVTD Gross MW	VTD Gross MW
C&I – Small	0.2	0.2
C&I – Large	31.1	31.1
Energy Efficient Homes (BDR)	2.2	2.2
Total	**33.5**	**33.5**

G.5.2 Residential Behavioral Demand Response

Penn Power's BDR program operates as a randomized control trial – customers were randomly selected and placed into control and treatment groups. As of the beginning of the 2017 summer DR season, there were 30,186 premises in the treatment group and 19,120 premises in the control group. At the end of the DR season, these numbers were 28,864 and 18,310 respectively.

Prior to the DR events, homes in the treatment group are notified of a pending DR event by the program's ICSP (Oracle) with the expectation that customers will curtail load during the event itself. The means by which load curtailment is achieved isn't obvious, though ADM notes that Oracle is involved in participant education and coaching. On average, load reductions are not very big – approximately 0.06 kW per home, which is approximately 2% of household demand during peak hours on peak days. As an illustration, see Figure 89. In this figure, control group and treatment group load shapes on the first DR event day are compared. The impact is small but certainly noticeable. With ~30,000 homes in the treatment group, small impacts add up.

Figure 89: Residential DR on June 13, 2017



Savings calculations for the residential DR component relied on a control group comparison and regression modeling. The regression model only used data from event hours on event days. Explanatory variables included date and hour fixed effects, an interaction between the treatment indicator variable and the date/time fixed effects, and three lag variables. The lag variables are customer-specific constants that were calculated based on May 2017 consumption. Steps taken in producing these lag variables are as follows:

- Limit the load data to non-holiday weekdays in May. Further, just look at common event hours (hours beginning 14-17).

- Create three temperature bins based on maximum daily temperature: 60 to 70 (no cooling), 70 to 80 (medium cooling), and above 80 (high cooling).
- In each temperature bin, calculate average load for each customer.

Figure 90 compares May weekday (non-holiday) usage in the treatment and control groups for the three bins (plus a fourth bin – temperature below 60) discussed above. The main takeaway from this figure is that the treatment and control groups were, on average, hardly distinguishable in terms of hourly load profiles. Additionally, and perhaps as one would expect, overall usage increases in the higher temperature bins. Because the control group homes and treatment group homes were exposed to the same weather conditions, temperature itself was not included as an explanatory variable in the model.

Figure 90: Usage by Temperature Bin

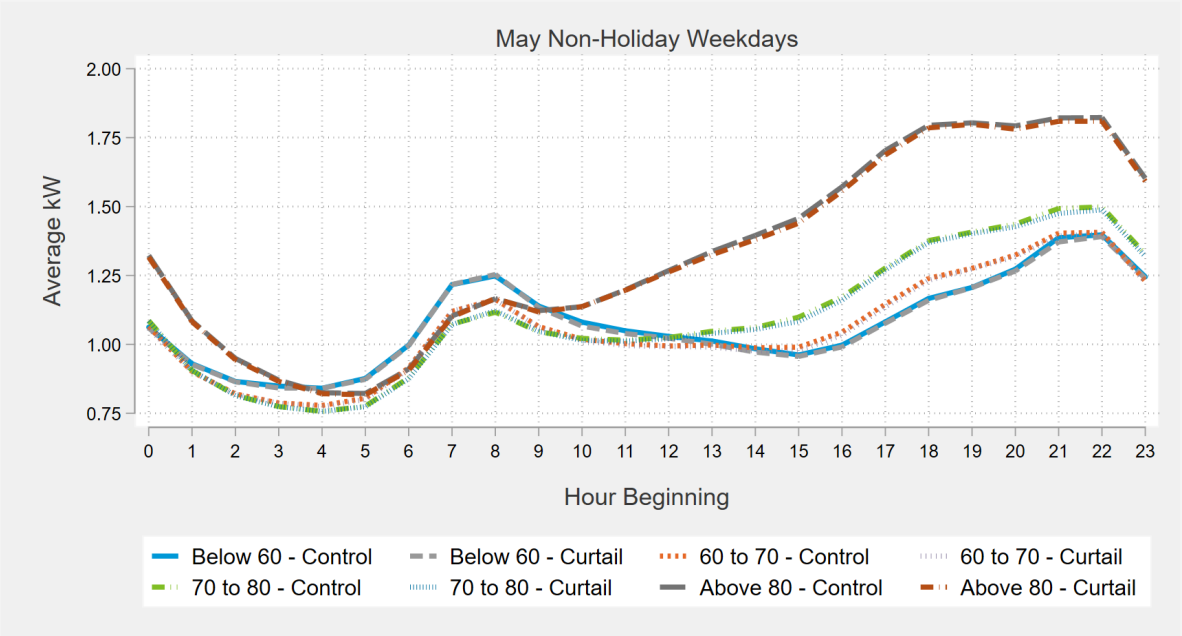


Table 224 shows the relevant regression coefficients (treatment effect by hour and date), participant counts, and aggregate impacts. Note that the regression coefficients nor the aggregate impacts are adjusted for line losses in this table. The practical interpretation of the first regression coefficient in the table (-0.050) is that average demand in the treatment group was about 0.05 kW lower than the average control group load (after controlling for date, time, and the customer-specific usage patterns captured by the lagged variables).

Table 224: Regression Output and Participant Counts

Date	Hour	Coefficient	Participants	Aggregate Impact (MW)
6/13	14	-0.050	30,041	-1.50
	15	-0.072	30,041	-2.16
	16	-0.075	30,041	-2.25
	17	-0.062	30,041	-1.86
7/20	14	-0.045	29,602	-1.33
	15	-0.067	29,602	-1.98
	16	-0.091	29,602	-2.69
	17	-0.097	29,602	-2.87
7/21	14	-0.042	29,588	-1.24
	15	-0.068	29,588	-2.01
	16	-0.034	29,588	-1.01
	17	-0.074	29,588	-2.19

The average impact across the twelve event hours was–1.93 MW. Multiplying this value by Penn Power's line loss multiplier for residential customers (1.0949) yields an average savings estimate of 2.1 MW per event hour. This matches the gross MW value calculated by ADM. That said, the SWE's per-event averages differ slightly. For 6/13, 7/20, and 7/21, the SWE per-event average impacts (adjusted for line losses) are 2.1 MW, 2.4 MW, and 1.8 MW respectively. ADM's per-event average impacts were 2.0 MW, 2.5 MW, and 2.0 MW, respectively. Note that with either set of per-event averages, Penn Power is still comfortably above the 85% threshold for each event and the contribution towards the Phase III DR compliance target across the three events is the same.

G.5.3 Commercial and Industrial

ADM's CBL selection method for C&I participants was thoughtful and relied on non-event day testing. At a minimum, the following CBLs were considered for each participant:

- Linear modeling
- PJM high 4-of-5 with weather sensitive adjustment (WSA) and weekday specific options
- High 6-of-7 with WSA and weekday specific options
- 10-of-10 with WSA and weekday specific options
- 20-of-20 with WSA option

From the list above, the top three CBLs for each participant were selected. The basis for "top three" was the lowest relative root mean square error (RRMSE) on non-event, non-holiday, non-shutdown weekdays. On event days, a weighted average of these three CBL types was used in

creating the actual CBL. The weights, in this case, were equivalent to the inverse squares of the RRMSEs. For a hypothetical event hour, Table 225 provides an illustration.

Table 225: CBL-of-CBLs Illustration

CBL Type	CBL	Non-Event Day RRMSE	Inverse Square of RRMSE	Weight
10-of-10	1,100	7.1%	198.37	35.7%
10-of-10 with WSA	1,200	7.2%	192.90	34.7%
20-of-20	1,300	7.8%	164.37	29.6%

Thus, the CBL-of-CBLs value would be: 1,100*0.357 + 1,200*0.347 + 1,300*0.296 = 1,193.90.

Several of the baseline types ADM considered involved a weather sensitive adjustment (which can be positive or negative). The WSA is a function of three terms: the temperature during the event hour, the average temperature during the same hour across days in the CBL lookback window, and the participant-specific WSA coefficient. Respectively, think of these components as X, Y, and Z. The WSA was then calculated as follows:

$$WSA = Z * (A - B)$$

Regarding the participant-specific WSA coefficient, this value was derived as follows:

- Map each participant to a weather station. Merge weather data in with load data.
- Drop any days outside of the DR season (June – September).
- Drop any holidays, event days, shutdown days, or weekends.
- Keep only event hours (hours ending 15-18).
- Calculate the average load and average temperature during the event window for each day in the data set. Drop any days where the average temperature during the event window is less than 75 degrees (F).
- Using the averages calculated in the previous step, run a simple linear regression model with load as the response variable and temperature as the explanatory variable.

The regression coefficient for the temperature variable is the WSA coefficient.

Using the load and temperature data provided by ADM, the SWE was able to replicate all values that feed into the savings estimate – all WSA coefficients, all WSAs, all interim CBLs, and all CBL-of-CBLs. Table 226 provides a summary of the results.

Table 226: Penn Power C&I DR Audit Summary

Group	Count	Gross MW Impact– ADM	Gross MW Impact– SWE	% of Total Savings
In SWE Sample	5	31.2	31.2	99.7%
Not in SWE Sample	4	0.1	---	0.3%
Total	**9**	**31.3**	**---**	**100%**

Figure 91 shows the load, CBL, and DR impacts (expressed as positive values) for one of Penn Power's largest participants during the DR event on 7/21/2017, and Figure 92 shows the same values for another of Penn Power's largest participants on 6/13/2017. In both cases, the load shed is obvious and the CBL-of-CBLs is very reasonable. One feature that stands out in Figure 91 is the volatility of this site's load throughout the day.

Figure 91: Load, CBL, and Impacts for a Large Industrial Participant

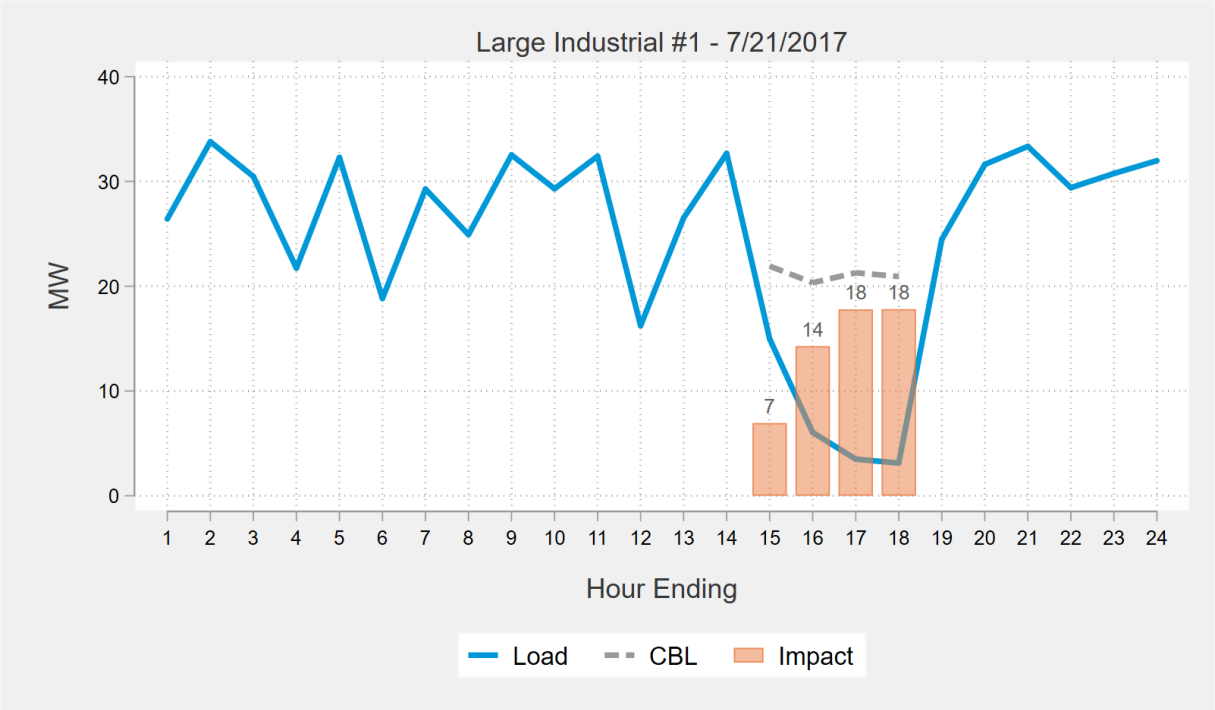
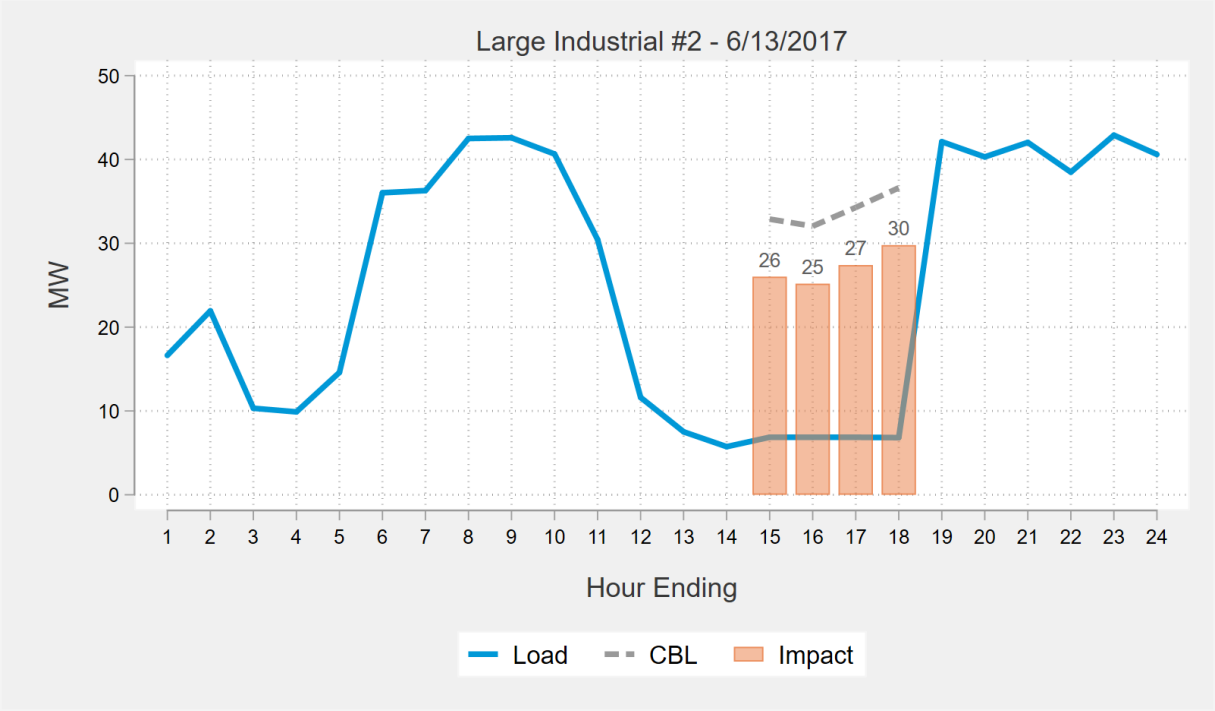


Figure 92: Load, CBL, and Impacts for Another Large Industrial Participant



In the course of our audit, the SWE came across one noteworthy item. Note that this item had no impact on average savings. For one of the participants in our sample, one of the interim CBLs used was the classic PJM high 4-of-5. When calculating this CBL for the events on 7/20 and 7/21, the SWE noticed that the two of the lookback days were tied in terms of average load. Indeed, these two days ranked lower than the other three days in the lookback window. This means that selecting high 4-of-5 would require a "tiebreaker." That said, the average event day savings are the same regardless of which day is kept as a baseline day. Table 227 shows the results. Note that "Actual" values in the table represent what ADM reported, and "Alternate" values represent what would have been if the 4-of-5 tiebreaker fell in the other direction. For any given hour, the actual and alternative savings differ slightly. However, on average, there are no differences.

Table 227: 4-of-5 Tiebreaker Differences

Event Date	Hour	Actual CBL	Actual Savings	Alternate CBL	Alternate Savings
7/20/2017	15	3,896	1,657	3,900	1,661
7/20/2017	16	3,890	1,705	3,889	1,703
7/20/2017	17	3,623	1,427	3,622	1,426
7/20/2017	18	3,602	1,373	3,601	1,373
Average		**3,753**	**1,541**	**3,753**	**1,541**
7/21/2017	15	3,870	1,581	3,874	1,584
7/21/2017	16	3,881	1,634	3,879	1,633
7/21/2017	17	3,632	1,397	3,631	1,395
7/21/2017	18	3,637	1,430	3,636	1,429
Average		**3,755**	**1,510**	**3,755**	**1,510**

G.6 NTG

G.6.1 Residential Programs

Tetra Tech estimated a PY9 NTG for the Appliance Turn-n Program and the New Homes Program. The Direct Install Program and the Energy Efficiency Kits Program NTG were drawn from the PY8 NTG evaluation.

For the Appliance Turn-in Program, Tetra Tech used primary data collection (participant surveys) to estimate NTG. NTG was estimated with the recommended UMP appliance recycling protocol. Tetra Tech measured free-ridership but not spillover due to program design and assigned the average NTG score for about 10% of the sample due to incomplete survey responses (for FE overall, specifics imputation by EDC was not reported).

Tetra Tech assigned the HERs component of the program an 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.

An NTG of 0.6 was applied to the New Homes components of the Program. Tetra-Tech conducted secondary NTG research across six similar programs offered in non-First Energy territories and applied the average of these programs NTG as the New Homes NTG.

For the Residential Energy Efficient Products Program, Tetra Tech applied the NTG from Phase II to all components of the program.

Table 228: Summary of NTG Estimates for Penn Power Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.42	0	0.58	125
Estimated	Upstream Lighting	--	--	0.39	--
PY8	EE Kits	0.21	0.03	0.82	--
RCT	Home Energy Reports	0	0	1	--
PY8	Direct Install			0.82	
Secondary Research	New Homes	--	--	0.60	--
PY8	Upstream Electronics	--	--	0.50	--
PY8	HVAC	--	--	0.56	--
PY8	Residential Appliances	--	--	0.47	--

G.6.2 Low-Income Residential Programs

Tetra Tech assigned LIEEP an NTG of 1, in keeping with the PY9 Evaluation Plan and SWE Phase III Evaluation Framework.

G.6.3 C&I Programs

Tetra Tech did not conduct NTG research in PY9 for Energy Solutions for Small Business Program or for the Energy Solutions for Large Business Program.

The estimated PY8 NTG was applied to the Small Business NTG for the Lighting, Custom, and Prescriptive components. The PY8 and PY9 NTG for these components differ slightly due to the differences in strata weighting between the two efforts.

Tetra Tech evaluated the Residential Appliance Program and estimated it's NTG for PY9 and applied the residential NTG to the small business component.

Tetra Tech was to evaluate the Small Business Direct Install NTG during PY9 but found that the Small Business Direct Install component was solely lighting retrofits. Tetra Tech then reasoned that the Small Business Lighting component NTG should be applied to Direct Install even though the Lighting NTG was based on the PY8 evaluation.

The Energy Solutions for Large Business Program NTG was evaluated in PY8 and these NTG values were then applied to the PY9 NTG. Values of NTG across programs for PY8 and PY9 vary slightly due to the difference in strata weighting in each effort.

Table 229: Summary of NTG Estimates for Penn Power C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Small Energy Solutions for Business Lighting	--	--	0.75	--
PY8	Small Energy Solutions for Business Custom	--	--	0.46	--
PY8	Small Energy Solutions for Business Prescriptive	--	--	0.38	--
PY9 Residential NTG	Small Energy Solutions for Business Appliance Turn-In	--	--	0.58	--
PY8 ESB Lighting NTG	Small Energy Solutions for Business Direct Install	--	--	0.75	--
PY8	Small Energy Solutions for Business Total	--	--	0.73	--
PY8	Large Energy Solutions for Business Lighting	--	--	0.75	--
PY8	Large Energy Solutions for Business Custom	--	--	0.46	--
PY8	Large Energy Solutions for Business Prescriptive	--	--	0.38	--
PY8	Large Energy Solutions for Business Total	--	--	0.67	--

G.7 TRC

Table 230 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for Penn Power's PY9 individual programs and overall portfolio. The SWE found no major inconsistencies between the TRC model outputs and the TRC results shown in the PY9 annual report.

The primary differences for the PY9 TRC from the previous program year are the inclusion of fossil fuel and water saving benefits under the Total NPV Lifetime Non-Electric Benefits and two C&I demand response programs.

Table 230: Summary of Penn Power's PY9 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	434	261	1.66	252	261	0.96
Energy Efficient Homes	4,266	2,817	1.51	3,406	2,508	1.36
Energy Efficient Products	5,175	2,379	2.17	2,054	1,160	1.77
Low-Income Energy Efficiency	865	1,265	0.68	865	1,265	0.68
C&I Energy Solutions for Business– Small	5,873	4,876	1.20	4,271	3,624	1.18
C&I Energy Solutions for Business– Large	4,788	3,898	1.23	3,172	2,707	1.17
Governmental & Institutional Tariff	194	223	0.87	146	176	0.83
C&I Demand Response Program – Small	16	10	1.59	16	10	1.59
C&I Demand Response Program – Large	2,641	493	5.35	2,641	493	5.35
Portfolio Total	**24,252**	**16,224**	**1.49**	**16,823**	**12,203**	**1.38**

Of Penn Power's nine energy-efficiency programs offered, seven were found to be cost-effective and two were non-cost-effective using gross verified savings. Using net verified savings, six were found to be cost-effective and three were non-cost-effective.. The Appliance Turn-in program was cost-effective using gross verified savings, but non-cost-effective using net verified savings. The C&I Demand Response – Small and – Large programs were new programs in PY9 and were found to be cost effective. 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
- C&I Demand Response Program – Small
- C&I Demand Response Program– Large

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
- C&I Demand Response Program – Small
- C&I Demand Response Program– Large

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

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

- Low-income Energy Efficiency
- Governmental & Institutional Tariff
- Appliance Turn-in
- Low-income Energy Efficiency
- Governmental & Institutional Tariff

G.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- Penn Power's annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broader peak definition than Act 129 peak hours defined in the 2016 TRM. The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions.
- 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 TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. The SWE verified that the savings were accounted for in accordance to the Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test. The TRC model claimed 13,733 thousand gallons of water saved or approximately $909,000 in avoided costs.
- 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 231 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 231: Penn Power Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.49	1.38
Without Dual Baseline	1.65	1.46

- The SWE verified that the demand response program TRC ratio meets the 75% participant cost assumption where 75% of customer incentive payment is used as a proxy for participant cost.
- In PY8, the SWE recommended the Programmable Thermostat EUL be updated from 11 to 15 in PY9 reporting. The PY9 TRC model completed this update.

The SWE noted a minor issue pertaining to the implementation of the TRC model. The avoided cost of distribution capacity should not be applied to participants who take service at primary voltage. The SWE recommends breaking out transmission and distribution avoided costs and accounting for only generation capacity and transmission avoided costs when calculating large C&I demand response program benefits in future year reporting.

G.8 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

FirstEnergy's evaluation contractor, ADM Associates, prepared a single, comprehensive evaluation plan for the four FirstEnergy EDCs that addressed evaluation activities for all of Phase III. In PY9 the ADM team submitted a sampling memo for the C&I DR program, which the SWE reviewed and approved with minor comments and suggestions.

In addition to reviewing FirstEnergy's sampling memo, the SWE reviewed two survey instruments, one for appliance retailers and one for the C&I DR program participants.

H.2 Sample Design Review

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

The Phase III Evaluation Framework established a maximum allowable level of sampling uncertainty of ± 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 due program delivery channel or supported technology.

Grouping projects by equipment type and program delivery method leads to more meaningful evaluation results than tariff-based program definitions, each of which would include the same mix of measures. This evaluation strategy also makes sample design more efficient because the same projects are more likely to share similar characteristics across rates classes (i.e., Small C&I, Large C&I, and Government) than a heterogeneous mixture of measures within a single class. For example, projects from West Penn Power's 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 (No projects approved in PY9)

ADM established a series of initiatives and designed the impact evaluation samples for each to meet the 85/15 precision requirement. Table 232 lists each initiative and the corresponding relative precision of the PY9 gross verified savings estimate for all initiatives that include sampling uncertainty.

Table 232: Relative Precision of WPP PY9 Gross Verified Energy Savings Estimates by Sampling Initiative

Initiative	Relative Precision at 85% Confidence Level (±)
Residential Appliance Turn-In (ATI)	6.5%
Low-Income ATI	9.2%
C&I ATI	10.8%
Res EE Kits	3.9%
Low-Income EE Kits	11.6%
Res Direct Install	9.9%
Low-Income Direct Install	10.5%
Res Upstream Lighting	10.0%
Res Upstream Electronics	0.0%
Res HVAC	12.2%
Residential Appliances	13.0%
Low-Income Appliances	32.3%
Residential New Construction	7.0%
C&I Lighting	15.1%
C&I Custom	3.6%
C&I Prescriptive	10.8%

With the exception of the C&I Lighting and the Low-Income Appliances Initiative, each of the sampling initiatives shown in Table 232 produced verified gross savings estimates of better than ±15% precision at the 85% confidence level. C&I Lighting is close to the threshold and now additional information is provided as to why it did not meet the target. ADM notes that the relative precision for the LI Appliances Initiative was high due to realization rates far above 100% for clothes washers and heat pump water heaters. They attribute the large realization rates to conservative ex-ante values for those appliances.

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 PY9 verification activities is discussed in detail in Appendix H.4.

The Behavioral Modification subprogram provides home energy reports to residential customers in the West Penn Power service territory. The subprogram is divided between standard residential customers and Low-Income customers and each is administered as a randomized control trial

(RCT). Participants are enrolled in experimental cohorts and a monthly billing analysis regression is the used to calculate savings. All program participants are included in the regression model so there is no sampling error. There is estimation error that results because a regression model is not able to fully capture the variation present in the data. Precision requirements for behavioral program are unique, with The Phase III Evaluation Framework requiring the solution-level verification achieve an *absolute* precision of ±0.5% at the 95% confidence level (two-tailed). Table 233 shows the absolute precisions of the behavioral program components.

Table 233: Absolute Precisions of WPP PY9 Behavioral Subprogram Gross Verified Energy Savings Estimates

Stratum	Absolute Precision at 95% Confidence Level (±)
Residential	0.14%
Low-Income	0.54%

Demand Response programs offered by the West Penn Power in PY9 include Demand Response C&I – Small and Demand Response C&I – Large. Starting in PY10 West Penn Power will also offer a Behavioral Demand Response Program to residential customers. Gross impact evaluations for the C&I Demand Response Programs do not rely on sampling but instead consist of establishing a customer baseline load (CBL) for each program participant. The estimation error present in establishing these baselines yields a relative precision of ±38% at the 90% confidence level for both the small and large programs.

H.3 Reported Gross Savings Audits

H.3.1 Tracking Data Review

This section of the memo summarizes the SWE's assessment of the reported gross savings, participation counts, and incentives reported in West Penn Power's PY9 Annual Report. Specifically, the values we examined are:

- Reported gross energy savings (MWh) for each program,
- Reported gross peak demand savings (MW) for each program,
- Participation for each program, and
- Incentive dollars for each program.

The SWE leveraged West Penn Power's Q1-Q4 tracking data to audit these values. Note that the SWE does not receive the full tracking data set, rather a subset of the full tracking data set tailored to our PY9 quarterly data request. Also note that demand response (DR) or home energy report (HER) programs are not audited using the tracking data, thus they are not included in the tables or totals in the following sections. The SWE's findings regarding West Penn Power's demand response programs can be found in Appendix H.5, and our findings regarding the HER components of the Energy Efficient Homes and Low-Income Energy Efficiency programs can be found in Appendix H.4.1.3.

Table 234 summarizes the SWE's ex-ante findings regarding energy savings. The 'Match' column contains 'Yes' if the tracking data supports the values in West Penn Power's PY9 Annual Report and 'No' otherwise. For each program, the SWE was able to replicate the values reported by West Penn Power.

Table 234: MWh Savings by Program

Program	Annual Report MWh	Tracking Data MWh	Match
Appliance Turn-in	5,884	5,884	Yes
Energy Efficient Homes	21,332	21,332	Yes*
Energy Efficient Products	27,051	27,051	Yes
Low-Income Energy Efficiency	9,426	9,426	Yes*
C&I Energy Solutions for Business – Small	31,549	31,549	Yes
C&I Energy Solutions for Business – Large	41,790	41,790	Yes
Governmental & Institutional Tariff	9,426	9,426	Yes
Portfolio Total	**146,458**	**146,458**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 235 summarizes the SWE's review of reported gross peak demand savings by program. The SWE's records matched West Penn Power's reported peak demand savings for all seven programs. Note a difference of 0.01 MW for the Energy Efficient Homes program – this can likely be attributed to rounding.

Table 235: MW Savings by Program

Program	Annual Report MW	Tracking Data MW	Match
Appliance Turn-in	0.76	0.76	Yes
Energy Efficient Homes	2.96	2.97	Yes*
Energy Efficient Products	3.72	3.72	Yes
Low-Income Energy Efficiency	0.74	0.74	Yes*
C&I Energy Solutions for Business – Small	4.43	4.43	Yes
C&I Energy Solutions for Business – Large	4.95	4.95	Yes
Governmental & Institutional Tariff	0.02	0.02	Yes
Portfolio Total	**17.58**	**17.58**	**Yes***

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Table 236 summarizes the SWE's ex-ante findings regarding program participation. For three of the seven programs, the SWE was able to replicate West Penn Power's participation count. For two other programs, the SWE's count differed from West Penn Power's count by fewer than three participants.

For the two remaining programs, the SWE calculated directionally similar participant counts. Note that these two programs both have HER components – the counts for those programs are not included. The values shown in the "Annual Report Participants" for those two programs represent the difference between the value for the full programs (inclusive of the HER components) and the maximum number of treatment group homes active in the HER program during PY9. The difference between the SWE and FirstEnergy participant counts for the Low-Income Energy Efficiency program is likely a function of the counting logic for accounts that participate more than once within a given program year.

Table 236: Participation by Program

Program	Annual Report Participants	Tracking Data Participants	Match
Appliance Turn-in	5,500	5,500	Yes
Energy Efficient Homes	61,791	59,036	No*
Energy Efficient Products	317,480	317,479	No
Low-Income Energy Efficiency	8,016	12,327	No*
C&I Energy Solutions for Business – Small	789	789	Yes
C&I Energy Solutions for Business – Large	126	126	Yes
Governmental & Institutional Tariff	302	301	No
Portfolio Total	**394,004**	**395,558**	**No**

*The Energy Efficient Homes and Low-Income Energy Efficiency programs have HER components that are not represented in this table.

Finally, Table 237 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 calculate directionally similar (but not always equal) incentive dollars for six of the seven programs. For these six programs, the portfolio totals are very similar – $6,173,000 in the Annual Report and $6,179,000 in the tracking data.

For the remaining program – EE Homes – West Penn Power's Annual Report and the tracking data disagree by a large margin. In part, this may 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. That said, the difference ($2,785,000) is quite a bit larger than the amount West Penn Power had earmarked for EE kits in their PY9 EE&C plan ($1,020,000).

Table 237: Incentives by Program ($1,000)

Program	Annual Report Incentives	Tracking Data Incentives	Match
Appliance Turn-in	$308	$307	No
Energy Efficient Homes	$3,260	$469	No
Energy Efficient Products	$1,832	$1,941	No
Low-Income Energy Efficiency	$99	$91	No
C&I Energy Solutions for Business – Small	$1,665	$1,573	No
C&I Energy Solutions for Business – Large	$1,787	$1,795	No
Governmental & Institutional Tariff	$482	$472	No
Portfolio Total	**$9,433**	**$6,648**	**No**

H.3.2 Project File Reviews

H.3.2.1 Residential

As part of the reported savings (i.e., ex-ante) review, the SWE conducted a project file review of a sample of West Penn Power's residential project files for PY9 using the project file documentation provided by West Penn Power, the program implementors, and the evaluation contractor, ADM. This is in response to the SWE's standing quarterly data request. The project file packages included rebate applications, equipment invoices, equipment specification sheets, and post-inspection forms. Most of the project file packages that were uploaded included a majority of the documentation requested. Initially, project file documentation was not provided for the Low-Income WARM program for quarters 3 and 4but was later provided by ADM upon request.

Table 238 presents a summary of SWE's residential project file reviews. In addition to verifying that documentation was present and corresponded accurately with the quarterly tracking data, the SWE conducted a review of the sampled project files to verify that correct values and algorithms from the Pennsylvania TRM were applied to the reported savings. The evaluator, ADM, was cooperative in working with the SWE on questions and comments as the ex-ante review took place and were able to clarify that all issues arising from this review were addressed during verified savings calculations.

Table 238: West Penn Power PY9 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?[1]
Appliance Turn-in Program	Appliance Turn-in Program	28	✓	✓	✓	✓
Energy Efficient Homes Program	School Education	3	✓	✓	✓	✓
Energy Efficient Homes Program	EE Kits	3	✓	✓	✓	✓
Energy Efficient Homes Program	Audits	3	✓	✓	✓	✓
Energy Efficient Homes Program	New Homes	24	✓	✓	✓	✓
Energy Efficient Products Program	Appliances and Electronics	28	✓	✓	✓	✓
Energy Efficient Products Program	Lighting	24	✓	✓	✓	✓
Energy Efficient Products Program	HVAC	24	✓	✓	✓	✓
Low-Income Energy Efficiency Program	Weatherization	12	✓	✓	✓	✓

*The number of files reviewed reflects the total number for all First Energy EDCs.

As detailed above, the requested number of project files and supporting details were submitted for the residential programs. Below is a summary of the project file reviews, including issues or discrepancies found between the project file packages and quarterly tracking data.

HVAC

The HVAC project files typically matched the quarterly tracking data; however, the SWE found one discrepancy in the heating and cooling capacity between the sampled project files and tracking data.

- For heat pump projects, the TRM requires separate inputs for heating and cooling capacity to calculate savings. In the tracking data, capacity was displayed as a singular 'tons' variable.[101]

The evaluator, ADM, worked with the SWE to clarify this discrepancy. Their approach is to use single point estimates for these values for the reported ex-ante savings, and to then pull the heating and cooling capacities directly from the AHRI database and other independent sources during the verified savings calculations.

Upstream Lighting

The Upstream Lighting files matched the tracking data; however, a discrepancy between the tracking data and the TRM equation was observed.

- In the TRM, the base wattage variable for specialty bulbs is dependent on bulb shape and lumen range; however, the tracking data did not break out bulb shape enough to make this determination.[102]

ADM again worked with the SWE to clarify this issue. This is corrected during the verified savings calculations, which are entirely independent from these ex-ante calculations. The model numbers are used to pull in all bulb information, including specific shape, from a compiled database, primarily using ENERGY STAR data.

Appliances

The Appliance files typically matched the tracking data, but the SWE had a question about the reported savings.

- Reported ex-ante savings were based on TRM defaults values despite the EDC collected data for those values being available.

ADM confirmed that defaults are used at the ex-ante level, but the model specific TRM values are used in verified savings calculations.

Low-Income WARM

Project files for the Low-Income WARM program typically matched the tracking data for Q1 and Q2. However, the SWE noticed that project files were not provided initially for Q3 and Q4.

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[101] For example, for a mini split project, the heating capacity might be 12k BTU, and the cooling capacity 9k BTU, but this would appear in a single 'tons' variable as 12k BTU in the tracking data. As noted, ADM reported that this is corrected in the verified savings calculations.

[102] For example, a specialty bulb at 500 lumens could have a base wattage of 40, 45, 60, or 65 depending on the shape, but there is no way to tell which value should be used without more specific shape categories being used. ADM confirmed that this is addressed in the verified savings calculations.

ADM was notified of this and quickly provided a sample of project files for these quarters, and no discrepancies were found.

H.3.2.2 Non-Residential

The SWE reviewed West Penn Power's C&I projects for PY9 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, equipment invoices, and equipment specification sheets. Most of the project file packages included all documentation requested. For lighting projects, West Penn Power's ICSP uses their own lighting calculator. In PY9, the inputs to the ICSP's lighting calculators were also transcribed into the Appendix C lighting calculator.

Project files were generally well organized, complete. A number of minor issues were noted, as presented in Table 239.

Table 239: West Penn Power PY9 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?
FESPPS1534492169	Lighting	✗	✓	✓	✓	✓	-
FESPPS1534687519	ECM Motors	✓	✓	✗	✓	-	✗
FESPPS1534444779	Lighting	✓	✓	✓	✓	✓	-
FESPPS1534484282	Street Lighting	✗	✓	✓	✓	✓	-
FESPPS1535190524	Kitchen Equipment	✓	✓	✓	✓	✓	-
FESPPS1535190459	Lighting	✓	✓	✓	✓	✓	-
FESPPS1536122782	Office Equipment	✓	✓	✓	✓	✓	-
FESPPS1537129860	ECM Motors	✓	✓	✓	✓	-	✗
FESPPS1537130453	Kitchen Equipment	✓	✗	✓	✓	✗	-
FESPPS1537734576	Lighting Controls	✓	✓	✓	✓	-	✓
FESPPS1537882884	Kitchen Equipment	✓	✓	✗	✓	✗	-
FESPPS1537731912	Lighting	✓	✓	✓	✓	✓	-

Specific issues noted during the project file review process are addressed individually by project below.

Street lighting project FESPPS1534484282 and lighting project FESPPS1534492169774 did not include an Appendix C lighting calculator. However, the ICSP's calculator appeared to be following TRM methodology for the project.

Project FESPPS1534687519 for ECM motors in refrigeration equipment had several errors in the savings algorithm. The savings calculation included five motors, while the invoice and spec sheets indicated six motors were affected. Additionally, one of the motors was listed as 1/3 HP whereas the spec sheets listed it as 1/15 HP. Finally, the reported savings were calculated using shaded pole motors as the baseline. The project was a 'replace on burnout' retrofit, so PSC moors should have been used as the baseline. Project FESPPS1537129860 was a similar ECM motor measure where a SP baseline was used when PSC would be more appropriate.

Project FESPPS1537882884 included an error in the tracking database. Tracking data showed savings for three new refrigerators and three freezers. The project invoice and savings calculation were for only two refrigerators and three freezers. Additionally, the baseline change relevant to PY9, as defined in the TRM, was not incorporated into the savings calculation.

The process by which the ICSP's calculators are transcribed into the Appendix C calculator preserves much of the Appendix C functionality but does overwrite some functions. Baseline fixture wattage lookups are preserved. Hours of operation, coincidence factors, and interactive factors are directly transcribed from the ICSP's calculator in a manner that overwrites the formulas built-in to the Appendix C calculator. For future years, the ICSP and the evaluator should consider improving the transcription process so that these parameters are calculated directly by the Appendix C calculator as intended.

Additionally, calculators submitted for prescriptive measures are locked. Worksheet and cell permissions could be modified to allow the SWE to view inputs and algorithms in the calculator. This would facilitate more thorough project reviews and evaluations in the future.

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 Penn Power portfolio of residential programs. West Penn 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 evaluation details differ or where the SWE audits determined that certain subprograms showed discrepancies not shared by others in a program). Note that the SWE reports residential savings in 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 240 provides a summary of the evaluation and M&V approaches used by West Penn Power in their PY9 verified savings calculations. Note that the SWE adjusted verified savings in the PY9 Annual Report due to overestimated savings for the Upstream Lighting program but that the discrepancy is less than 1% of portfolio savings and can be corrected in EDC reporting beginning in PY10.[103]

Table 240: Residential Program Evaluation Activities – West Penn Power

Program/ Subprogram	Surveys	Site Visits	Desk Review[a]	Billing Analysis	Applied PY8 RR
Appliance Turn-In					
Appliance Turn-in (LI & Non-LI)	✓	--	✓	--	--
EE Homes					
EE Kits	✓	--	✓	--	--
EE Kits- Low-Income	✓	--	✓	--	--
Home Energy Reports	--	--	✓	✓	--
Residential Direct Install	✓	--	✓	--	--
Residential New Construction	--	✓	✓	--	--
Upstream Lighting					
Upstream Lighting	✓	--	✓	--	--
EE Products					
Upstream Electronics	--	--	✓	--	--
HVAC	✓	--	✓	--	--
Appliances	✓	--	✓	--	--
Appliances- Low-Income	✓	--	✓	--	--
Low-Income WARM					
Low-Income WARM-Extra Measures	--	✓	✓	✓	--
Low-Income WARM-Multifamily	--	✓	✓	✓	--
Low-Income WARM-Plus	--	✓	✓	✓	--

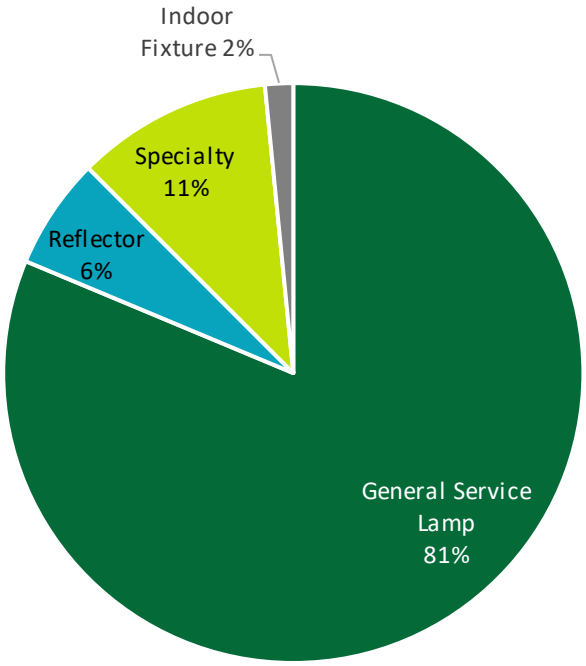
[a] The Desk Review column includes: database reviews, application reviews, and/or engineering desk reviews.

[103] 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.

H.4.1.1 Upstream Lighting & Cross-Sector Sales

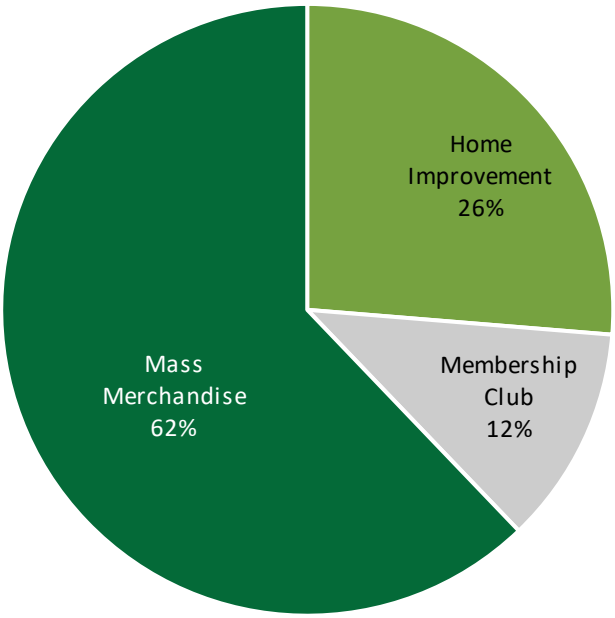
Customers purchased over 800 thousand efficient light bulbs and fixtures through West Penn Power's PY9 upstream lighting program. Figure 93 displays the distribution of sales by product type. Over four-fifths (81%) of the products were general service lamps.

Figure 93: West Penn Power PY9 Upstream Lighting Sales by Product Type



Over one-half (62%) of West Penn Power's PY9 upstream light bulbs and fixtures were sold through mass merchandise stores, while around one-quarter (26%) were sold through home improvement stores (Figure 94).

Figure 94: West Penn Power PY9 Upstream Lighting Sales by Retail Channel



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 generally agrees with ADM's verified gross savings for the Upstream Lighting Initiative but has adjusted verified savings for the errors detailed below.

The SWE observed 480 unique lighting model numbers in the PY9 tracking system and was able to locate 475 of these model numbers in the ENERGY STAR certified products lists for light bulbs and light fixtures. The five models the SWE was not able to verify as ENERGY STAR certified represent 0.1% 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 URLs ADM provided and found that they aligned for most models. The team observed minor discrepancies in efficient product description, wattage, and/or lumens for two of the models, but it is unclear if these discrepancies are due to rounding, errors in the PY9 tracking system, errors in the ENERGY STAR certified products lists, or product changes. 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 one model, resulting in verified savings being overestimated by 44 MWh. The impact of the discrepancies the SWE identified on portfolio-level savings is minor, less than 0.1%.

Cross-Sector Sales

ADM did not conduct cross-sector sales research in PY9. ADM applied the PY8 cross-sector sales estimate of 8.3% to PY9 sales.

Recommendations

The SWE does not have any recommendations based on its review of the PY9 upstream lighting analysis. However, the following recommendation from the PY8 SWE report regarding cross-sector sales research still stands:

- 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 minor issues that caused a negligible difference in savings, detailed below.

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 H.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 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 dishwashers, resulting in a negligible increase in savings.[104] The SWE recommends applying the correct TRM algorithm inputs to more accurately capture 2016 TRM savings in future years.

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 H.4.1.1 of this appendix.

Analysis files and data sets included in the gross impact data were reviewed for all HVAC, appliance, and consumer electronics measures included in the program. The SWE found that in all cases the correct TRM vales and algorithms were used, the verified savings were correct, and

[104] ADM used a default energy savings of 29.4 kWh per year for non-electric (gas) water heating but the 2016 TRM default is 26.4 kWh (Table 2-90 of the 2016 TRM).

the savings and sample sizes included in the annual request data matched those reported in the PY9 annual report.

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.

Appliance Turn-In Program (Low-Income and Non-Low-Income)

The SWE performed audits on all measures included in the Appliance Turn-In Program, including dehumidifiers, refrigerators and freezers, and room air conditioners. Overall, the SWE concluded that the proper TRM algorithms and protocols were used, and that verified savings were correct. Sample sizes in the annual request data did not match the achieved sample sizes included in the annual report.

H.4.1.3 Behavior

Approximately 18% of West Penn Power's verified gross energy savings for PY9 came from Home Energy Reports issued to around 176,000 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 PY9. By cohort, Table 241 shows average kWh savings and average percent savings per participant in PY9. Note that the 'Number of Participants' column shows the average number of participants during PY9.

Table 241: Average PY9 kWh Savings per Participant

Sector	Cohort Start Date	Number of Participants	Average PY9 kWh Savings	Average PY9 % Savings
Low-income	June 2012	11,245	212	1.35%
Residential	June 2012	114,942	193	1.28%
Low-income	January 2014	4,121	232	1.71%
Residential	January 2014	17,870	329	1.81%
Residential	December 2014	27,636	123	0.92%

The following sections highlight some of the more important audit steps and findings: the calendarization of billing data, group equivalence, duplicating participant counts, the calculation of lag terms, missing eligibility filters, and energy and demand savings.

Calendarization

The first step the SWE took was to review ADM's calendarized data. "Calendarization" is a process that prorates billing data into a common calendar month basis shared by all accounts. Our review of the calendarized data had three primary components:

- Check the coding of the "pre" and "post" indicator variables;
- Confirm that the calendarized average daily usage values are correct; and
- Confirm that the lag terms (average usage in the pre-period, average summer usage in the pre-period, average winter usage in the pre-period) are correct.

Our team found no issues in the coding of the pre and post indicator variables. Table 242 shows summary statistics calculated for ADM's calendarized data and the SWE's calendarized data.[105] The distribution of average daily kWh is basically identical in the two data sets.

Table 242: Comparison of Calendarized Data

Variable	Mean	5th Percentile	25th Percentile	75th Percentile	95th Percentile
Average Daily kWh – ADM	42.93	17.90	27.66	51.89	87.79
Average Daily kWh – SWE	42.93	17.90	27.66	51.90	87.73

Regarding the lag terms, the SWE found that ADM's calculations were sound. ADM did not calculate summer or winter lag terms in cases where pre-period summer or winter data did not exist. Because we found no issues with ADM's calendarized data, the figures, tables, and summary statistics presented herein were created or calculated using ADM's calendarized data rather than our own.

Group Equivalence

After reviewing the calendarization, the SWE compared average daily consumption (kWh) between the treatment and control groups during the pre-treatment period. Table 243 shows the results for each cohort. Note that calendarized data was used to calculate the averages and any customer without at least 12 month of pre-treatment data was dropped. To avoid comparing averages calculated over different time spans (e.g., 14 months and 12 months), averages within each month were calculated before calculating overall averages for each customer. The 'P-value' column indicates the likelihood that the observed differences could happen by chance if the two experimental cells use the same amount of energy, on average. A p-value less than 0.05 indicates that the difference in average consumption between the two groups is statistically significant.

[105] The table only summarizes records that were in both the ADM and SWE data sets. A small percentage of account/month combinations from the ADM data set were not in the SWE data set, but the majority of these were June 2018 records (PY10) that the SWE dropped.

One cohort was found to have statistically significant pre-treatment differences between the treatment and control groups – the Low-income June 2012 cohort. That said, the SWE believes that the model being used to estimate savings (lagged seasonal) accounts for this difference.

Table 243: Group Equivalence in the Pre-Period

Sector	Cohort Start Date	Average Daily kWh – Control	Average Daily kWh – Treated	P-value
Low-income	June 2012	45.3	44.2	0.01
Residential	June 2012	43.5	43.5	0.70
Low-income	January 2014	39.7	39.8	0.84
Residential	January 2014	53.7	53.8	0.76
Residential	December 2014	38.7	38.7	0.89

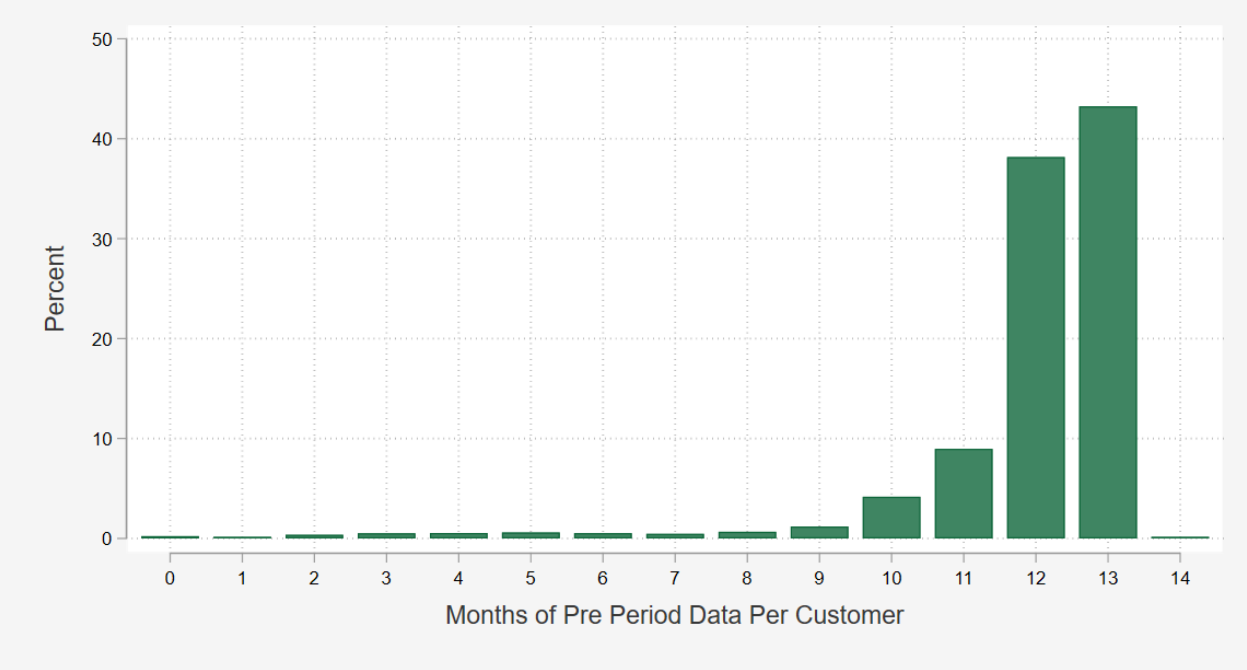
Participation Counts

The SWE leveraged the raw, un-calendarized billing data to audit participant counts. Because billing cycles can exceed 31 days in length (meaning bill dates can occasionally skip over a month), the SWE calculated the number of unique IDs beyond a certain bill 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 2018. We removed any records with a billing end date prior to 3/1/2018, then counted the number of unique IDs in the remaining records. Using this method, we calculated participant counts that matched the reported counts.

Eligibility Filters

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 95 shows the distribution of the number of months of pre-period data per customer. Across all West Penn Power cohorts, 18.4% of homes had less than 12 months of pre-period data.

Figure 95: 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 12 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 (used in the lagged seasonal model specification) be calculated? For a given customer, suppose there is only one month of pre-period summer usage. Should the lagged summer variable (average daily consumption during summer months in the pre-period) be based on that lone summer month? Or should it be treated as a missing value?

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. For PY10, the SWE recommends West Penn Power investigate homes with less than 12 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 12 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: 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.)

Impact Coefficients and Energy Savings

The SWE performed savings calculations using two approaches. First, in an effort to replicate ADM's savings values, we ran the LS model without filtering out homes with less than 12 months of pre-period data. Next, the SWE dropped any participant without at least 12 months of pre-period data and re-ran the LS model for each cohort. On average, the two methods produced similar impacts (in magnitude). Impact 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 244 shows impact estimates for each cohort. Note that a different impact estimate was calculated for each month in PY9 – the estimates shown in the table reflect the averages of the PY9 monthly estimates (weighted by month duration). Using the first impact estimate as an example, the practical interpretation is as follows: treatment group homes in the low-income July 2012 cohort saved 0.13 kWh per day, on average, during PY9.

Table 244: Impact Coefficients

Sector	Cohort Start Date	Impact Estimate (kWh saved per home per day)	Impact Estimate – At least 12 Months of Pre
Low-income	June 2012	-0.13	-0.08
Residential	June 2012	-0.59	-0.57
Low-income	January 2014	-0.65	-0.78
Residential	January 2014	-0.93	-0.94
Residential	December 2014	-0.34	-0.27

Table 245 shows ADM's and the SWE's aggregate energy savings (MWh) for each cohort. On aggregate, the SWE's savings estimate was approximately 1,476 MWh less than ADM's estimate. The biggest differences were for two of the residential cohorts – June 2012 and December 2014 (-903 MWh and–737 MWh, respectively). As noted, the SWE approves of ADM's MWh and MW savings estimates as the behavioral protocol of the Evaluation Framework did not mandate that only accounts with at least 12 months of pre-period data could be used in a billing analysis.

Table 245: Energy Savings Comparison

Sector	Cohort Start Date	ADM MWh Savings	SWE MWh Savings	Difference (SWE – ADM)
Low-income	June 2012	2,387	2,289	–97
Residential	June 2012	22,144	21,241	–903
Low-income	January 2014	957	1,121	164
Residential	January 2014	5,876	5,974	98
Residential	December 2014	3,388	2,650	–737
Total		**34,751**	**33,275**	**–1,476**

Demand Savings

As with energy savings, the SWE's audit of HER demand savings involved two primary steps. First, we replicated ADM's calculations, then we substituted our own regression coefficients (based on homes with at least 12 months of pre-period data) into ADM's calculations. The results, which mirrored the results for energy savings, are shown in Table 246. On aggregate, the SWE method resulted in a decrease of 0.16 MW in demand savings.

Table 246: Demand Savings Comparison

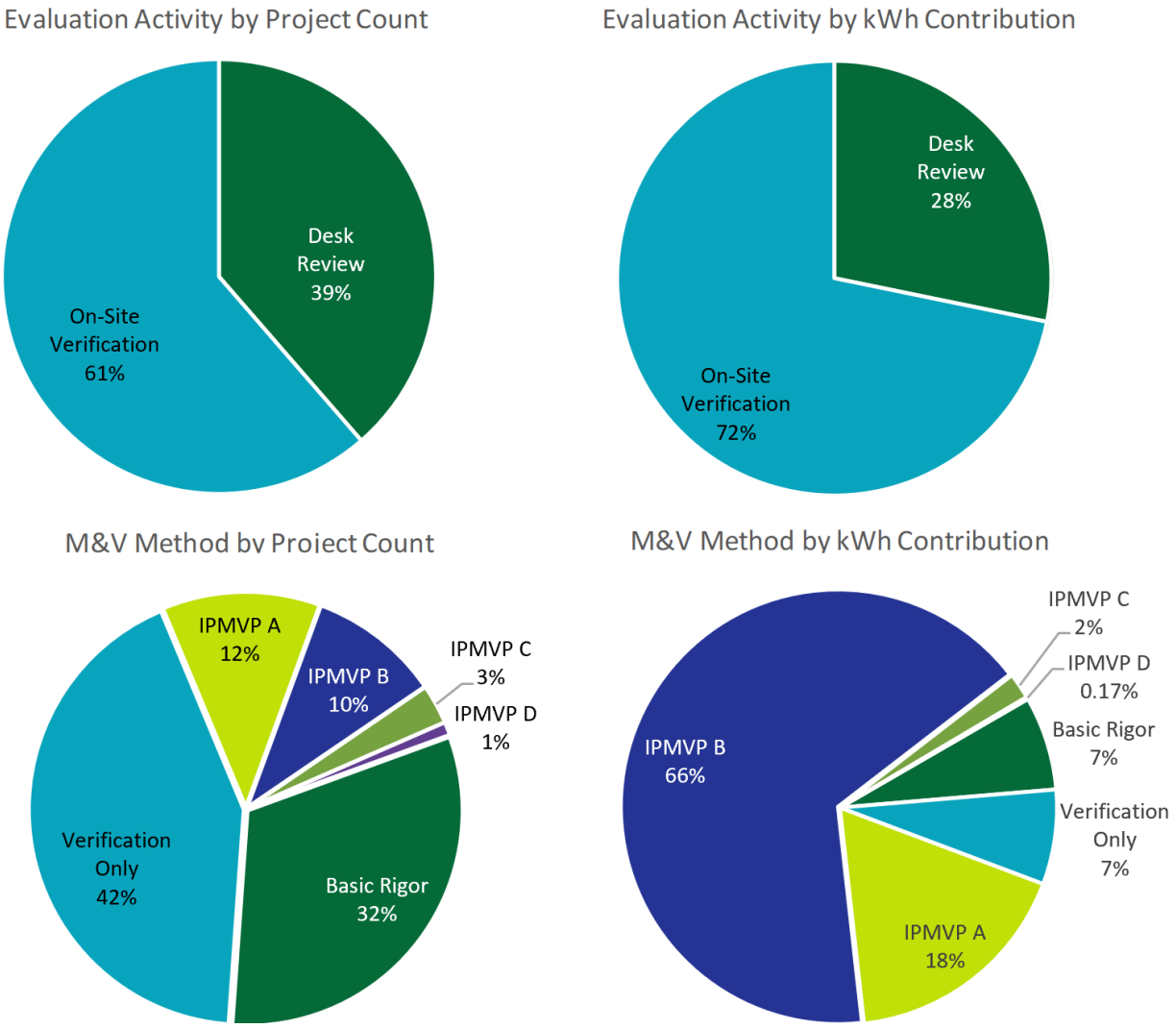
Sector	Cohort Start Date	ADM MW Savings	SWE MW Savings	Difference (SWE – ADM)
Low-income	June 2012	0.27	0.25	–0.01
Residential	June 2012	2.46	2.37	–0.09
Low-income	January 2014	0.11	0.13	0.02
Residential	January 2014	0.67	0.68	0.01
Residential	December 2014	0.37	0.29	–0.08
Total		**3.88**	**3.72**	**-0.16**

In reviewing ADM's methodology, we noted one minor issue. This issue concerns Step 3 of their demand savings calculation, which posts that demand savings will be estimated as a function of three 8760 load shapes: heat pumps, interior lighting, and flat (1/8760 for every hour). In the R code ADM provided, the noted regression model does not include the 'flat' end use. If the flat term had been included, total MW savings for West Penn Power would be 3.01 MW rather than 3.88 MW. For PY10, we would recommend either (1) updating the narrative in the annual report so that the flat end use is not included, or (2) updating the analysis to include the flat end use.

H.4.2 Non-Residential Audit Activities

Figure 96 provides a summary of the evaluation activities and M&V approaches utilized by West Penn Power's evaluation contractor in their PY9 verified savings calculations, summarized by total evaluated project counts and separately by energy savings contribution. For PY9, West Penn Power's evaluation contractor completed site visits to 61% of projects, and these projects represented 72% of total evaluated energy savings. A total of 62 site visits were conducted. IPMVP Option B was employed for the majority (66%) of total evaluated energy savings. Basic Rigor (desk review without a site visit) was employed for appliance recycling projects, a small selection of lighting projects, and two prescriptive projects.

Figure 96: Summary of West Penn Power's C&I Evaluation Activities



West Penn Power's evaluation contractor conducted sampling within defined evaluation initiatives. Measures across West Penn Power's C&I programs are assigned to one of five evaluation initiatives, as West Penn Power's programs target specific sectors of C&I customers, but offerings are often identical across the programs. Table 247 provides a summary of the evaluation activities and M&V approaches West Penn Power's evaluation contractor used across strata for all projects by initiative.

Table 247: Summary of West Penn Power's PY9 C&I Evaluation Activities by Initiative

Initiative / Strata	Sample Quantity	RR	Basic Rigor	On-Site Verification Only	IPMVP A	IPMVP B	IPMVP C	IPMVP D
Appliance Turn-In	**22**	**84%**	**22**	**0**	**0**	**0**	**0**	**0**
Appliance Recycling-1	22	84%	22	0	0	0	0	0
Custom	**18**	**94%**	**0**	**4**	**0**	**10**	**3**	**1**
Custom-1	7	80%	0	3	0	3	0	1
Custom-2	6	65%	0	1	0	3	2	0
Custom-Certainty	5	100 %	0	0	0	4	1	0
Lighting	**31**	**116 %**	**8**	**11**	**12**	**0**	**0**	**0**
Lighting-1	5	98%	1	4	0	0	0	0
Lighting-2	12	128 %	2	5	5	0	0	0
Lighting-3	9	110 %	4	1	4	0	0	0
Lighting-Certainty	5	99%	1	1	3	0	0	0
Prescriptive	**30**	**66%**	**2**	**28**	**0**	**0**	**0**	**0**
Prescriptive-1	26	93%	2	24	0	0	0	0
Prescriptive-2	4	40%	0	4	0	0	0	0
TOTAL	**101**		**32**	**43**	**12**	**10**	**3**	**1**

The SWE's review of verified savings for non-residential programs found that, overall, the verified savings estimation were aligned with the Evaluation Framework, followed proper custom site specific M&V activities, applied TRM protocols correctly, and that the verified savings are generally accurate. The following sections describe the SWE's audit of the verified savings methodology for non-residential programs in further detail.

H.4.2.1 Appliance Turn-In Initiative

The evaluation contractor conducted phone and online surveys to verify projects in this initiative. No site visits were conducted for these projects. Impacts were calculated using TRM calculations using project-specific data from the tracking system or verification surveys when available. TRM default values were used in absence of project-specific data.

H.4.2.2 Custom Initiative

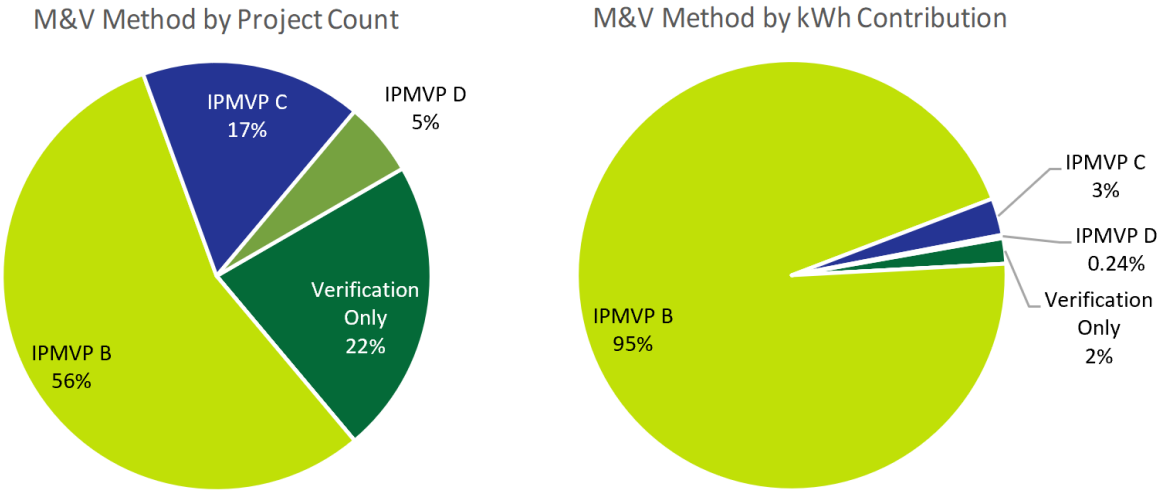
Evaluation activities for this initiative include site visits and/or IPMVP evaluation methods for all sampled projects. Site visits are always conducted unless the evaluation can be satisfactorily conducted remotely using data provided by the customer (EMS data, billing data, etc.). All

sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

West Penn Power's evaluation contractor employed three strata for projects in the Custom initiative. The largest projects, with ex ante savings estimates of 500 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

The distribution of rigor across the sample strata is in keeping with Table 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. IPMVP Options were employed to evaluate 98% of the evaluated sample, as shown in Figure 97.

Figure 97: Summary of West Penn Power's C&I Custom Evaluation Activities



H.4.2.3 Direct Install Initiative

West Penn Power had no participating projects in this initiative in PY9.

H.4.2.4 Lighting Initiative

Evaluation activities for this initiative include site visits for most projects and primary data collection of lighting hours of use for medium and high savings projects. TRM deemed hours of operation were applied for low savings projects. All sampled projects undergo a full documentation review prior to site visits, and site-specific M&V plans are developed for most.

West Penn Power's evaluation contractor employed four strata for projects in the Lighting initiative. The largest projects, with ex ante savings estimates of 750 MWh or more, are separated into a 'certainty' stratum. These projects are automatically sampled for evaluation, and evaluation activities are generally completed prior to rebate approval.

IPMVP Option A using standalone data loggers to measure lighting hours of use was employed for the majority of projects evaluated in this initiative.

H.4.2.5 Prescriptive Initiative

Evaluation activities for this initiative include verification site visits for most projects and application of TRM-based savings calculation methodologies. All sampled projects undergo a full documentation review prior to site visits. This documentation review included identification of the appropriate TRM or IMP protocol and the defined key input parameters.

West Penn Power's evaluation contractor employed two strata for projects in the Prescriptive initiative, with the threshold set at 20 MWh of annual energy savings.

IPMVP-based methods were not employed for this initiative. All projects were evaluated using engineering algorithms following on-site verification visits in most cases.

H.4.2.6 Ride-Along Site Visits

Table 248 provides an overview of the SWE milestones for the audit of West Penn Power's site inspection efforts.

Table 248: West Penn Power Ride-along Audit Milestones

Site Inspections Audited	Energy Savings Audited (kWh)	Field Engineers Observed	Measure Types Observed	Attainment Percentage
4	812,807	2	4	98%

Overall, the SWE agreed with the methods of calculation employed by West Penn Power's evaluation contractor. The calculations and accompanying reports were easy to follow and showed evidence that the TRM was being followed appropriately. Of the four projects reviewed, the SWE recommended an adjustment to energy savings for only one project. For this project, the SWE found that an input value to the TRM protocol had been misinterpreted by the implementer and the evaluation contractor. Correcting the input value resulting in an energy attainment percentage of 50% for that project.

H.4.2.7 Verified Savings Desk Reviews

Table 249 provides an overview of the SWE milestones for the verified savings review of evaluated West Penn Power projects.

Table 249: West Penn Power Verified Savings Desk Review Milestones

Projects Reviewed	Energy Savings Reviewed (kWh)	Demand Reduction Reviewed (kW)	kWh Attainment Percentage	kW Attainment Percentage
5	14,703,904	562	100%	100%

Overall, the SWE found that West Penn Power's evaluation contractor demonstrated general adherence to the TRM for prescriptive measures and employed sound engineering methods to evaluate custom projects. The SWE asserts that ADM conducted appropriate M&V efforts, and that sufficient documentation supporting savings analyses was provided. Among the five projects reviewed, the SWE found no basis for recommending adjustments to energy or demand savings.

H.5 DEMAND RESPONSE

According to the Phase III Implementation Order, West Penn Power's Phase III demand response (DR) compliance target is 64 MW. Note that compliance is determined based on the average MW performance across all DR event hours for the Phase and DR goals are assessed at the system level, meaning that line loss adjustments are applied to the load impacts measured at the customer meter. Additionally, the Implementation Order directs EDCs to obtain no less than 85% of the target in any single event. For West Penn Power, this translates to a 54.4 MW minimum performance level for any given DR event. Decisions about which day DR events are called are guided by a set of prescriptive directions issued by the PUC in the Phase III Implementation Order and Clarification Order. West Penn Power called DR events on the three days those guidelines required.

On January 15, 2018 the West Penn Power/ADM team filed its first PY9 semi-annual report. This filing reported the PY9 verified gross impacts as calculated by ADM. The DR performance estimates were unchanged in the PY9 Semi-Annual and Final Annual Reports. Table 250 shows West Penn Power's performance across the three events during the 2017 DR season. West Penn Power's PY9 average performance (81.9 MW) was comfortably above its Phase III target of 64 MW. Regarding the per-event target of 54.4 MW, the average impact for the first two events exceeded this value. The point estimate for the third event (47.7 MW) was less than 54.4 MW, but the 90% error bounds around this point estimate do contain the target. The large size of the error bounds is attributable to large C&I customers with highly volatile loads.

Table 250: West Penn Power Performance by Event

Date	Average Small C&I MW Impact	Average Large C&I MW Impact	Average Portfolio MW Impact	% of Phase III Target
6/13/2017	3.3 +/- 1.4	119.9 +/- 48.5	123.3 +/- 48.5	193%
7/20/2017	2.4 +/- 1.6	72.3 +/- 46.7	74.7 +/- 46.7	113%
7/21/2017	2.3 +/- 2.4	45.4 +/- 47.0	47.7 +/- 47.0	75%
Average			**81.9 +/- 29.9**	**128%**

The West Penn Power/ADM team also submitted a response to the SWE DR data request. The data elements of this request included ADM's R scripts as well as:

- A workbook describing how ADM calculated uncertainty bands (i.e., margin of error) for their X-of-Y CBLs
- A data set that provided the top three CBLs for each participant and the relative root mean square error (RRMSE) for each CBL/participation combination
- For each event hour, a record of which facilities participated, their reference load, metered load, and verified DR impact
- For eleven sites selected by the SWE, the hourly load data needed to replicate the ADM impact estimates. Note that these eleven sites accounted for approximately 100% of

West Penn Power's gross verified PY9 DR impacts. Also note that one of the other workbooks provided by ADM showed which days were ineligible baseline days

- Historical weather data that was used in creating weather sensitive adjustments, as well as a lookup that mapped each participant to a weather station

The data request response and a few follow-up emails formed the basis of the SWE audit activities – which are described in this memo. The SWE found the approaches implemented by ADM to be well-aligned with the Evaluation Framework and consistent with industry best-practice. The execution of the analysis was thorough and free of errors. The SWE agrees with the PY9 gross verified savings estimates and will recommend the Commission adopt them when assessing compliance with Phase III targets.

H.5.1 Replicate Program Totals

West Penn Power's PY9 DR program had 31 participants – 12 categorized as Large C&I and 19 others categorized as Small C&I. ADM's verified gross peak demand savings generated by these sites are shown in Table 251. Note that these values are adjusted for line losses (by a multiplier of 1.079). For each DR event hour during the 2017 DR season, the SWE was provided with the metered load and CBL for each participant. Using this data, the SWE was able to replicate the PYVTD gross MW for both components of the C&I DR program.

Table 251: West Penn Power DR Savings

Program	PYVTD Gross MW	VTD Gross MW
C&I – Small	2.7	2.7
C&I – Large	79.2	79.2
Energy Efficient Homes (BDR)	N/A	N/A
Total	**81.9**	**81.9**

H.5.2 Reference Load Selection

ADM's CBL selection method was thoughtful and relied on non-event day testing. At a minimum, the following CBLs were considered for each participant:

- Linear modeling
- PJM high 4-of-5 with weather sensitive adjustment (WSA) and weekday specific options
- High 6-of-7 with WSA and weekday specific options
- 10-of-10 with WSA and weekday specific options
- 20-of-20 with WSA option

From the list above, the top three CBLs for each participant were selected. The basis for "top three" was the lowest relative root mean square error (RRMSE) on non-event, non-holiday, non-shutdown weekdays. On event days, a weighted average of these three CBL types was used in

creating the actual CBL. The weights, in this case, were equivalent to the inverse squares of the RRMSEs. For a hypothetical event hour, Table 252 provides an illustration.

Table 252: CBL-of-CBLs Illustration

CBL Type	CBL	Non-Event Day RRMSE	Inverse Square of RRMSE	Weight
10-of-10	1,100	7.1%	198.37	35.7%
10-of-10 with WSA	1,200	7.2%	192.90	34.7%
20-of-20	1,300	7.8%	164.37	29.6%

Thus, the CBL-of-CBLs value would be: 1,100*0.357 + 1,200*0.347 + 1,300*0.296 = 1,193.90.

H.5.3 Weather Sensitive Adjustments (WSAs)

Several of the baseline types ADM considered involved a weather sensitive adjustment (which can be positive or negative). The WSA is a function of three terms: the temperature during the event hour, the average temperature during the same hour across days in the CBL lookback window, and the participant-specific WSA coefficient. Respectively, think of these components as X, Y, and Z. The WSA was then calculated as follows:

$$WSA = Z * (A - B)$$

Regarding the participant-specific WSA coefficient, this value was derived as follows:

- Map each participant to a weather station. Merge weather data in with load data.
- Drop any days outside of the DR season (June – September).
- Drop any holidays, event days, shutdown days, or weekends.
- Keep only event hours (hours ending 15-18).
- Calculate the average load and average temperature during the event window for each day in the data set. Drop any days where the average temperature during the event window is less than 75 degrees (F).
- Using the averages calculated in the previous step, run a simple linear regression model with load as the response variable and temperature as the explanatory variable.

The regression coefficient for the temperature variable is the WSA coefficient.

H.5.4 Findings

For the eleven sites in our sample, the SWE was able to reproduce all inputs that feed into the savings – all WSA coefficients, all WSAs, all interim CBLs, and all CBL-of-CBLs. Table 253 provides a summary of the results. Note that the sites that were not in the SWE's sample produces negative impacts, on average.

Table 253: West Penn Power C&I DR Audit Summary

Group	Count	Gross MW Impact – ADM	Gross MW Impact– SWE	% of Total Savings
In SWE Sample	11	82.1	82.1	100.2%
Not in SWE Sample	20	-0.2	---	-0.2%
Total	**31**	**81.9**	**---**	**100%**

Figure 98 shows the load, CBL, and DR impacts (expressed as positive values) for one of West Penn Power's largest participants during the DR event on 7/20/2017, and Figure 99 shows the same values for another of West Penn Power's largest participants on 6/13/2017. Of note is the volatility of participant loads for these two participants on these two days.

Figure 98: Load, CBL, and Impacts for a Large Industrial Participant

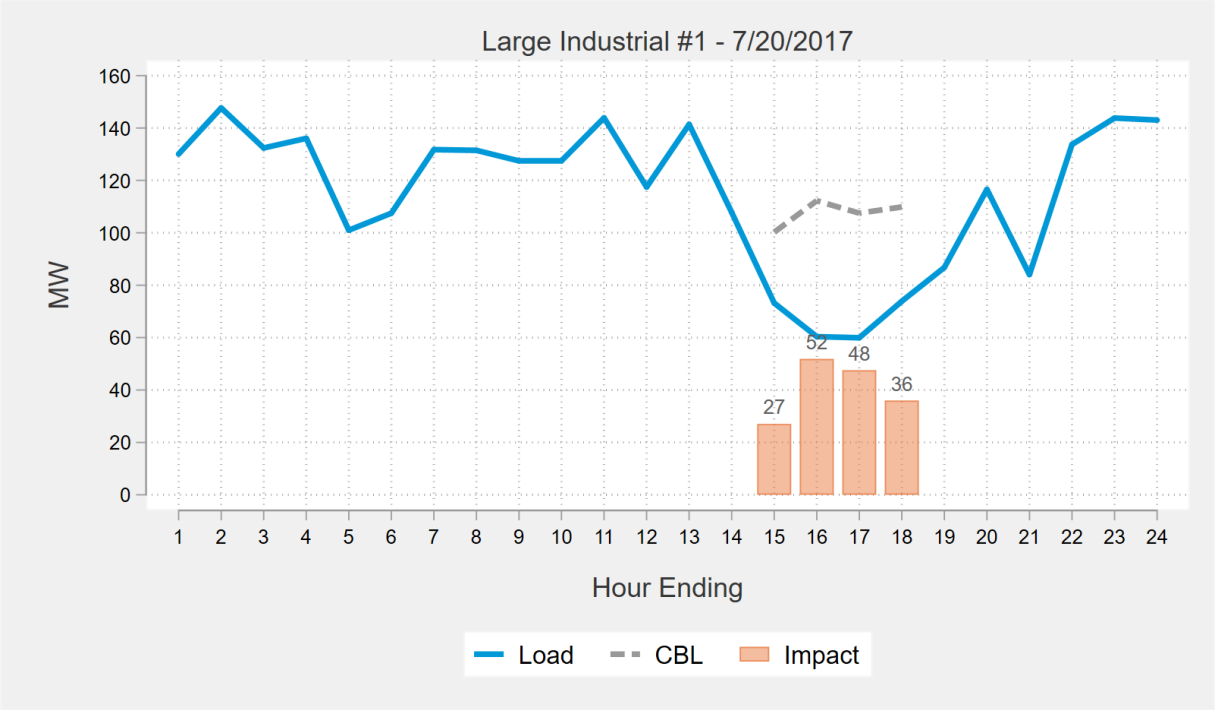
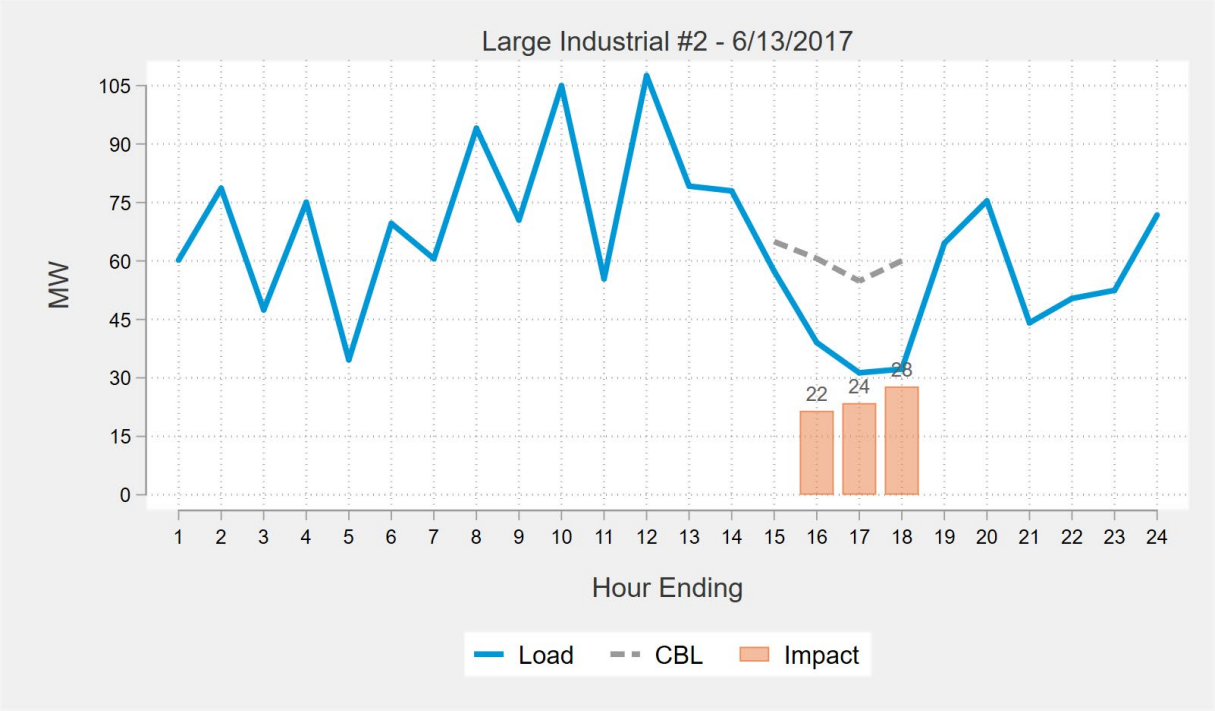


Figure 99: Load, CBL, and Impacts for Another Large Industrial Participant



H.6 NTG

H.6.1 Residential Programs

Tetra Tech estimated a PY9 NTG for the Appliance Turn-in Program and the New Homes Program. The Direct Install Program and the Energy Efficiency Kits Program NTG were drawn from the PY8 NTG evaluation.

For the Appliance Turn-In Program, Tetra Tech used primary data collection (participant surveys) to estimate NTG. NTG was estimated with the recommended UMP appliance recycling protocol. Tetra Tech measured free-ridership but not spillover due to program design and assigned the average NTG score for about 10% of the sample due to incomplete survey responses (for FE overall, specifics imputation by EDC was not reported).

Tetra Tech assigned the HERs component of the program an 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.

An NTG of 0.6 was applied to the New Homes components of the Program. Tetra-Tech conducted secondary NTG research across six similar programs offered in non-FirstEnergy territories and applied the average of these programs NTG as the New Homes NTG.

For the Residential Energy Efficient Products Program, Tetra Tech applied the NTG from Phase II to all components of the program.

Table 254: Summary of NTG Estimates for WPP Residential Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
Estimated	Appliance Turn-in	0.49	0.0	0.51	250
PY8	Upstream Lighting	--	--	0.27	--
PY8	EE Kits	0.21	0.03	0.82	--
RCT	Home Energy Reports	0	0	1	--
PY8	Direct Install			0.82	
Secondary Research	New Homes	--	--	0.60	--
PY8	Upstream Electronics	--	--	0.50	--
PY8	HVAC	--	--	0.50	--
PY8	Residential Appliances	--	--	0.50	--

H.6.2 Low-Income Residential Programs

Tetra Tech assigned LIEEP an NTG of 1, in keeping with the PY9 Evaluation Plan and SWE Phase III Evaluation Framework.

H.6.3 C&I Programs

Tetra Tech did not conduct NTG research in PY9 for Energy Solutions for Small Business Program or for the Energy Solutions for Large Business Program.

The estimated PY8 NTG was applied to the Small Business NTG for the Lighting, Custom, and Prescriptive components. The PY8 and PY9 NTG for these components differ slightly due to the differences in strata weighting between the two efforts.

Tetra Tech evaluated the Residential Appliance Program and estimated it's NTG for PY9 and applied the residential NTG to the small business component.

Tetra Tech was to evaluate the Small Business Direct Install NTG during PY9 but found that the Small Business Direct Install component was solely lighting retrofits. Tetra Tech then reasoned that the Small Business Lighting component NTG should be applied to Direct Install even though the Lighting NTG was based on the PY8 evaluation.

The Energy Solutions for Large Business Program NTG was evaluated in PY8 and these NTG values were then applied to the PY9 NTG. Values of NTG across programs for PY8 and PY9 vary slightly due to the difference in strata weighting in each effort.

Table 255: Summary of NTG Estimates for WPP C&I Program

Approach	Program	Free-Ridership	Spillover	NTG	Sample Size
PY8	Small Energy Solutions for Business Lighting	--	--	0.83	--
PY8	Small Energy Solutions for Business Custom	--	--	0.47	--
PY8	Small Energy Solutions for Business Prescriptive	--	--	1	--
PY9 Residential NTG	Small Energy Solutions for Business Appliance Turn-In	--	--	0.51	--
PY8 ESB Lighting NTG	Small Energy Solutions for Business Direct Install	--	--	0.83	--
PY8	Small Energy Solutions for Business Total	--	--	0.82	--
PY8	Large Energy Solutions for Business Lighting	--	--	0.83	--
PY8	Large Energy Solutions for Business Custom	--	--	0.47	--
PY8	Large Energy Solutions for Business Prescriptive	--	--	1	--
PY8	Large Energy Solutions for Business Total	--	--	0.63	--

H.7 TRC

Table 256 presents TRC NPV benefits, TRC NPV costs, and the TRC ratios for West Penn's PY9 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 PY9 annual report.

The primary differences for the PY9 TRC from the previous program year are the inclusion of fossil fuel and water saving benefits under the Total NPV Lifetime Non-Electric Benefits and two C&I demand response programs.

Table 256: Summary of West Penn's PY9 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	1,782	835	2.14	909	835	1.09
Energy Efficient Homes	14,541	7,975	1.82	11,907	7,324	1.63
Energy Efficient Products	12,103	8,595	1.41	3,580	3,840	0.93
Low-Income Energy Efficiency	2,266	3,160	0.72	2,266	3,160	0.72
C&I Energy Solutions for Business – Small	15,496	16,010	0.97	12,689	13,439	0.94
C&I Energy Solutions for Business – Large	19,629	16,641	1.18	12,425	11,450	1.09
Governmental & Institutional Tariff	3,585	4,849	0.74	2,987	4,090	0.73
C&I Demand Response Program – Small	229	51	4.44	229	51	4.44
C&I Demand Response Program – Large	6,724	1,491	4.51	6,724	1,491	4.51
Portfolio Total	**76,355**	**59,608**	**1.28**	**53,716**	**45,680**	**1.18**

Of West Penn's nine energy-efficiency programs offered, six were found to be cost-effective and three were non-cost-effective using gross verified savings. Using net verified savings, five were found to be cost-effective and four were non-cost-effective. The Energy Efficient Homes program was cost-effective when using gross verified savings, but non-cost-effective when using net verified savings. The C&I Demand Response – Small and – Large programs were new programs in PY9 and were found to be cost effective. 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
- C&I Demand Response Program– Large

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

Net verified savings

Cost-Effective Programs (TRC > 1):

- Appliance Turn-in
- Energy Efficient Products
- C&I Energy Solutions for Business– Small
- C&I Energy Solutions for Business – Large
- C&I Demand Response Program– Large

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

- Energy Efficient Homes

- Low-income Energy Efficiency Products
- C&I Energy Solutions for Business – Small
- Governmental & Institutional Tariff

- Low-income Energy Efficiency Products
- C&I Energy Solutions for Business – Small
- Governmental & Institutional Tariff

H.7.1 Notes from the TRC Model Review

All four FirstEnergy companies utilized the same TRC model template but had independent inputs specific to that company.

- West Penn's annual electric energy savings are calculated and allocated by month and time of day (on-peak and off-peak). FirstEnergy applies a broader peak definition than Act 129 peak hours defined in the 2016 TRM. The SWE verified that the avoided costs and load profiles share common on-peak and off-peak definitions.
- 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 TRC model accounted for fossil fuel and water savings benefits under Total NPV Lifetime Non-Electric Benefits. The SWE verified that the savings were accounted for in accordance to the Guidance on Inclusion of Fossil Fuel and Water Benefits in TRC Test. The TRC model claimed 64,920 thousand gallons of water saved or approximately $4,297,000 in avoided costs.

- 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 257 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 257: West Penn Portfolio TRC with and without Dual Baseline Calculations

	Gross TRC	Net TRC
Dual Baseline	1.28	1.18
Without Dual Baseline	1.40	1.22

- The SWE verified that the demand response program TRC ratio meets the 75% participant cost assumption where 75% of customer incentive payment is used as a proxy for participant cost.
- In PY8, the SWE recommended the Programmable Thermostat EUL be updated from 11 to 15 in PY9 reporting. The PY9 TRC model completed this update.

The SWE noted a minor issue pertaining to the implementation of the TRC model. The avoided cost of distribution capacity should not be applied to participants who take service at primary voltage. The SWE recommends breaking out transmission and distribution avoided costs and accounting for only generation capacity and transmission avoided costs when calculating large C&I demand response program benefits in future year reporting.

H.8 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 Met-Ed previously applies to all four FirstEnergy utilities, including West Penn.

Appendix I ACEEE Scorecard

The tables in this appendix provide the data needed for the ACEEE State Energy Efficiency Scorecard: Pennsylvania's statewide EE budgets and expenditures, verified gross annual and lifetime savings, and verified net annual and lifetime savings.

Table 258: PA Statewide EE Budgets and Expenditures

EDC	Actual PY9 Expenditures	Approved Budget for PY9
PECO	$57,241,000	$56,200,000
PPL	$52,962,000	$55,561,000
Duquesne Light	$15,821,000	$15,671,000
FE: Met-Ed	$16,924,025	$21,748,713
FE: Penelec	$16,521,734	$21,628,711
FE: Penn Power	$5,868,652	$5,791,571
FE: West Penn	$18,341,321	$19,815,488
Statewide	**$183,679,732**	**$196,416,484**

Table 259: PA Statewide Gross Verified Annual and Lifetime MWh Savings

EDC	Gross Verified Annual Savings	Gross Verified Lifetime Savings
PECO	390,151	3,272,168
PPL	382,522	3,943,804
Duquesne Light	101,065	1,091,283
FE: Met-Ed	176,665	1,552,459
FE: Penelec	154,637	1,467,719
FE: Penn Power	57,354	568,987
FE: West Penn	195,498	1,870,298
Statewide	**1,457,892**	**13,766,718**

Table 260: PA Statewide Net Verified Annual and Lifetime MWh Savings

EDC	Net Verified Annual Savings	Net Verified Lifetime Savings
PECO	284,902	2,389,459
PPL	304,945	3,143,998
Duquesne Light	57,923	625,433
FE: Met-Ed	121,784	1,070,187
FE: Penelec	113,365	1,075,991
FE: Penn Power	39,674	393,591
FE: West Penn	140,476	1,343,915
Statewide	**1,063,069**	**10,038,462**