BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of The Dayton Power and Light Company's Portfolio Status Report	))	Case No. 18-0742-EL-POR

THE DAYTON POWER AND LIGHT COMPANY'S
COMBINED NOTICE
OF FILING PORTFOLIO STATUS REPORT
AND APPLICATION TO ADJUST BASELINES

The Dayton Power and Light Company ("DP&L" or "the Company") hereby submits its annual Portfolio Status Report pursuant to Section 4901:1-39-05(C) of the Ohio Administrative Code ("O.A.C."), addressing the performance of all of DP&L's approved energy efficiency and peak demand reduction programs over calendar year 2017. As shown in the attached Portfolio Status Report, DP&L has met its statutory benchmarks for energy efficiency and peak demand reduction.

DP&L also makes application pursuant to Section 4928.66(A)(2)(c) of the Ohio Revised Code ("O.R.C.") and O.A.C. §4901:1-39-05(B) to adjust its sales and demand baselines to normalize for weather. As described in the 2017 Benchmark Report, included within the Portfolio Status Report as Appendix B, the changes requiring adjustments to the baselines were outside of DP&L's reasonable control. Appendix B contains all assumptions, rationales, and calculations, and proposes methodologies and practices to be used in the proposed adjustments or normalizations to support DP&L's application to adjust baselines, as required by O.A.C. §4901:1-39-05(B).

1. DP&L is a public utility and electric light company as defined by Sections 4905.02 and 4905.03(C) of the O.R.C. respectively, and an electric distribution utility as defined by O.R.C. §4928.01(A)(6).

2. Pursuant to O.R.C §4928.66(A)(1)(a), DP&L is required to "implement energy efficiency programs that achieve energy savings equivalent to at least three-tenths of one per cent of the total, annual average, and normalized kilowatt-hour sales of the electric distribution utility during the preceding three calendar years to customers in this state. An energy efficiency program may include a combined heat and power system placed into service or retrofitted on or after the effective date of the amendment of this section by S.B. 315 of the 129th general assembly, September 10, 2012, or a waste energy recovery system placed into service or retrofitted on or after September 10, 2012, except that a waste energy recovery system described in division (A)(38)(b) of section 4928.01 of the Revised Code may be included only if it was placed into service between January 1, 2002, and December 31, 2004. For a waste energy recovery or combined heat and power system, the savings shall be as estimated by the public utilities commission. The savings requirement, using such a three-year average, shall increase to an additional five-tenths of one per cent in 2010, seven-tenths of one per cent in 2011, eight-tenths of one per cent in 2012, nine-tenths of one per cent in 2013, and one per cent in 2014 . In 2015 and 2016, an electric distribution utility shall achieve energy savings equal to the result of subtracting the cumulative energy savings achieved since 2009 from the product of multiplying the baseline for energy savings, described in division (A)(2)(a) of this section, by four and two-tenths of one per cent. If the result is zero or less for the year for which the calculation is being made, the utility shall not be required to achieve additional energy savings for that year, but may achieve additional energy savings for that year. Thereafter, the annual savings requirements shall be, for years 2017, 2018, 2019, and

2020, one per cent of the baseline, and two per cent each year thereafter, achieving cumulative energy savings in excess of twenty-two per cent by the end of 2027."

3. O.R.C. §4928.66(A)(1)(b) requires that DP&L "implement peak demand reduction programs designed to achieve a one per cent reduction in peak demand in 2009 and an additional seventy-five hundredths of one per cent reduction each year through 2014. In 2015 and 2016, an electric distribution utility shall achieve a reduction in peak demand equal to the result of subtracting the cumulative peak demand reductions achieved since 2009 from the product of multiplying the baseline for peak demand reduction, described in division (A)(2)(a) of this section, by four and seventy-five hundredths of one per cent. If the result is zero or less for the year for which the calculation is being made, the utility shall not be required to achieve an additional reduction in peak demand for that year, but may achieve an additional reduction in peak demand for that year. In 2017 and each year thereafter through 2020, the utility shall achieve an additional seventy-five hundredths of one per cent reduction in peak demand."

4. O.R.C. §4928.66(A)(2)(a) provides: "The baseline for energy savings under division (A)(1)(a) of this section shall be the average of the total kilowatt hours the electric distribution utility sold in the preceding three calendar years, and the baseline for a peak demand reduction under division (A)(1)(b) of this section shall be the average peak demand on the utility in the preceding three calendar years."

5. As more fully described, and supported in DP&L's 2017 Benchmark Report, included with the Portfolio Status Report as Appendix B, DP&L applies to make adjustments to its baseline to normalize for weather changes, reasonable arrangements, statutory portfolio plan opt-outs, and mercantile customers.

6. As more fully explained in the 2017 Benchmark Report, and supported by Schedule 1 and the corresponding Workpapers A, C, D, and E, DP&L's 2017 normalized energy efficiency baseline is 12,658,728 MWh and DP&L's 2017 incremental normalized energy efficiency reduction benchmark is 126,587 MWh. DP&L's cumulative energy efficiency reduction benchmark is 714,771 MWh.

7. DP&L's 2017 normalized peak demand reduction baseline, as fully explained in its 2017 Benchmark Report, and supported by Schedule 2 and the corresponding Workpapers B, C, D, and E is 2,704 MW and DP&L's 2017 normalized peak demand reduction benchmark is 148.7 MW.

8. DP&L's 2017 energy efficiency and demand reduction programs, designed to achieve the required energy savings and demand reductions for 2017, were filed as part of a comprehensive energy efficiency and peak-demand reduction program portfolio in Case No. 16-649-EL-POR, *In the Matter of the Application of The Dayton Power and Light Company for Approval of Its Energy Efficiency and Demand Reduction Program Portfolio Plan for 2017 through 2019.* In December 2016, a Stipulation and Recommendation was filed effectively extending the Portfolio Plan approved in 13-0833-EL-POR with certain modifications to cover the 2017 program year. That Stipulation and Recommendation was approved by a Commission Order dated September 27, 2017.

9. O.A.C. §4901:1-39-05(C) provides: "by March fifteenth of each year, each electric utility shall file a portfolio status report addressing the performance of all approved energy efficiency and peak-demand reduction programs in its program portfolio plan over the previous calendar year. . ." The Commission granted a waiver of O.A.C. §4901:1-39-05(C) that permits each electric utility to file its Annual Portfolio

Status Report on or before May 15, 2016, and May 15 of each reporting year thereafter through 2018.[1]

10. DP&L timely submits the attached Portfolio Status Report ("Report") which includes the following components:

(1) A Compliance Demonstration which includes: (a) an update to DP&L's initial benchmark report (Report, Compliance Demonstration); (b) a comparison of the applicable benchmarks to the actual energy savings and peak demand reductions achieved (Report, Compliance Demonstration); and (c) an affidavit regarding compliance with the statutory benchmarks (Exhibit 2).

(2) A Program Performance Assessment, including: (a) a description of each approved energy efficiency or peak-demand reduction program implemented in the previous calendar year (Report, Residential Programs, Non-Residential Programs, Cross Sector Programs, and Customer Education); and (b) an evaluation, measurement, and verification report by The Cadmus Group, Inc. ("Cadmus Report", Exhibit 1); and (c) a recommendation with respect to continuation, modification or elimination of each program (Report, Recommendations).

12. As described in the Report, and as attested to in the attached Affidavit of the President and Chief Executive Officer of DP&L, DP&L has met its 2017 statutory benchmarks for energy efficiency and peak demand reduction.

WHEREFORE, DP&L respectfully requests that the Commission issue an order finding that DP&L has complied with its 2017 statutory energy efficiency and peak

[1] Entry dated *In the Matter of the Application of Ohio Edison Company, The Cleveland Electric Illuminating Company and The Toledo Edison Company for a Waiver with Regard to Rule 4901:1-35-05(C), Ohio Administrative Code*, Case No. 16-72-EL-WVR, Entry (February 24, 2016).

demand reduction benchmark requirements and acknowledging DP&L compliance with the Program Portfolio Status Report requirements found in O.A.C. § 4901:1-39-05(C).

Respectfully submitted,

/s/ Michael J. Schuler _____

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May 15

2018

2017 Energy Efficiency and Demand Reduction/Response Portfolio Status Report

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EXECUTIVE SUMMARY

OVERVIEW

In April 2013, The Dayton Power and Light Company (DP&L) filed a three-year Energy Efficiency and Demand Response Portfolio Plan in Case No. 13-0833-EL-POR and 13-0837-EL-WVR. A settlement agreement was reached with all intervening stakeholder groups, and the plan was approved by the Commission on December 4, 2013. The plan covers the years 2013 through 2015.

Consistent with Ohio Senate Bill 310, DP&L continued programs approved in Case No. 13-0833 –EL-POR through 2016, providing customers with a variety of energy efficiency choices. Specifically, DP&L offered customers five residential programs, four business programs and two residential pilot programs. Through the process, DP&L kept the energy efficiency collaborative informed of its progress and worked directly with several collaborative members to either implement programs or market them to various customer groups.

In June 2016, DP&L filed a three-year Portfolio Plan in Case No. 16-0649-EL-POR and 16-1369-EL-WVR. In September 2017, a settlement agreement was approved by the Commission, effectively extending the Portfolio Plan approved in 13-0833-EL-POR with certain modifications to cover the 2017 program year.

It should be noted that actual energy and demand savings have been reported in each of the previous years as follows:

- 2009 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on March 12, 2010, in Case No. 10-0303-EL-POR.
- 2010 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on March 15, 2011, in Case No. 11-1276-EL-POR.
- 2011 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2012, in Case No. 12-1420-EL-POR.
- 2012 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2013, in Case No. 13-1140-EL-POR.
- 2013 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2014, in Case No. 14-0738-EL-POR.
- 2014 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2015, in Case No. 15-0777-EL-POR.
- 2015 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2016, in Case No. 16-0851-EL-POR
- 2016 Energy Efficiency and Demand Reduction/Response Portfolio Status Report filed on May 15, 2017, in Case No. 17-1092-EL-POR

SAVINGS CALCULATIONS

The energy and demand savings calculations were based mainly on the State of Ohio Energy Efficiency Technical Reference Manual (TRM), filed August 6, 2010 under Case No. 09-0512-GE-UNC. However, there were exceptions for measures not included in the TRM or where evaluations resulted in a valid alternate calculation. A discussion of calculation methodology is included in the Cadmus EM&V report, attached as Exhibit 1.

COMPLIANCE SUMMARY

From 2009 through 2016, DP&L reported cumulative energy efficiency program savings of 1,354,416 MWh and mercantile program savings of 54,187 MWh. The 2017 energy efficiency programs generated 186,702 MWh and mercantile programs generated 14,057 MWh. Therefore, cumulative annualized energy savings for 2009 through 2017 are 1,609,362 MWh.

From 2009 through 2016, DP&L reported cumulative demand savings from energy efficiency programs of 207.7 MW and 15.9 MW of cumulative demand savings from mercantile commitments. The 2017 energy efficiency programs generated 28.2 MW and mercantile programs generated 2.4 MW of energy efficiency demand for integration with DP&L's program portfolio. Therefore, total 2017 cumulative demand savings are 254.2 MW.

Based on this performance, DP&L surpassed its 2017 cumulative benchmark targets of 714,771 MWh and 148.7 MW. A more detailed analysis is provided in the Compliance Demonstration portion of this report.

	MWh	**MW**
Cumulative 2009 – 2016 Total Savings	1,408,603	223.6
2017 Energy Efficiency Actuals	186,702	28.2
2017 Mercantile Commitments	14,057	2.4
Cumulative 2009 – 2017 Total Savings	1,609,362	254.2
Cumulative 2017 Benchmarks	714,771	148.7

2017 PROGRAM SUMMARY

2017 Annualized Program Results

Program	2017 Energy (MWh)	2017 Demand (MW)
Residential Lighting	43,777	5.23
Residential HVAC Rebates	7,422	1.59
Residential Appliance Recycling	8,003	1.64
Residential School Education[1]	3,602	0.19
Residential Low Income Affordability	926	0.13
Non-Residential Prescriptive Rebates	93,401	14.56
Non-Residential Custom Rebates	27,542	4.45
Mercantile Customer Commitments	14,057	2.40
Non-Residential PJM Demand Response	0	0
Pilot Programs	2,029	0.41
T&D Infrastructure Improvements	0	0
Total	200,759	30.60

[1] 2017 savings are savings from the 2016/2017 school year.

BANKED ENERGY SAVINGS

DP&L plans to bank the excess energy savings achieved cumulatively through 2017 and apply the excess toward future benchmarks. The total amount of banked energy savings is 894,591 MWh and is calculated as follows:

2017 Actual Cumulative Energy Savings – 2017 Cumulative Benchmark = Banked Energy Savings

1,609,362 MWh – 714,771 MWh = 894,591 MWh

EVALUATION, COST EFFECTIVENESS

Attached to this report, as Exhibit 1, is the 2017 evaluation, measurement, and verification report produced by The Cadmus Group (Cadmus).

In addition, Cadmus performed cost effectiveness tests for each of the programs and for the portfolio as a whole. These are the Total Resource Cost Test (TRC), the Utility Cost Test (UCT), the Participant Cost Test (PCT), the Ratepayer Impact Measure (RIM), and the Societal Test (SCT). DP&L's portfolio was cost effective as measured by the TRC. A detailed review of the cost effectiveness tests and program-specific results can be found in the cost effectiveness section of the EM&V report, included as Exhibit 1.

	Primary	Secondary			
	Total Resource Cost Test	**Utility Cost Test**	**Ratepayer Impact Measure Test**	**Participant Cost Test**	**Societal Cost Test**
DP&L Portfolio	1.30	3.58	0.48	2.67	1.71

2017 PROGRAM COST SUMMARY

PROGRAM	2017 Filed	2017 Actual
Residential Lighting*		
Incentive Costs	$1,716,965	$1,607,164
Marketing & Administration	$1,055,824	$949,044
Program Total	$2,772,789	$2,556,208
Residential HVAC Rebates		
Incentive Costs	$1,808,012	$1,315,057
Marketing & Administration	$976,234	$595,518
Program Total	$2,784,246	$1,910,575
Residential Appliance Recycling*		
Incentive Costs	$325,000	$324,071
Marketing & Administration	$764,656	$700,566
Program Total	$1,089,656	$1,024,637
Residential Low Income Affordability		
Incentive Costs	$997,892	$573,385
Marketing & Administration	$251,834	$151,321
Program Total	$1,249,726	$724,706
Residential School Education		
Incentive Costs	$98,103	$134,413
Marketing & Administration	$237,270	$152,783
Program Total	$335,373	$287,196
Non-Residential Prescriptive Rebates**		
Incentive Costs	$6,103,926	$6,259,825
Marketing & Administration	$1,661,467	$1,371,329
Program Total	$7,765,393	$7,631,154
Non-Residential Custom Rebates**		
Incentive Costs	$1,718,812	$1,716,866
Marketing & Administration	$1,108,240	$918,344
Program Total	$2,827,052	$2,635,210
Non-Residential Mercantile Program		
Incentive Costs	$637,479	$689,867
Marketing & Administration	$194,040	$72,212
Program Total	$831,519	$762,079

*Reflects transfer of $300,000 from Residential Lighting to Residential Appliance Recycling.

2017 PROGRAM COST SUMMARY (CONTINUED)

PROGRAM	2017 Filed	2017 Actual
PJM Demand Response**		
Incentive Costs	$0	$0
Marketing & Administration	$0	$0
Program Total	$0	$0
Education		
General Energy Efficiency Education & Outreach	$886,745	$397,937
Marketing & Administration	$15,748	$66,247
Program Total	$902,493	$464,184
Pilot Programs		
Incentive Costs	$747,828	$547,071
Marketing & Administration	$320,498	$191,049
Program Total	$1,068,326	$738,120
Evaluations, Measurement & Verification	$808,272	$819,375
Total Program Costs	**$22,434,845**	**$19,553,444**

**Reflects transfer of $600,000 from Non-Residential Custom and $34,007 from PJM Demand Response to Non-Residential Prescriptive.

COMPLIANCE DEMONSTRATION

BENCHMARK REPORT UPDATE

In accordance with O.A.C. Section 4901:1-39-05(C)(1)(a) DP&L is filing its 2017 Benchmark Report, included in this filing as Appendix B.

DP&L's 2017 cumulative energy and peak demand reduction benchmark targets are as follows:

Normalized Energy Reduction Benchmark (MWh)	714,771
Normalized Peak Demand Reduction Benchmark (MW)	148.7

For informational purposes, included below are Schedules 1 and 2 from DP&L's 2017 Benchmark Report.

Schedule 1

THE DAYTON POWER & LIGHT COMPANY

2017 Benchmark Report

Energy Efficiency Baseline and Benchmark Calculation

		2014	2015	2016	2017
1	**Baseline Calculation Components**				
2	Retail MWh Sales [1]	14,024,297	13,920,987	14,241,625	
3					
4	**Normalizing Adjustments**				
5	Reasonable Arrangement Adjustment [2]	409,206	419,976	436,902	
6	Opt-Out Customer Adjustment [3]	873,803	913,138	912,022	
7	Mercantile Customer Adjustment [4]	51,408	58,180	65,220	
8	Total Adjusted Retail Sales (2)+(5)	12,792,696	12,646,053	12,957,921	
9	Weather Normalization Factor [5]	0.98349	0.99504	0.98869	
10	Normalized Retail Energy Sales (6)*(7)	12,581,489	12,583,329	12,811,367	
11					
12	**2017 Normalized Energy Efficiency Baseline**				
13	3 Year Normalized Average (MWh)				12,658,728
14					
15	**Calculation of 2017 Energy Efficiency Reduction Benchmark**				
16	Normalized Preceding 3 Year Average Sales (11)				12,658,728
17	2017 Incremental Energy Efficiency Reduction Benchmark % [6]				1.00%
18	2017 Incremental Energy Efficiency Reduction Benchmark (14)*(15)				126,587
19	2014 Energy Efficiency Reduction Benchmark [7]				588,184
20	**2017 Cumulative Energy Efficiency Reduction Benchmark (16)+(17)**				**714,771**

Page 1

[1] Retail sales for the period 2014-2016 are reported in PUCO Form FE-D1 (Case No. 18-0467-EL-FOR See Workpaper A, Column (6).

[2] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(i).

[3] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(ii).

[4] See Workpaper C for calculation of Mercantile Customer Adjustment.

[5] See Workpaper E for calculation of the weather normalization factor.

[6] Energy Efficiency benchmark as established in O.R.C. §4928.66(A)(1)(a).

[7] 2014 Cumulative Energy Efficiency Reduction Benchmark as established in Case No. 15-0777-EL-POR, Schedule 1, line 21.

Schedule 2

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
Peak Demand Baseline and Benchmark Calculation

		2014	2015	2016	2017
1	**Baseline Calculation Components**				
2	Peak MW Demand [1]	2,756	2,845	2,883	
3					
4	**Normalizing Adjustments**				
5	Reasonable Arrangement Adjustment [2]	77	70	74	
6	Opt-Out Customer Adjustment [3]	117	103	125	
7	Mercantile Customer Adjustment [4]	16	17	18	
8	Total Adjusted Peak Demand (2)+(5)	2,578	2,690	2,702	
9	Weather Normalization Factor [5]	1.00544	1.05062	0.99723	
10	Normalized Peak Demand (6)*(7)	2,592	2,826	2,694	
11					
12	**2017 Normalized Peak Demand Reduction Baseline**				
13	3 Year Normalized Average (MW)				2,704
14					
15	**Calculation of Normalized 2017 Peak Demand Reduction Benchmark**				
16	Normalized Preceding 3 Year Average Peak Demand (11)				2,704
17	2017 Peak Demand Reduction Benchmark % [6]				5.50%
18	**2017 Peak Demand Reduction Benchmark (14)*(15)**				**148.7**

Page 1

[1] Peak demand for the period 2014-2016 is reported in PUCO Form FE-D3. See Workpaper B.

[2] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(i).

[3] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(ii).

[4] See Workpaper C for calculation of Mercantile Customer Adjustment.

[5] See Workpaper E for calculation of weather normalization factor.

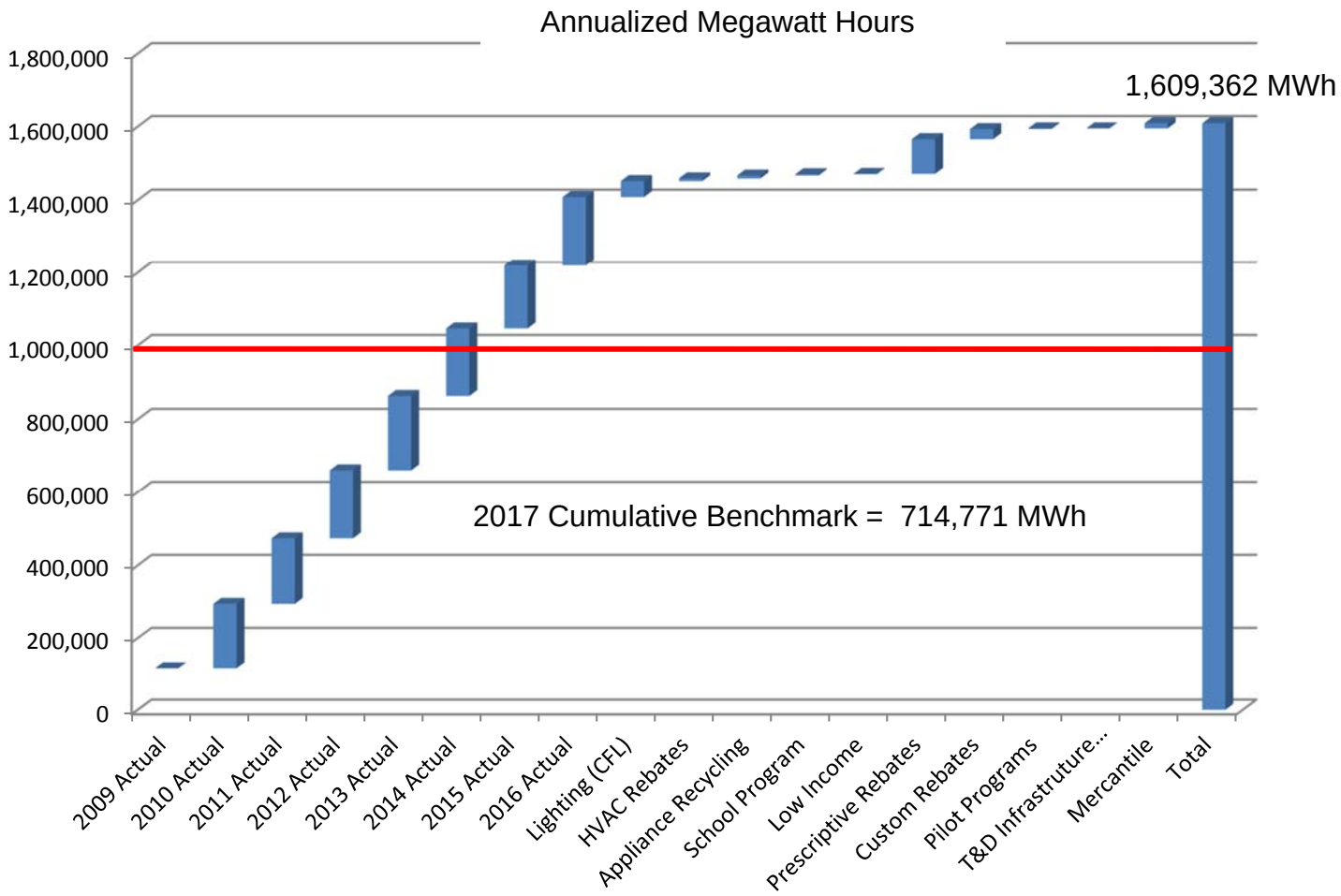
[6] Peak Demand Reduction benchmark as established in O.R.C § 4928.66(A)(1)(b).

2017 FILED VERSUS ACTUAL ENERGY SAVINGS

Below, in tabular and graph form, are the programs' energy and demand savings as filed, as well as the corresponding energy and demand actual 2017 program performance. The actual performance is then compared to the 2017 energy and peak demand reduction benchmarks to demonstrate DP&L's compliance.

PROGRAM	2017 Filed (MWh)	Annualized 2017 Actual (MWh)	Variance (MWh)
Residential Lighting	50,573	43,777	-6,796
Residential HVAC Rebates	8,814	7,422	-1,392
Residential Appliance Recycling	4,274	8,003	3,729
Residential School Education	2,377	3,602	1,225
Residential Low Income Affordability	1,083	926	-157
Non-Residential Prescriptive Rebates	54,446	93,401	38,955
Non-Residential Custom Rebates	28,144	27,542	-602
Non-Residential Mercantile Commitments	8,822	14,057	5,235
Non-Residential PJM Demand Response	0	0	0
Pilot Programs	0	2,029	2,029
Transmission & Distribution Infrastructure Improvements	0	0	0
Total	**158,533**	**200,759**	**42,226**

2017 ENERGY ACTUALS COMPARED TO CUMULATIVE BENCHMARKS

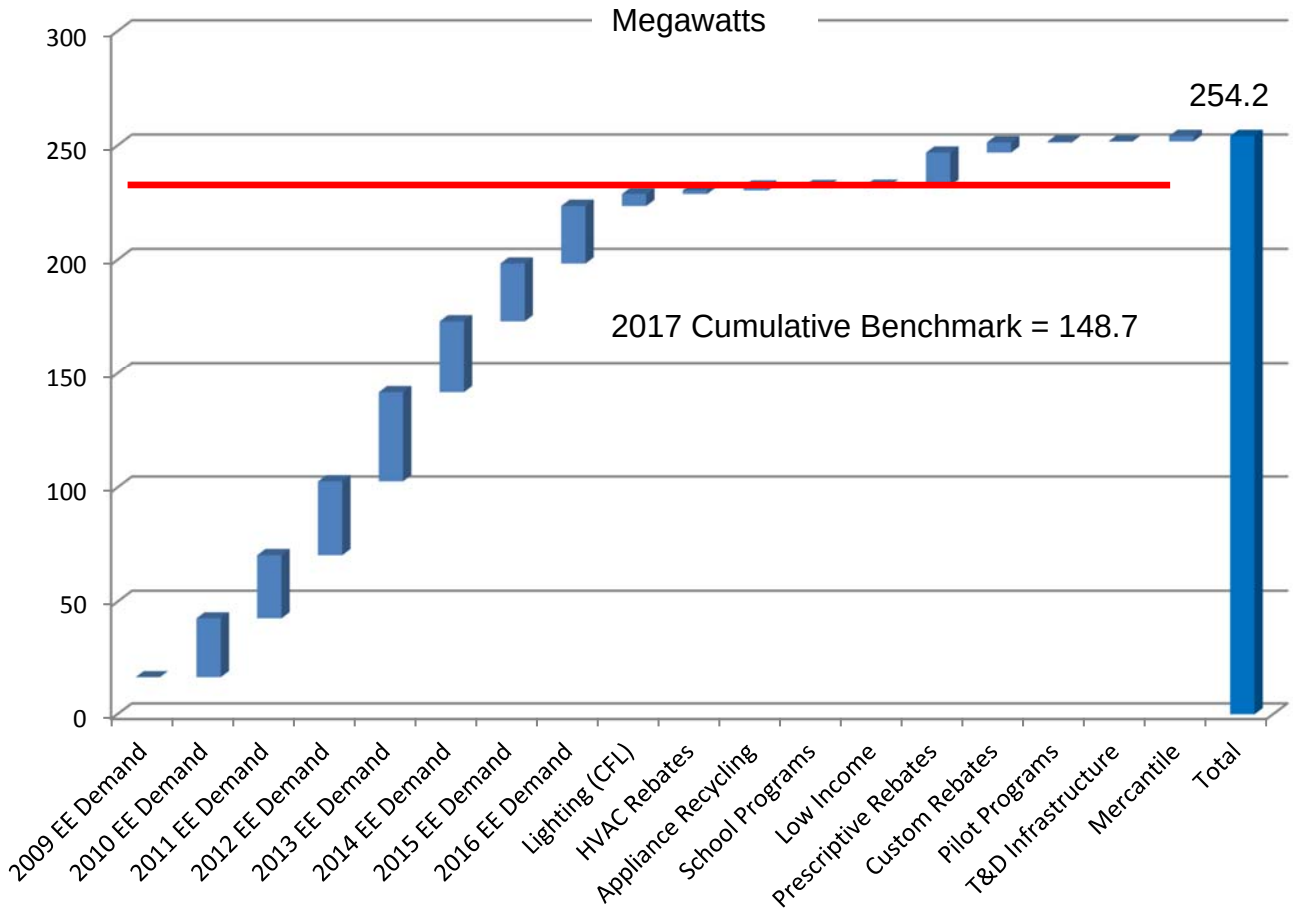


	MWh
Cumulative 2009 – 2016 Total Savings	1,408,603
2017 Energy Efficiency Actuals	186,702
2017 Mercantile Commitments	14,057
Cumulative 2009-2017 Total Savings	1,609,362
Cumulative 2017 Benchmark	714,771

2017 FILED VERSUS ACTUAL DEMAND SAVINGS

PROGRAM	2017 Filed (MW)	Annualized 2017 Actual (MW)	Variance (MW)
Residential Lighting	6.04	5.23	-0.81
Residential HVAC Rebates	2.71	1.59	-1.12
Residential Appliance Recycling	0.76	1.64	0.88
Residential School Education	0.02	0.19	0.17
Residential Low Income Affordability	0.16	0.13	-0.03
Non-Residential Prescriptive Rebates	9.64	14.56	4.92
Non-Residential Custom Rebates	5.16	4.45	-0.71
Non-Residential Mercantile Commitments	4.12	2.40	-1.72
Non-Residential PJM Demand Response	6.00	0.00	-6.00
Pilot Programs	0.00	0.41	0.41
Transmission & Distribution Infrastructure Improvements	0.00	0.00	0.00
Total	34.61	30.60	-4.01

2017 DEMAND ACTUALS COMPARED TO CUMULATIVE BENCHMARKS



	MW
Cumulative 2009 – 2016 Total Savings	223.6
2017 Energy Efficiency Actuals	28.2
2017 Mercantile Commitments	2.4
Cumulative 2009-2017 Total Savings	254.2
Cumulative 2017 Benchmark	148.7

RESIDENTIAL PROGRAMS

RESIDENTIAL LIGHTING

PROGRAM DESCRIPTION

The Residential Lighting Program is an upstream, manufacturer buy-down of light-emitting diode bulbs (LED) sold at the retail level. No coupon or rebate form is required; the customer receives the discount at the register at the time of purchase.

The objective of the program is to increase the number of long-life, Energy Star qualified LEDs sold to DP&L customers by providing incentives to decrease consumer costs. The program increases consumer awareness and acceptance of energy-efficient lighting technology.

The Residential Lighting Program is designed for all DP&L residential customers who purchase bulbs through retail channels. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

This program started in February 2009 and continued through 2017.

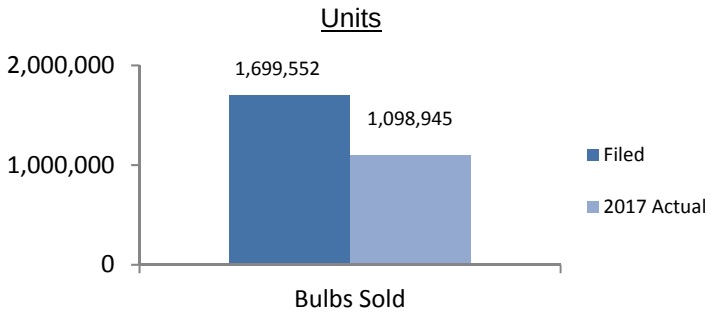
PERFORMANCE SUMMARY

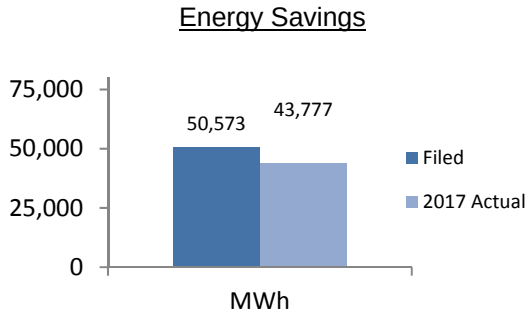
During 2017, a total of 1,098,945 bulbs were sold to residential customers throughout the DP&L service territory, resulting in gross annualized energy savings of 43,777 MWh and peak demand savings of 5.23 MW. Keys to the program's success include offering customers a wide variety of lighting choices with attractive discounts as well as a broad, and convenient, retail distribution network.

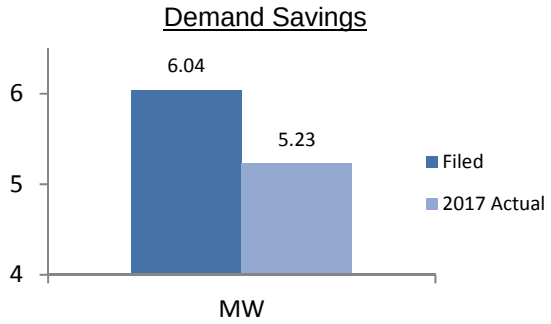
Program evaluations and national trends suggest that five percent of discounted LEDs were purchased by non-residential customers. As a result, five percent of savings and costs from the Residential Lighting Program have been reallocated to the Non-Residential Prescriptive Rebates Program. The metrics in this section reflect the 5% reallocation.

Additionally, in 2017, DP&L requested and was granted permission from the PUCO to transfer $300,000 from the Residential Lighting program to the Residential Appliance Recycling program to provide additional incentives to meet high customer demand in that program. Transfer of these funds is reflected in the filed program budget.

2017 Performance

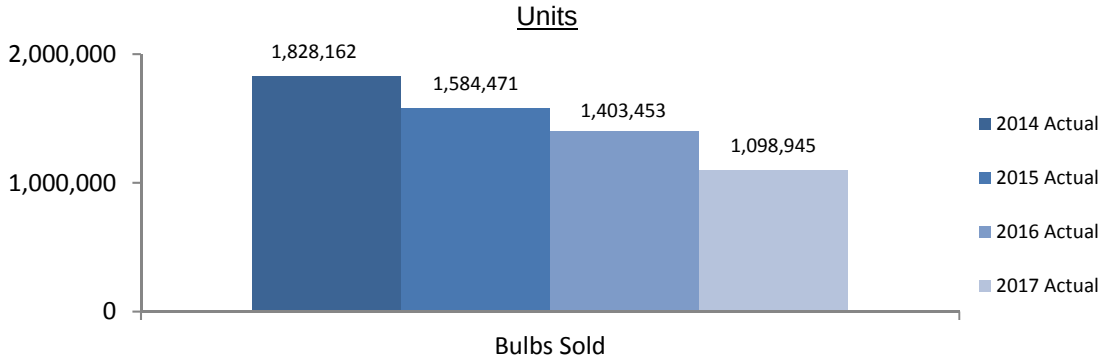


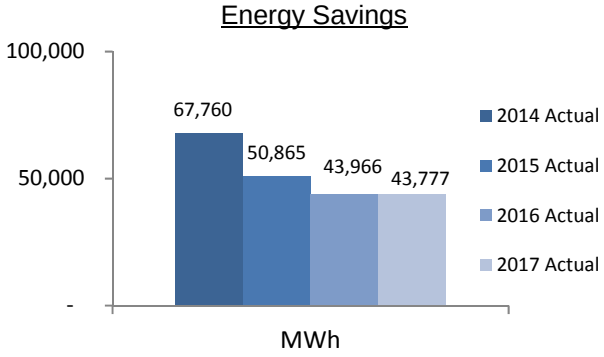


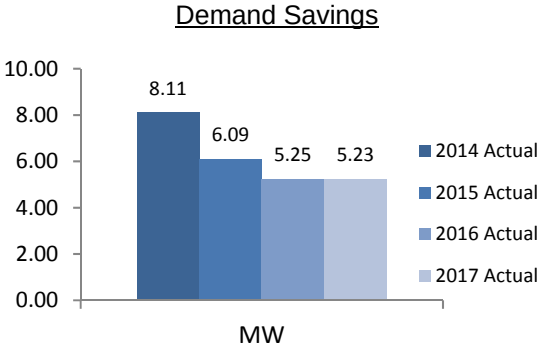


All "filed" numbers are taken from DP&L's program portfolio filing; Case No. 13-0833-EL-POR.

Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$1,716,965	$1,607,164
Marketing & Admin	$1,055,824	$949,044
Total Costs	$2,772,789	$2,556,208

IMPLEMENTATION REVIEW

Implementation Strategy

With a lighting discount program, a third-party implementation vendor offers significant value due to its experience running similar programs as well as existing lighting manufacturer and retailer relationships. As such, DP&L determined that program implementation would be most effectively managed by a third-party implementation partner.

At the conclusion of a Request for Proposal (RFP) process, CLEAResult (formerly Applied Proactive Technologies), based in Springfield, Massachusetts, was selected as the implementation partner. In its proposal, CLEAResult demonstrated a sound process for quickly and effectively implementing programs based on its fifteen-year track record of successfully implementing similar programs for utility clients, including AEP Ohio, in 20 states throughout the country.

Targeted Products

DP&L's Residential Lighting Program is designed to provide customers with an extensive choice of products, so customers can select the types of bulbs that best meet their needs. In total, the 2017 DP&L program offered customers a choice of 634 different LED products. The most popular products by type included: 9-watt A19 LEDs (standard LEDs) and 10-watt BR30 LEDs (specialty LEDs). DP&L offers soft white, bright white and daylight colored bulbs. Customers could choose between the following LED bulb types: 3-way, dimmable, globe, A-line, reflector, and candelabra. For standard LEDs, the average discount was $1.26 per bulb with discounts ranging from $0.50 to $2.00. For specialty LEDs, the average discount offered was $1.99 per bulb with discounts ranging from $0.75 to $4.00, depending on the type of bulb.

Targeted Retailers, Locations

To make the program convenient and accessible for all customers, DP&L's program enlisted the participation of the traditional "big box" retailers as well as independent hardware and specialty locations. Both big box and independent retailers add value to the program, but big box retailers sell significant volume, allowing the program to reach the largest number of DP&L customers as quickly as possible.

The primary participating retail outlets were concentrated in the Dayton metropolitan area to match the location of the highest volume of DP&L residential customers. DP&L also offered the program in outlying areas, giving all residential customers the

opportunity to participate. In addition, an online retailer was included in the program to provide an additional convenient option for customers.

Retail locations were carefully selected to minimize the potential for participation from non-DP&L customers. The highest concentration of retailer locations coincides with geographic areas that have the highest concentration of DP&L customers. Retailer locations outside of the DP&L service territory were excluded. In communities served by municipal utilities or on the edge of the DP&L service territory, store locations were minimized.

Participating Retailers

Retailer	# of Locations	Retailer	# of Locations
Ace Hardware	12	Menards	4
Batteries Plus	3	Rural King	4
Costco	1	Online	1
Dickman Supply	4	Sam's Club	3
Dollar Tree	17	Target	4
Home Depot	7	Walmart	17
Lowes	12	Total	94
Meijer	6		

Staffing

Two CLEAResult staff members managed the program and served as DP&L's direct points-of-contact. These experienced managers supported three local field staff members. The local field staff was responsible for visiting participating retail outlets to ensure that discounted products were stocked on the shelves, priced and labeled correctly, so customers received the discounts at the register. The local field staff was also responsible for promoting the program at a number of community events.

Marketing

In order to promote LEDs and the lighting program discounts to its customers, DP&L employed a breadth of marketing methods. Starting with the assumption that the majority of lighting purchasing decisions are made in the store at the time of purchase, the core of the marketing efforts focused on point-of-purchase (POP) materials. For instance, DP&L created a special sticker which is placed next to the standard price sticker to alert customers to program discounts. A "vertical beam sign" protrudes into the aisle and calls attention to the available discounts and the benefits of efficient lighting. CLEAResult works with retail management staff at the national level to create approved templates for in-store signage. And, local field staff work with local store managers to position the discounted bulbs and signage in highly visible areas whenever possible.

Point-of-Purchase Material Samples

Vertical Beam Sign

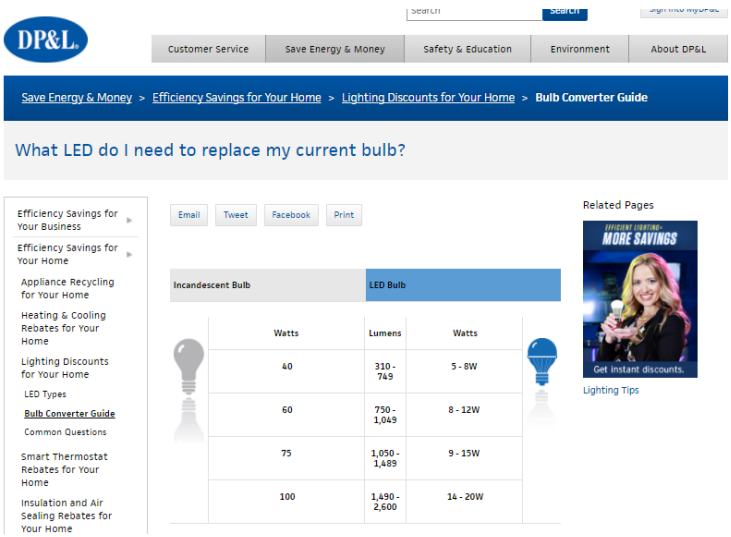
Shelf Sticker

8x10 Shelf Sign

Beyond the POP materials, DP&L also promotes the Residential Lighting Program to customers via a web site, bill inserts, presence at special events, and mass media advertising.

The Residential Lighting program's web pages on the DP&L company web site provide a description of bulb types and their applications, conversions of wattages from incandescent to LED, and answers to frequently asked questions.

Customers can also access an online retailer to place an order of discounted bulbs.



Web Site

The Residential Lighting program landing page gives a description of the residential lighting program and allows customers to navigate to other pages for more information.

Bill Insert

Bill inserts were mailed to 450,000 residential customers in April.

Community Outreach Events

The CLEAResult local field staff attended 47 local community and in-store events to discuss the Residential Lighting program, LEDs, and their benefits.

Education, General Awareness

DP&L conducted a mass media education and general awareness campaign promoting the value of energy efficiency and the available residential programs. A complete discussion of this campaign can be found in the Education, Awareness Building & Market Transformation Activities section.

Community Partnerships

DP&L was able to utilize promotional benefits provided via existing corporate sponsorships of local organizations, like the minor league Dayton Dragons baseball team.

Customer Service

In all programs, customer service is a critical element of program success. As such, DP&L designed a number of customer service elements into its programs, some of which have been previously discussed.

The program web pages (discussed in the Residential Lighting Program Marketing section) allow DP&L to provide a breadth of information for all customers with internet access. The web pages not only educate about LEDs, but also help customers locate available discounts near their home.

For those without internet access, or who want to speak to a representative, DP&L set up a program hotline number staffed by CLEAResult employees. The staff has been trained to answer detailed questions about the Residential Lighting Program and help customers locate available discounts.

DP&L maintains its own customer service center, accepting calls regarding all functions of DP&L. DP&L management staff continues to update customer service center staff regarding program details as needed.

The CLEAResult local field staff continues to be a large component of DP&L's customer service, ensuring the accuracy of prices and products in stores, which helps to meet customers' expectations. In a retail environment, it is possible for POP materials to be inadvertently removed or placed next to products that may or may not be discounted as restocking occurs. Regular, in-person store visits are an essential element of the program. CLEAResult performed more than 2,100 store visits in 2017. In addition, the local field staff was in direct contact with customers at 47 local community events and in-store events in 2017, answering questions and helping to educate customers about the program.

RESIDENTIAL HVAC REBATES

PROGRAM DESCRIPTION

The Residential HVAC Rebates Program offers rebates for the installation of new or replacement, high efficiency central air conditioning and heat pump systems. The participating HVAC contractor submits the rebate for the customer, and the customer receives a rebate check in the mail.

The objective of the program is to reduce energy consumption and peak demand savings by incentivizing customers to purchase efficient HVAC equipment that goes above and beyond the current minimum standard for efficiency.

This program is designed for any homeowner or landlord purchasing a new or replacement HVAC unit that will be installed at a residence within the DP&L service territory. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

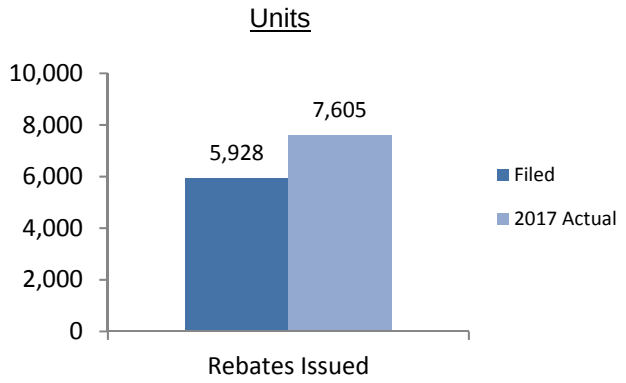
The program started in June 2009 with a core group of 23 participating contractors and has increased to 157 participating contractors by the end of 2017.

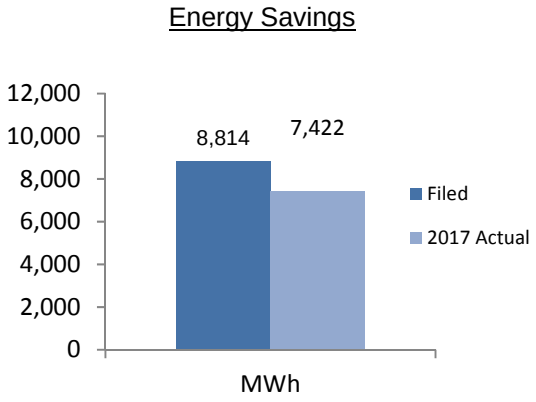
PERFORMANCE SUMMARY

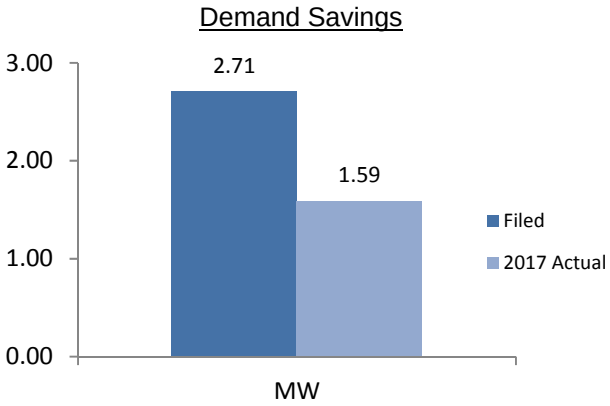
During 2017, a total of 7,605 HVAC rebates were issued throughout the DP&L service territory, resulting in gross annualized energy savings of 7,422 MWh and peak demand savings of 1.59 MW. Keys to the program's success include offering customer rebates on a wide variety of HVAC products and insulation and weatherization services through a widespread contractor network.

The filed goals presented in the following charts reflect a continuation of the 2015 and 2016 budgets and energy savings goals, consistent with the PUCO order in Case No. 16-0649-EL-POR. However, DP&L implemented the HVAC program to conform to new, lower budget and savings goals, per the 2017-2019 portfolio plan filing and corresponding RFP effort. Therefore, the reported results are substantially lower than filed goals.

2017 Performance







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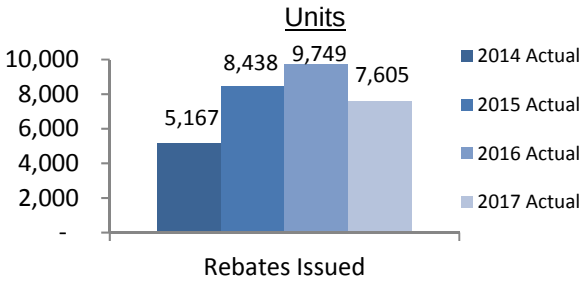
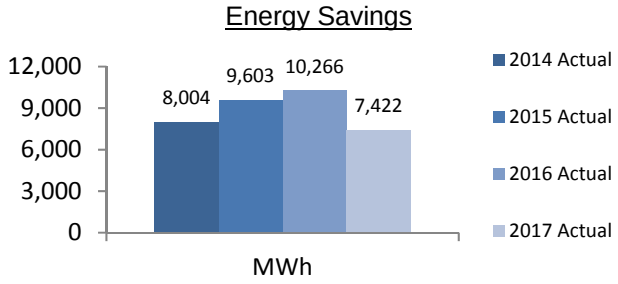
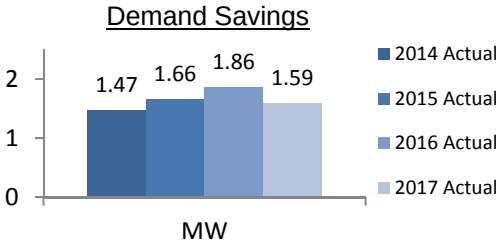
Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$1,808,012	$1,315,057
Marketing & Admin	$976,234	$595,518
Total Costs	$2,784,246	$1,910,575

IMPLEMENTATION REVIEW

Implementation Strategy

With a Residential HVAC Rebate Program, it is valuable to have a third-party implementation vendor with experience running similar programs that require building a network of HVAC contractors. Therefore, DP&L determined that program implementation would be most effectively managed by a third-party implementation partner.

At the conclusion of a 2016 RFP process, CLEAResult won the bid to implement the 2017 Residential HVAC Rebate Program.

Targeted Products

DP&L offered rebates for central HVAC systems in three categories: New Construction; Replacement; and Early Retirement, with tiers for higher efficiency levels. DP&L customers can select the system manufacturer and model of their choice, but are only eligible to receive a rebate if the system meets the Seasonal Energy Efficiency Rating (SEER) requirements, or the Energy Efficiency Ratio (EER) requirements for ground source heat pumps. DP&L also offers rebates for the installation of electronically commutated motors (ECM) used in high efficiency, gas furnaces. In 2017, the most popular central system rebate was for early retirement air conditioners at SEER 14/15, followed by early retirement air conditioners at SEER 16+. DP&L issued 1,920 rebates for programmable, smart and wi-fi thermostats. Eleven Smart Thermostats were incentivized at $50 between January and February, before the Smart Thermostat Pilot had begun. Additionally, DP&L offered incentives for home insulation and weatherization on electrically heated homes.

Rebates Offered

Central Air Conditioning

SEER Efficiency Rating	New Construction	Replacement	Early Retirement
14-15	$100	$100	$200
16+	$150	$150	$300

Air-Source Heat Pumps

SEER Efficiency Ratio	New Construction	Replacement	Early Retirement
15	$150	$150	$300
16+	$250	$150	$450

Mini-Splits

SEER Efficiency Ratio	New Construction	Replacement
14+	$150	$150
15+	$200	$200

*Mini-splits are not eligible for early retirement rebates.

Ground-Source Heat Pumps

EER Efficiency Ratio	New Construction	Replacement	Early Retirement
16-18	$800	$800	$1,000
19+	$1,000	$1,000	$1,250

Electronically Commutated Motors

Cooling Type	New Construction	Replacement
Furnace only	$50	$50
Air conditioner	$50	$50
Heat pump	$25	$25

Thermostats

Cooling Type	Programmable w/Air Conditioner	Programmable w/Heat Pump	Smart Thermostat
	$20	$40	$50

Heat Pump Water Heater

Heating Type	Gas Furnace	Heat Pump
	$400	$400

The following are descriptions of the different rebate categories for HVAC equipment.

New Construction – High-efficiency, new equipment installed in an existing home, a new home, or a home addition where there is no previously existing central air conditioning or heat pump system.

Replacement – High-efficiency, new equipment installed as a replacement for existing equipment not meeting early retirement eligibility requirements.

Early Retirement – High-efficiency, new equipment installed as a replacement for existing equipment that meets the following requirements:

Existing equipment is in working order, regardless of age OR

Existing equipment is less than or equal to 20 years old and is repairable for less than $1000.

Rebates Issued

Technology	Rebates Issued 2017
Air Conditioners	2,524
Air Source Heat Pumps	748
Ductless Mini-Splits	185
Ground Source Heat Pumps	52
ECMs	2,053
Thermostats	1,920
Heat Pump Water Heaters	21
Air Sealing	47
Wall Insulation	13
Attic Insulation	42
TOTAL	7,605

Targeted Contractors

CLEAResult recruited a network of contractors to market, recommend, and install eligible HVAC equipment. Contractors must be certified by DP&L to participate in the program and must sign a partnership agreement. Certification qualifications include: a valid HVAC license; minimum levels of insurance; Environmental Protection Agency-certified technicians; and a Better Business Bureau rating higher than B-. Large contractors were targeted first, which allowed the program to reach the greatest number of DP&L customers as quickly as possible. Continually, smaller, independent contractors were recruited, so that by the end of 2017, the program had 157 participating contractors located throughout the DP&L service territory.

To make the program convenient and accessible for all customers, customers may purchase an eligible HVAC system from any DP&L certified contractor of their choice. If a customer's existing contractor is not already a certified contractor, CLEAResult will work to recruit the contractor into the program so the customer does not have to switch contractors.

When purchasing qualifying equipment, participating contractors complete the rebate application on the customers' behalf. DP&L customers then receive the rebate via a check mailed to their home.

Staffing

CLEAResult's local staff members manage the program and serve as DP&L's direct point-of-contact. The local field staff, consisting of a program manager, account manager, administrative coordinator, data entry specialist, and part-time quality control auditor, is responsible for maintaining relationships with HVAC contractors to ensure the program is mutually beneficial and successful. For contractors to be most successful in the program, they need to have a thorough understanding of program guidelines and buy-in to the DP&L program design and processes. CLEAResult maintains regular contact with contractors to discuss program issues, potential solutions, and opportunities for improvement.

CLEAResult closely monitors rebate applications for accuracy of rebate values and eligibility of equipment. CLEAResult also performs quality control checks on a portion of all system installations and accompanying paperwork to ensure contractors adhere to the program guidelines. Contractors who exhibit a track record of poor quality work or customer complaints are removed from the program. The local staff is supported by the experienced managers and support team located in the CLEAResult main office.

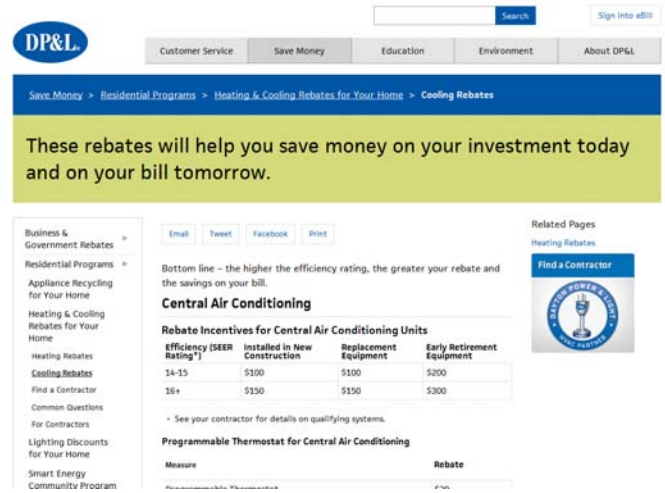
Marketing

The program is designed to be marketed largely through participating HVAC contractors. Since contractors work directly with DP&L customers, they are able to offer rebates at the point-of-sale. Participating contractors are motivated to offer the rebates as a sales tool, providing a discount that non-participating contractors cannot. To

support contractors and help advertise the program, DP&L created a series of marketing pieces including web pages, fliers, bill inserts, and mass media marketing.

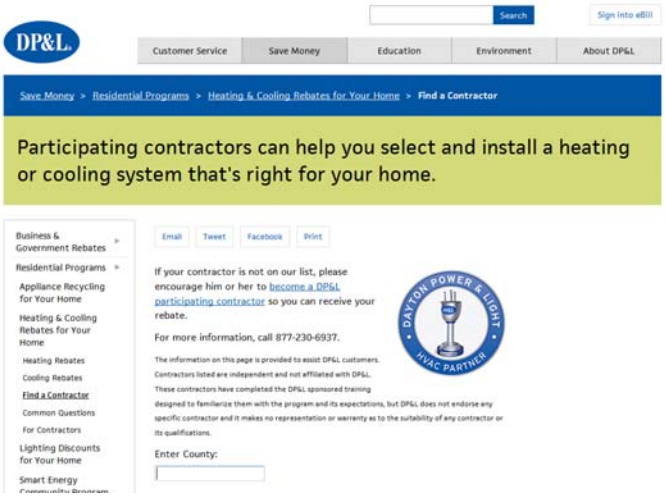
The HVAC rebate program web pages on the DP&L company web site provide an overview of the program, a list of eligible equipment, and answers to frequently asked questions. One page is dedicated to helping customers find a participating contractor. Customers can search by their home county and see a list of all contractors serving that area. This page also mentions the ability to recruit the customer's preferred contractor.

The web portal contains a special log-in section for participating contractors. The portal displays program news and answers to frequently asked questions.



Customer Web Pages

The HVAC program landing page gives a description of the residential HVAC rebates program and allows customers to navigate to other pages for more information.



Web Site Contractor Locator

The contractor locator allows customers to search for participating contractors by their home county.

Education, General Awareness

DP&L conducted a mass media education and general awareness campaign promoting the value of energy efficiency and the available residential programs, including HVAC rebates. A complete discussion of this campaign can be found in the Education, Awareness Building & Market Transformation Activities section.

Bill Insert

Bill inserts were mailed to 450,000 customers in May and June.

Flyer

Program fliers were distributed to customers at community outreach events attended by the residential lighting program field staff, creating promotional efficiencies among programs.

Customer Service

In all programs, customer service is a critical element of program success. As such, DP&L designed a number of customer service elements into its program, some of which have been previously discussed.

The web pages and contractor locator (discussed in the Residential HVAC Rebates Marketing section) allow DP&L to provide a breadth of information for all customers with internet access. The contractor locator allows customers to conveniently access a way to participate in the program.

For those without internet access, or who want to speak to a representative, DP&L set up a program hotline number staffed by CLEAResult employees. The staff has been trained to answer detailed questions about the Residential HVAC Rebates Program and help customers locate participating contractors in their area.

DP&L maintains its own customer service center, accepting calls regarding all functions of DP&L. DP&L management staff continues to update customer service center staff regarding program details as needed.

The large number of participating contractors is an important component of DP&L's customer service. The contractors are located throughout DP&L's service territory, making the rebates accessible to all customers. In addition, the ability to recruit a customer's current contractor is a large source of satisfaction for both the customer and the contractor.

The CLEAResult local staff is another significant element of DP&L's customer service, serving both the contractors and the customers. For contractors to be most successful in the program, they need to have a thorough understanding of program guidelines and buy-in to the program design and processes. CLEAResult maintains regular contact with contractors to discuss program issues, potential solutions, and opportunities for improvement.

In addition, CLEAResult's quality control of contractors' work allows DP&L customers to receive their rebates, as promised. CLEAResult performs quality control checks on five percent of all system installations and five percent of pre-installations for early retirement systems. Equipment is reviewed along with the accompanying paperwork to ensure contractors adhere to the program guidelines. CLEAResult's oversight ensures the program's integrity is maintained and customers are treated properly and fairly. Contractors who exhibit a track record of poor quality work or customer complaints are removed from the program.

RESIDENTIAL APPLIANCE RECYCLING

PROGRAM DESCRIPTION

The Residential Appliance Recycling Program allowed for the collection of working refrigerators, freezers, room air conditioners, and dehumidifiers. The appliances were picked up directly from customers' homes, at no cost to the customer, and were transported to a facility in Lima, Ohio to be deconstructed and recycled according to the Environmental Protection Agency's (EPA) best practices. Customers participating in the program in 2017 received a $50 rebate check for each refrigerator and freezer recycled, and $20 for each room air conditioner and dehumidifier recycled.

The objective of the program was to promote the retirement and recycling of inefficient appliances from households by offering an incentive for working equipment as well as information and education on the cost of keeping an inefficient unit in operation.

The Residential Appliance Recycling Program was designed for any residential customer with working refrigerators or freezers. The appliances were required to be plugged in and in working condition. All targeted customers taking delivery service from DP&L were eligible for this program regardless of their choice of generation supplier.

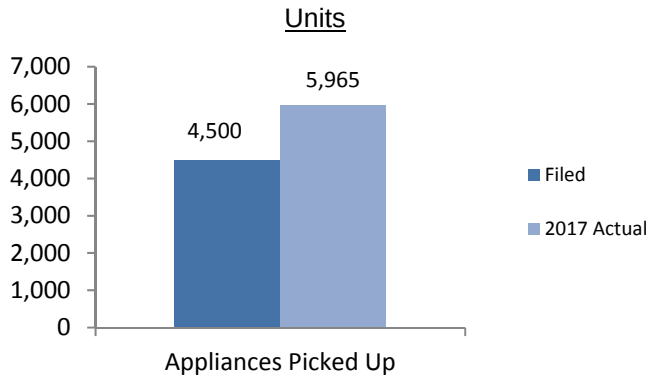
This program started in May 2009 and continued through 2017.

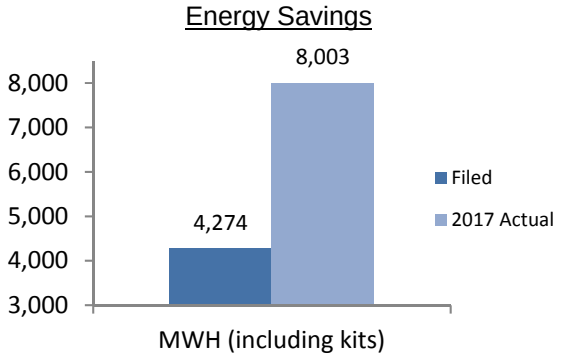
PERFORMANCE SUMMARY

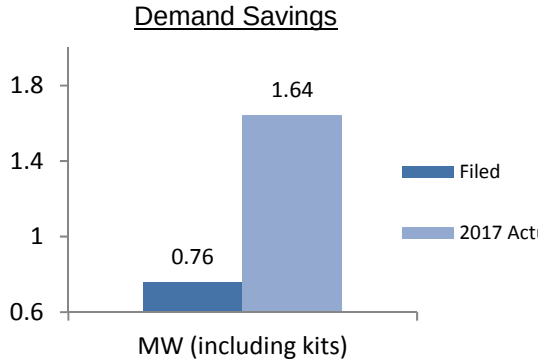
During 2017, 5,965 appliances were collected throughout the DP&L service territory, resulting in annualized energy savings of 7,417 MWh and peak demand savings of 1.58 MW. Additionally, DP&L continued distributing energy savings kits to customers when picking up their appliance to be recycled. Energy kit savings resulted in annualized energy savings of 586 MWh and peak demand savings of 0.06 MW. Therefore, the total gross annualized energy savings for the Residential Appliance Recycling Program were 8,003 MWh and peak demand savings of 1.64 MW.

Additionally, in 2017, DP&L requested and was granted permission from the PUCO to transfer $300,000 from the Residential Lighting program to the Residential Appliance Recycling program to provide additional incentives to meet high customer demand in that program. Transfer of these funds is reflected in the filed program budget.

2017 Performance







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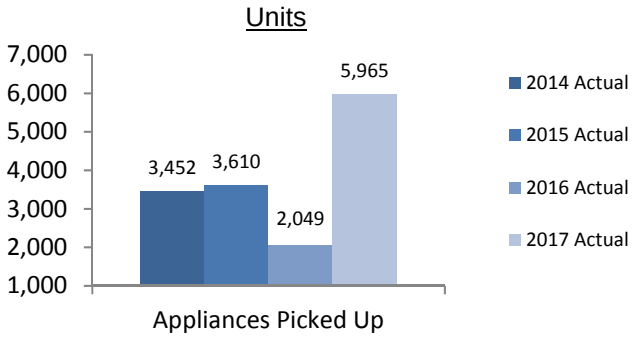
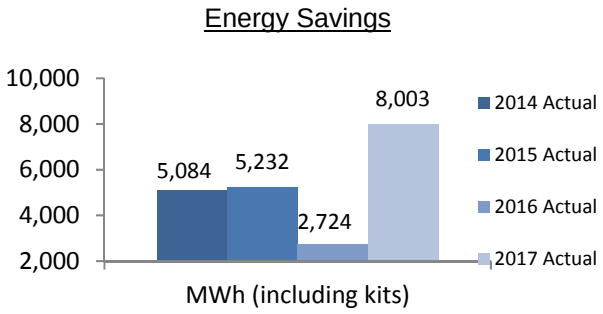
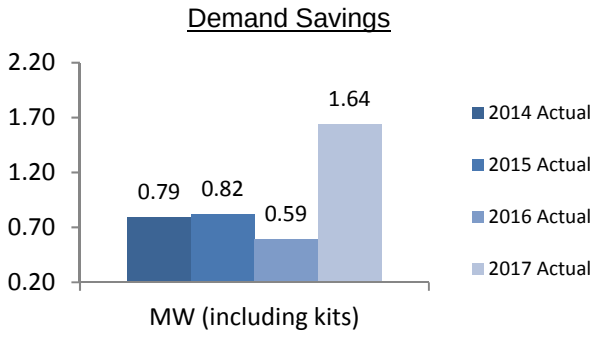
Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$325,000	$324,071
Marketing & Admin	$764,656	$700,566
Total Costs	$1,089,656	$1,024,637

IMPLEMENTATION REVIEW

Implementation Strategy

Appliance recycling and proper disposal of materials require technical expertise, available recycling facilities, and qualified crews in the field. As such, DP&L determined a third-party implementation partner, specializing in this area, provided the best means of effectively managing the program.

At the conclusion of a 2016 Request for Proposal (RFP) process, Recleim, based in Atlanta, Georgia was selected as the implementation partner. In its proposal, Recleim demonstrated a sound process for efficiently and properly colleting and deconstructing appliances, as well as the recycling and disposal of appliance components. Recleim had experience implementing programs for clients like ComEd, PPL Electric Utilities and UGI Utilities. Key program management personnel also had many years of experience working for clients throughout the country, including DP&L, on an appliance recycling program with a former vendor.

Targeted Products

DP&L offered rebates for working refrigerators and freezers functioning both as secondary units and primary units, which were likely on their way to becoming secondary units in a garage or basement. The unit was required to be 10 to 30 cubic feet in size, which is the traditional size for units used in a residential setting. DP&L also collected working room air conditioners and dehumidifiers that were picked up along with a refrigerator or freezer.

Before an appliance was removed from the home, Recleim inspected the appliance to ensure it was in working condition and was plugged in. Non-working appliances or those that are unplugged are not eligible for removal.

Rebates Issued by Order Date 2017

Month	Refrigerators	Freezers	Room Air Conditioners	Dehumidifiers
January	257	50	27	18
February	161	23	16	6
March	257	65	21	15
April	302	77	22	8
May	474	114	59	29
June	690	177	108	103
July	456	110	36	30
August	512	104	27	38
September	354	80	31	14
October	320	73	25	24
November	237	36	15	10
December	277	43	19	15
Total	4,297	952	406	310

Of the 5,965 units collected in 2017, the average year the appliances were made was 1996.

The rebate amount was $50 per refrigerator and freezer collected and $20 for each room air conditioner and dehumidifier collected. Customers were paid via digital check, pre-paid Visa card, or check mailed directly to their homes.

Home Energy Savings Kits
In 2017, DP&L continued distributing energy savings kits to customers when picking up their appliance to be recycled. This customer service element enabled customers to save more energy at home and increased program savings.

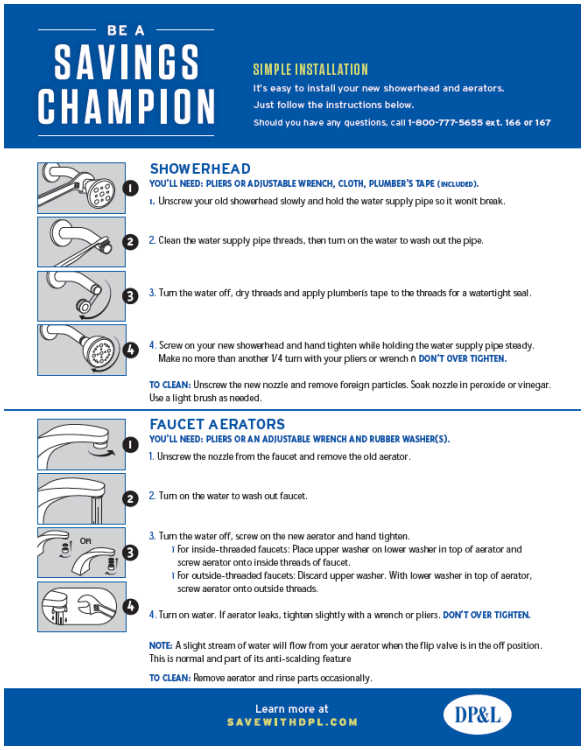
Energy savings kits included:

- 2 9W LED bulbs
- 1 Earth Massage Showerhead
- 1 Kitchen Faucet Aerator
- 1 Bathroom Faucet Aerator
- 1 Roll of TeflonTape for Aerator Installation
- 1 Flyer with Installation Instructions and Promotional Information about Other DP&L Energy Efficiency Programs

Each participating customer was offered an energy savings kit, but customers could choose whether to accept it. In 2017, 4,416 energy savings kits were distributed.

Energy Savings Kits Distributed to Appliance Recycling Program Participants

Flyer Included in Energy Savings Kits
Installation Instructions and Promotion of Other DP&L Energy Efficiency Programs



Targeted Locations

To make the Residential Appliance Recycling Program convenient and accessible to all residential customers, Recleim crews were available to pick up appliances from every geographic area of the DP&L service territory. Recleim scheduled pick-up dates and routes according to geography, targeting one region of the service territory each day.

Staffing

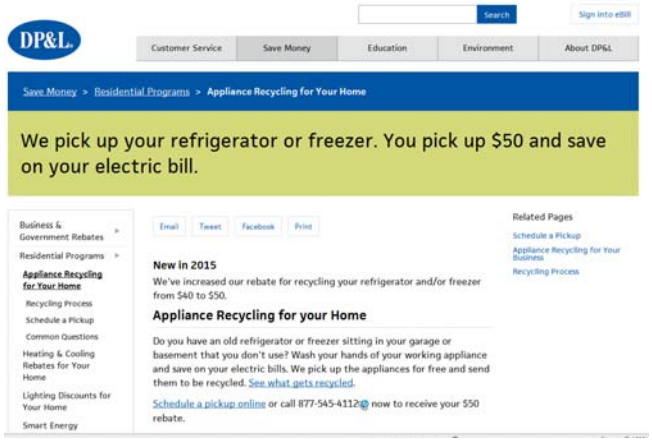
A senior program manager served as the DP&L point-of-contact. The Recleim program manager regularly communicated with the DP&L program manager to ensure the program was on track to meet targets. The Recleim program manager also coordinated all the project's tasks and served as the hub of communication to Recleim support staff in technical support, customer service, check processing, and operations.

The collection logistics facility in Columbus, Ohio was managed by an on-site facility manager who planned the crew's pick-up routes and managed the collection and tracking of units. Crews of two were dispatched each day from the facility to the pick-up routes. Three times per week, collected units were transported from the logistics facility to Recleim's state-of-the-art de-manufacturing plant in Lima, Ohio, opened in Fall 2017. This plant opening brought more than 100 jobs to the Lima area. Recleim safely disposed of toxins and chlorofluorocarbon (CFC-11) gases from foam insulation. After capturing toxins (oils, mercury, PCBs) and other substances (CFC-11 and other foam insulation blowing agents and CFC-12 and other refrigerants), Recleim recycled all the plastic, metals and glass in the appliances. Nearly 100 percent of a refrigerator's components were reused rather than going to the landfill. The facility manager was responsible for ensuring all material handling processes complied with the best practices of the U.S. Environmental Protection Agency (EPA). DP&L is a utility partner in the EPA's Responsible Appliance Disposal Program. Recleim tracked and reported all program activity required by the RAD program.

Marketing

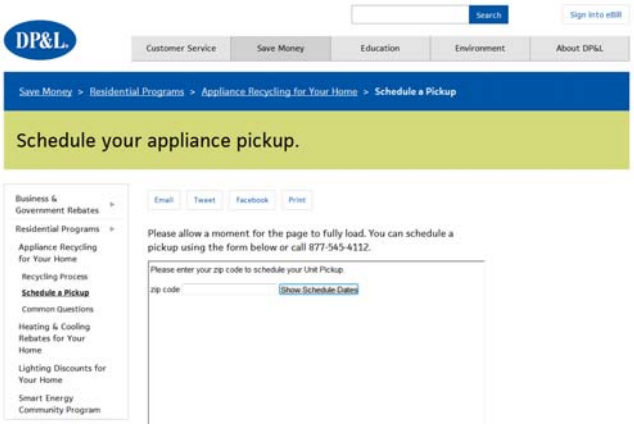
DP&L utilized a variety of marketing methods to promote the appliance recycling program to customers, including bill inserts, web pages, and mass media advertisements. The marketing collateral emphasized the cost of operating a second refrigerator or freezer and the rebate offered to program participants.

The customer web pages on the DP&L web site informed customers of program eligibility requirements, answers to frequently asked questions, and an overview of the recycling process. In addition, customers were able to register and schedule a pick-up via a web interface.



Customer Web Pages

The appliance recycling program landing page gave a description of the program and allowed customers to navigate to other pages for more information.



Online Registration

Online registration allowed customers to schedule a pick-up at their home.

Education, General Awareness

DP&L conducted a mass media education and general awareness campaign promoting the value of energy efficiency and the available residential programs. A complete discussion of this campaign can be found in the Education, Awareness Building & Market Transformation section.

Bill Insert

Bill inserts were mailed to 450,000 customers in April and May.

Flyer

Program fliers were distributed to customers at community outreach events attended by the residential lighting program field staff, creating promotional efficiencies among programs.

Customer Service

In all programs, customer service is a critical element of program success. As such, DP&L designed a number of customer service elements into its program, some of which have been previously discussed.

The web portal and online registration tool served as a convenient way for customers to learn about the program and schedule a pick-up of their appliance. Customers were able to search for times when an Recleim crew would be working in their area and select the date of their choice for a pick-up.

For those without internet access, or for customers who wanted to talk to a representative, DP&L set up a program hotline number staffed by Recleim employees. The staff was trained to answer detailed questions about the Residential Appliance Recycling Program and to assist customers in scheduling appointments.

DP&L maintains its own customer service center, accepting calls regarding all functions of DP&L. DP&L management staff continued to update customer service center staff regarding program details as needed.

For the customer's convenience, Recleim crews called 24 to 48 hours before the appointment date to confirm a four-hour window for the pick-up. On the day of the appointment, Recleim crews called the customer 30 minutes prior to the expected arrival time.

Recleim crews conveniently retrieved the appliances from hard-to-access locations, like basements; the customer needed only to clear a path to the appliance. Customers were paid via digital check, pre-paid Visa card, or check mailed directly to their homes. Rebate processing was managed by Recleim.

RESIDENTIAL SCHOOL EDUCATION

PROGRAM DESCRIPTION

The School Education Program is designed to educate students about energy and energy efficiency, and reduce electricity use of program participants. Take-home energy savings kits are provided to students as well as accompanying classroom curriculum that is aligned with national and state education standards. Additional training events are held throughout the year for both teachers and students. This program is delivered jointly with the local gas company in order to educate students about using both gas and electricity efficiently.

The objectives of the program are to: 1) reduce electricity use of program participants in selected schools; 2) educate students and their families about energy, energy efficiency, and the effects of their energy usage decisions; and 3) create energy awareness among students that will promote energy efficient habits throughout their lives.

The Residential School Education Program is available to public and private school districts in the DP&L service territory.

This portfolio status report discusses and reports savings for the 2016-17 school year only. Results for the 2017-18 school year will be presented in the 2018 annual portfolio status report.

PERFORMANCE SUMMARY

During the 2016-17 school year, 9,102 energy savings kits were distributed to teachers and taken home by students. Savings garnered via the installation of LED light bulbs, LED night lights, faucet aerators and energy efficient showerheads provided in students' take-home kits were gross annualized energy savings of 3,602 MWh and peak demand savings of 0.19 MW.

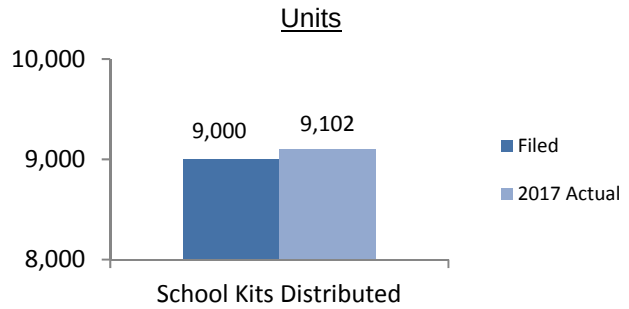
Since a central element of this program is educational, it is important to also measure the performance of the program based on participant feedback and educational impact. OEP conducted surveys of participating teachers. Survey results are as follows:

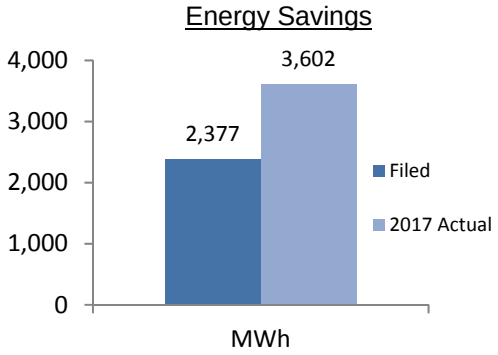
- Ninety one percent of teachers agreed that the activities helped their students better understand energy and energy efficiency.
- Ninety percent of teachers agreed that the program changed the students' and/or family's attitudes or behavior toward energy efficiency.
- Nearly 100 percent of teachers said they would conduct the unit again.

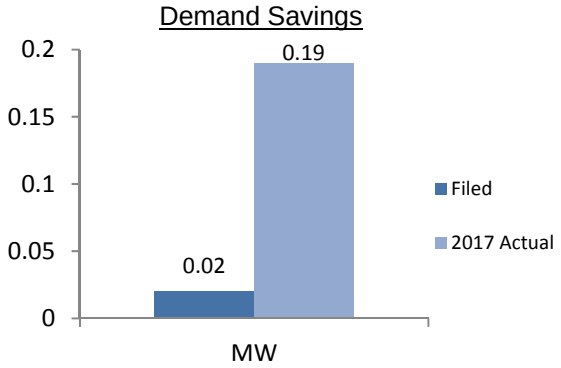
These are a few comments from participating teachers regarding the program:

- These lessons provide wonderful, hands-on experiences that the students understand AND can easily pass on to their parents, older relatives, and neighbors.
- I think it helps students to consider their use of energy and how they can control to help their families and their own future.
- I have used these units for many years now. They are always well organized and the kids like them. I really like the lighting lesson and so do the kids.
- I look forward to conducting this unit again. It is relevant, you provide great learning activities that are fun and purposeful, and it aligns directly with our science standards. It is a win-win for students, families, and, of course, me.
- I would normally dread an energy unit, but this program has made it one of my favorites all year! Both the students and I LOVE all of the hands-on learning this unit provides!

2017 Performance

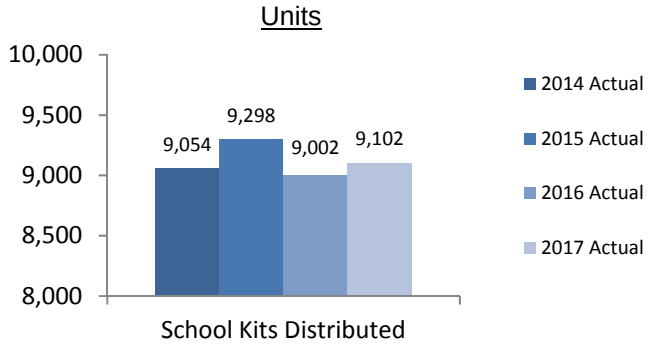


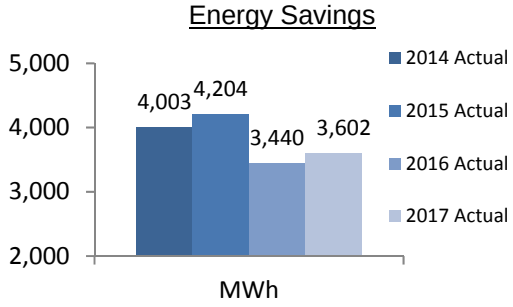


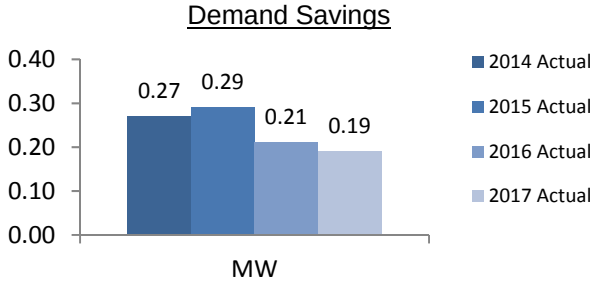


All "filed" numbers are taken from DP&L's program portfolio filing; Case No. 13-0833-EL-POR.

Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$98,103	$134,413
Marketing & Admin	$237,270	$152,783
Total Costs	$335,373	$287,196

IMPLEMENTATION REVIEW

Implementation Strategy

Implementing a school education program requires expertise of education standards and teachers' methods, as well as relationships with school district administrators and teachers. As such, DP&L determined a third-party implementation partner, specializing in this area, provided the best means of effectively managing the program.

DP&L selected Ohio Energy Project (OEP) as its implementation partner. OEP is uniquely qualified to provide energy efficiency education based on its existing relationships with school districts and experience delivering similar programs throughout Ohio. OEP is currently operating the same type of program for AEP Ohio.
DP&L partners with Vectren and OEP to deliver a school program which addresses both electric and natural gas savings. The joint effort with Vectren was pursued with the encouragement of DP&L's energy efficiency collaborative.

Targeted Products

Participating teachers were provided energy savings kits to be sent home with each participating student. Each component of the take-home kit was discussed in the classroom, informing students how to properly install and use the item, as well as the way it helps save energy. As a result of our partnership with Vectren, kit components address electric, gas, and water savings.

Each teacher was provided with a complete curriculum designed to accompany and educate students about the items contained in the take-home energy savings kit. The curriculum included classroom activities, experiments, and games, all meeting state of Ohio education standards. The curriculum also covered subjects like properties of energy, electric generation fuel sources, home energy audit suggestions, appliance energy usage comparisons, CFL versus incandescent cost comparisons, home temperature measurement exercises, and weatherization information.

In addition, teachers were given materials needed to teach the program curriculum in their classrooms. Teachers were given kits that contained classroom teaching tools, activities, and games that reinforce concepts such as renewable and nonrenewable resources, and energy transformations.

Take-Home Kit Contents

Item	Description
2 9W LED	Long-life light bulb with up to 90% energy savings. Lasts up to 25 times longer than an incandescent bulb.
Foam Weather-Strip	Adhesive backed weather stripping, good for sealing out drafts in doors and windows.
Self-Stick Door Sweep	Adhesive-backed PVC door sweep. Seals door gaps and prevents drafts.
Flow Meter Bag	Test your water faucets to see how much water they use.
Earth Massage Showerhead	This product saves water and the energy required to heat the water.
2 Bathroom Sink Aerators	Consistent water pressure from a bathroom sink aerator. This product saves water and the energy required to heat the water.
1 Kitchen Sink Aerator	Consistent water pressure from a kitchen sink aerator. This product saves water and the energy required to heat the water.
Refrigerator Thermometer Card	Credit card-sized measuring device to determine whether refrigerator is at an efficient temperature.
LED Night Light	Light Emitting Diode (LED) technology creates suitable yet energy efficient light.
Hot Water Temperature Card	Credit card-sized device measures the temperature of hot tap water. Card provides suggested range for setting water heater temperature to optimize efficiency.
DP&L Residential Energy Efficiency Programs Flier	Handout describing DP&L's energy efficiency programs which can help save energy and money.

Sample In-Class Activity

Comparing EnergyGuide Labels Answer Key

Comparing EnergyGuide Labels

Your family needs to buy a new water heater. Water heaters usually last a long time—10 years or more—so you can save a lot of money using an energy-efficient one. Use the chart below to figure out which water heater to buy, comparing the information on the EnergyGuide labels.

Water Heater 1—Purchase Price: $750.00

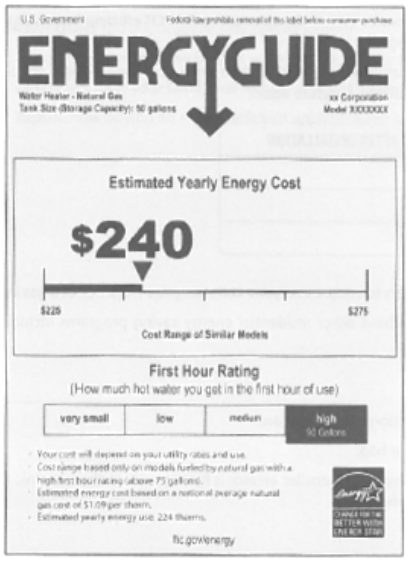
WATER HEATER 1	EXPENSES	COST TO DATE
Purchase Price	$750	$750
Year One	$240	$990
Year Two	$240	$1,230
Year Three	$240	$1,470
Year Four	$240	$1,710
Year Five	$240	$1,950
Year Six	$240	$2,190
Year Seven	$240	$2,430

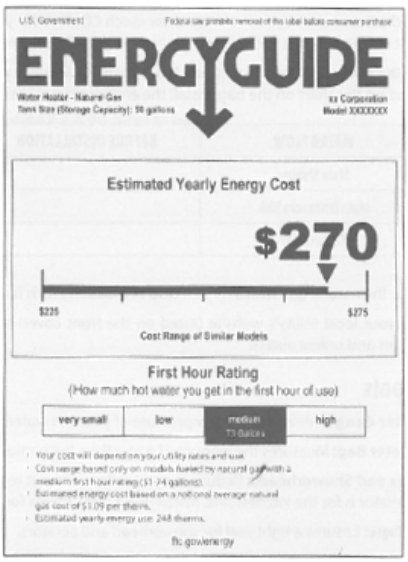
Water Heater 2— Purchase Price: $650.00

WATER HEATER 2	EXPENSES	COST TO DATE
Purchase Price	$650	$650
Year One	$270	$920
Year Two	$270	$1,190
Year Three	$270	$1,460
Year Four	$270	$1,730
Year Five	$270	$2,000
Year Six	$270	$2,270
Year Seven	$270	$2,540

How many years will it take before you begin to save money? ***Four years***

How much money will you have saved after seven years? ***$110.00***





Targeted Locations

The program was offered to school districts across DP&L's service territory, grades 5-12. One hundred and thirty-two teachers participated from 84 schools in 50 school districts. Participating school districts were located in 15 counties in DP&L's service territory.

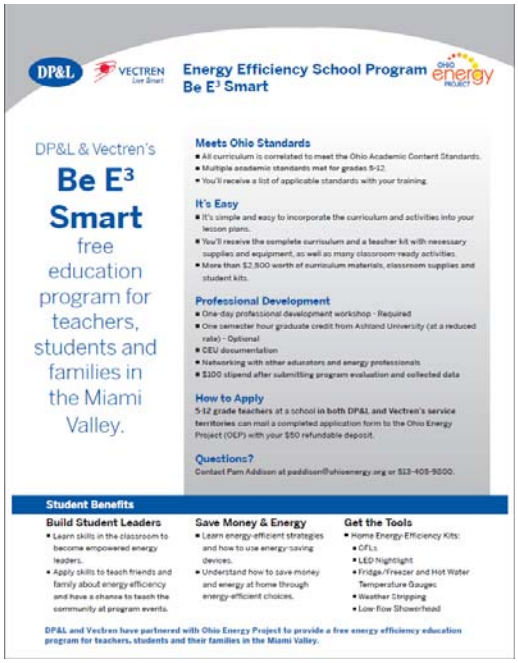
Staffing

The program is implemented by Ohio Energy Project. OEP maintains offices in Columbus and Cincinnati. One program manager, based in the Columbus office, served as DP&L's primary point-of-contact and program coordinator. The OEP program manager regularly communicated with the DP&L program manager to coordinate logistics and ensure the program is on track to meet targets. The OEP program manager also coordinates all the project's tasks and serves as the hub of communication to all OEP staff in management, accounting, and program operations.

Marketing

For purposes of recruitment for program participation, limited marketing activities were performed by DP&L. OEP recruited participants by distributing a flyer and program application, produced by DP&L, to school administrators, curriculum coordinators, and teachers. OEP also promoted the program at workshops, tours, and conferences throughout the year. Recruitment efforts emphasized the educational value of the program as well as the availability of the energy savings materials.

DP&L worked with school districts to promote the activities and educational impacts of the program. Press releases were distributed throughout the year and media was invited to attend program events. DP&L also provided customizable news releases to teachers so school districts could tell their specific educational story to their local newspaper.



DP&L VECTREN Energy Efficiency School Program Be E³ Smart Ohio energy PROJECT

DP&L & Vectren's **Be E³ Smart** free education program for teachers, students and families in the Miami Valley.

Meets Ohio Standards
- All curriculum is correlated to meet the Ohio Academic Content Standards.
- Multiple academic standards met for grades 5-12.
- You'll receive a list of applicable standards with your training.

It's Easy
- It's simple and easy to incorporate the curriculum and activities into your lesson plans.
- You'll receive the complete curriculum and a teacher kit with necessary supplies and equipment, as well as many classroom-ready activities.
- More than $2,500 worth of curriculum materials, classroom supplies and student kits.

Professional Development
- One-day professional development workshop - Required
- One semester hour graduate credit from Ashland University (at a reduced rate) - Optional
- CEU documentation
- Networking with other educators and energy professionals
- $100 stipend after submitting program evaluation and collected data

How to Apply
5-12 grade teachers at a school in both DP&L and Vectren's service territories can mail a completed application form to the Ohio Energy Project (OEP) with your $50 refundable deposit.

Questions?
Contact Pam Addison at paddison@ohioenergy.org or 513-408-9200.

Student Benefits

Build Student Leaders
- Learn skills in the classroom to become empowered energy leaders.
- Apply skills to teach friends and family about energy efficiency and have a chance to teach the community at program events.

Save Money & Energy
- Learn energy-efficient strategies and how to use energy-saving devices.
- Understand how to save money and energy at home through energy-efficient choices.

Get the Tools
- Home Energy-Efficiency Kits:
  - CFLs
  - LED Nightlight
  - Fridge/Freezer and Hot Water Temperature Gauges
  - Weather Stripping
  - Low-flow Showerhead

DP&L and Vectren have partnered with Ohio Energy Project to provide a free energy efficiency education program for teachers, students and their families in the Miami Valley.

Program Flyer/Application

OEP distributed program flyers and applications to school administrators, curriculum coordinators, and teachers.

Students learn how to save energy at fair

The Dayton Power and Light Co. and Vectren Energy Delivery of Ohio held an energy fair Friday to teach young people throughout the Miami Valley about saving energy. Nearly 400 students attended the fair at the University of Dayton's River Campus building in Dayton. BOB GARLOCK / STAFF

News Coverage

Local media regularly responded to DP&L's invitations to attend school program events.

Grassroots Marketing

All program materials alert students and families that DP&L and Vectren care about helping them reduce their energy consumption.

Customer Service

In all programs, customer service is a critical element of program success. This program lends itself well to customer service due to the breadth and depth of program elements provided for customers, at no charge. More than 9,000 DP&L customer families were impacted by the free energy savings measures provided through the take-home energy savings kits. Students and their families were served through the educational lessons and take-home materials designed to help them know how to make smart energy usage decisions.

Participating teachers were provided with free teaching materials to use in the classroom. All materials were laminated and ready to use, which removed the legwork for teachers. Classroom activities help teachers to “bring science to life” and connect students to the material in new ways.

Hundreds of students and teachers were provided with unique opportunities to attend trainings sessions at DP&L, the University of Dayton, and other energy-related facilities throughout the region.

The OEP program manager was available to participating teachers as their direct point-of-contact for questions or issues with program materials or lessons.

RESIDENTIAL LOW INCOME AFFORDABILITY

PROGRAM DESCRIPTION

Through the Residential Low Income Affordability Program, home energy audits and inspections are conducted, and cost-effective efficiency measures are installed for qualifying customers. Two categories of eligible measures are available to customers, depending on whether their home is heated or cooled with electricity. A limited number of health and safety measures may also be addressed through the program.

The objective of the Low Income Affordability Program is to identify and implement energy efficiency measures for qualifying homes, reducing the home owners' electric bill and saving energy. The program has the secondary benefit of reducing customer arrearages, which can help save money for all customers.

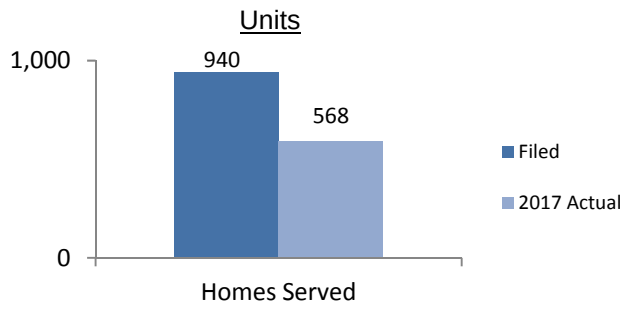
This program is available to low-income residential electric customers within the DP&L service territory with household incomes equal to or less than 200 percent of the federal poverty level or who are qualified and approved for one of the following: the Ohio Home Weatherization Assistance Program (HWAP), the Percentage of Income Payment Plan (PIPP), or the Home Energy Assistance Program (HEAP). Eligible households include single-family and multi-family homes. This program is available to all qualifying electric customers taking delivery service from DP&L, regardless of their choice of generation supplier.

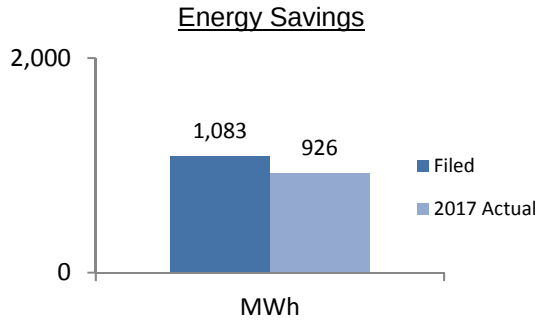
The program is implemented by the Ohio Partners for Affordable Energy (OPAE) through community action agencies located in DP&L's service area.

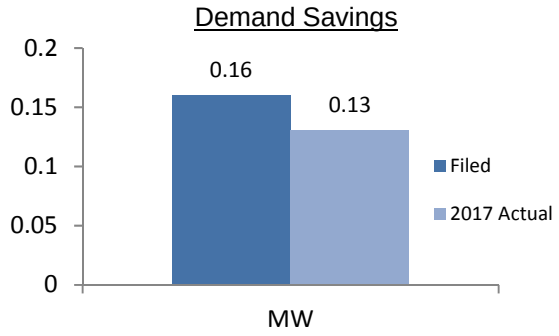
PERFORMANCE SUMMARY

During 2017, 568 unique customers' homes throughout the DP&L service territory were served through this program, resulting in gross annualized energy savings of 926 MWh and peak demand savings of 0.13 MW.

2017 Performance

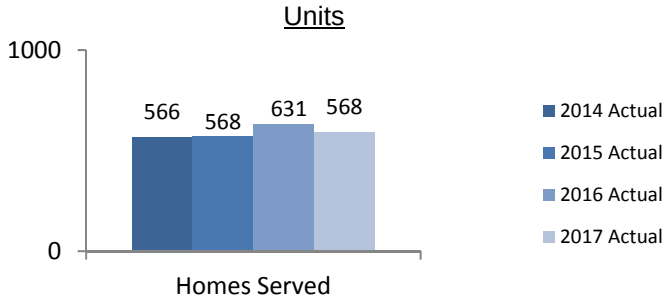


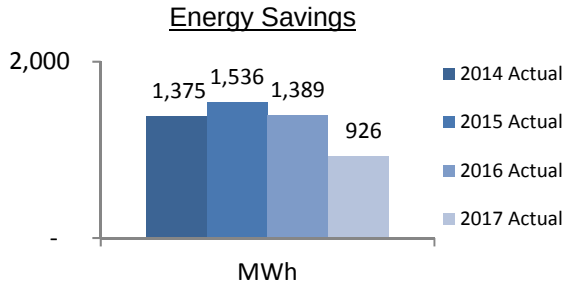


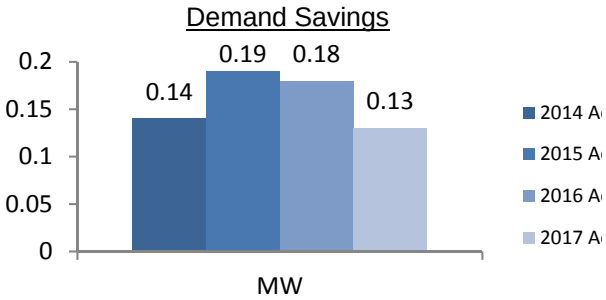


All "filed" numbers are taken from DP&L's program portfolio filing; Case No. 08-1094-EL-SSO.

Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$997,892	$573,385
Marketing & Admin	$251,834	$151,321
Total Costs	$1,249,726	$724,706

IMPLEMENTATION REVIEW

Implementation Strategy

DP&L partners with Ohio Partners for Affordable Energy (OPAE), based in Findlay, Ohio, to bring low-income customers the benefits of this program. OPAE implements this same type of program for FirstEnergy and AEP.

The program is provided to eligible customers in conjunction with OPAE's and subcontracting agencies' use of other state, utility, and community-based weatherization and energy efficiency services funding. The consolidation of funding sources is designed to save administrative costs and provide more benefits in a timely, cost-effective manner.

Targeted Products

OPAE or subcontracting agencies may begin their work with a home audit to determine necessary measures. For all customers, eligible measures may include: installation of energy efficient light fixtures and light bulbs, and metering and replacement of inefficient or inoperable refrigerators and freezers. In addition, for the customers who heat or cool their homes with electricity, eligible measures may also include ceiling and perimeter insulation and duct sealing or insulation.

DP&L places a high priority on safety. We recognize certain weatherization and energy efficiency measures cannot be completed or installed because of unsafe conditions such as faulty outlets or overloaded circuits. Therefore, electrical safety and health measures are available to eligible customers, regardless of the fuel used as the primary heating source. Health and safety measures may include: replacement of outlets, switches, fuse boxes, circuit breaker boxes, and wiring; repair or replacement of roofs, sump pumps, and well pumps; hot water tank replacement; and replacement of inefficient electric stoves and electric dryers.

The maximum cost of the efficiency solutions funded through this program is $5,000 for a single-family home, and $50,000 for a multi-family dwelling.

Targeted Locations

OPAE delivers the program through the community action agencies located in the DP&L service area. These agencies include Community Action Partnership of the Greater Dayton Area; Clinton County Community Action Program; Bridges Community Action Partnership; Community Action Commission of Fayette County; Highland County Community Action Organization; and Pickaway County Community Action Organization.

This ensures customers throughout the DP&L service area will be reached through the program.

Staffing

The program is managed by OPAE through the community action agencies. OPAE is responsible for managing the relationships with the agencies to ensure approved work is being performed in eligible customers' homes. Through the agencies, OPAE ensures the participating contractors are trained and certified to complete work according to the Weatherization Program Standards. The OPAE staff processes the paperwork and documentation from contracted agencies regarding completed jobs and jobs in progress. OPAE is also responsible for monitoring and reporting program performance.

Marketing

OPAE and the community action agencies market this program directly to agency clients. In 2017, DP&L provided a variety of promotional items for distribution by the community action agencies to clients served through the program. The items included a checklist detailing the measures installed, magnetic clips, magnetic calendars, and coloring books for those clients with small children.

Customer Service

Due to the unique nature of the program, OPAE, through the community action agencies, is responsible for delivering the program in a high quality and cost-effective manner. OPAE is responsible for ensuring all services, materials, and supplies are of good quality and installed in a professional, workmanlike way, and all contractors are trained and certified to complete work according to the Weatherization Program Standards.

DP&L maintains its own customer service center, accepting calls regarding all functions of DP&L. DP&L management staff continues to update customer service center staff regarding program details as needed.

NON-RESIDENTIAL PROGRAMS

NON-RESIDENTIAL PRESCRIPTIVE REBATES

PROGRAM DESCRIPTION

The Non-Residential Prescriptive Rebate Program (Rapid Rebates® Program) provides non-residential customers with incentives for new equipment purchases that reduce energy consumption and demand. Technologies covered in the program include energy efficient lighting, HVAC, motors, drives and compressed air.

The objective of the program is to help business and government customers overcome the upfront cost hurdle associated with energy efficient technologies.

The Rapid Rebates® Program is designed for all DP&L business and government customers who purchase new energy efficient equipment through a manufacturer, distributor or contractor. All business and government customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

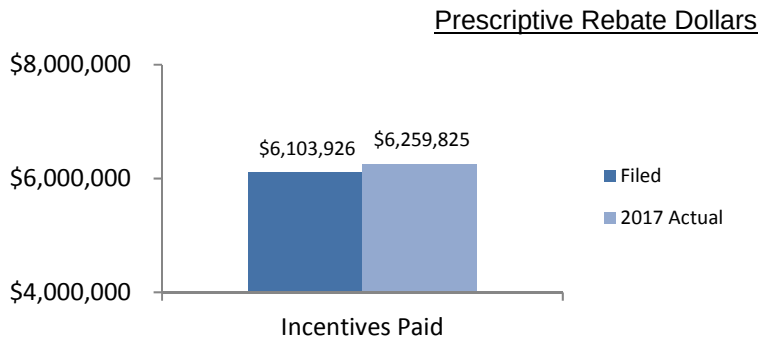
DP&L began accepting online Rapid Rebate® applications on April 1, 2009. In 2017, 67 unique measures were offered through the Rapid Rebates® Program. DP&L received 1,531 Rapid Rebate® applications and paid 1,345 Rapid Rebates in 2017.

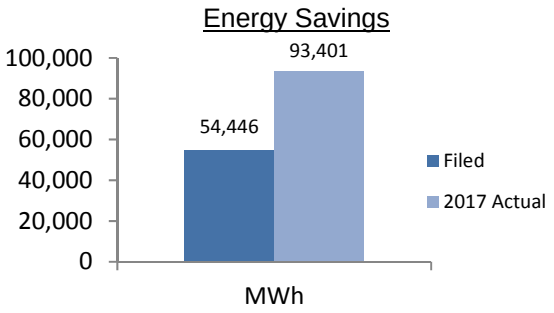
PERFORMANCE SUMMARY

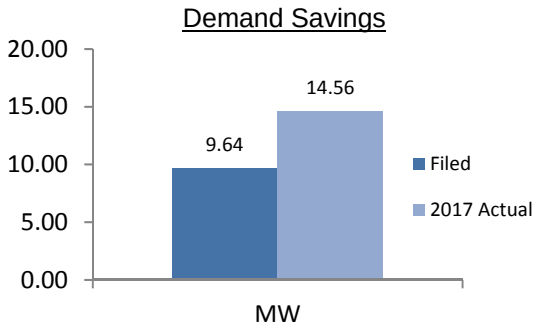
During 2017, DP&L paid $5,842,661 in Rapid Rebates® to business and government customers, resulting in gross annualized energy savings of 77,603 MWh and peak demand savings of 11.17 MW. Keys to the program's success include continued operation of a customer-friendly online application system, quality customer service and follow through, and strong relationships with Channel Partners.

It should be noted an additional 7,570 MWh and 1.45 MW in savings were realized through the Midstream Prescriptive Rebate channel which included $324,746 in incentives. Also, in 2017 DP&L extended the Appliance Recycling Program to business customers. This resulted in 172 units collected from business customers which accounts for 229 MWh of energy savings, 0.05 MW of peak demand savings and $7,830 in incentives paid. Additionally, five percent of savings and costs from the Residential Lighting Program have been reallocated to the Non-Residential Prescriptive Rebate Program, representing 7,999 MWh, 1.89 MW and $84,588 of incentive costs. This is due to the fact that program evaluations and national trends suggest five percent of bulbs in retail locations were purchased by non-residential customers. As such, all metrics in this section include Midstream Program costs and savings, Appliance Recycling costs and savings, as well as a proportional five percent reallocation from the Residential Lighting Program.

2017 Performance

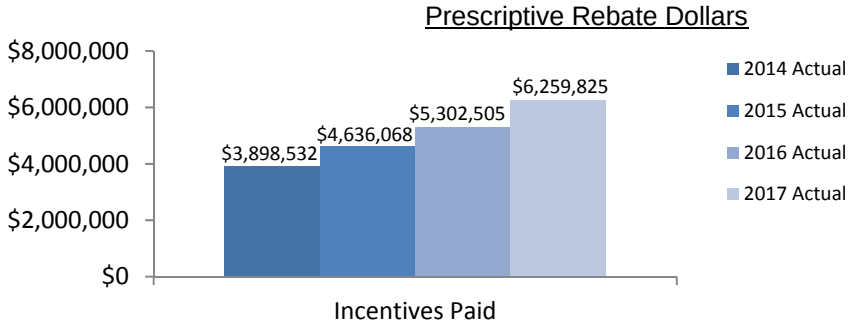


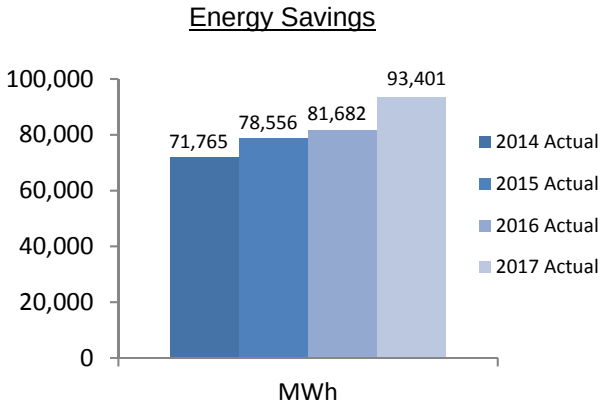


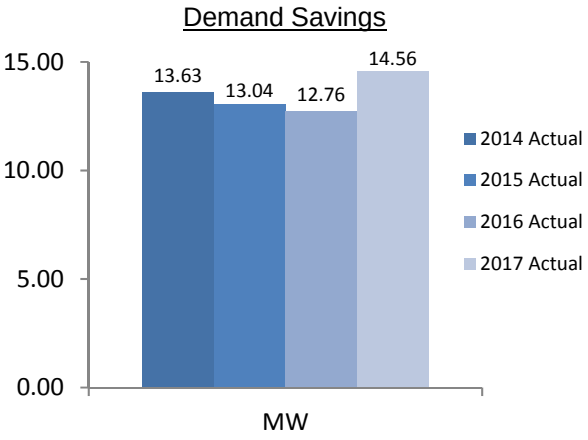


All "filed" numbers are taken from DP&L's program portfolio filing; Case No. 13-0833-EL-POR.

Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$6,103,926	$6,259,825
Marketing & Admin	$1,661,467	$1,371,329
Total Costs	$7,765,393	$7,631,154

In 2017, DP&L requested and was granted permission from the PUCO to transfer $600,000 from the Custom Rebate program and $34,007 from the PJM Demand Response program to the Prescriptive Rebate program to provide additional incentives to meet high customer demand in the Prescriptive Rebate program. Transfer of these funds is reflected in the filed program budget.

IMPLEMENTATION REVIEW

Implementation Strategy

Since 2009, DP&L has implemented and managed the Prescriptive Rebate program internally. DP&L chose this course of action, as opposed to hiring an outside implementer, for several reasons. First, implementing the program in-house significantly strengthens DP&L employee knowledge of energy efficiency programs and technologies. Second, it provides DP&L with the opportunity to build relationships with contractor networks and customers, leading to quality customer service. And third, unlike the residential programs, we do not believe a third-party rebate provider adds significant value at this point in the program lifecycle. Potential rebate volume for business customers is lower than for residential customers, and DP&L continues to be able to process this lower volume of rebates internally.

DP&L offers a midstream, buy-down of lighting currently sold through 23 electrical distributor locations. No coupon or rebate form is required; the customer receives the discount at the register at the time of purchase. The customer provides information to verify they are a non-residential customer. The goal of the midstream channel is to reach those customers who are not using the traditional prescriptive program. CLEAResult is the implementer of the midstream channel. In 2017, midstream sales accounted for approximately 10% of Prescriptive Rebate program energy savings.

Targeted Products

DP&L's Prescriptive Rebate program was designed to provide business and government customers with an extensive choice of energy efficient, retrofit opportunities. In 2017, 67 unique measures were available for Rapid Rebates®. This extensive list broadens the number of customers who can potentially participate in programs. The list of measures was developed, and is continually updated, based on industry accepted standards for high efficiency equipment and the associated energy and demand savings. Rapid Rebate® incentives disbursed to customers ranged from $3 to $361,520 in 2017.

Prescriptive Rebate Allocation

Product Type	Rebate Dollars Paid	Energy Saved (MWh)	Demand Saved (MW)
Lighting	$4,697,544	51,817	6.64
HVAC	$359,664	4,647	1.06
Compressed Air	$160,300	1,680	0.10
Motors	$473,065	19,459	3.37
Midstream Lighting Channel	$324,746	7,570	1.45
Residential Reallocation	$84,588	7,999	1.89
Appliance Recycling	$7,830	229	0.05
Channel Partner Rewards	$152,088	-	-
TOTAL	$6,259,825	93,401	14.56

DP&L does not endorse any equipment manufacturers or suppliers in the Prescriptive Rebate program. Business and government customers may purchase any brand of equipment from any supplier they choose, as long as the equipment is new and meets the eligibility requirements detailed on the measure lists. Additionally, equipment must use electricity as the fuel source and be replacing existing equipment or be installed as part of a retrofit project.

Application Process

DP&L's Prescriptive Rebate application process was designed to be customer friendly and comprehensive. The application is completely online which makes it convenient for customers and efficient for program control purposes. The application consists of three pages. The first page asks for basic customer information such as company name, address, installation address, DP&L account number, facility type and hours of operation, and contractor contact information. On the second page, customers choose from a drop-down list of measures, enter the manufacturer and model numbers, and input the appropriate quantities. The third page allows customers to upload supporting documentation to their application, such as specification sheets, engineering calculations and invoices. When the customer has entered all measures for which they are applying, they "submit rebate" and receive a confirmation number. When customers or contractors have questions, DP&L staff is available to guide them through the process.

The online Rapid Rebate® application is electronically submitted to DP&L for review. Applications must be complete and include the necessary contact information, equipment specification, and equipment costs. DP&L then reviews the application, verifies the information provided, and sends a confirmation email indicating the application has been approved. If the application has been approved, the funds will be reserved. Program guidelines request the customer or vendor provide DP&L with proof of purchase within 60 days of the approval notification. To be eligible for an incentive, the equipment for the customer's project must be purchased during the calendar year in which the customer's rebate application is submitted to DP&L. Proof of purchase may come in the form of an invoice, purchase order or other supporting document. If proof of purchase is not received, DP&L reserves the right to remove the fund reservations.

Applicants can reapply for rebates but they will be placed in the back of the queue. The equipment should be installed and ready to operate within 120 days of application approval and DP&L must be notified of the installation. DP&L must be provided with a final invoice reflecting the true costs of purchasing and installing the energy savings measure (including all materials, labor, and equipment discounts) as well as equipment serial numbers. If the installation does not occur within 120 days, the customer may request an extension from DP&L using the Online Extension Request Form. Extension requests are handled on a case by case basis. DP&L releases the rebate funds to the customer within approximately 30 days of receiving the verification of installation.

DP&L reserves the right to inspect the installed measure(s) prior to releasing any funds to ensure compliance with the program terms and conditions. A verification audit is performed on every Prescriptive Rebate greater than $10,000. Additionally, DP&L audits a random sampling of rebates less than $10,000. In 2017, 17 percent of all Rapid Rebates were audited. Third party engineers and contractors are utilized to perform pre- and post-installation verification audits for a sampling of projects rebated through the Prescriptive Rebate program.

Staffing

DP&L has three program managers to manage the business rebate programs, including the Prescriptive Rebate program, and serve as DP&L's direct point-of-contact with customers. The internal staff is responsible for reviewing, approving and processing rebate applications. They track and report all incentive dollars as well as energy and demand savings. The staff is also responsible for promoting the program to customers through a variety of marketing tools and business and community events.

Marketing

In order to promote the Prescriptive Rebate program to business and government customers, DP&L employed a variety of marketing methods. These methods included publication of program information on the company website, print literature, bill inserts, inserts in local business journals, mass media advertising, presentations at community- and vendor-sponsored events, one-on-one marketing by DP&L major account managers, and the continued utilization of a Channel Partner network.

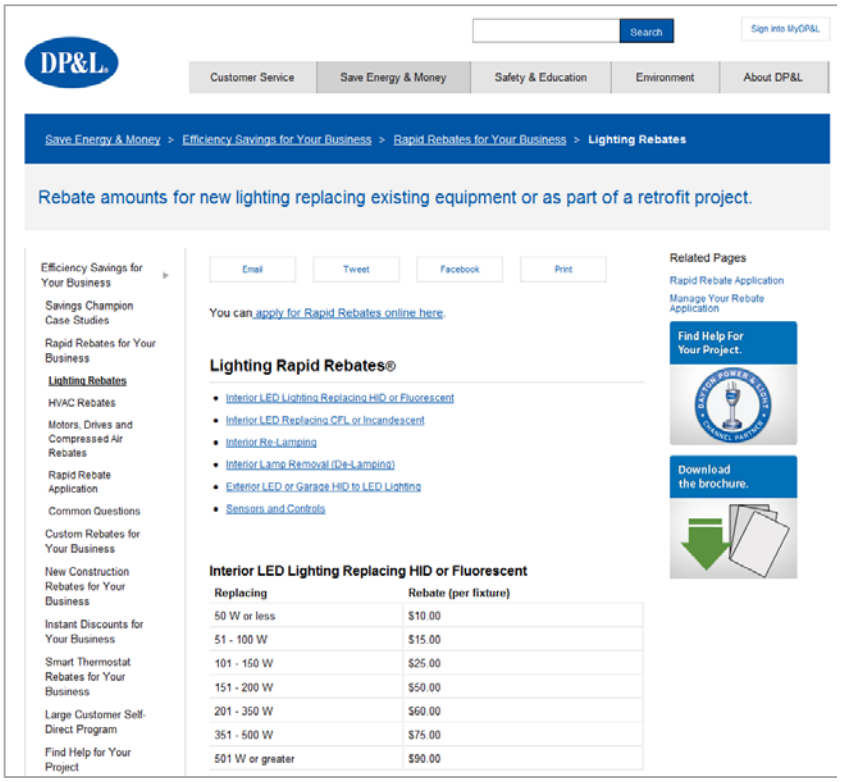
Channel Partners are contractors, engineers and distributors with energy efficiency experience. They have participated in DP&L rebate workshops and are familiar with using DP&L rebate programs to help customers save money. Channel Partners are viewed as an invaluable third party "marketing extension" of DP&L's internal group of program managers. They have direct contact with customers on a daily basis and can influence the customer's purchasing decisions. Of the $5,690,573 in prescriptive incentives paid to customers in 2017, Channel Partners were involved in securing $3,152,771 or 55 percent of those dollars.

DP&L partnered with Dayton Regional Green, Vectren, IGS, and Energy Optimizers USA to sponsor the Bring Your Green Challenge 2.0. The Bring Your Green Challenge 2.0 is the second iteration of a friendly year-long contest for government buildings, commercial property owners/managers and office tenants to reduce costs while

reducing greenhouse gas emissions and resources used. The highly interactive program encourages participants to assess their practices and engage their employees to foster a culture of sustainability. Online tools, trainings, workshops, best practices, and technical assistance will be provided along the way. During the year-long contest, participants were also eligible for a 50% increase in standard rebate values. The initiative began in August of 2017 and will go thru July of 2018. Results will be reported in the 2018 status report.

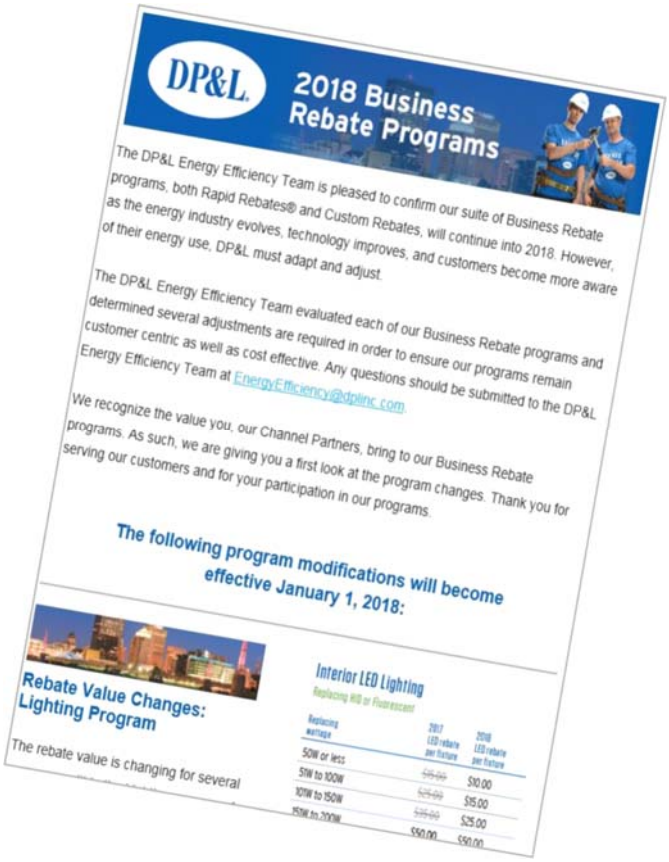
Channel Partners

Channel Partners participate in DP&L rebate workshops and are familiar with using DP&L rebate programs to help customers save money.



Website

The Business Rebates pages on the DP&L website give a description of the Prescriptive Rebate program and allow customers to navigate to other pages for more information or apply online for a rebate.



DP&L

2018 Business Rebate Programs

The DP&L Energy Efficiency Team is pleased to confirm our suite of Business Rebate programs, both Rapid Rebates® and Custom Rebates, will continue into 2018. However, as the energy industry evolves, technology improves, and customers become more aware of their energy use, DP&L must adapt and adjust.

The DP&L Energy Efficiency Team evaluated each of our Business Rebate programs and determined several adjustments are required in order to ensure our programs remain customer centric as well as cost effective. Any questions should be submitted to the DP&L Energy Efficiency Team at EnergyEfficiency@dplinc.com.

We recognize the value you, our Channel Partners, bring to our Business Rebate programs. As such, we are giving you a first look at the program changes. Thank you for serving our customers and for your participation in our programs.

The following program modifications will become effective January 1, 2018:

Rebate Value Changes: Lighting Program

The rebate value is changing for several

Interior LED Lighting

Replacing MH or Fluorescent

Replacing wattage	2017 LED rebate per fixture	2018 LED rebate per fixture
50W or less	~~$15.00~~	$10.00
51W to 100W	~~$25.00~~	$15.00
101W to 150W	~~$35.00~~	$25.00
151W to 200W	$50.00	$50.00

Newsletter

Channel Partners are kept up-to-date on program news and changes through a quarterly Channel Partner newsletter.

BE A SAVINGS CHAMPION

GET INSTANT, IN-STORE LIGHTING DISCOUNTS

Instant discounts on a variety of efficient ENERGY STAR and DESIGN LIGHTS CONSORTIUM certified products like LED lamps and fixtures, and T8 lamps for your business.

DP&L

Be a savings champion. Visit DPANDL.COM/SAVE to learn more.

LEARN MORE AT energystar.gov

QUALIFIED PRODUCT TYPES	MAX DISCOUNT PER UNIT
LED A-Line bulb	$3 - $6
LED Candelabra	$1 - $3
LED Linear 4' T8 lamp	$4
LED Reflectors (BR30, BR40, R20, R30, MR16, PAR16, PAR20, PAR30 & PAR38)	$7 - $10
LED Downlight Retrofit Kit	$10
LED Fixtures (2X2 & 2X4)	$13 - $17
LED Exterior Wall Packs / Floods	$25 - $70
LED High/Low Bay Fixtures	$40 - $80
Reduce Wattage 4 ft Linear Fluorescent T8 (25W & 28W)	$0.50 - $1
T5 Hi Output 4 ft Linear	$1

*Check participating distributor for qualifying products and details. Lamps must be ENERGY STAR(r) certified. Fixtures must be DLC certified. Reduced wattage 4 ft linear lamps must be CEE certified.

DP&L

Participating Partners:

Batteries Plus (206 Spring.) - Dayton	(937) 938-6083
Batteries Plus (3510 York.) - Dayton	(937) 387-0686
Batteries Plus - Springfield	(937) 398-0044
Batteries Plus - Bellbrook	(937) 433-9222
Becker Electric - Dayton	(800) 762-9515
Becker Electric - Sidney	(937) 497-8050
All Phase Electric - Urbana	(937) 652-1299
All Phase Electric - Springfield	(937) 323-7555
City Electric - Beavercreek	(937) 431-8371
City Electric - Troy	(937) 335-6908
City Electric - Waynesville	(937) 885-5098
City Electric - Springfield	(937) 322-0771
City Electric - Dayton	(937) 848-8127
Daycoa - Medway	(937) 849-1315
Dickman Supply - Greenville	(937) 548-4303
Dickman Supply - Sidney	(937) 492-6166
WESCO - Dayton	(800) 837-6570

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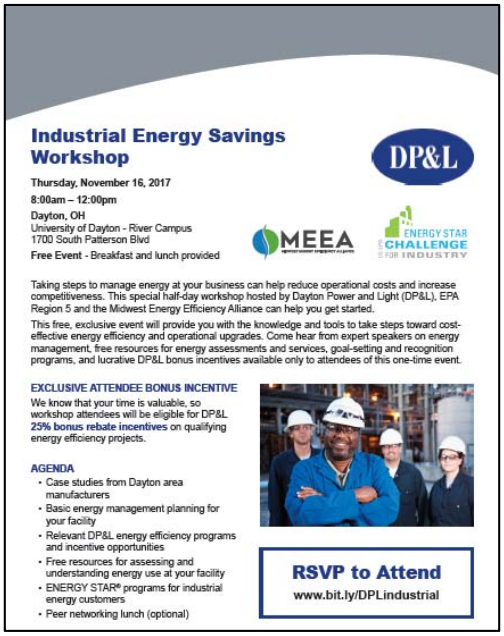
Bill Insert

Bill inserts were mailed to 50,000 customers in April and July.

Print Literature

DP&L used standard print materials for hand-outs at meetings with customers and at a variety of speaking events.



Event Sponsorships

DP&L Business Programs frequently sponsor and participate in community- and vendor-sponsored events. Events in 2017 included: DRG Sustainability Luncheons, Bring Your Green Contest, Dayton Green Expo, an Industrial Energy Efficiency Forum, and numerous Channel Partner training and customer appreciation events.

Print Ads

The Business Rebate programs were advertised through placement of ads in local and regional magazines and newspapers including Dayton Daily News, which has a circulation of over 100,000.

Collaborative Partners

DP&L continues to work with its collaborative partners to promote programs.

Customer Service

In all programs, customer service is a critical element for success. As such, DP&L designed a number of customer service elements into the Rapid Rebate® Program, some of which have been previously discussed.

The Rapid Rebate® section of the DP&L website acts as the main information portal for customers, contractors, distributors and other program participants. It contains a listing of all eligible measures and the rebate amounts, as well as access to the online application. The online application process is akin to online shopping. When the customer has entered all measures for which they are applying, they "submit rebate" and receive a confirmation number. The confirmation number allows the customer to access their application's status and upload documents to their application.

In addition to being an effective means of marketing the program, Channel Partners are also a valuable resource for delivering the program to customers in a quality manner. Channel Partners are trained on both the measures that are rebated through the program and on the application process. Many Channel Partners have taken the rebate programs and used them to offer a "turn-key" experience for the customer, including the approximate rebates in customer quotes and applying for the rebates on behalf of customers. Through this process, customers can have confidence the proposed equipment will be eligible while allowing DP&L to work with the Channel Partner to clarify any issues that may arise. In short, the Channel Partners are an effective "middleman" for the program with proper upfront training and ongoing program communication.

To encourage Channel Partners to continue to provide excellent service to customers, the Channel Partner Rebate Rewards program was launched in 2011. Channel Partners who are listed on the rebate application are automatically enrolled. Once a minimum of $10,000 in DP&L Rapid Rebates® have been attributed to a Channel Partner in a program year, they begin to earn a cash bonus equal to 5 percent of the DP&L rebates paid to the customer. This incentivizes the Channel Partner to complete the rebate application for the customer. In 2017, DP&L paid $152,088 in prescriptive Channel Partner Rebate Rewards.

As a quality control measure, the auditing process ensures contractors and vendors are not misrepresenting the program. From a customer service perspective, customers appreciate and welcome the audit process, as it gives them unbiased energy savings data. They can use this data in submitting comprehensive post-analysis reports on their capital projects.

To make communication convenient for the customer, the Business Programs staff maintains an Energy Efficiency Inbox, energyefficiency@dplinc.com, a clearinghouse for general program questions business and government customers may have.

DP&L staffs its own business call center, the Business Solutions Center, catering to DP&L business customers and their billing and other general inquiries. DP&L Business Program management staff conducted training sessions for business solutions center staff regarding energy efficiency program details. This was to ensure DP&L phone representatives had a basic understanding of the program, could assist customers in navigating the website or point them to the Energy Efficiency inbox.

NON-RESIDENTIAL CUSTOM REBATES

PROGRAM DESCRIPTION

The Non-Residential Custom Rebate Program provides business and government customers with incentives for equipment purchases and industrial process improvements that reduce energy consumption and demand. Custom Rebates are for equipment that is not covered by DP&L's Prescriptive Rebate program and is generally best suited for customized industry-specific or facility-specific applications.

The objective of the program is to help business and government customers overcome the upfront cost hurdle associated with energy efficient technologies and to promote innovative and emerging technologies.

The Custom Rebate Program is designed for all DP&L business and government customers who purchase new energy efficient equipment through a manufacturer, distributor or contractor. All business and government customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

In 2017, DP&L received 131 Custom Rebate applications. DP&L paid 90 Custom Rebates in 2017.

PERFORMANCE SUMMARY

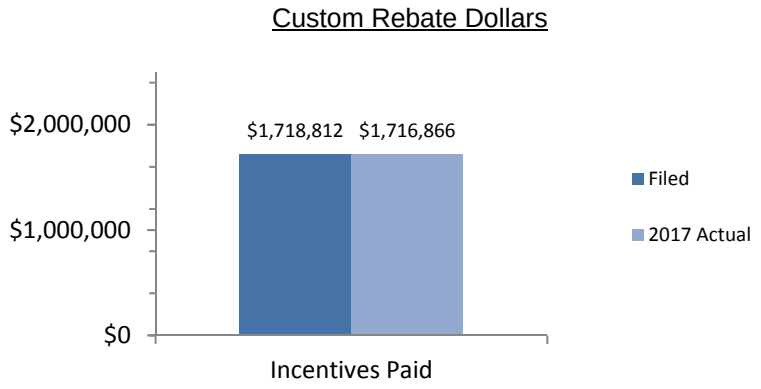
During 2017, DP&L paid $784,787 in Custom Rebates to business and government customers, resulting in gross annualized energy savings of 18,678 MWh and peak demand savings of 2.59 MW. Keys to the program's success include continued operation of a customer-friendly online application system, quality customer service and follow through, and strong relationships with Channel Partners.

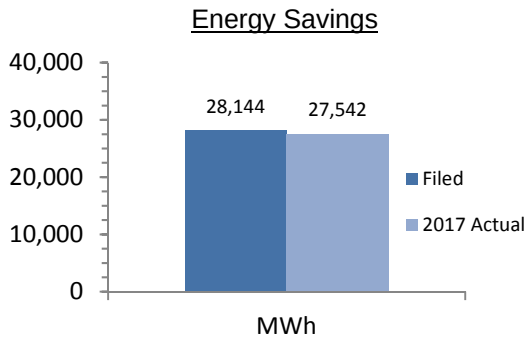
New Construction Rebates are included in the Custom Rebate Program. The New Construction Rebates promote energy efficient design strategies by incenting reductions in the amount of energy a completed new construction project or major addition would use. In 2017, DP&L received 52 New Construction Rebate applications. Forty-four New Construction Rebates were paid in 2017, accounting for 6,628 MWh and 1.75 MW of annual savings, and $546,685 in rebates paid.

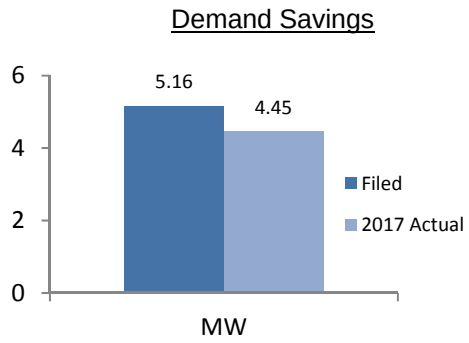
Retro-commissioning Rebates are included in the Custom Rebate Program. Retro-commissioning is a process by which existing building control systems are optimized to perform as efficiently and effectively as possible. DP&L's retro-commissioning rebate aims to help customers understand opportunities to save energy costs within their facility by co-funding a retro-commissioning study. Upon conclusion of the study, the customer is responsible for paying 20% of the study cost and facilitating implementation of recommended measures. Following successful implementation, the customer receives a rebate calculated based upon actual kilowatt hours saved. In 2017, DP&L received nine Retro-commissioning Rebate applications. Eight projects were completed in 2017, accounting for 2,236 MWh and 0.11 MW of annual savings, and $314,739 in rebates paid.

Business audits are funded through the Custom Rebate budget. All commercial and industrial customers with facilities served by DP&L are eligible to participate. The objective of the audit is to help customers understand how energy is being used, prioritize potential projects, calculate project paybacks and identify rebates for which they are eligible. DP&L reimburses 50 percent of the cost of the audit and pays the remaining 50 percent if the customer implements electricity-saving projects within 1 year of the audit. DP&L does not supply the auditing services. Rather, customers can choose the third-party audit firm they would like to utilize. In 2017, twenty-four (24) entities applied for audits, accounting for $106,655 in incentive payments. Since the Business Audit program's inception in September 2010, 233 facility audits have been completed.

2017 Performance







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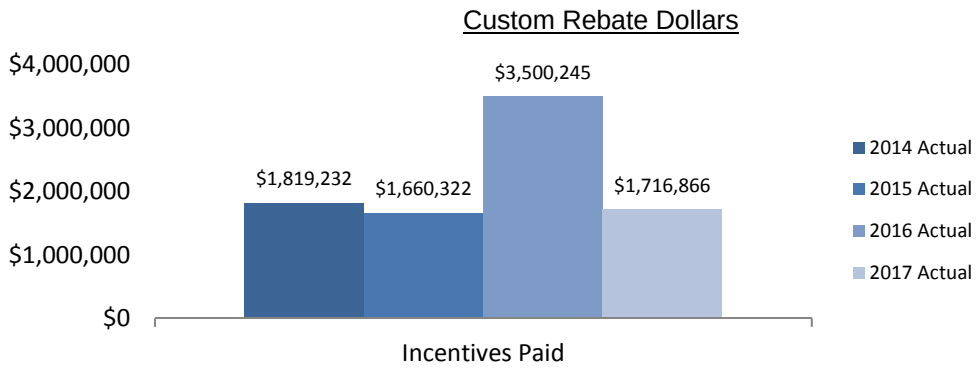
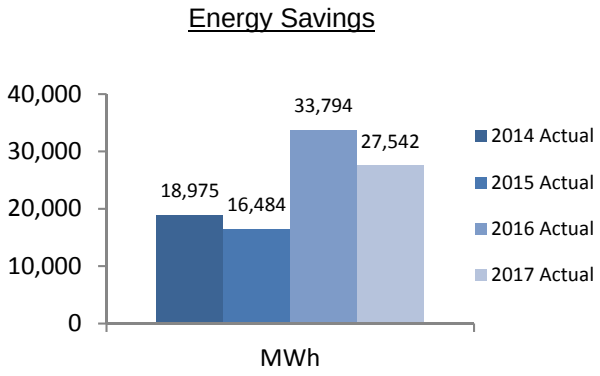
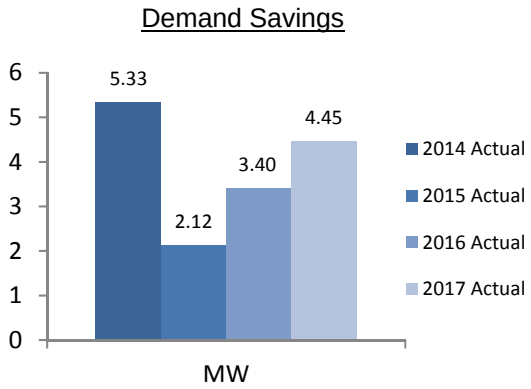
Four-Year Trend Analysis







Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$1,718,812	$1,716,866
Marketing & Admin	$1,108,240	$918,344
Total Costs	$2,827,052	$2,635,210

In 2017, DP&L requested and was granted permission from the PUCO to transfer $600,000 from the Custom Rebate program and $34,007 from the PJM Demand Response program to the Prescriptive Rebate program to provide additional incentives to meet high customer demand in the Prescriptive Rebate program. Transfer of these funds is reflected in the filed program budget.

IMPLEMENTATION REVIEW

Implementation Strategy

Since 2009, DP&L has implemented and managed the Custom Rebate program internally. DP&L chose this course of action, as opposed to hiring an outside implementer, for several reasons. First, implementing the program in-house significantly strengthens DP&L employee knowledge of energy efficiency programs and technologies. Second, it provides DP&L with the opportunity to build relationships with contractor networks and customers, leading to quality customer service. And third, unlike with the residential programs, DP&L does not believe a third party implementer

adds significant value at this point in the program. DP&L continues to be able to process the volume of Custom Rebates internally.

Targeted Products
DP&L's Custom Rebate program was designed to provide business and government customers with an opportunity to receive rebates for implementing innovative energy efficient emerging technologies and process improvements. Rebate checks disbursed to customers in 2017 ranged from $54 to $357,735.

In 2015 a Combined Heat and Power (CHP) incentive structure was developed to fit into the Custom Rebate program, with rebate levels calculated using "Other" as the project type. No CHP projects were applied for or completed in 2017.

Custom Rebate Allocation

Product Type	Rebate Dollars Paid	Energy Saved (MWh)	Demand Saved (MW)
Lighting	$139,652	2,579	0.21
HVAC	$41,758	1,016	0.02
Other, includes: • Plastic extrusion projects • Multi-compressor compressed air systems • Large VFDs	$529,355	15,083	2.36
New Construction	$546,685	6,628	1.75
Retro-Commissioning	$314,739	2,236	0.11
Business Audits	$106,655	-	-
Channel Partner Rewards	$38,022		
Total	$1,716,866	27,542	4.45

In 2017, Custom Rebates were rebated per the following schedule:

Project Type	Rebate Calculation
Lighting	$0.05/kWh + $50/KW
HVAC	$0.10/kWh + $100/KW
Other	$0.08/kWh + $100/KW

DP&L does not endorse any equipment manufacturers or suppliers in the Custom Rebate program. Business and government customers may purchase any brand of equipment from any supplier they choose, as long as the equipment is new and meets the eligibility requirements. Equipment must use electricity as the fuel source and be replacing existing equipment or be installed as part of a retrofit project. Projects are required to have a payback of less than 7 years before rebates are applied. The 7-year maximum payback helps to promote cost effectiveness.

New Construction Rebates are calculated in one of two ways. The lighting power density (LPD) incentive encourages the inclusion or installation of lighting designs and equipment that provide quality lighting at lower installed wattages. The incentive is calculated on a per square foot basis for LPD performance exceeding ANSI/ASHRAE/IESNA Standard 90.1-2007, or for those applications received in 2017, Standard 90.1-2010.

$Incentive_{LPD} = (LPD_{baseline} – LPD_{actual}) \times area \times \$0.30$

Alternately, customers can choose to have their new building evaluated using the Whole Building Energy Performance Baseline Improvement method. This method incents customers who design their buildings to be more efficient than a baseline building constructed to ANSI/ASHRAE/IESNA Standard 90.1-2007, or for those applications received in 2017, Standard 90.1-2010. To be eligible for a whole building incentive, the customer must provide documentation of an energy model in accordance with ANSI/ASHRAE/IESNA Standard 90.1, Appendix G. Incentives are calculated using the following incentive rate guidelines. To receive an incentive, a project must achieve an annual electric energy and demand savings of 5 percent or better than baseline.

Incentive Rate Guidelines		
First Year Annual Electric Reduction	Energy Incentive Rate	Demand Incentive Rate
5-10% over baseline	$0.05/kWh	$50/KW
>10% over baseline	$0.08/kWh	$75/KW
>20% over baseline	$0.10/kWh	$100/KW

Application Process

DP&L's Custom Rebate application process was designed to be customer friendly and comprehensive. The application is completely online which makes it convenient for customers and efficient for program control purposes. Customers must apply for a Custom Rebate prior to beginning their project. The pre-approval phase allows DP&L the opportunity to perform pre-installation auditing (in some cases, metering) of the affected systems. The application consists of three pages. The first page asks for basic customer information such as company name, address, installation address, DP&L account number, facility type and hours of operation, and contractor contact information. On the second page, customers enter a detailed project description, their baseline energy and demand usage, and their proposed energy and demand usage. The third page allows customers to upload supporting documentation to their application, such as specification sheets, engineering calculations and invoices. When the customer has input all their data, they "submit rebate" and receive a confirmation number. When customers or contractors have questions, DP&L staff is available to guide them through the process.

The customer or vendor completes the online Custom Rebate application and submits it electronically to DP&L for review. Applications must be complete and include the necessary contact information, equipment specifications, and equipment costs. Additionally, applicants must submit a full description of how the energy and demand savings were calculated. DP&L then reviews the application, verifies the information provided, and sends a confirmation email indicating the application has been approved. If the application has been approved, the funds will be reserved. Program guidelines suggest the customer or vendor provide DP&L with proof of purchase within 60 days of the approval notification. Proof of purchase may come in the form of an invoice, purchase order or other supporting document. If proof of purchase is not received, DP&L reserves the right to remove the fund reservation. Applicants can reapply for rebates but they will be placed in the back of the queue. The equipment should be installed and ready to operate within 120 days of application approval and DP&L must be notified of the installation. DP&L must be provided with a final invoice reflecting the true costs of purchasing and installing the energy savings measure (including all materials, labor, and equipment discounts) as well as equipment serial numbers. If the installation does not occur within 120 days, the customer may request an extension from DP&L using the Online Extension Request Form. Extension requests are handled on a case by case basis. DP&L releases the rebate funds to the customer within approximately 30 days of receiving the verification of installation.

DP&L reserves the right to inspect the installed measure(s) prior to releasing any funds to ensure compliance with the program Terms and Conditions. A verification audit is performed on every Custom Rebate greater than $10,000. To ensure energy and demand savings are calculated correctly, many Custom Rebates are audited. This often requires equipment metering. In 2017, 65 percent of Custom Rebates were audited. In addition to the internal staff, third party engineers and contractors are utilized to perform pre- and post-installation verification audits for a sampling of projects rebated through the Custom Rebate program.

Staffing

DP&L has three program managers to manage the business rebate programs, including the Custom Rebate Program, and serve as DP&L's direct point-of-contact with customers. The internal staff is responsible for reviewing, approving and processing rebate applications. They track and report all incentive dollars as well as energy and demand savings. The staff is also responsible for promoting the program to customers through a variety of marketing tools and business and community events.

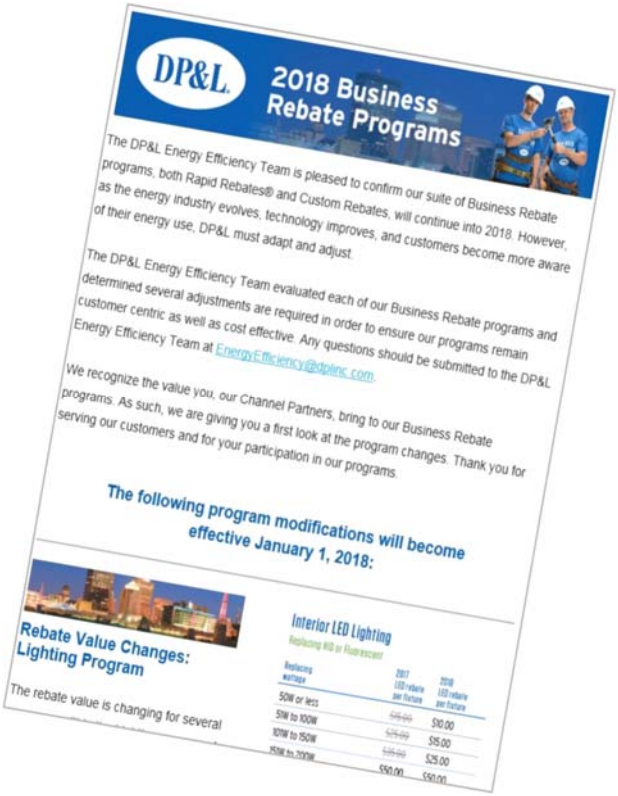
Marketing

For efficiency and cost-effectiveness purposes, DP&L often promotes the Custom Rebate Program as it promotes its Rapid Rebates®. DP&L employs a variety of marketing methods, including publication of program information on the company website, print literature, bill inserts, inserts in local business journals, mass media advertising, presentations at community- and vendor-sponsored events, one-on-one marketing through major account managers, and the creation of the Channel Partner network.

Channel Partners are contractors, engineers and distributors with energy efficiency experience. They have participated in DP&L rebate workshops and are familiar with using DP&L rebate programs to help customers save money. Channel Partners are viewed as an invaluable third party "marketing extension" of DP&L's internal group of program managers. They have direct contact with customers on a daily basis, and can influence the customer's purchasing decisions. Of the $1,257,450 in Custom incentives paid to customers in 2017, Channel Partners were involved in securing $355,677 or 28.3 percent of those dollars.

Channel Partners

Channel Partners participate in DP&L rebate workshops and are familiar with using DP&L rebate programs to help customers save money.



DP&L

2018 Business Rebate Programs

The DP&L Energy Efficiency Team is pleased to confirm our suite of Business Rebate programs, both Rapid Rebates® and Custom Rebates, will continue into 2018. However, as the energy industry evolves, technology improves, and customers become more aware of their energy use, DP&L must adapt and adjust.

The DP&L Energy Efficiency Team evaluated each of our Business Rebate programs and determined several adjustments are required in order to ensure our programs remain customer centric as well as cost effective. Any questions should be submitted to the DP&L Energy Efficiency Team at EnergyEfficiency@dplinc.com.

We recognize the value you, our Channel Partners, bring to our Business Rebate programs. As such, we are giving you a first look at the program changes. Thank you for serving our customers and for your participation in our programs.

The following program modifications will become effective January 1, 2018:

Rebate Value Changes: Lighting Program

The rebate value is changing for several

Interior LED Lighting

Replacing Will or Fluorescent

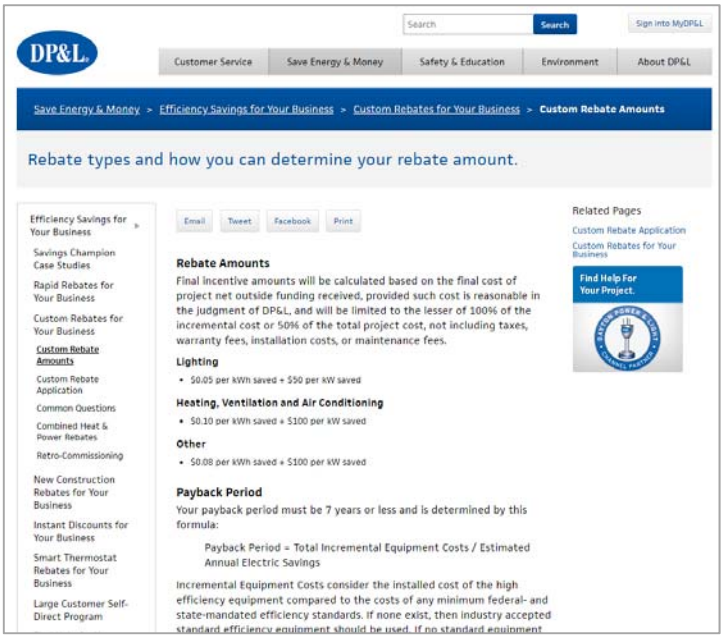
Replacing wattage	2017 LED rebate per fixture	2018 LED rebate per fixture
50W or less	[illegible]	$10.00
51W to 100W	[illegible]	$35.00
101W to 150W	[illegible]	$25.00
151W to 200W	$50.00	$50.00

Newsletter

Channel Partners are kept up-to-date on program news and changes through a quarterly Channel Partner newsletter

Event Sponsorships

DP&L Business Programs frequently sponsor and participate in community- and vendor-sponsored events. Events in 2017 included: DRG3 Sustainability Luncheons, Dayton Green Expo and numerous Channel Partner training and customer appreciation events.



Website

The Business Rebates pages on the DP&L website give a description of the Custom Rebate program and allow customers to navigate to other pages for more information or apply online for a rebate.

Print Literature

DP&L used standard print materials for hand-outs at meetings with customers and at a variety of speaking events

Print Ads

The Business Rebate programs were advertised through placement of ads in local and regional magazines and newspapers including Dayton Daily News, which has a circulation of over 100,000.

Collaborative Partners

DP&L continues to work with its collaborative partners to promote programs

Customer Service

In all programs, customer service is a critical element to success. As such, DP&L designed a number of customer service elements into the Custom Rebate Program, some of which have been previously discussed.

The Custom Rebate section of the DP&L website acts as the main information portal for customers, contractors, distributors and other program participants. The website contains all Custom Rebate eligibility requirements, as well as access to the online application. Customers receive a confirmation number when they submit an online custom rebate application. The confirmation number allows the customer to access their application's status upload documents to their application.

In addition to being an effective means of marketing the program, Channel Partners are also a valuable resource for delivering the program to customers in a quality manner. Channel Partners are trained on the custom rebate application process. Many Channel Partners have taken the rebate programs and used them to offer a "turn-key" experience for the customer, including the approximate rebates in customer quotes and applying for the rebates on behalf of customers. Through this process, customers can have confidence the proposed project will be eligible for a rebate while allowing DP&L to work with the Channel Partner to clarify any issues that may arise. In short, the Channel Partners are an effective "middleman" for the program with proper upfront training and ongoing program communication.

As a quality control measure, the auditing process ensures contractors and vendors are not misrepresenting the program. From a customer service perspective, customers appreciate and welcome the audit process, as it gives them unbiased energy savings data. They can use this data in submitting positive post-analysis reports on their capital projects.

To make communication convenient for the customer, the Business Programs staff maintains an Energy Efficiency Inbox, energyefficiency@dplinc.com, a clearinghouse for general program questions business and government customers may have.

Lastly, DP&L maintains its own customer service center, accepting calls regarding all functions of DP&L. DP&L Business Program management staff conducted training sessions for customer service center staff regarding program details. This was to ensure DP&L phone representatives had a basic understanding of the energy efficiency programs, and could assist customers in navigating the website or point them to the Energy Efficiency Inbox.

MERCANTILE SELF-DIRECT PROGRAM

PROGRAM DESCRIPTION

Pursuant to O.R.C §4928.66, mercantile customers may commit their peak demand reduction, demand response and energy efficiency projects for integration with an electric utility's programs. DP&L's Self-Direct Program consists of the company allowing mercantile customers to commit their resources for integration in DP&L's programs in exchange for a one-time payment, a commitment payment or exemption from the Energy Efficiency Rider (EER). This Self-Direct Program is available to customers who consume 700,000 kWh or more per year or are part of a regional or national account and who commit their demand and energy savings to be integrated into DP&L's energy efficiency programs.

In 2017, consistent with the Commission's program for mercantile customers to commit energy efficient/peak demand reduction adopted in Case No.10-834-EL-EEC, DP&L's Self-Direct Program allows mercantile customers who have successfully identified and documented savings from energy efficiency projects since January 1, 2014 to apply for a one-time incentive payment or an exemption from the EER. If a customer provides all the necessary project documentation, DP&L will file a joint application with the customer, requesting PUCO approval of an incentive payment or exemption from the EER for a period of time. Rules also permit a customer to file directly with the PUCO.

The one-time payments are reduced to 75 percent of the incentive amount the customer could have received for the same project under the 2017 Rapid Rebate® or Custom Rebate programs. EER exemption requests are based on the percentage of demand and energy saved versus the overall customer demand and energy consumed. The EER exemption is proposed to last as long as the percentage of savings achieved by the customer exceeds the legislated demand and/or energy targets on an individual basis. Customers may participate as an individual facility or have the option to aggregate all facilities into a single application. All applications are filed at the PUCO individually and reviewed on a case-by-case basis.

All mercantile applications must be approved by the PUCO prior to taking effect.

PERFORMANCE SUMMARY

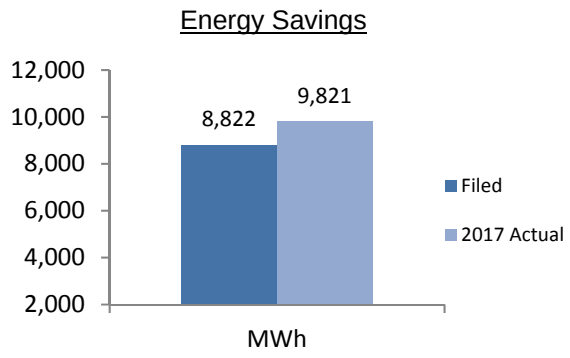
During 2017, DP&L paid nineteen applications with customers requesting a one-time incentive payment for historical energy efficiency projects. These applications were filed using the PUCO-issued mercantile template format and resulted in demand savings of 1.69 MW and energy savings of 9,821 MWh.

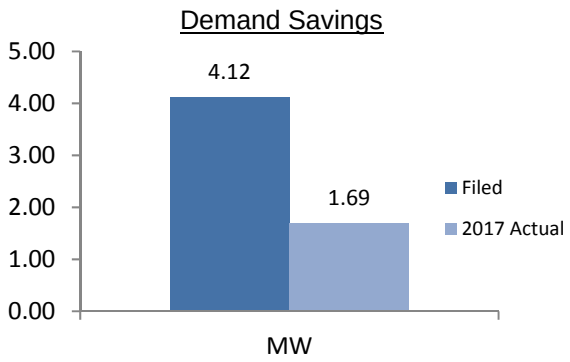
Savings continue to be claimed on a single energy efficiency rider exemption (10-2205-EL-EEC), which was filed in 2010 and approved by the Commission on December 7, 2011.

2017 Mercantile Program Summary		Approved by PUCO	Energy Savings (kWh)	Demand Savings (kW)	Incentive Payment
One-Time Incentive Payments for Energy Efficiency					
Reed Elsevier	16-2208-EL-EEC	✓	1,837,848	209.8	$126,005.88
Speedway	16-2329-EL-EEC	✓	324,500	20.8	$14,250.15
Reed Elsevier	17-0303-EL-EEC	✓	3,530,280	403.0	$242,041.80
City of Dayton	17-1937-EL-EEC	✓	133,356	0.00	$21,468.75
Johnstone Supply	17-0859-EL-EEC	✓	29,342	3.4	$2,032.50
Miami Valley Hospital South	17-0305-EL-EEC	✓	52,220	9.1	$3,554.33
Orbis	17-1941-EL-EEC	✓	684,682	126.2	$50,545.92
Fort Recovery Industries	17-0858_EL-EEC	✓	222,234	17.2	$14,624.10
West-Liberty Salem Schools	17-1663-EL-EEC	✓	522,256	261.9	$51,000.00
NCR	17-0498_EL-EEC	✓	645,598	74.5	$44,323.38
Advance Auto Beavercreek	17-0861-EL-EEC	✓	32,143	8.0	$1,833.54
Hughes Peters	17-0863-EL-EEC	✓	18,135	14.2	$1,800.00
Montgomery County St. Vincent DePaul	17-2096-EL-EEC	✓	584,745	149.9	$27,550.68
Sugar Creek Packing	17-0862-EL-EEC	✓	99,615	9.1	$4,773.75
Dayton Progress	17-1938-EL-EEC	✓	27,626	2.5	$1,012.50
Central State University	17-1939-EL-EEC	✓	198,786	112.0	$18,227.16
Dayton Metro Libraries	17-2093-EL-EEC	✓	16,672	58.6	$16,672.18
Honda	17-2094-EL-EEC	✓	842,391	207.8	$45,000.00
Mechanicsburg Exempted School District	17-2095-EL-EEC	✓	18,527	6.5	$3,150.00
Subtotal Energy Efficiency Incentive Payments			9,820,956	1,694.5	$689,866.62
Energy Efficiency Rider Exemptions					
	10-2205-EL-EEC*	✓	4,235,798	667.3	
TOTAL 2017 Mercantile Savings			14,056,754	2,361.8	$689,866.62

*2017 Savings numbers reflect a one-time adjustment to include 2015 and 2016 savings in DP&L's cumulative savings.

2017 Performance





All "filed" numbers are taken from DP&L's program portfolio filing; Case No. 13-0833-EL-POR.

Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$637,479	$689,867
Marketing & Admin	$194,040	$72,212
Total Costs	$831,519	$762,079

IMPLEMENTATION REVIEW

Implementation Strategy

DP&L is implementing this program in-house, utilizing business program managers. This provides a dedicated point of contact at DP&L to assist the customer through the process. It is the program manager's responsibility to understand program details, communicate the program to customers, and help customers manage their way through the mercantile process.

Targeted Customers

DP&L has determined approximately 1,200 customers qualify for the Self-Direct Program based on the law's minimum usage criteria of 700,000 kWh per year, set forth in O.A.C. §4901:1-39(P).

Staffing

DP&L utilizes business program managers to manage the Self-Direct Program. These managers focus on managing all stages of the Self-Direct Program including program design, PUCO rule review, marketing and customer service.

Marketing

To promote the Self-Direct Program, DP&L educates industry contractors and distributors about its availability. Their knowledge about local efficiency projects was used to establish leads for potential customers that may have implemented projects in the 2014 to 2016 timeframe.

Customer Service

DP&L utilizes its business program managers to provide customers with a single point of contact to assist with the mercantile application process. DP&L's program managers are knowledgeable about program rules, requirements and procedures and can help customers with their initial analysis related to program savings and expected energy efficiency rider costs. Further, DP&L can provide the regulatory and legal support required to make initial filings and assist throughout the regulatory process.

PJM DEMAND RESPONSE

PROGRAM DESCRIPTION

The Non-Residential PJM Demand Response program allows mercantile customers to commit their PJM Demand Response attributes to DP&L.

The objective of the program is to supplement the peak demand reductions achieved from energy efficiency programs in order to ensure compliance with the peak demand reduction benchmarks. Savings are claimed based on the actual peak demand response participating customers report into PJM's eLRS system in a given program year.

This program is available to customers who consume 700,000 kWh or more per year or are part of a regional or national account. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier. Qualifying customers must meet the requirements of the PJM Demand Response program and be participating in the program through a curtailment service provider.

PERFORMANCE SUMMARY

During 2017, DP&L was able to achieve compliance with the peak demand reduction benchmarks solely through its energy efficiency programs. As such, DP&L did not utilize the PJM Demand Response program in 2017.

Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
Incentive Costs	$0	$0
Marketing & Admin	$0	$0
Total Costs	$0	$0

In 2017, DP&L requested and was granted permission from the PUCO to transfer $600,000 from the Custom Rebate program and $34,007 from the PJM Demand Response program to the Prescriptive Rebate program to provide additional incentives to meet high customer demand in the Prescriptive Rebate program. Transfer of these funds is reflected in the filed program budget.

CROSS SECTOR PROGRAMS

PILOT PROGRAMS

PROGRAM DESCRIPTION

Pilot programs are intended to allow DP&L the flexibility to research or pilot programs to test their feasibility for cost-effective savings and potential inclusion in future portfolio plans. The objective of the Pilot Program is to develop and deploy new opportunities as they arise. Results of the pilot programs may also inform mid-stream adjustments to the current plan programs as needed.

PERFORMANCE SUMMARY

During 2017, DP&L implemented two Residential pilot programs: People Working Cooperatively (PWC) and Residential Smart Thermostats. Total energy savings from 2017 pilot programs were 2,029 MWh and peak demand savings were 0.41 MW.

Budget, Cost Summary

Budget Category	Filed 2017	Smart Thermostats	PWC	Total
Incentive Costs	$747,828	$378,357	$168,714	$547,071
Marketing & Admin	$320,498	$155,707	$35,342	$191,049
Total Costs	$1,068,326	$534,064	$204,056	$738,120

PEOPLE WORKING COOPERATIVELY

In September 2014, DP&L began a pilot program intended to enhance PWC's "whole house" critical repairs, energy conservation and modification programs. Electric conservation services assist low income homeowners and renters who pay for their electric utility services with needed electric energy conservation services. These electric services are often performed as part of a more extensive mix of services for DP&L's customers aimed at assisting the customer to remain successfully in a safer, more secure environment, while simultaneously reducing unnecessary electric usage. An added benefit of this pilot program is reduced electric costs for low income customers.

During 2017, 186 unique customers participated in the PWC pilot program which accounted for 302 MWh of energy savings and 0.16 MW in demand savings. A majority of the savings were attributed to upgrading customers' lighting and refrigerators.

People Working Cooperatively Pilot		
Costs	Energy Saved (MWh)	Demand Saved (MW)
$204,056	302	0.16

In 2017, DP&L provided a variety of promotional items for distribution to clients served through the PWC pilot program. The items included a checklist detailing the measures installed, magnetic clips, magnetic calendars, and coloring books for those clients with small children.

SMART THERMOSTATS

The Smart Thermostats pilot offers rebates toward the purchase of a new smart thermostat. Customers could purchase a smart thermostat through a variety of distribution channels and receive a rebate of $75. For example, customers could purchase a thermostat through a retail outlet, online store or through a participating HVAC contractor. The program increases consumer awareness and acceptance of smart thermostats and their benefits. Several rebates, when combined with the Vectren Smart Thermostat rebate, were limited to equipment purchase price.

During 2017, DP&L paid $378,357 in Smart Thermostat rebates to customers, resulting in gross annualized energy savings of 1,727 MWh and peak demand savings of 0.25 MW.

Units in Each Channel

Channel	Quantity
Retail Mail-In/Online Portal	879
DP&L Online Store	94
Nest.com	3,672
Residential HVAC Program	356
IGS Markdown	40
Total	5,041

DP&L's smart thermostat rebate pilot was designed to provide customers an incentive for purchasing a qualifying thermostat. In 2017, DP&L defined a smart thermostat as one that includes occupancy sensing or geofencing, wi-fi capabilities, and a learning mechanism. During 2017 a qualified products list was used to determine qualifying equipment.

DP&L worked with implementation partner(s) that oversaw all details of the process including placement of in-store signage, audited retail outlets to confirm appropriate program policies are being implemented, tracked the number of efficient products purchased, and processed incentives.

Keys to the program's success include partnerships with Vectren and Nest and leveraging CLEAResult's field representatives' presence in retail locations through the Residential Lighting Program.

Marketing materials were distributed to communicate the availability of rebates for customers as well as the benefits of smart thermostats. Marketing tactics included in-store signage, bill stuffers, web pages, mass media advertising, and presence at community events, all with the goal of increasing program awareness and customer participation.

Program participants are residential customers of DP&L. Non-residential customers, while not a targeted group, could also participate in the Smart Thermostat pilot by applying for a smart thermostat rebate through the Non-residential Prescriptive program.

Smart Thermostat Pilot		
Costs	Energy Saved (MWh)	Demand Saved (MW)
$534,064	1,727	0.25

TRANSMISSION AND DISTRIBUTION INFRASTRUCTURE IMPROVEMENTS

PROGRAM DESCRIPTION

Pursuant to O.R.C §4928.66(A)(2)(d), programs implemented by a utility to meet the statutory reduction requirements may include transmission and distribution infrastructure improvements.

In December, 2011, DP&L filed an application (11-6010-EL-POR) with the Public Utilities Commission of Ohio to include energy efficiency gains resulting from the upgrade of the company's distribution network from 4 kilovolt (kV) to 12 kilovolt distribution lines, for activities completed in the years 2010 and 2011. On August 7, 2013, the Commission approved the application, allowing DP&L to include those savings in the program portfolio plan covering 2009 through 2011.

In April, 2013, DP&L filed an updated portfolio plan (13-0833-EL-POR) for energy efficiency programs for years 2013 through 2015. Part of this plan included DP&L's intention to count savings toward its statutory benchmarks associated with infrastructure improvements. Increasing the operating voltage on the distribution system, as was done in the 4 kV to 12 kV project, is one example of an infrastructure improvement project cited in the plan. The plan was approved by the Commission on December 4, 2013.

As stated in both 11-6010-EL-POR and 13-0833-EL-POR, DP&L is not seeking to recover 4 kV to 12 kV costs through the Energy Efficiency Rider.

PERFORMANCE SUMMARY

DP&L reported savings associated with a 4 kV to 12 kV project in the 2013 Portfolio Status Report (14-0738-EL-POR). DP&L is not claiming savings from any additional transmission and distribution infrastructure projects in 2017.

CUSTOMER EDUCATION

In 2017, DP&L's customer education activities included a mass media campaign, in-person events and participation in various community events and conferences.

Budget, Cost Summary

Budget Category	Filed 2017	Actual 2017
General Education, Awareness Building	$902,493	$464,184
Total Costs	$902,493	$464,184

MASS MEDIA CAMPAIGN

During 2017, DP&L aired a multi-media educational and promotional campaign including television, radio, print, outdoor, online advertising and social media targeted to all of its customers. The goals of the campaign were to communicate the value of energy efficiency and increase the awareness of available energy efficiency programs. In addition, the campaign provided a general level of program marketing support, helping to promote the continued expansion of customer participation in energy efficiency programs.

The concept of the campaign is a sports-hero theme entitled "Savings Champion." The use of savings has a two-fold message – save money and save energy. In the first set of ads in the campaign, DP&L created everyday situations where customers make changes to their energy habits and are rewarded with play-by-play announcers humorously describing the action as if it were a sporting event. In 2016, DP&L launched the second set of ads of the campaign, going behind-the-scenes and on the set with the play-by-play announcers. DP&L continued to use this same set of ads in 2017.

Television Script Example 1

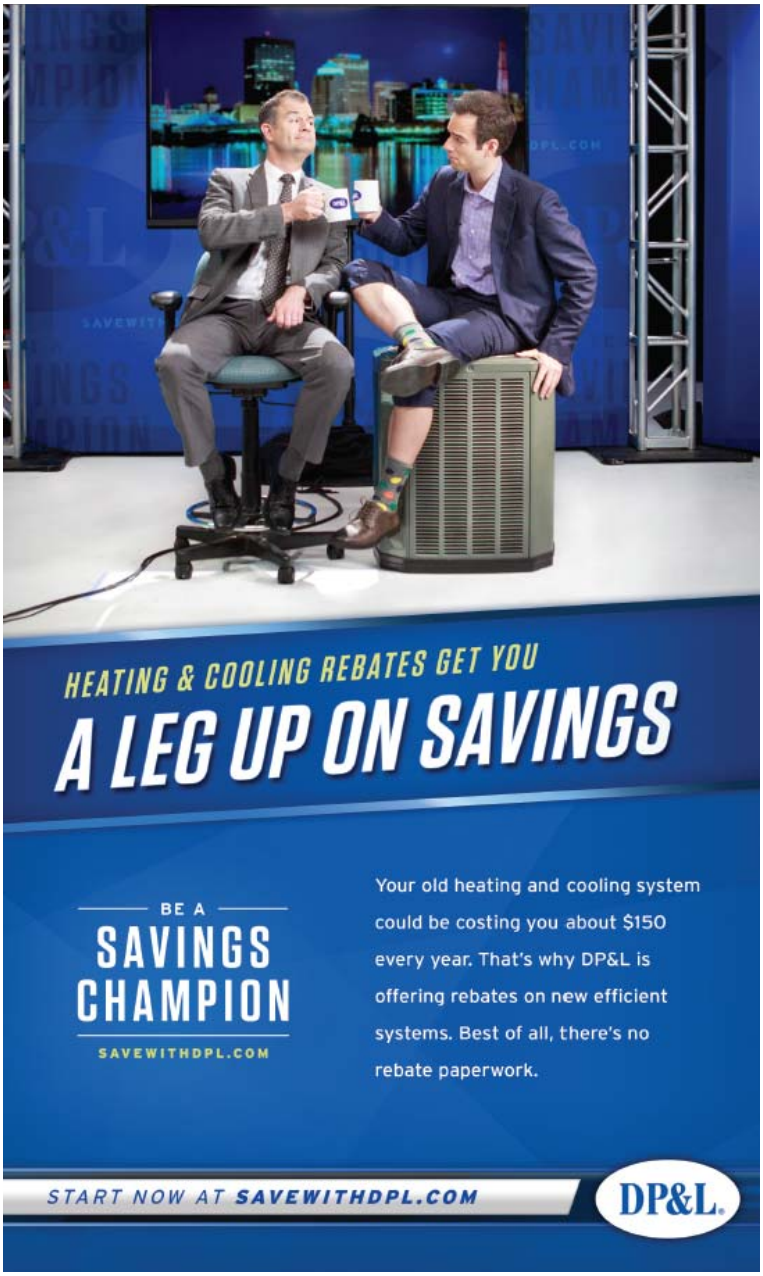
Visuals	Announcer Voice Over	
The spot takes place in the break room of a TV studio/newsroom. The three sportscasters beginning their lunch break. The refrigerator is prepped with Dayton references.	DAN: Whew, tough segment out there.	
Dan opens the refrigerator and tosses Bob's lunch to him. It's prepared in a soft-sided "lunch box."	BOB: Ha! You try saying residential appliance recycling.	
Dan and Stacey look at each other a little perplexed because it's not that difficult to say.	STACEY: You know I'm recycling my old refrigerator with DP&L.	
Pointing to refrigerator and explaining to Bob that she is recycling her old refrigerator.	STACEY: Yeah… They pay me $50 for it and I'll save about $150 a year in energy costs. DP&L even has free, convenient pick-up.	
Dan perks up when he hears about the $50.		
	BOB / STACEY: What do you think Dan… Dan?	
Bob and Stacey ask Dan's opinion but as we cut to see him, both he and the break room refrigerator are gone.	STACEY: Be a Savings Champion and recycle your old refrigerator or freezer. Visit savewithdpl.com to schedule a pick-up.	
Cut to Dan pushing the refrigerator across the set. Savings Champion, DP&L, website on screen over footage.	BOB: Dan Roberts has left the building.	
Cut back to the break room.		

Television Script Example 2

Visuals	Announcer Voice Over	
Dan is at the DP&L desk. He turns and addresses the camera. He is very "news-anchorey" as this is a promo for the team.	ALL AUDIO IS VO IN THIS SPOT. DAN: When it comes to saving you energy <u>and</u> money…	
Cut to Stacey in front of the monitor. We see a shot of Dayton on the screen. She, too turns to camera, and slings her hair around.	STACEY: …there's one team the Miami Valley can count on.	
Bob walks to the desk and goes to lean on it next to Dan.	BOB: The DP&L Savings Champion team.	
Cut to Stacey at the monitor to the right. A rebates graphic is on screen. She looks to camera confidently.	STACEY: For generous heating and cooling rebates… you can turn to us.	
Dan is flipping a fluorescent bulb in slow-mo.	BOB: For instant, in-store discounts on energy efficient lighting… we keep you connected.	
Cut to Bob who is leaning against a refrigerator.	DAN: And for free appliance pick-up and recycling that pays you $50… we're your local authority.	
The team gathers together in front of the anchor, crosses their arms and looks to camera. Dan loses his footing or has difficulty crossing his arms the same as the others.	STACEY: Get a fresh perspective on everything that saves Miami Valley residents energy and money.	

The Savings Champion logo and website come up over footage.		

Print Example



Events

In-person events played a significant role in the Savings Champion campaign. In-person events allowed DP&L to bring the campaign to life and to directly connect with customers while educating not only about DP&L's rebate programs but also about energy efficiency principles.

OTHER ACTIVITIES

In 2017, DP&L performed other education and awareness activities, some at the request of organizations and customers. These included:

Participation in various events and conferences including the Ohio Weatherization Conference, the Dayton Home and Garden Show, an energy fair at Wright-Patterson Air Force Base, Heapy Green Expo, and luncheons for the Dayton Regional Green Sustainability Initiative.

- Energy efficiency presentations to community groups, using a presentation created by DP&L called "Top Ten Ways to Save Energy in the Home."

- Participation in Earth Day events hosted by some of our largest customers.

- Coordinating an Energy Bike program. Teachers participating in our school education program can pick up the energy bike from a DP&L facility and use it for teaching and demonstrations in their classrooms.

- Various interviews with the news media about ways to reduce energy consumption.

RECOMMENDATIONS

The previous pages of this report contain a thorough description of each energy efficiency program, how it is being implemented and marketed, and the results produced to date.

DP&L undertook a comprehensive review of its programs as a part of developing its 2013-15 portfolio plan, which was filed in April of 2013 as PUCO Case No. 13-0833-EL-POR and 13-0837-EL-WVR. The programs in that plan were reviewed with stakeholder groups and a stipulation settlement was reached with all parties. The plan was approved by the Commission on December 4, 2013. Consistent with Ohio Senate Bill 310, DP&L continued programs approved in Case No. 13-0833 –EL-POR through 2016. In June 2016, DP&L filed a three-year Portfolio Plan in Case No. 16-0649-EL-POR and 16-1369-EL-WVR. In September 2017, a settlement agreement was approved by the Commission, effectively extending the Portfolio Plan approved in 13-0833-EL-POR with certain modifications to cover the 2017 program year.

Overall, DP&L is pleased with the progress of its energy efficiency initiatives. The program spending in 2017 was 13 percent below filed budgets while program savings performance was 127 percent of 2017 filed targets.

As with any type of implementation, there is opportunity to improve, including recommendations outlined in the Cadmus report (Exhibit 1). Over the course of the coming year, DP&L will continue to work with its implementation vendors, its collaborative members and its evaluations provider to make adjustments and improvements to its programs.

DP&L filed a 2018-2020 Portfolio Plan on June 15, 2017, PUCO Case No. 17-1398-EL-POR. DP&L reached a stipulation with multiple intervening parties, which was approved by the Commission in October of 2017. DP&L recommends implementing programs consistent with the Stipulation and Recommendation approved by the Commission in that case.

APPENDIX A – ANNUAL REPORT STANDARDIZED TEMPLATE

Ohio Utility Energy Efficiency Savings Summary

1 Incremental Savings from Programs in Year 2017

	Ex Ante Gross Savings			Realization Rate		Actual Expenditures			Participation		Weighted Program Measure Life	TRC Test Ratio	PAC Test Ratio
	A	B	C	D	E	F	G=F/A	H=F/C	I	J	K=C/A	L	M
	First Year Annual Energy Savings	First Year Peak Demand Savings	Lifetime Savings	Energy Savings (Ex Post Gross/Ex Ante Gross)	Demand Savings (Ex Post Gross/Ex Ante Gross)	Program Costs	Ex Ante First Year Cost Per First Year Annual Savings (F/A)	Ex Ante First Year Cost per Lifetime Savings (F/C)	Participation Number	Description (Units Description is provided in the PSR)	Years	By Program	By Program
	MWh	MW	MWh	%	%	$	$/kWh	$/kWh					
Residential Programs													
Efficient Lighting	43,777	5.23	205,752	101%	101%	$2,556,208	$0.06	$0.01	1,098,945	Bulbs	4.7	4.61	3.08
HVAC Equipment	7,422	1.59	92,033	100%	100%	$1,910,575	$0.26	$0.02	7,605	Rebates	12.4	0.47	1.97
Appliance Recycling	8,003	1.64	60,823	100%	100%	$1,024,637	$0.13	$0.02	5,965	Appliances	7.6	2.47	2.43
School Education	3,602	0.19	18,370	100%	100%	$287,196	$0.08	$0.02	9,102	Kits	5.1	2.57	2.31
Income Eligible Efficiency	926	0.13	7,315	100%	100%	$724,706	$0.78	$0.10	568	Homes	7.9	0.42	0.39
Total Residential	**63,730**	**8.78**	**384,293**	**100%**	**100%**	**$6,503,322**	**$ 0.10**					**1.42**	**2.17**
Business Programs													
Rapid Rebates	93,401	14.56	915,330	97%	96%	$7,631,154	$0.08	$0.01	1,345	Rebates	9.8	1.23	4.62
Custom Rebates	27,542	4.45	341,521	98%	98%	$2,635,210	$0.10	$0.01	90	Rebates	12.4	1.31	5.10
Mercantile Self-Direct	14,057	2.40	140,570	N/A	N/A	$762,079	$0.05	$0.01	19	Applications	10.0	1.98	7.38
Total Business	**135,000**	**21.41**	**1,397,421**	**98%**	**97%**	**$11,028,443**	**$ 0.08**					**1.30**	**4.93**
Other Programs													
Pilot Program (Income Eligible)	302	0.16	2,386	100%	100%	$204,056	$0.68	$0.09	186	Homes	7.9	0.60	0.54
Pilot Program (Smart Thermostat)	1,727	0.25	17,270	100%	N/A	$534,064	$0.31	$0.03	5,041	Thermostats	10.00	0.43	1.06
Customer Education and Marketing	N/A	N/A	N/A	N/A	N/A	$464,184	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Evaluations, Measurement & Verification	N/A	N/A	N/A	N/A	N/A	$819,375	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Other	**2,029**	**0.41**	**N/A**	**100%**	**100%**	**$2,021,679**							
Portfolio Total	**200,759**	**30.60**	**1,781,714**	**98%**	**98%**	**$19,553,444**	**$ 0.10**					**1.30**	**3.58**

2 Information Relative to Statutory Targets for Year 2017

3 year baseline retail normalized (mercantile, weather, opt-out, etc.) sales (MWh)	12,658,728
2017 Annual Benchmark Target (%)	1%
2017 Savings (MWh)	200,759
2017 Achievement (%)	159%

3 Banked Savings in Year 2017

2017 Excess Savings Banked Toward Future Compliance (MWh)	74,172
Total Banked Savings Remaining After 2017 (MWh)	894,591

4 Opt Out - Three year baseline in 2017

Total Opt Out load (MWh)	899,654

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report

The Dayton Power and Light Company ("DP&L" or "the Company") herewith submits its updated Benchmark Report ("Benchmark Report") pursuant to Section 4901:1-39-05(C)(1)(a) of the Ohio Administrative Code ("O.A.C"). In this report, DP&L identifies the energy and demand baselines for kilowatt-hour sales and kilowatt demand for reporting year 2017 based on the preceding three calendar years (2014, 2015, and 2016) as specified in Section 4928.66(A)(2)(a) of the Ohio Revised Code ("O.R.C."), along with DP&L's energy saving and peak demand reduction statutory benchmarks. In this report, DP&L also makes adjustments pursuant to O.R.C. §4928.66(A)(2)(a)(i) and (ii), O.R.C. §4928.66(A)(2)(c) and O.A.C §4901:1-39-05(B) to adjust its sales and demand baselines to normalize for weather and changes to DP&L's customer base related to reasonable arrangements, statutory portfolio plan opt-outs, and mercantile opt-out applications. DP&L's benchmarks and adjustments are supported by the descriptions shown below, including the method of calculating the baselines, supporting data, assumptions, rationales, and calculations as required by O.A.C. §4901:1-39-05(B).

DP&L 2017 Energy Efficiency Baseline Calculation

Consistent with the definition of "Energy baseline" pursuant to O.A.C. §4901:1-39-01(J), DP&L's Total Retail sales for the three preceding calendar years (2014, 2015, and 2016), which are shown below, were taken from DP&L's most recent long-term forecast report found on the Electric Utility Ohio Service Area Energy Consumption Forecast (PUCO Form FE-D1) and included as Workpaper A.

2014: 14,024,297 MWh
2015: 13,920,987 MWh
2016: 14,241,625 MWh

DP&L 2017 Peak Demand Baseline Calculation

Consistent with the definition of "Peak-demand baseline" pursuant to O.A.C. §4901:1-39-01(S), DP&L's Peak Demands for the three preceding calendar years (2014, 2015, and 2016), which are shown below, were taken from DP&L's most recent long-term forecast report found on the Electric Utility Ohio Seasonal Peak Load Demand Forecast (PUCO Form FE-D3) and included as Workpaper B.

2014: 2,756 MW
2015: 2,845 MW
2016: 2,883 MW

Normalizing Adjustments

Adjustments for Reasonable Arrangement and Statutory Opt-Out Customers

Pursuant to O.R.C §4928.66(A)(2)(a)(i) and (ii), an electric distribution utility must adjust its baseline to exclude the load and usage of both customers "for which a reasonable arrangement has been approved under section 4905.31 of the Revised Code" and "that has opted out of the utility's portfolio plan under section 4928.6611 of the Revised Code". DP&L has identified the customers that fall under these sections and both adjustments are included on Schedules 1 and 2.

Adjustment for Mercantile Customers

Pursuant to O.R.C §4928.66(A)(2)(c), an electric distribution utility must adjust its baseline to exclude the effects of all energy efficiency or peak demand reduction programs that may have existed during the period used to establish the baseline. Therefore, in addition to the adjustment for reasonable arrangement and statutory opt-out customers, DP&L also adjusted its baseline to account for the energy efficiency and peak demand reduction that was realized in connection with the approval of mercantile self-direct applications. With the exception of two applications, such mercantile applications, which included energy efficiency projects for the 2009-2016 timeframe, were approved by the Commission under the 60-day automatic approval in 2010, 2011, 2012, 2013, 2014, 2015, 2016, and 2017 pursuant to the Commission's pilot program for Mercantile Customers as established in Case No. 10-834-EL-EEC. Two of the mercantile applications were approved by the Commission for exemption from DP&L's Energy Efficiency Rider as a result of implementation of energy efficiency projects. The adjustment for Mercantile Customers is shown in more detail in Workpaper C.

Weather normalization

Weather-normalization adjusts actual weather-sensitive retail sales by class (Residential, Commercial, and Public Authority) to account for the difference between actual and normal heating and cooling degree days based on historical use per customer per day per cooling degree day and heating degree day relationships for these classes.

Workpaper D, pages 1-3 calculate the weather normalized retail sales and peak demands for the period. The weather normalization factor is the ratio of weather normalized values to actual values (sales or peak demands) and is calculated on Workpaper E.

The annual MWh sales adjusted for mercantile opt out applications are multiplied by the Weather Normalization Factors to yield the Normalized Retail Energy Sales (MWh). The same process is applied to calculate Weather Normalized Peak Demands (MW).

DP&L 2017 Normalized Energy Efficiency Baseline Calculation

DP&L's 2017 Normalized Energy Efficiency baseline calculation is shown on Schedule 1. The methodology is consistent with O.A.C. §4901:1-39-01(J) and includes the adjustments described

above. The normalized retail energy sales for 2014, 2015, and 2016 are averaged over the three years, to produce DP&L's 2017 Normalized Energy Efficiency Baseline of 12,685,728 MWh.

DP&L 2017 Energy Efficiency Reduction Benchmark Calculation

As described in O.R.C. §4928.66(A)(1)(a), beginning in 2009, an electric distribution utility shall: "Implement energy efficiency programs that achieve energy savings equivalent to at least three-tenths of one per cent of the total, annual average, and normalized kilowatt-hour sales of the electric distribution utility during the preceding three calendar years to customers in this state. The savings requirement, using such a three-year average … shall be, for years 2017, 2018, 2019, and 2020, one per cent of the baseline."

DP&L's 2017 Normalized Energy Efficiency Baseline of 12,658,728 MWh is multiplied by the 2017 Energy Efficiency Reduction Benchmark percentage of 1.00% pursuant to O.R.C. §4928.66(A)(1)(a). The result is DP&L's 2017 Incremental Energy Efficiency Reduction Benchmark of 126,587 MWh. DP&L's 2017 cumulative Energy Efficiency Reduction Benchmark is 714,771 MWh. The calculations are shown on Schedule 1.

DP&L 2017 Normalized Peak Demand Baseline Calculation

DP&L's 2017 Normalized Peak Demand Reduction baseline calculation is shown on Schedule 2. The methodology is consistent with O.A.C. §4901:1-39-01(S) and includes the adjustments described above. DP&L's Normalized Peak Demands for 2014, 2015, and 2016 are averaged over the three years, to produce DP&L's 2017 Normalized Peak Demand Baseline of 2,704 MW.

DP&L 2017 Peak Demand Reduction Benchmark Calculation

As described in O.R.C. §4928.66 (A)(1)(b), beginning in 2009, an electric distribution utility shall:

> "Implement peak demand reduction programs designed to achieve a one per cent reduction in peak demand in 2009 and an additional seventy-five hundredths of one per cent reduction each year through 2014. In 2017 and each year thereafter through 2020, the utility shall achieve an additional seventy-five hundredths of one per cent reduction in peak demand."

DP&L's 2017 Normalized Peak Demand Reduction Baseline of 2,704 MW is multiplied by the 2017 Peak Demand Reduction Benchmark percentage of 5.50% pursuant to O.R.C. §4928.66 (A)(1)(b). The result is DP&L's 2017 Peak Demand Reduction Benchmark of 148.7 MW. The calculation is shown on Schedule 2.

Schedule 1

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
Energy Efficiency Baseline and Benchmark Calculation

		2014	2015	2016	2017
1	**Baseline Calculation Components**				
2	Retail MWh Sales [1]	14,024,297	13,920,987	14,241,625	
3					
4	**Normalizing Adjustments**				
5	Reasonable Arrangement Adjustment [2]	409,206	419,976	436,902	
6	Opt-Out Customer Adjustment [3]	873,803	913,138	912,022	
7	Mercantile Customer Adjustment [4]	51,408	58,180	65,220	
8	Total Adjusted Retail Sales (2)+(5)	12,792,696	12,646,053	12,957,921	
9	Weather Normalization Factor [5]	0.98349	0.99504	0.98869	
10	Normalized Retail Energy Sales (6)*(7)	12,581,489	12,583,329	12,811,367	
11					
12	**2017 Normalized Energy Efficiency Baseline**				
13	3 Year Normalized Average (MWh)				12,658,728
14					
15	**Calculation of 2017 Energy Efficiency Reduction Benchmark**				
16	Normalized Preceding 3 Year Average Sales (11)				12,658,728
17	2017 Incremental Energy Efficiency Reduction Benchmark % [6]				1.00%
18	2017 Incremental Energy Efficiency Reduction Benchmark (14)*(15)				126,587
19	2014 Energy Efficiency Reduction Benchmark [7]				588,184
20	**2017 Cumulative Energy Efficiency Reduction Benchmark (16)+(17)**				**714,771**

[1] Retail sales for the period 2014-2016 are reported in PUCO Form FE-D1 (Case No. 18-0467-EL-FOR). See Workpaper A, Column (6).

[2] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(i).

[3] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(ii).

[4] See Workpaper C for calculation of Mercantile Customer Adjustment.

[5] See Workpaper E for calculation of the weather normalization factor.

[6] Energy Efficiency benchmark as established in O.R.C. §4928.66(A)(1)(a).

[7] 2014 Cumulative Energy Efficiency Reduction Benchmark as established in Case No. 15-0777-EL-POR, Schedule 1, line 21.

Schedule 2

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
Peak Demand Baseline and Benchmark Calculation

		2014	2015	2016	2017
1	**Baseline Calculation Components**				
2	Peak MW Demand [1]	2,756	2,845	2,883	
3					
4	**Normalizing Adjustments**				
5	Reasonable Arrangement Adjustment [2]	77	70	74	
6	Opt-Out Customer Adjustment [3]	117	103	125	
7	Mercantile Customer Adjustment [4]	16	17	18	
8	Total Adjusted Peak Demand (2)+(5)	2,578	2,690	2,702	
9	Weather Normalization Factor [5]	1.00544	1.05062	0.99723	
10	Normalized Peak Demand (6)*(7)	2,592	2,826	2,694	
11					
12	**2017 Normalized Peak Demand Reduction Baseline**				
13	3 Year Normalized Average (MW)				2,704
14					
15	**Calculation of Normalized 2017 Peak Demand Reduction Benchmark**				
16	Normalized Preceding 3 Year Average Peak Demand (11)				2,704
17	2017 Peak Demand Reduction Benchmark % [6]				5.50%
18	**2017 Peak Demand Reduction Benchmark (14)*(15)**				**148.7**

[1] Peak demand for the period 2014-2016 is reported in PUCO Form FE-D3. See Workpaper B.

[2] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(i).

[3] Adjusted in compliance with O.R.C. §4928.66(A)(2)(a)(ii).

[4] See Workpaper C for calculation of Mercantile Customer Adjustment.

[5] See Workpaper E for calculation of weather normalization factor.

[6] Peak Demand Reduction benchmark as established in O.R.C § 4928.66(A)(1)(b).

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report

PUCO FORM FE-D1: ELECTRIC UTILITY OHIO SERVICE AREA ENERGY CONSUMPTION FORECAST
(Megawatt-Hours Per Year)

		1	2	3	4	5	5a	6	7	8
	YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION (a)	OTHER (b)	ENERGY EFFICIENCY & DEMAND RESPONSE	TOTAL END USER CONSUMPTION 1+2+3+4+5-5a	LOSSES AND UNACCOUNTED FOR	NET ENERGY FOR LOAD 6+7
-5	2013	5,226,437	3,697,532	3,552,428	3,913	1,349,658		13,829,968	563,041	14,393,009
-4	2014	5,344,082	3,714,874	3,651,720	3,336	1,310,285		14,024,297	565,882	14,590,179
-3	2015	5,187,751	3,742,101	3,684,745	3,885	1,302,505		13,920,987	530,476	14,451,463
-2	2016	5,253,286	3,788,252	3,852,079	3,647	1,344,361		14,241,625	534,154	14,775,779
-1	2017	4,993,562	3,673,103	3,831,994	3,052	1,276,536		13,778,247	457,775	14,236,022
0	2018	5,330,298	3,779,861	3,880,551	3,034	1,278,466	182,894	14,089,316	528,461	14,617,777
1	2019	5,415,419	3,826,301	3,951,917	3,064	1,277,255	360,302	14,113,655	529,354	14,643,009
2	2020	5,489,757	3,848,165	4,011,998	3,093	1,275,671	532,386	14,096,298	528,717	14,625,015
3	2021	5,564,060	3,888,116	4,074,014	3,121	1,273,726	699,308	14,103,729	528,990	14,632,719
4	2022	5,649,381	3,938,057	4,134,479	3,148	1,271,469	861,766	14,134,768	530,129	14,664,897
5	2023	5,738,502	3,990,857	4,193,928	3,175	1,268,874	1,019,393	14,175,944	531,640	14,707,584
6	2024	5,830,347	4,039,720	4,237,732	3,201	1,265,948	1,172,291	14,204,657	532,694	14,737,351
7	2025	5,916,552	4,089,387	4,277,674	3,226	1,262,700	1,320,582	14,228,957	533,586	14,762,543
8	2026	6,001,250	4,139,817	4,321,101	3,260	1,259,121	1,464,326	14,260,223	534,733	14,794,956
9	2027	6,086,903	4,190,187	4,372,993	3,380	1,255,033	1,602,301	14,306,195	536,420	14,842,615
10	2028	6,165,866	4,236,380	4,417,012	3,495	1,250,471	1,734,757	14,338,466	537,605	14,876,071

(a) Transportation includes railroads & railways.

(b) Other includes Street & Highway Lighting, Public Authorities and Interdepartmental Sales.

Workpaper B

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report

PUCO FORM FE-D3: ELECTRIC UTILITY OHIO SEASONAL PEAK LOAD DEMAND FORECAST
(Megawatts)

		Native Load				Internal Load			
	Year	Summer	Demand Response	Net Summer	Winter (a)	Summer	Demand Response	Net Summer	Winter (a)
-5	2013	2937			2777	2937			2777
-4	2014	2756			2568	2756			2568
-3	2015	2845			2453	2845			2453
-2	2016	2883			2486	2883			2486
-1	2017	2771			2598	2771			2598
0	2018	2949	27	2922	2525	2949	27	2922	2525
1	2019	2984	54	2930	2552	2984	54	2930	2552
2	2020	3013	79	2934	2568	3013	79	2934	2568
3	2021	3041	104	2937	2593	3041	104	2937	2593
4	2022	3073	128	2945	2620	3073	128	2945	2620
5	2023	3106	151	2955	2649	3106	151	2955	2649
6	2024	3136	173	2963	2664	3136	173	2963	2664
7	2025	3164	196	2968	2686	3164	196	2968	2686
8	2026	3193	216	2977	2710	3193	216	2977	2710
9	2027	3225	237	2988	2729	3225	237	2988	2729
10	2028	3253	256	2997	2750	3253	256	2997	2750

(a) Winter load reference is to peak loads which follow the summer peak load.

THE DAYTON POWER AND LIGHT COMPANY
2017 Benchmark Report
Adjustment for Mercantile Customers

		Demand Savings (kW)			Energy Savings (kWh)		
Ln	Customer	2014	2015	2016	2014	2015	2016
1	**2010 Mercantile Customer Adjustment ***						
2	Customer A	499.4	499.4	499.4	1,914,690	1,914,690	1,914,690
3	Customer B	13.2	13.2	13.2	202,161	202,161	202,161
4	Customer C	294.5	294.5	294.5	959,998	959,998	959,998
5	Customer D	91.5	91.5	91.5	91,554	91,554	91,554
6	Customer E	261.5	261.5	261.5	261,565	261,565	261,565
7	Customer F	237.0	237.0	237.0	1,000,430	1,000,430	1,000,430
8	Customer G	97.1	97.1	97.1	526,864	526,864	526,864
9	**Total 2010 Adjustment**	**1,494.2**	**1,494.2**	**1,494.2**	**4,957,262**	**4,957,262**	**4,957,262**
10							
11	**2011 Mercantile Customer Adjustment ***						
12	Customer H	108.7	108.7	108.7	952,131	952,131	952,131
13	Customer I	120.5	120.5	120.5	620,513	620,513	620,513
14	Customer J	192.5	192.5	192.5	958,979	958,979	958,979
15	Customer K	8.1	8.1	8.1	40,600	40,600	40,600
16	Customer L	137.9	137.9	137.9	996,566	996,566	996,566
17	Customer M	275.2	275.2	275.2	233,127	233,127	233,127
18	Customer N	39.6	39.6	39.6	141,247	141,247	141,247
19	EER Exemption Applications	2,474.3	2,694.9	2,921.4	13,170,751	14,578,033	15,985,452
20	**Total 2011 Adjustment**	**3,356.8**	**3,577.4**	**3,803.9**	**17,113,914**	**18,521,196**	**19,928,615**
21							
22	**2012 Mercantile Customer Adjustment ***						
23	Customer O	57.1	57.1	57.1	499,656	499,656	499,656
24	Customer P	406.3	406.3	406.3	210,142	210,142	210,142
25	Customer Q	13.7	13.7	13.7	171,581	171,581	171,581
26	Customer R	2.3	2.3	2.3	44,855	44,855	44,855
27	Customer S	44.4	44.4	44.4	329,770	329,770	329,770
28	Customer T	158.0	158.0	158.0	785,861	785,861	785,861
29	Customer U	31.7	31.7	31.7	38,516	38,516	38,516
30	Customer V	1,719.8	1,719.8	1,719.8	1,120,905	1,120,905	1,120,905
31	Customer W	144.4	144.4	144.4	123,863	123,863	123,863
32	Customer X	517.3	517.3	517.3	2,269,477	2,269,477	2,269,477
33	Customer Y	162.1	162.1	162.1	209,352	209,352	209,352
34	Customer Z	312.8	312.8	312.8	201,505	201,505	201,505
35	Customer AA	-	-	-	43,804	43,804	43,804
36	Customer AB	365.0	365.0	365.0	300,316	300,316	300,316
37	**Total 2012 Adjustment**	**3,934.9**	**3,934.9**	**3,934.9**	**6,349,603**	**6,349,603**	**6,349,603**

* These Mercantile Applications (except the EER exemption applications) were approved by the Commission in 2010, 2011, 2012, 2013, 2014, 2015, 2016, AND 2017 respectively under the 60 day automatic approval, pursuant to the Commission's pilot program for Mercantile Customers as established in Case No. 10-834-EL-EEC. These adjustments are prorated and based on the timeframe that the energy efficiency was achieved. The EER exemption applications were approved by the Commission in 2011 for exemption from DP&L's Energy Efficiency Rider.

THE DAYTON POWER AND LIGHT COMPANY
2017 Benchmark Report
Adjustment for Mercantile Customers

		Demand Savings (kW)			Energy Savings (kWh)		
Ln	Customer	2014	2015	2016	2014	2015	2016
38	**2013 Mercantile Customer Adjustment ***						
39	Customer AC	8.2	8.2	8.2	86,204	86,204	86,204
40	Customer AD	8.2	8.2	8.2	129,307	129,307	129,307
41	Customer AE	48.8	48.8	48.8	599,123	599,123	599,123
42	Customer AF	22.8	22.8	22.8	84,096	84,096	84,096
43	Customer AG	3.3	3.3	3.3	10,207	10,207	10,207
44	Customer AH	204.1	204.1	204.1	542,722	542,722	542,722
45	Customer AI	24.0	24.0	24.0	189,977	189,977	189,977
46	Customer AJ	405.9	405.9	405.9	2,126,547	2,126,547	2,126,547
47	Customer AK	33.0	33.0	33.0	154,080	154,080	154,080
48	Customer AL	218.3	218.3	218.3	216,992	216,992	216,992
49	Customer AM	200.8	200.8	200.8	540,896	540,896	540,896
50	Customer AN	123.6	123.6	123.6	54,750	54,750	54,750
51	Customer AO	171.2	171.2	171.2	423,159	423,159	423,159
52	Customer AP	41.0	41.0	41.0	104,383	104,383	104,383
53	Customer AQ	49.8	49.8	49.8	368,815	368,815	368,815
54	Customer AR	179.6	179.6	179.6	56,845	56,845	56,845
55	Customer AS	6.5	6.5	6.5	35,395	35,395	35,395
56	Customer AT	193.0	193.0	193.0	420,485	420,485	420,485
57	Customer AU	29.1	29.1	29.1	59,532	59,532	59,532
58	Customer AV	23.1	23.1	23.1	310,768	310,768	310,768
59	Customer AW	670.1	670.1	670.1	883,003	883,003	883,003
60	Customer AX	649.0	649.0	649.0	1,339,124	1,339,124	1,339,124
61	**Total 2013 Adjustment**	**3,313.4**	**3,313.4**	**3,313.4**	**8,736,410**	**8,736,410**	**8,736,410**
62							
63	**2014 Mercantile Customer Adjustment ***						
64	Customer AY	1,165.8	1,165.8	1,165.8	227,155	227,155	227,155
65	Customer AZ	230.5	230.5	230.5	62,687	62,687	62,687
66	Customer BA	3.7	3.7	3.7	7,004	7,004	7,004
67	Customer BB	2.5	2.5	2.5	5,850	5,850	5,850
68	Customer BC	2.3	2.3	2.3	188,773	188,773	188,773
69	Customer BD	37.2	37.2	37.2	198,588	198,588	198,588
70	Customer BE	30.5	30.5	30.5	367,804	505,377	505,377
71	Customer BF	10.6	10.6	10.6	115,403	115,403	115,403
72	Customer BG	30.0	30.0	30.0	135,168	135,168	135,168
73	Customer BH	308.3	308.3	308.3	139,753	139,753	139,753
74	Customer BI	62.7	62.7	62.7	427,286	427,286	427,286
75	Customer BJ	41.8	41.8	41.8	173,925	173,925	173,925
76	Customer BK	40.0	40.0	40.0	214,461	253,584	253,584
77	Customer BL	7.1	7.1	7.1	44,055	44,055	44,055
78	Customer BM	30.7	30.7	30.7	138,154	138,154	138,154
79	**Total 2014 Adjustment**	**2,003.7**	**2,003.7**	**2,003.7**	**2,446,066**	**2,622,762**	**2,622,762**

* These Mercantile Applications (except the EER exemption applications) were approved by the Commission in 2010, 2011, 2012, 2013, 2014, 2015, 2016, AND 2017 respectively under the 60 day automatic approval, pursuant to the Commission's pilot program for Mercantile Customers as established in Case No. 10-834-EL-EEC. These adjustments are prorated and based on the timeframe that the energy efficiency was achieved. The EER exemption applications were approved by the Commission in 2011 for exemption from DP&L's Energy Efficiency Rider.

THE DAYTON POWER AND LIGHT COMPANY
2017 Benchmark Report
Adjustment for Mercantile Customers

Ln	Customer	Demand Savings (kW) 2014	2015	2016	Energy Savings (kWh) 2014	2015	2016
80	**2015 Mercantile Customer Adjustment ***						
81	Customer BN	22.9	22.9	22.9	55,295	132,704	132,704
82	Customer BO	173.2	173.2	173.2	194,532	194,532	194,532
83	Customer BP	96.0	96.0	96.0	104,887	104,887	104,887
84	Customer BQ	0.2	0.2	0.2	24,453	46,331	46,331
85	Customer BR	200.9	200.9	200.9	1,615,884	1,615,884	1,615,884
86	Customer BS	-	-	-	39,384	39,384	39,384
87	Customer BT	8.0	8.0	8.0	32,740	34,112	34,112
88	Customer BU	-	-	-	218	26,775	27,636
89	Customer BV	-	-	-	731,528	1,036,807	1,036,807
90	Customer BW	-	28.3	28.3	-	162,708	166,284
91	Customer BX	-	23.5	23.5	-	48,298	49,224
92	Customer BY	-	7.5	7.5	1,647	9,572	9,572
93	Customer BZ	15.6	18.0	18.0	245,924	248,372	248,372
94	Customer CA	295.7	295.7	295.7	462,249	462,249	462,249
95	Customer CB	-	8.1	8.1	-	22,184	33,276
96	**Total 2015 Adjustment**	**812.5**	**882.3**	**882.3**	**3,508,741**	**4,184,799**	**4,201,254**
97							
98	**2016 Mercantile Customer Adjustment ***						
99	Customer CC	58.0	58.0	58.0	508,428.0	508,428.0	508,428.0
100	Customer CD	547.7	547.7	547.7	3,886,531.0	3,923,184.0	3,923,184.0
101	Customer CE	-	404.2	404.2	273,572.0	3,350,208.0	3,350,208.0
102	Customer CF	-	-	-	28,790.0	65,308.0	65,308.0
103	Customer CG	83.4	83.4	83.4	339,461.0	579,261.0	579,261.0
104	Customer CH	109.0	109.0	109.0	1,133,243.0	1,133,243.0	1,133,243.0
105	Customer CI	-	-	51.8	-	27,475.0	65,941.0
106	Customer CJ	48.6	48.6	48.6	112,189.0	267,522.0	267,522.0
107	**Total 2016 Adjustment**	**846.7**	**1,250.9**	**1,302.7**	**6,282,214**	**9,854,629**	**9,893,095**
108	**2017 Mercantile Customer Adjustment ***						
109	Customer CJ	12	14	21	137,025	245,682	324,189
110	Customer CK	210	210	210	1,837,848	1,837,848	1,837,848
111	Customer CL	-	-	403	-	294,190	3,530,280
112	Customer CM	6	6	6	17,910	35,820	37,187
113	Customer CN	-	-	75	-	-	395,687
114	Customer CO	-	-	-	-	-	1,261
115	Customer CP	-	-	-	-	-	10,717
116	Customer CQ	-	-	9	-	-	57,571
117	Customer CR	-	-	-	-	-	33,339
118	Customer CS	-	-	126	-	93,193	684,682
119	Customer CT	-	17	17	-	103,706	222,234
120	Customer CU	-	-	244	-	-	401,136
121	Customer CV	-	-	-	-	-	3,119
122	Customer CW	-	-	-	-	-	232,642
123	Customer CX	-	-	3	-	-	16,188
124	Customer CY	-	-	112	-	50,247	198,789
125	Customer CZ	-	5	34	-	48,929	117,215
126	Customer DA	1	62	69	20,637	243,433	427,056
127	Customer DB	-	-	-	-	-	-
128	**Total 2017 Adjustment**	**228.8**	**313.2**	**1,327.5**	**2,013,420**	**2,953,048**	**8,531,140**
129							
130	**Total Adjustment (All Years)**	**15,991.0**	**16,770.0**	**18,062.6**	**51,407,630**	**58,179,709**	**65,220,141**

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DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
2014 Weather Normalization

2014 Actual Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	Peak
Residential	660,643	563,039	489,958	332,822	333,913	427,393	442,140	437,488	348,432	295,321	452,746	546,495	5,330,390	MW
Commercial	327,879	294,965	301,979	268,523	306,704	334,330	343,401	337,738	303,818	301,823	286,924	305,103	3,713,187	September
Industrial	296,466	267,929	300,504	291,207	314,237	322,997	308,066	325,156	303,563	352,938	298,939	270,385	3,652,387	Actual
Other	113,389	101,212	109,279	100,956	115,670	113,291	118,311	118,409	111,922	109,465	97,452	100,806	1,310,162	**2756**
														Load Factor[1]
Total Retail	**1,398,377**	**1,227,145**	**1,201,720**	**993,508**	**1,070,524**	**1,198,011**	**1,211,918**	**1,218,791**	**1,067,735**	**1,059,547**	**1,136,061**	**1,222,789**	**14,006,126**	53.81%

2014 WN Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	WN Peak[2]
Residential	613,469	508,540	448,696	361,648	275,350	355,695	541,764	390,491	349,340	305,078	403,361	590,890	5,144,322	MW
Commercial	310,071	278,917	297,451	268,523	295,232	318,773	365,784	327,720	308,666	301,224	282,289	313,368	3,668,018	September
Industrial	296,466	267,929	300,504	291,207	314,237	322,997	308,066	325,156	303,563	352,938	298,939	270,385	3,652,387	WN
Other	113,389	101,212	109,279	100,956	115,670	113,291	118,311	118,409	111,922	109,465	97,452	100,806	1,310,162	**2771**
Total WN Retail Sales	**1,333,395**	**1,156,598**	**1,155,930**	**1,022,334**	**1,000,489**	**1,110,756**	**1,333,925**	**1,161,776**	**1,073,491**	**1,068,705**	**1,082,041**	**1,275,449**	**13,774,889**	

All sales in MWh

[1]Peak Load Factor is calculated by dividing peak month sales by the number of hours in the month then dividing the result by the peak demand [peak month sales/hours in month)/peak demand]

[2]Weather normalized peak is calculated by applying the peak load factor to the normalized peak month sales [(peak month sales/hours in month)/peak month load factor]

[3]Other Includes Public Authorities, Street Railway, and Street Lighting

DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
2015 Weather Normalization

2015 Actual Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	Peak
Residential	595,932	567,578	480,855	309,098	343,471	422,024	448,313	496,958	345,868	306,720	360,121	455,164	5,132,102	MW
Commercial	320,378	299,827	303,247	267,584	316,830	327,215	354,656	338,603	326,276	317,257	266,314	308,372	3,746,559	July
Industrial	296,625	283,321	288,204	309,435	318,126	318,807	332,930	316,534	330,157	381,877	235,554	269,165	3,680,735	Actual
Other	110,918	103,452	105,683	100,860	113,892	110,075	125,265	109,357	121,003	113,630	89,959	102,727	1,306,821	**2845**
														Load Factor[1]
Total Retail	**1,323,853**	**1,254,178**	**1,177,989**	**986,977**	**1,092,319**	**1,178,121**	**1,261,164**	**1,261,452**	**1,123,304**	**1,119,484**	**951,948**	**1,135,428**	**13,866,217**	59.58%

2015 WN Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	WN Peak[2]
Total Residential	595,282	481,730	465,210	341,504	246,855	356,792	465,495	537,983	289,335	324,361	414,934	593,690	5,113,171	MW
Commercial	320,174	270,568	301,919	267,584	290,384	315,075	358,443	348,655	313,148	317,257	267,404	326,085	3,696,696	July
Industrial	296,625	283,321	288,204	309,435	318,126	318,807	332,930	316,534	330,157	381,877	235,554	269,165	3,680,735	WN
Other	110,918	103,452	105,683	100,860	113,892	110,075	125,265	109,357	121,003	113,630	89,959	102,727	1,306,821	**2989**
Total WN Retail Sales	**1,322,999**	**1,139,071**	**1,161,016**	**1,019,383**	**969,257**	**1,100,749**	**1,282,133**	**1,312,529**	**1,053,643**	**1,137,125**	**1,007,851**	**1,291,667**	**13,797,423**	

All sales in MWh

[1]Peak Load Factor is calculated by dividing peak month sales by the number of hours in the month then dividing the result by the peak demand [peak month sales/hours in month)/peak demand]

[2]Weather normalized peak is calculated by applying the peak load factor to the normalized peak month sales [(peak month sales/hours in month)/peak month load factor]

[3]Other Includes Public Authorities, Street Railway, and Street Lighting

DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
2016 Weather Normalization

2016 Actual Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	Peak
Residential	687,000	488,000	379,000	326,000	329,000	445,000	516,000	613,000	380,000	313,000	351,000	544,000	5,371,000	MW
Commercial	376,000	314,000	264,000	272,000	301,000	334,000	366,000	378,000	333,000	308,000	283,000	306,000	3,835,000	July
Industrial	369,000	311,000	285,000	317,000	324,000	330,000	340,000	336,000	340,000	335,000	317,000	308,000	3,912,000	Actual
Other	173,000	103,000	103,000	102,000	111,000	110,000	126,000	118,000	124,000	109,000	99,000	103,000	1,381,000	**2883**
														Load Factor[1]
Total Retail	**1,605,000**	**1,216,000**	**1,031,000**	**1,017,000**	**1,065,000**	**1,219,000**	**1,348,000**	**1,445,000**	**1,177,000**	**1,065,000**	**1,050,000**	**1,261,000**	**14,499,000**	62.85%

2016 WN Calendar Retail Sales

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD	WN Peak[2]
Residential	703,000	513,000	461,000	340,000	312,000	400,000	477,000	495,000	311,000	323,000	393,000	537,000	5,265,000	MW
Commercial	380,000	319,000	268,000	273,000	301,000	324,000	358,000	352,000	317,000	296,000	284,000	304,000	3,776,000	July
Industrial	369,000	311,000	285,000	317,000	324,000	330,000	340,000	336,000	340,000	335,000	317,000	308,000	3,912,000	WN
Other	173,000	102,000	103,000	102,000	111,000	110,000	126,000	119,000	125,000	109,000	99,000	103,000	1,382,000	**2875**
Total WN Retail Sales	**1,625,000**	**1,245,000**	**1,117,000**	**1,032,000**	**1,048,000**	**1,164,000**	**1,301,000**	**1,302,000**	**1,093,000**	**1,063,000**	**1,093,000**	**1,252,000**	**14,335,000**	

All sales in MWh

[1]Peak Load Factor is calculated by dividing peak month sales by the number of hours in the month then dividing the result by the peak demand [peak month sales/hours in month)/peak demand]

[2]Weather normalized peak is calculated by applying the peak load factor to the normalized peak month sales [(peak month sales/hours in month)/peak month load factor]

[3]Other Includes Public Authorities, Street Railway, and Street Lighting

THE DAYTON POWER & LIGHT COMPANY
2017 Benchmark Report
Weather Normalization Factors

Year	Actual Calendar Retail Sales[1]	Weather Normalized Retail Sales[2]	Energy Weather Normalization Factor[3]
	(a)	(b)	(c)
2014	14,006,126	13,774,889	0.98349
2015	13,866,217	13,797,423	0.99504
2016	14,499,000	14,335,000	0.98869

	Actual System Peak Demands[1]	Weather Normalized Peak Demands[2]	Demand Weather Normalization Factor[3]
2014	2,756	2,771	1.00544
2015	2,845	2,989	1.05062
2016	2,883	2,875	0.99723

[1] Workpaper D, Pages 1-3.

[2] Weather normalization sales and peaks are based on normal heating and cooling degree day adjustments (Workpaper D, Pages 1-3).

[3] Weather normalization factor (c)= (b)/(a).

2017 Evaluation, Measurement, and Verification Final Report

May 7, 2018

Dayton Power and Light
1900 Dryden Road
Dayton, Ohio 45439

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Executive Summary

In 2013, Dayton Power and Light (DP&L) filed a three-year Energy Efficiency and Demand Response Plan (Case No. 13-0833-EL-POR) that covered the years 2013 through 2015, outlining a portfolio of residential and business programs in response to Senate Bill 221 (S.B. 221). Consistent with Ohio Senate Bill 310, DP&L continued programs from Case No. 13-0833-EL-POR in 2016 and 2017. DP&L selected Cadmus to evaluate its residential and commercial energy efficiency portfolio for the 2017 program year. This document summarizes the evaluation results for the 2017 programs.

Primary impact evaluation objectives included the following:

- Assess the appropriateness of the programs' gross *ex ante* claimed savings
- Calculate gross *ex post* (verified gross and adjusted gross) saving estimates
- Determine program and portfolio cost-effectiveness

Primary process evaluation objectives included the following:

- Assess overall satisfaction with select programs
- Identify program design and delivery changes that would improve the performance of select programs

Cadmus presents three saving values throughout this report: *ex ante* claimed, verified gross, and adjusted gross. These values should be interpreted as follows:

- ***Ex ante Savings*:** *Ex ante* estimates are generally the same values as used by DP&L in its filed and approved plans. These estimates establish savings goals for DP&L's portfolio. Comparing *ex ante* values to approved plan goals presents an appropriate metric for program and portfolio accomplishments. In 2017, the Portfolio exceeded its overall goal, with a few programs falling short.
- **Verified Gross Savings:** Adjustments to *ex ante* participation, based primarily on survey or on-site verification, result in verified gross savings. The unit energy savings (UES) estimation approach (e.g., Ohio TRM or deemed savings) remains the same as that used in *ex ante* claimed savings. A verified gross savings realization rate represents how well a program or portfolio is performing; it assesses metrics that are reasonably within DP&L's control. Per Ohio rules, the verification process is intended to confirm that measures were actually installed, installation meets reasonable quality standards, measures are operating correctly, and measures are expected to generate predicted savings.[1]
- **Adjusted Gross Savings:** Adjustments to *ex ante* participation, based on survey or on-site verification, and adjustments to UES and per-unit demand reduction estimates (based on

[1] Ohio Administrative Code. Chapter 4901:1-39-05(C)(2)(b), Energy Efficiency Programs: Benchmark and Annual Status Reports. December 10, 2009. Available online: http://codes.ohio.gov/oac/4901:1-39-05

engineering reviews of savings, statistical models, or other approaches), yield adjusted gross savings. Cadmus provides these estimates to present a more refined level of assessment and they should be used for future program planning. Specifically, the Public Utilities Commission of Ohio (PUCO) should use adjusted gross savings results from evaluations conducted for the various Ohio investor-owned utilities when updating the Ohio TRM.

Table 1 provides saving results by program, both as *ex ante* claimed, verified gross, and adjusted gross. *Ex ante* energy savings exceeded filed program goals by 27%. *Ex ante* demand reduction exceeded filed program goals by 7%.

Table 1. Portfolio Evaluation Results

Program	2017 Program Goals		*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Residential								
Lighting	50,573,236	6,044	43,777,456	5,233	44,192,190	5,282	42,702,563	4,517
Appliance Recycling	4,273,944	758	8,003,102	1,639	8,003,102	1,639	6,039,762	1,268
Income Eligible Efficiency (OPAE)	1,083,240	162	925,681	126	925,681	126	814,597	110
Heating and Cooling Rebates	8,814,339	2,713	7,421,781	1,590	7,454,386	1,594	6,807,414	1,489
Energy Education (Be E³ Smart)	2,376,762	21	3,602,458	188	3,602,458	188	3,602,458	188
Nonresidential								
Prescriptive	54,446,250	9,636	93,401,031	14,560	90,624,217	14,043	84,878,212	13,814
Custom	28,143,971	5,164	27,542,177	4,455	27,066,918	4,357	18,018,808	2,514
Pilot Programs								
Income Eligible Efficiency (PWC)	Not Filed	Not Filed	301,725	165	301,725	165	301,725	165
Smart Thermostats	Not Filed	Not Filed	1,727,141	249	1,722,140	248	1,420,611	0
Mercantile*	8,822,371	4,129	14,056,754	2,362	N/A	N/A	N/A	N/A
Total (without Mercantile)	**149,711,742**	**24,498**	**186,702,553**	**28,204**	**183,892,817**	**27,641**	**164,586,149**	**24,065**
Total (with Mercantile)	**158,534,113**	**28,627**	**200,759,307**	**30,566**	**183,892,817**	**27,641**	**164,586,149**	**24,065**

*Cadmus does not evaluate the Mercantile Self-Direct program. *Ex ante* savings are provided by DP&L.

Table 2 provides program and portfolio-level realization rates, comparing verified and adjusted gross savings and demand reduction against *ex ante* savings.

Table 2. Portfolio Realization Rates

Program	Verified Gross Realization Rate		Adjusted Gross Realization Rate	
	kWh	kW	kWh	kW
Residential				
Lighting	101%	101%	98%	86%
Appliance Recycling	100%	100%	75%	77%
Income Eligible Efficiency (OPAE)	100%	100%	88%	88%
HVAC Equipment	100%	100%	92%	94%
Energy Education (Be E³ Smart)	100%	100%	100%	100%
Nonresidential				
Prescriptive	97%	96%	91%	95%
Custom	98%	98%	65%	56%
Pilot Programs				
Income Eligible Efficiency (PWC)	100%	100%	100%	100%
Smart Thermostats	100%	100%	82%	--
Total	**98%**	**98%**	**90%**	**87%**

Cadmus found portfolio-level realization rates of 98% for energy savings and demand reduction, comparing verified gross savings to *ex ante* claimed savings. Where differences occur, they result from Cadmus applying ISR estimates collected through primary data collection or benchmarking, electric and gas water heater saturation rates, or estimates for the percentage of residential measures installed in non-residential applications, that differ from those used by DP&L.

Differences between *ex ante* claimed and adjusted gross saving resulted from differences in calculation methodologies, data sources available at the time, or both. These typically resulted from DP&L following the approved Ohio TRM, and Cadmus referencing other sources. The PUCO has established the state's TRM and its saving estimates as a "safe harbor" for utilities to use when planning and reporting *ex ante* saving estimates, and DP&L has generally aligned itself with this practice. Due to the lack of updates to the Ohio TRM, deviations in saving estimates are expected. For instance, in 2017 Cadmus installed power metering equipment and light logging equipment for 51% of the sampled Prescriptive and Custom non-residential projects. Metering analysis indicated lower hours of operation and/or load for incentivized equipment during peak periods resulting in reduced demand savings for 27% of metered projects. However, two of the metered projects with reduced demand savings accounted for 73% of all claimed savings. These two projects involved the installation of over 2,000 VFDs serving motors at a glass manufacturing facility. Cadmus installed power meters on 29 representative VFDs serving the facility. Meter data analysis indicated lower maximum demand than expected and lower load profiles for all motors, resulting in lower energy savings and demand reduction. If these projects had been excluded, the Prescriptive and Custom Nonresidential programs would have shown higher adjusted gross realization rates for energy savings and demand reduction.

Lower adjusted gross savings realization rates for other programs were due to Cadmus conducting billing analyses or applying new engineering models to the program or measure category. These adjustments do not indicate poor program performance, but rather reflect changes in technology and baselines and suggest areas that the PUCO may want to investigate when updating the Ohio TRM.

The overall portfolio proved cost-effective, with a total resource cost (TRC) of 1.30 and a utility cost test (UCT) of 3.58. As with the previous evaluation, individual residential programs fell below the 1.0 TRC benefit/cost ratio, including the Residential HVAC Rebate, the Smart Thermostat program, and the Income Eligible Efficiency programs. The HVAC Rebate program, however, proved cost-effective for the UCT. The Nonresidential Prescriptive and Custom programs proved cost-effective from both the TRC and UCT perspectives. Consistent with the previous two evaluations, Cadmus used *ex ante* savings to calculate cost-effectiveness results.

Cadmus performed limited process activities in the 2017 program year. Cadmus conducted an interview with DP&L staff in the fall of 2017 to gather updates on program changes and also conducted interviews with implementer staff for the Appliance Recycling and Smart Thermostats Rebate programs. Cadmus also implemented participant surveys for the Appliance Recycling program and the Smart Thermostats Rebate pilot. The surveys collected primary data from program participants, which informed the impact analyses, determining inputs such as in-service rates (ISR), and the process analyses, and identifying elements such as customer satisfaction. Surveys show high satisfaction levels among customers with program delivery elements (e.g., rebate amounts, energy savings, incented equipment, overall program experiences).

Pilots have proven to be an effective and efficient approach to identifying potential new program offerings. In 2017, DP&L continued to diversify its portfolio, adding one residential pilot program (Smart Thermostat Rebates). The process evaluation activities revealed high customer satisfaction with the program. Opportunities exist to improve certain program implementation elements (e.g., participant experience with installation).

Cadmus recommends that DP&L continue to identify and launch promising pilots each year, as allowable under current plans and budget. The pilot process allows DP&L to test new and innovative program offerings and to investigate their impacts on portfolio savings as well as on customer engagement and satisfaction at minimal costs.

In summary, Cadmus found DP&L's overall accounting of energy savings and demand reduction adhered to the principles established in Ohio, and findings were those expected. Cadmus identified areas where incremental changes could improve program offerings and implementation, and this evaluation report notes these throughout.

Introduction and Purpose of the Study

For the impact evaluations, Cadmus assessed and documented program savings, including *gross* savings relative to *ex ante* claimed saving values.

For the process evaluations, Cadmus sought to achieve the following:

- Document satisfaction and feedback from the perspectives of program and implementation staff, and, for select programs, of participants
- Provide timely feedback to enable program process improvements

Table 3 provides the evaluation effort's general researchable questions and supporting activities. The following sections present program-specific researchable questions.

Table 3. Overall Researchable Questions and Supporting Activities

Researchable Question	Activity Used to Address Question
What changes to design and delivery would improve program performance?	• Program and implementation staff interviews • Participant surveys • Program database review
How effective have the programs been in recruiting and training market actors?	• Program and implementation staff interviews
What barriers exist to increased customer participation, and how effectively do the programs address those barriers?	• Program and implementation staff interviews • Participant surveys
What gross energy and demand reductions did the programs achieve?	• Program database review • Data verification • Site visits • Participant surveys • Engineering analysis • Billing analysis • Regression analysis
How satisfied were participants with the program?	• Participant surveys
Were the programs cost-effective? Was the portfolio cost-effective?	• Cost-effectiveness tests

Overall Evaluation Methodology

Cadmus evaluated each program using a unique set of techniques and activities. Primary evaluation activities included the following:

- Using engineering calculations to verify program *ex ante* claimed savings and to determine adjusted program gross kWh savings and kW reductions
- Performing site visits to verify measure installations

- Conducting a detailed review of project documentation, calculations, audit reports, and assumptions
- Conducting online and telephone surveys with participants to evaluate program processes and to inform the impact evaluation
- Conducting a billing analysis for Income Eligible Efficiency program (OPAE) and HVAC Equipment program participants
- Benchmarking important metrics from each program evaluation against those from recent comparable programs to provide additional context in interpreting the results

The tables in the program sections present the following:

- ***Ex Ante* Claimed Gross Savings:** Savings based on *ex ante* participation and calculation assumptions. Dayton Power and Light (DP&L) used multiple sources for claimed savings—primarily the 2010 State of Ohio Energy Efficiency Technical Reference Manual (Ohio TRM),[2] and results from previous Cadmus evaluation work. Therefore, *ex ante* savings and adjusted gross savings may be similar when DP&L applies preliminary evaluation results. Appendix I provides a detailed summary of the sources of *ex ante* claimed savings by measure.
- **Verified Gross Savings:** Savings resulting from adjustments to *ex ante* participation, based on survey or on-site verification. The unit energy savings (UES) estimation approach (e.g., Ohio TRM or deemed savings) remained the same as the *ex ante* claimed savings.
- **Adjusted Gross Savings:** Savings due to adjustments in *ex ante* participation, based on survey or on-site verification, and adjustments to UES and per-unit demand reduction estimates, based on engineering reviews of savings, statistical models, or other approaches.[3]

Adjusted gross savings represent the final evaluated *ex post* gross saving estimates. Each program-specific section provides a detailed explanation of adjustments made to calculate verified and adjusted gross savings.

Threats to Validity

Known threats to this evaluation's validity, possible bias sources, and methods used to address these issues include the following:

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[2] *State of Ohio Energy Efficiency Technical Reference Manual.* Prepared by Vermont Energy Investment Corporation for the Public Utilities Commission of Ohio. Filed August 6, 2010, under Case No. 09-0512-GE-UNC.

[3] In several cases using Ohio TRM calculations or assumptions, Cadmus incorporated feedback from the Joint Objections and Comments to the August 6, 2010, *Technical Resource Manual* from Ohio Edison Company, the Cleveland Electric Illuminating Company, the Toledo Edison Company, Columbus Southern Power Company, Ohio Power Company, Duke Energy Ohio, Inc., DP&L, and Industrial Energy Users-Ohio, filed November 3, 2010, in PUCO Case No. 09-512-GE-UNC (*Ohio TRM Joint Objections and Comments*). Where appropriate, the text notes this.

- Across all programs, to address telephone survey nonresponse bias, Cadmus utilized survey best practices, including the following:
  - Calling at different times of day
  - Calling on weekends
  - Scheduling callbacks
- In all cases using regression models, Cadmus made every attempt to guard against errors associated with omitted variables, improper functional forms, and inclusion of erroneous data.
- Across all programs, Cadmus implemented thorough quality control processes, ensuring multiple reviews and reviewers for every analysis and write-up.

Description of Programs Covered in Study

In 2017, Cadmus evaluated nine DP&L programs: five residential, two commercial and industrial, and two pilot programs (the evaluation did not include Mercantile Customer Participation or associated savings, but Cadmus did calculate cost-effectiveness for this program). Table 4 provides reported participation per program.

Table 4. Claimed Program Participants

Program	Reported Quantity	Unit Type
Residential Lighting	1,109,356	LEDs sold*
Appliance Recycling	5,965/172	Appliances recycled in residential/ nonresidential applications
Income Eligible Efficiency (OPAE)	592	Homes
Income Eligible Efficiency (PWC) Pilot	186	Projects completed
HVAC Equipment	7,609	Equipment rebated
Smart Thermostats	5,041	Smart thermostats rebated**
Energy Education (Be E³ Smart)	9,102	Energy Efficiency Kits distributed
Prescriptive	1,345 unique prescriptive projects, 60,543 midstream lamps, 20 midstream VFDs	Prescriptive projects completed/ Midstream lamps sold/Upstream lamps sold
Custom	91 unique projects	Projects completed

*Reflects 95.9% of all bulbs sold through the Residential Lighting program. The remaining 4.1% were allocated to the nonresidential prescriptive program's *ex ante* savings.

The 2017 *DP&L Annual Portfolio Status Report* presents program overviews in the program-specific chapters which follow.

Residential Lighting Program

This chapter describes the evaluation approach, detailed findings, conclusions, and recommendations for the Residential Lighting Program.

Evaluation Overview

Cadmus' evaluation of the 2017 Residential Lighting Program followed the evaluation activities and researchable questions outlined in Table 5.

Table 5. Key Researchable Questions

Researchable Question	Activity Used to Address Question
What are the gross savings?	• Review of secondary sources, the Ohio TRM, and the program database • Engineering analysis • Program database review
Is the program cost-effective?	• Cost-effectiveness analysis

In 2017, the Residential Lighting program ceased distributing CFL bulbs, transitioning to distributing only LED bulbs. The baseline wattage of the bulbs has also been changed to reflect wattages of bulbs replaced rather than using EISA guidelines, which reflect federal requirements for newly purchased bulbs.

Detailed Evaluation Findings

The program achieved *ex ante* savings of 43,777,456 kWh and 5,233 kW, falling short of the savings goals of 50,573,236 kWh and 6,044 kW. Verified gross savings represent realization rates of 101% against both *ex ante* claimed energy savings and demand reduction.

Table 6 provides program *ex ante* claimed, verified gross, and adjusted gross savings (kWh) and demand (kW) reductions. Key impact evaluation findings follow.

Table 6. Residential Lighting Program Claimed and Achieved Energy Savings*

Program	*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision***
LEDs**	43,777,456	5,233	44,192,190	5,282	42,702,563	4,517	± 14.4%

*Savings reflect the percentage of bulbs installed in residential applications.
**Values in table may not sum exactly to 100% due to rounding.
***Precision at 90% confidence.

- Consistent with the previous evaluation, the 2017 *ex ante* methodology used the lumen equivalence method to determine differences between efficient and baseline wattages ("delta watts") for savings. This method aligned with the approach recommended by the Uniform

Methods Project (UMP),[4] and it reflected the method Cadmus used to determine adjusted gross savings in the current and previous evaluations. Using this methodology, adjusted savings strongly corresponded with *ex ante* savings.

- Of a total of 1,156,784 bulbs rebated through the program, 1,098,945 bulbs were allocated toward the Residential Lighting program's *ex ante* savings, accounting for 95% of the total bulbs rebated. The other remaining 5% of bulbs were allocated to the commercial prescriptive program.
- While most inputs aligned between *ex ante* and adjusted gross savings, lower WHFs and lower in-service rates (ISR) for LEDs lowered adjusted gross savings and demand reduction. Conversely, a lower percentage of bulbs installed in commercial applications increased adjusted gross savings.
- The total number of LED bulbs increased over the last two years, from 172,028 LEDs in 2015, to 329,375 LEDs in 2016, to 1,156,784 bulbs (all LEDs) in 2017, although this number is lower than the 1,403,453 total bulbs (which included both CFLs and LEDs) sold in 2016.
- Standard LEDs made up 77.7% of all bulbs, with outputs between 800 and 1,099 lumens. Also known as 60-watt replacement bulbs, bulbs in this category averaged 9.5 watts.

Evaluation Data Collection Methods

In evaluating the 2017 program, the evaluation team used the following approaches.

Program Database Review

Cadmus reviewed the data provided by CLEAResult, verifying that each measure included model numbers and reported savings. Cadmus found the data provided to be complete and in good condition. Using the ENERGY STAR light bulb database, Cadmus determined watts, lumens, and other defining characteristics for each bulb, based on its model number and the measure's description. Cadmus used other information provided by CLEAResult (e.g., LED/CFL, bulb shape, wattage) for reference when exact matches could not be found.

Process Evaluation Methodology and Findings

For 2017, Cadmus did not conduct a full process evaluation for the program. Rather, to gather information about program changes, the evaluation team spoke with DP&L staff in summer 2017. Staff reported that the program ceased to distribute CFL bulbs, switching to all-LED bulbs. CLEAResult continued to implement the program.

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[4] U.S. Department of Energy. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 21: Residential Lighting Evaluation Protocol.* February 2015. Available online: https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf

Impact Evaluation Methodology and Findings

Calculating Adjusted Gross Savings

Cadmus used the following approaches and algorithms to evaluate the 2017 Residential Lighting program:

$$\Delta kWh = \frac{\Delta Watts}{1{,}000} * ISR * HOU * 365 * WHF_e$$

$$\Delta kW = \frac{\Delta Watts}{1{,}000} * ISR * WHF_d * CF$$

Where:

ΔWatts	= delta watts = $W_{baseline} - W_{efficient}$
ISR	= in-service rate
HOU	= hours of use per day
WHF_e	= WHF for energy
WHF_d	= WHF for demand
CF	= summer peak coincidence factor

Table 7 shows values used to calculate energy and demand reductions for *ex ante*, verified, and adjusted gross savings. Additional details follow.

Table 7. 2017 Residential Lighting Program Energy and Demand Savings Calculation Inputs

Variable	*Ex Ante*	Verified	Adjusted Residential	Commercial
HOU/day	2.85	2.85	2.85	9.66
WHF_e	1.07	1.07	1.06	1.10
WHF_d	1.21	1.21	1.06	1.20
ISR_{LED}	0.98	0.98	0.96	0.96
ΔWatts	Varies*	Varies*	Varies*	Varies*
CF	0.11	0.11	0.11	0.76
Allocation	95%	95%	95.9%	*Ex ante* = 5% Verified/Adjusted = 4.1%

*Both 2017 *ex ante* and adjusted ΔWatts inputs were based on lumen equivalence and varied by bulb.

In-Service Rates

Cadmus calculated a 96% ISR for LEDs using an average of site visit data from five evaluations including one conducted for DP&L. The 96% value is appropriate to use for *ex ante* and verified gross saving estimates since it was the value used for program planning purposes.

Table 8. Inventory Studies' LED ISRs

Utility	LED ISR
DP&L	100%
Midwest Utility 1	91%
Midwest Utility 2	96%
Midwest Utility 3	91%
Southern Utility 1	100%
Average	**96%**

Hours of Use

Cadmus used the Ohio TRM hours-of-use (HOU) value of 2.85 hours per day—the same value used in Cadmus' evaluation of the 2016 Residential Lighting program—to calculate savings for residential bulbs sold through the program. In 2012, Cadmus estimated HOU using a statistical model that employed a pooled set of light meter data from evaluations in various states (including Maryland, Missouri, Maine, and Michigan) as well as from the 2009 DP&L evaluation. Cadmus modeled HOU as a function of room types, existing CFL saturations, and the presence of children in a home, resulting in an estimated 2.26 HOU. In 2011, the same model, containing fewer pooled meters, resulted in an estimated 2.39 HOU.

Waste Heat Factor

Cadmus used a 1.06 waste heat factor (WHF)—the same value used in last year's evaluation—when calculating energy and demand reductions. In 2013, Cadmus updated this value with indoor/outdoor weighting to reflect 2013 inventory study results. The inventory study found the same percentage of bulbs installed outside as those found in site visits conducted during 2009 (8%). As the percentage of bulbs installed outdoors did not change, neither did WHF values. Cadmus applied the indoor/outdoor weighting because the Ohio TRM indicated its 1.07 WHF_e did not include bulbs installed outside. Consistent with the previous evaluations, Cadmus updated the WHF_d from its 1.21 *ex ante* value to 1.06, reflecting the Ohio TRM *Joint Objections and Comments.*

Coincidence Factor

Consistent with previous evaluations, Cadmus used a residential summer peak coincidence factor (CF) of 0.11 to determine demand reductions. As the Ohio TRM and its *Joint Objections and Comments* document suggested different CFs (0.11 and 0.16, respectively), Cadmus performed a high-level review of CFs from other comparable TRMs. The Ohio TRM's 0.11 CF aligned more closely with other TRM values and, thus, seemed more valid for the evaluation's use.

Wattage Baseline

Cadmus used baseline wattage values consistent with the lumen-equivalence method described in the U.S. Department of Energy's (DOE) Uniform Methods Project (UMP) (as part of its delta watt calculations). This method maps each efficient wattage to a corresponding baseline wattage by using the lumen output of the efficient bulb to determine the least efficient wattage allowed by federal standards.

Nonresidential Allocation

Cadmus used a nonresidential allocation value of 4.1%—the same value used in the 2016 evaluation—to determine the percentage of bulbs allocated toward small commercial applications. In 2015, Cadmus calculated the nonresidential allocation of program bulbs by estimating the total number of program bulbs reported as installed in small commercial applications, and then dividing this estimate by the total number of program bulbs sold. The evaluation used data from general-population customer surveys and from DP&L's customer records to estimate the nonresidential allocation of program bulbs.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Adjust baseline wattages for future evaluations.** Cadmus and DP&L have agreed that 2017 will be the last year for which Cadmus will use the current methodology to determine the baseline wattage of replaced bulbs. For future evaluations, Cadmus will use wattages more closely aligned with the wattage of the bulbs being replaced. This change aligns with Ohio Senate Bill 310 which allows utilities to claim savings based on as-found conditions.
- **Consider updating the LED installation rate.** The current LED installation rate of 96% may no longer reflect current market conditions. The installation rate is derived from primary data collected approximately five years ago. Since then, the price of LEDs has significantly declined and retailers are now offering more multipack options. The need for bulb replacements is also less due to efficient lighting having much longer lifetimes and efficient lighting saturations increasing in homes. Cadmus recommends reviewing recent secondary evaluations and technical reference manuals from other states and deriving a new LED installation rate average that can be used for *ex ante* and verified savings starting in 2018.

Residential Appliance Recycling Program

This chapter describes the approach used in evaluating the Residential Appliance Recycling Program (ARP), presents detailed findings, and offers conclusions and recommendations.

Evaluation Overview

Cadmus' evaluation of the 2017 ARP program followed the evaluation activities and researchable questions outlined in Table 9.

Table 9. Key Researchable Questions

Researchable Questions	Activity
What are average energy savings?	• Regression model • Participant survey
How accurately and consistently are relevant appliance unit data collected?	• Review of program database
How satisfied are customers with the program and DP&L overall? How efficient has program delivery been?	• Participant survey
Are there any potential barriers to the program's continued success?	• Stakeholder interview
Is the program cost-effective?	• Cost-effectiveness analysis

Detailed Evaluation Findings

The program achieved *ex ante* savings of (8,003,102) kWh and (1,638) kW, surpassing the program's goals of 4,273,944 kWh and 757 kW. Verified gross savings represented realization rates of 100% against *ex ante* claimed energy savings and demand reduction.

Table 10 provides program *ex ante* claimed, verified gross, and adjusted gross savings and demand reductions by measure. Key impact evaluation findings follow.

Table 10. Residential ARP Claimed and Achieved Energy Savings

Program	*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision
Refrigerators	5,912,672	945	5,912,672	945	4,421,858	688	± 8.9%
Freezers	1,184,288	190	1,184,288	190	673,631	105	± 21.8%
Room Air Conditioners	42,062	367	42,062	367	42,069	368	± 10.0%
Dehumidifiers**	277,636	73	277,636	73	277,636	73	± 10.0%
Kits***	586,445	61	586,445	61	624,568	35	± 16.7%
Total*	**8,003,102**	**1,638**	**8,003,102**	**1,638**	**6,039,762**	**1,268**	**± 7.1%**

*Values in table may not exactly sum to 100% due to rounding.

***Ex ante* dehumidifier values were based on Cadmus calculation for dehumidifiers sold after 2004.

****Ex ante* kit values were based on Cadmus calculations using parameters from 2015.

- Similar to 2016, two factors drove down the program's adjusted gross savings in 2017: the overall trend in decreasing units' age as the program matured; and the proportion of units manufactured after energy standards introduced in the early 1990's. Adjusted gross savings accounted for both factors. DP&L provided *ex ante* claimed savings, derived from the Ohio TRM. The TRM had not been updated to reflect trends in decreasing unit age.
- The program recycled more units in 2017 than in 2016, with 4,297 refrigerators, 952 freezers, and 5,965 total appliances recycled in 2017, compared to 1,349 refrigerators,392 freezers, and 2,049 total appliances in 2016. This increase resulted from ARP being offered for only five months of the year in 2016, and an increase in average monthly recycled units.
- The program also recorded recycling 130 refrigerators, 23 freezers, 15 room air conditioners, and 4 dehumidifiers from nonresidential customers. Savings from these appliances, however, and from 120 kits provided to their respective participants have been excluded from the ARP, and instead have been included in the Non-Residential Prescriptive program.
- The part-use factor, defined as the average proportion of the year during which appliances ran, did not change significantly for refrigerators or freezers compared with the 2015 and 2016 program year evaluations. Throughout the 2017 program year, recycled refrigerators operated 91% of the time and freezers operated 81% of the time, compared to part-use factors of 93% and 89%, respectively, in 2016; and 89% and 86%, respectively, in 2015.
- At the time of appliance pickups, participants received a kit of energy-efficient measures that contained two LED lightbulbs, one kitchen faucet aerator, one bathroom faucet aerator, and an energy-efficient showerhead. ISRs improved slightly from 2016, leading to higher kit savings.

Evaluation Data Collection Methods

In evaluating the 2017 program, Cadmus used the approaches discussed below.

Participant Telephone Survey

In January 2018, Cadmus surveyed a sample of 2017 ARP participants by appliance type to achieve 90% confidence within 10% precision for refrigerators and 90% confidence within 20% precision for freezers. The sample was stratified by refrigerators and freezers as dehumidifiers and room air conditioners counted as convenience measures offered to customers who recycled a refrigerator or freezer.

As shown in Table 11, Cadmus surveyed 70 participating households reported to have recycled a refrigerator through the program and 70 participating households reported to have recycled a freezer.

Table 11. Participant Survey Goals and Achievements

Total Participants Sampled	Total Planned 2017 Completes	Achieved 2017 Completes
Recycled Freezer	70	70
Recycled Refrigerator	70	70
Total	**140**	**140**

The survey questions sought to determine how participants learned of the program, how they used the appliances they recycled, their program satisfaction levels, and their demographics.

The survey included questions that addressed the following pertinent issues:

- **Verification of Measure Removed.** This survey section, which ensured contact with the appropriate individuals, contained questions related to participation recall, involvement in the decision-making process, and measure removal.
- **Appliance Context and the Decision-Making Processes.** These questions addressed key aspects of the participants' decision-making process and informed the verification analysis.
- **Program Satisfaction.** These questions collected process-related information regarding participants' satisfaction with the program and, if applicable, reasons for their dissatisfaction. The questions also addressed whether participants would refer others to the program.
- **Demographics.** This section captured household and respondent characteristics, including income, age, the home type and square footage, energy use, and household income.

In Situ Metering Data Set

Consistent with previous evaluations, Cadmus developed a multivariate regression model to estimate average unit energy consumption (UEC) for retired refrigerators and freezers. This model relied on an aggregated *in situ* metering dataset,[5] consisting of approximately 594 appliances, metered during evaluations conducted in California, Michigan, and Wisconsin between 2009 and 2013.

The Impact Evaluation Methodology and Findings section explains the refrigerator model specifications and corresponding freezer model that Cadmus developed and used in the 2017 evaluation.

Process Evaluation Methodology and Findings

Cadmus used participant surveys and stakeholder interviews to evaluate program satisfaction levels and delivery efficiency.

Participant Telephone Survey

Program Marketing and Participant Awareness

DP&L and Recleim marketed the ARP through an array of channels, including the following:

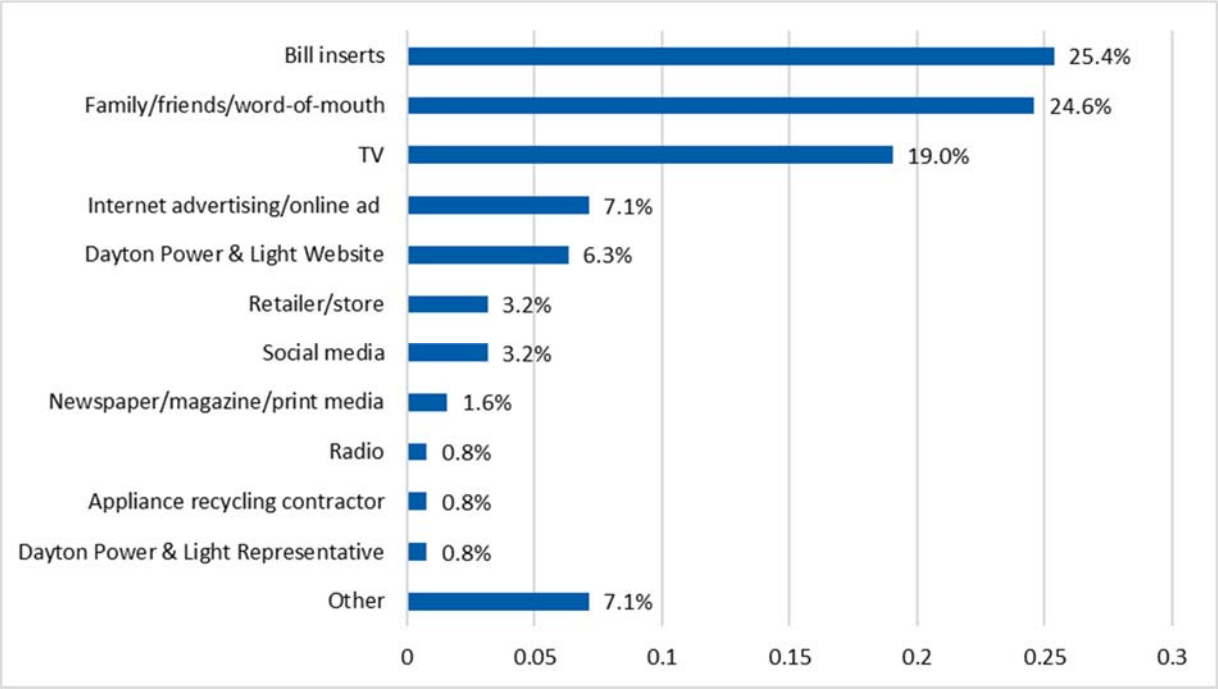
- Newspaper advertisements
- Television advertisements
- Online advertising
- Program website

[5] *In situ* metering takes place in the environment where appliances are typically used; this approach contrasts with lab testing, which meters units under controlled conditions.

- Bill inserts

Similar to previous years, survey data, shown in Figure 1, indicated that surveyed participants primarily learned of the program through bill inserts, word-of-mouth, or TV advertisements.

Figure 1. How Participants First Heard About the Program



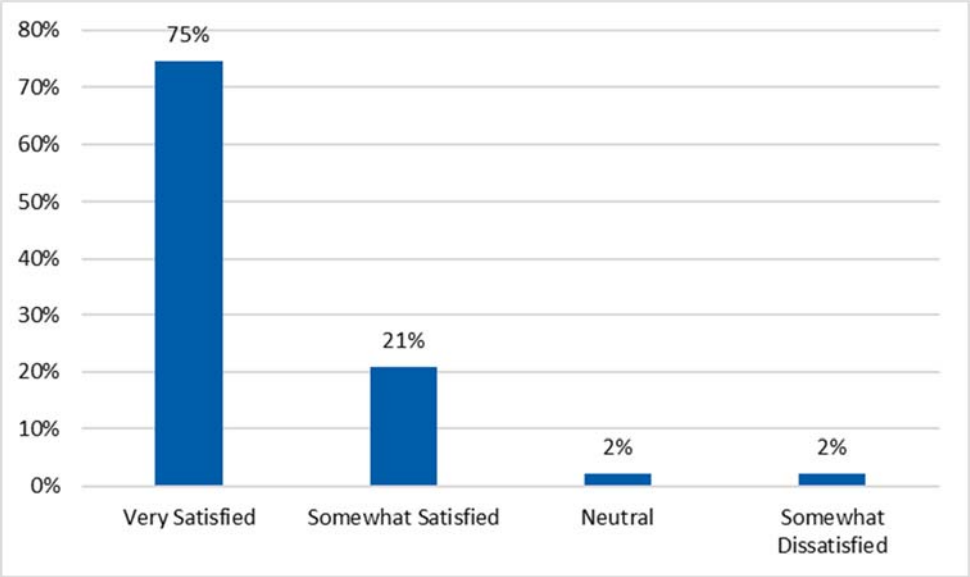
Source: 2017 ARP Participant Survey Question D1. "How did you first learn about DP&L's appliance pick-up and recycling program?" (n=126)

Participant Satisfaction

Customers remained satisfied with the incentive levels, with 100% of surveyed participants very satisfied or somewhat satisfied with the rebate amounts, 74% very satisfied, and 18% somewhat satisfied.

Dissatisfaction with wait times for appliance pick-ups decreased from 2016, with 2% reporting being "somewhat dissatisfied" or "very dissatisfied" in 2017, as shown in Figure 2—down from an 18% dissatisfaction rate in 2016.

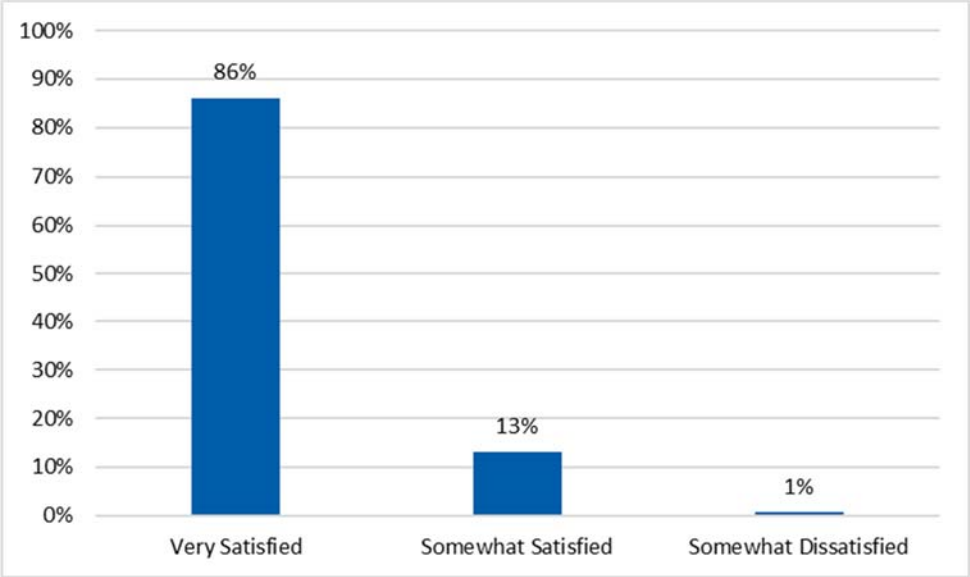
Figure 2. Satisfaction with Wait Time for Appliance Pick-Up



Source: 2017 ARP Participant Survey Question H6. "How satisfied were you with the wait time for appliance pick-up? Would you say you were: Very satisfied, somewhat satisfied, somewhat dissatisfied, or very dissatisfied?" (n=134)

Overall, surveyed participants expressed satisfaction with the program. As shown in Figure 3, approximately 99% reported being "very satisfied" or "satisfied" with the program, with 86% of all respondents saying they were "very satisfied." No surveyed participants reported being "very dissatisfied."

Figure 3. Overall Program Satisfaction



Source: 2017 ARP Participant Survey Question H11. "If you were rating your overall satisfaction with DP&L's Appliance Recycling Program, would you say you were: Very satisfied, somewhat satisfied, somewhat dissatisfied, or very dissatisfied?" (n=137)

Stakeholder Interviews

As part of the ARP process evaluation, Cadmus interviewed two program managers, one senior program manager, and an operations manager at the program implementer, Recleim, to gather their insights into the program's effectiveness. Program design remained unchanged from previous years.

Program Implementation and Delivery

Unlike in previous program years, in 2017 Recleim added a new channel for participants to receive their incentives. Past years' participants had to wait for their incentive to be processed and mailed to them. Recleim transitioned to emailing participants about three days after their appliance was picked up and offering a choice between waiting 5-7 days for a physical pre-paid Visa® card, or having a digital card emailed to them.

Program Marketing

As a potential area for improvement, program managers noted that the program was likely overmarketed, based on the program far exceeding its goals for units collected in 2017. The program implementer's goal was to collect 2,735 refrigerators and freezers in 2017, which was lower than the filed goal of 4,500 units recycled. In total the program collected 5,249 refrigerators and freezers in 2017.

Impact Evaluation Methodology and Findings

Table 12 shows distributions of refrigerators and freezers by configuration and the counts of room air conditioners (AC), dehumidifiers, and kits.

Table 12. Residential Program Participation by Measure

Measure	Configuration	Participation
Recycled Refrigerator	Bottom Freezer	199
	Side-by-Side	1,282
	Single Door	125
	Top Freezer	2,691
	Refrigerator Total*	**4,297**
Recycled Freezer	Chest	361
	Upright	591
	Freezer Total*	**952**
Recycled Room AC		**406**
Recycled Dehumidifier		**310**
Kits		**4,416**
Total**		**5,965**

*Configurations do not sum to total due to some units missing configuration data.

**Excluding Kits.

Summary of Program Participation

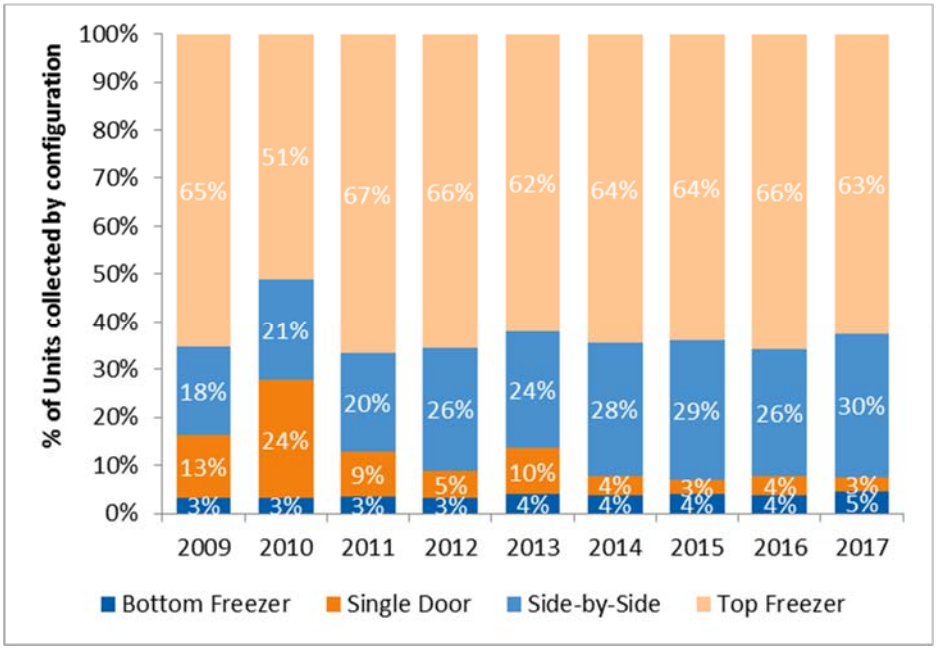
Table 13 shows the average age and size of units collected in 2017.

Table 13. Average Unit Age and Unit Size

Appliance	Average Age (Years)	Average Capacity (ft^3)
Refrigerator	20	20
Freezer	26	16

To determine trends in unit age, size, and configuration, Cadmus compared the 2017 results to tracking data results from past years. As shown in Figure 4, the configuration of refrigerators did not change substantially over the past several program years.

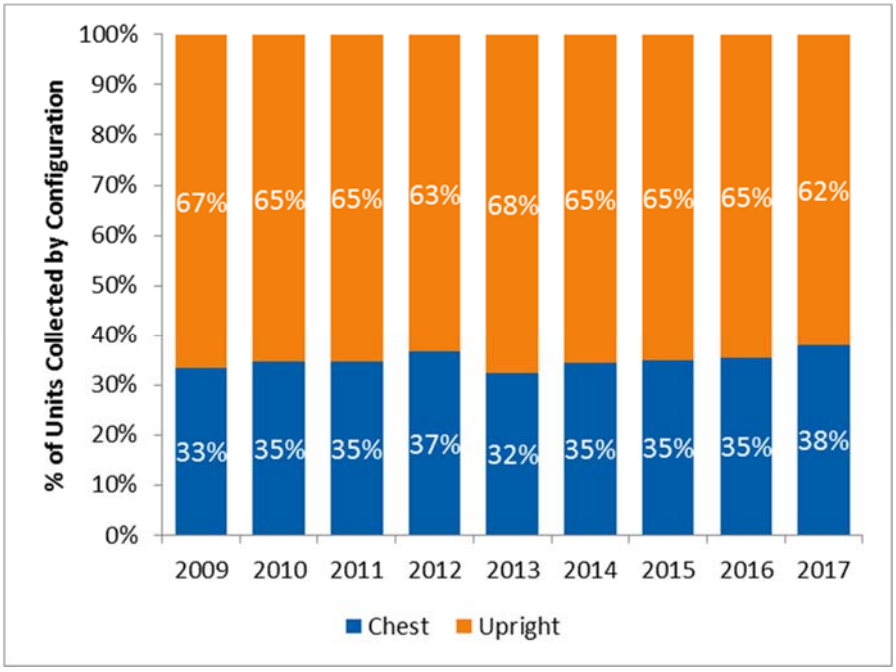
Figure 4. Refrigerator Configuration by Program Year



Source: 2017 ARP Program Tracking Database

As shown in Figure 5, freezer configurations did not substantially change over the program's life.

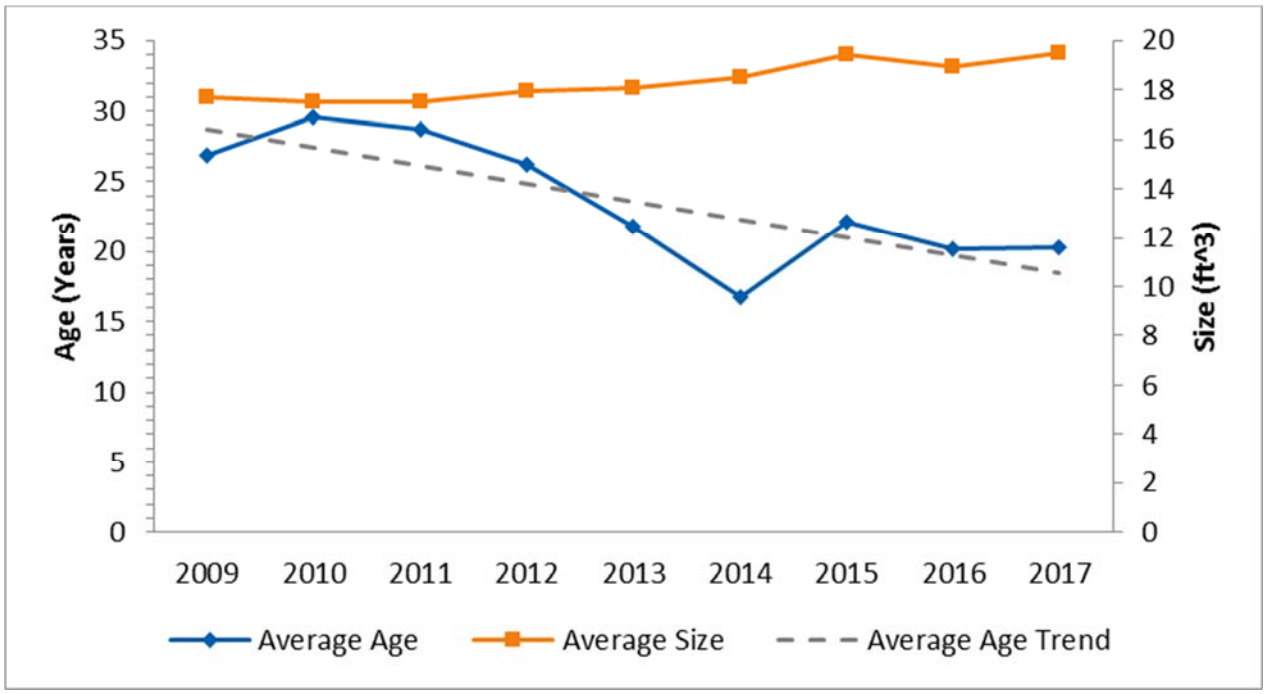
Figure 5. Freezer Configuration by Program Year



Source: 2017 ARP Program Tracking Database

In 2017, recycled refrigerators averaged 20 years old, with 20 cubic feet of internal capacity. As shown in Figure 6, the average appliance size did not change substantially since the program's inception. The figure's linear regression trend line shows the overall downward trend in average unit age.

Figure 6. Refrigerator Age and Size by Program Year



Source: 2017 ARP Program Tracking Database

The age decline serves as the primary driver for UEC decreases over the program's life. UECs have fallen over time, largely due to the 1990 National Appliance Energy Conservation Act standard (i.e., consuming substantially less energy than pre-standard units). Cadmus' regression model estimated that an average refrigerator recycled after 1990 consumed approximately 375 kWh less per year than one manufactured prior to the standard change (with 200 kWh less for freezers). This included standards set in 1993 and 2001. As the average age of appliances declines, fewer recycled appliances will be manufactured prior to appliance standards. Therefore, average units recycled become more efficient.

Average Annual Gross Energy Consumption

As shown in Table 14, Cadmus used regression models to estimate consumption for refrigerators and freezers, applying the aggregated *in situ* metering dataset from previous evaluations.[6] Each independent variable's coefficient indicated that variable's influence on daily consumption, holding all other variables constant. A positive coefficient indicated an upward influence on consumption; a negative coefficient indicated a downward effect.

[6] Cadmus Evaluation. 2013 *EM&V Report*. Filed May 15, 2014. Case No. 14-738-EL-POR: http://dis.puc.state.oh.us/DocumentRecord.aspx?DocID=fb8f219b-4024-4694-9908-1b2731540eb5

The coefficient's value indicated the marginal impact of a one-point increase in the independent variable on the UEC. For example, a 1 cubic foot increase in refrigerator size resulted in a 0.059 kWh increase in daily consumption. For dummy variables, the coefficient value represented the difference in consumption, assuming the given condition proved true. In the refrigerator model, a 0.560 variable coefficient identified a refrigerator as a primary unit; all else remaining equal, a primary refrigerator consumed 0.560 kWh more per day than a secondary unit.

Table 14 details final model specifications used to estimate energy consumption of participating refrigerators.

Table 14. Refrigerator and Freezer UEC Regression Model Estimates (Dependent Variable = Average Daily kWh)

Independent Variables	Refrigerator		Freezer	
	Coefficient	p-Value	Coefficient	p-Value
Intercept	0.805	0.537	-0.955	0.796
Age (years)	0.021	0.01	0.045	0.017
Dummy: Manufactured Pre-1990	1.036	0.191	0.543	0.421
Size (ft^3)	0.059	0.026	0.12	0.035
Dummy: Single Door	-1.751	0.339	N/A	N/A
Dummy: Side-by-Side	1.12	0.206	N/A	N/A
Dummy: Primary	0.56	0.19	N/A	N/A
Dummy: Chest Freezer	N/A	N/A	0.298	0.269
Interaction: Unconditioned Space x HDDs*	-0.04	0.011	-0.031	0.015
Interaction: Unconditioned Space x CDDs*	0.026	0.022	0.082	0.036

*CDDs/HDDs are weighted-averages from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 equals a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

After estimating the final regression models, Cadmus analyzed the corresponding characteristics (i.e., the independent variables) for participating appliances. Table 15 summarizes program averages or proportions for each independent variable.

Table 15. 2017 Participant Mean Explanatory Variables*

Independent Variables	Participant Population Mean Value	
	Refrigerator	Freezer
Age (years)	20.36	26.22
Dummy: Manufactured Pre-1990	0.22	0.46
Size (ft^3)	19.50	16.23
Dummy: Primary	0.63	N/A
Dummy: Single Door	0.03	N/A
Dummy: Side-by-Side	0.30	N/A
Dummy: Chest Freezer	N/A	0.38
Interaction: Unconditioned Space x CDDs	0.65	1.33
Interaction: Unconditioned Space x HDDs	4.34	8.85

*CDDs/HDDs are weighted-averages from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 equals a typical meteorological year, using median daily values for a variety of weather data collectec from 1991–2005.

Using values from Table 14 and Table 15, Cadmus calculated the estimated annual freezer UEC as follows:

$$\begin{aligned} Freezer\ UEC = {} & 365.25\ Days \\ & * \big((-.0955) + 0.045 * (26.22\ years\ old) + 0.543 \\ & * (46\%\ \text{units manufactured pre} - 1990) + 0.120 * (16.23\ \text{ft.}3) + 0.298 \\ & * (38\%\ \text{units that are chest freezers}) + \ 0.082 * (1.33\ \text{Unconditioneed CDDs}) \\ & - 0.031 * (8.85\ Unconditioned\ HDDs)\big) = 869\ kWh/year \end{aligned}$$

Figure 7 compares the distribution of estimated UEC values for refrigerators and freezers.

Figure 7. 2017 Distribution of Estimated Annual UECs by Appliance Type

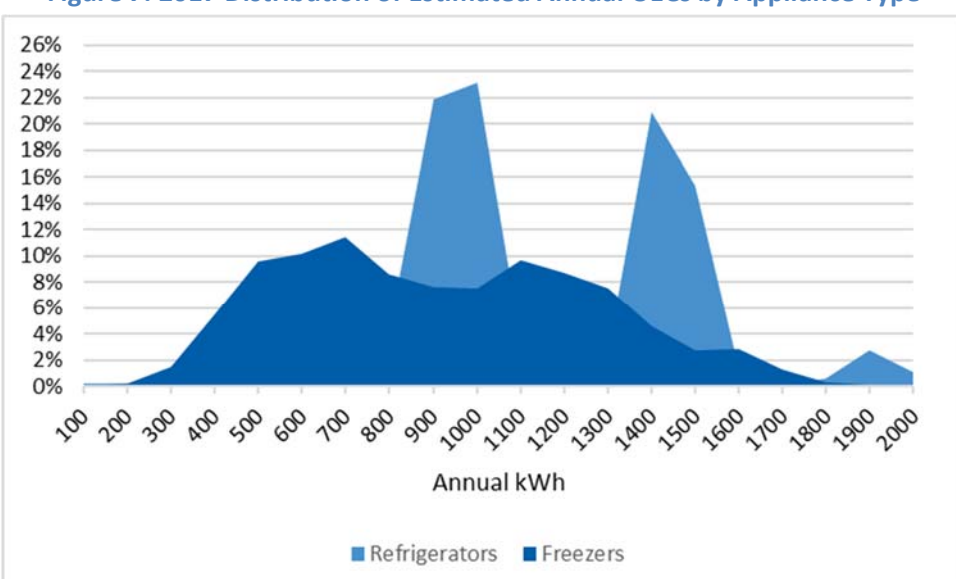


Table 16 presents estimated per-unit, average, annual energy consumption for refrigerators and freezers recycled in 2017.

Table 16. Estimate of Per-Unit Annual Energy Consumption

Appliance	*Ex Ante* Annual UEC (kWh/year)	*Ex Post* Annual UEC (kWh/year)	Precision*
Refrigerators	1,376	1,131	10.5%
Freezers	1,244	869	23.8%

*Precision at 90% confidence.

Room AC Savings Algorithm and Assumptions

Cadmus used the following savings calculations (outlined in the Ohio TRM) and assumptions drawn from Table 17 to calculate adjusted gross energy savings and demand reductions for Room ACs:

$$\Delta kWh = \left(\frac{Hours * BtuH * \left(\frac{1}{EERexist}\right)}{1000}\right) - \left(\%replaced * \frac{\left(Hours * BtuH * \frac{1}{EERnewbase}\right)}{1000}\right)$$

$$\Delta kWh = \left(\left(\frac{BtuH * \left(\frac{1}{EERexist}\right)}{1000}\right) - \left(\%replaced * \frac{\left(BtuH * \frac{1}{EERnewbase}\right)}{1000}\right)\right) * CF$$

Table 17. Room AC Energy and Demand Savings Calculation Inputs

Input	Description	Assumption	Source
Hours	Full Load Hours of Unit	233	2010 Ohio TRM
BtuH	Average Size of Rebated Unit in BTUs	8500	2010 Ohio TRM
EERexist	Efficiency of Existing Unit	7.7	2010 Ohio TRM
%replaced	Percentage of units Rebated that are Replaced	76%	2010 Ohio TRM
EERbase	Efficiency of Baseline Unit	9.8	2010 Ohio TRM
CF	Summer Peak Coincidence Factor	0.3	2010 Ohio TRM

Using the above inputs and due to the lack of tracking data on the average size of rebated units, *adjusted gross* savings equaled *ex ante* savings. For 406 room ACs recycled in the evaluated year, the program saved 42,062 kWh and 367 kW in total.

Dehumidifier Savings Algorithm and Assumptions

Cadmus used the following savings calculations to estimate energy and demand savings associated with the dehumidifier retirement measure. A Technical Support Document (TSD), published by DOE, outlined

the energy savings algorithm, with demand savings estimated as total energy savings divided by total runtime:[7] [8]

$$\Delta\text{kWh} = (HOU) * \left[\left(\frac{\text{CAP} * 0.473 * \%_{Dehum}}{Eff * 24}\right) + (\%_{fan} * \ kW_{Fan}) + \ (\%_{Stby} * kW_{Stby})\right]$$

$$\Delta\text{kW} = {}^{\Delta\text{kWh}}/_{HOU}$$

Table 18 describes the savings inputs and accounts for dehumidifier operations in three modes: dehumidification, fan-only, and standby or off mode.

Table 18. Residential Dehumidifier Energy and Demand Savings Calculation Inputs

Input	Unit	Assumption	Source
HOU	Hours of Use, per year	3,785	DOE
CAP	Dehumidifier capacity (pints/day)	Varies	DOE
0.473	Conversion factor: pints to liters	0.473	DOE
Eff	Dehumidifier efficiency (pints/kWh)	Varies	DOE
24	Hours per day	24	DOE
$\%_{Dehum}$	Fraction of time spent in Dehumidification mode	35.5%	DOE
$\%_{Fan}$	Fraction of time spent in Fan only Mode	7.0%	DOE
$\%_{Stby}$	Fraction of time spent in Standby/Off mode	57.7%	DOE
kW_{Fan}	Power draw in fan only mode	0.65	DOE
kW_{Stby}	Power draw in standby mode	0.01	DOE

Dehumidifier capacity and efficiency are equipment-specific characteristics, and dehumidifier efficiency requirements vary with the equipment's capacity. As these values were unavailable from the program tracking data, Cadmus relied on market baseline data and baseline engineering assumptions outlined in the TSD. Table 19 presents the average capacity, efficiency, and estimated savings by dehumidifier size.

Table 19. Average Capacity, Efficiency, and Energy Savings by Dehumidifier Capacity

Dehumidifier Capacity Bin			
Input	≤ 30 Pints / Day	30 - 45 Pints / Day	> 45 Pints / Day
Average Capacity (pints / day)	21.0	38.0	73.0
Average Efficiency (pints / kWh)	0.77	0.94	2.07
Estimated Energy Usage (kWh)	737.6	1,084.0	948.1

7 Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030

8 As participant survey data were not collected for dehumidifiers, no part-use factor was applied to account for how the dehumidifier would have been used in the program's absence.

Ultimately, Cadmus produced two estimates for energy and demand savings, corresponding to each of the two major dehumidifier vintages that DOE identified in the TSD, based on historical product shipment data: pre-2004 and post-2004. For each vintage, Table 20 provides market share estimates for the three capacity bins. Cadmus used these market share estimates to develop a single energy and demand savings value for each vintage.

Table 20. Dehumidifier Market Share by Vintage and Equipment Capacity

Market Share			
Vintage	≤ 30 Pints / Day	30 - 45 Pints / Day	> 45 Pints / Day
Pre-2004	57.1%	42.9%	0.0%
Post-2004	52.4%	42.9%	3.7%

Table 21 provides estimated average energy and demand savings.

Table 21. Evaluated Energy and Demand Savings, by Vintage

Vintage	kWh	kW
Pre-2004	886.2	0.234
Post-2004	895.6	0.237

Using the above inputs, Cadmus determined that the program's 310 dehumidifiers saved an estimated 277,636 kWh and 73 kW.

Kit Savings Algorithm and Assumptions

With each appliance pickup ordered, participants could elect to receive an energy-saving kit, which contained the following measures:

- Two 9-watt LEDs
- One energy-efficient showerhead
- One bathroom faucet aerator
- One kitchen faucet aerator
- Energy-saving educational materials and other program references

Table 22 presents an overview of calculated energy savings per kit, including adjustments for ISRs and electric water heater saturation rates. Differences between *ex ante* and *adjusted gross* savings were primarily driven by the transition to kits with two LEDs rather than kits with two CFLs (13W each) or one CFL and one LED (9W). As part of the phone survey, all participants were asked to verify which kit measures they had installed in their homes. ISRs from the participant survey were applied to all kit measures in calculating adjusted gross savings.

Table 22. Summary of Kit Energy Savings*

Measure	Quantity (Per Kit)	*Ex Ante* Energy Savings (kWh)	*Ex Ante* Demand Savings (kW)	*Adjusted Gross* Savings (kWh)	*Adjusted Gross* Demand Savings (kW)
9W LEDs	2	67.8	0.008	53.9	0.006
Bathroom Faucet Aerator	1	7.3	0.002	7.41	0.001
Kitchen Faucet Aerator	1	32.7	0.001	40.0	0.001
Energy Efficient Showerhead	1	25	0.003	40.1	0.001
Total Per Kit	**N/A**	**132.8**	**0.0140**	**141.4**	**0.008**

*Savings adjusted for ISRs and electric water saturation rates.

LED Bulbs

Cadmus used the following calculations (outlined in the Ohio TRM) and assumptions (shown in Table 23) to calculate adjusted gross energy savings and demand reductions for 9-watt LEDs:

$$\Delta kWh = \frac{\Delta Watts * ISR * HOU * WHFe}{1{,}000}$$

$$\Delta kW = \frac{\Delta Watts * ISR * WHFd * CF}{1{,}000}$$

Table 23. LED Energy and Demand Savings Calculation Inputs

Input	*Ex Ante* Assumption	Adjusted Assumption	Units	Source
Δ Watts	34	34	W	DOE UMP, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 9W LED
ISR	90%	72%	–	2017 ARP participant survey (n=73)
HOU	1,040	1,040	Hrs/year	2010 Ohio TRM
WHF_e	1.06	1.06	–	Adjusted 2010 Ohio TRM; assumed installations were indoors
WHF_d	1.06	1.06	–	Adjusted 2010 Ohio TRM, Ohio TRM Joint Objections and Comments
Summer Peak CF	0.11	0.11	–	2010 Ohio TRM

Using the above inputs, Cadmus determined each LED saved 27.0 kWh and 0.003 kW per year. The evaluation found 6,352 installations of 9-watt LEDs, leading to total adjusted gross savings of 238,074 kWh and summer coincident peak savings of 25.18 kW.

Bathroom and Kitchen Faucet Aerator

Cadmus used the following calculations (outlined in the Ohio TRM) and the assumptions presented in Table 24 to calculate energy savings and demand reductions for faucet aerators:

$$\Delta kWh = ISR * (GPM_{Base} - GPM_{Low}) * \frac{People}{Home} * \frac{min}{day} * \frac{days}{year} * \frac{1}{\frac{F}{home}} * 8.33 * (T_{FT} - T_{MAINS}) * \frac{1}{1{,}000{,}000} * \frac{1}{RE} * \frac{1}{0.003412}$$

$$\Delta kW = \frac{\Delta kWh}{\frac{People}{Home} * \frac{min}{day} * \frac{days}{year} * \frac{1}{\frac{F}{home}}} * CF$$

Cadmus updated Ohio TRM assumptions for the average number of people per household (using household sizes collected with the 2017 ARP participant survey). Additionally, in calculating savings, the team accounted for a 48.29% electric water heater saturation, calculated using the 2016 family home installation survey, conducted by the Ohio Energy Project (OEP) for DP&L's Be E³ Smart Energy Education Program.[9]

The evaluation also used assumptions for minutes-of-use per person, per day, and the assumed temperature of water used at the faucet, based on a water-metering study Cadmus conducted for Consumers Energy and DTE Energy in Michigan.[10]

Using these inputs, Cadmus determined that bathroom faucet aerators saved 7.4 kWh/unit annually, and kitchen faucet aerators saved 40.0 kWh/unit annually. Cadmus calculated peak demand savings of 0.0009 kW per bathroom faucet aerator installed and 0.0007 kW per kitchen faucet aerator installed.

Consequently, Cadmus estimated total adjusted gross savings of 32,713 kWh and 3.99 kW for bathroom faucet aerators, and 176,796 kWh and 3.15 kW for kitchen faucet aerators.

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9 OEP administered this survey in its capacity as implementer for the BE E³ Smart Energy Education program.

10 Cadmus and Opinion Dynamics. Memorandum regarding Showerhead and Faucet Aerator Meter Study. June 2012.

Table 24. Bathroom and Kitchen Faucet Aerator Energy and Demand Savings Calculation Inputs

Variable	Variable Definition	*Ex Ante*		Adjusted		Source
		Bathroom Aerator	Kitchen Aerator	Bathroom Aerator	Kitchen Aerator	
ISR	ISR or fraction of units installed	32%	29%	29%	32%	2017 ARP participant survey (n=77 and 79)
GPM_{BASE}	Gallons per minute of baseline faucet	2.2	2.2	2.2	2.2	2013 Cadmus Showerhead and Faucet Aerator Meter Study
GPM_{LOW}	Gallons per minute of low-flow faucet	1.0	1.5	1.0	1.5	Bathroom sink aerator: 1.0 GPM Niagara N3210N; kitchen sink aerator: 1.5 GPM Niagara N3115.
#people	Average number of people per household	2.31	2.31	2.59	2.59	2017 ARP participant survey
min/day	Minutes of use per person, per day	1.65	4.51	1.65	4.51	2013 Cadmus Showerhead and Faucet Aerator Meter Study
days/yr.	Days faucet used per year	365	365	365	365	2010 Ohio TRM Assumption
F/home	Average number of faucets in the home	2.5	1.0	2.5	1.0	Adjusted 2010 Ohio TRM Assumption
8.33	Constant to convert gals to lbs.	8.33	8.33	8.33	8.33	Adjusted 2010 Ohio TRM Assumption
1	Constant to convert lbs. and of water to BTU	1	1	1	1	2010 Ohio TRM Assumption
T_{FT}	Assumed temperature of water used	86	93	86	93	2013 Cadmus Showerhead and Faucet Aerator Meter Study

Variable	Variable Definition	*Ex Ante*		Adjusted		Source
		Bathroom Aerator	Kitchen Aerator	Bathroom Aerator	Kitchen Aerator	
T_{MAINS}	Assumed temperature of water entering house	57.7	57.7	57.7	57.7	Averaged monthly water main temperature, calculated using the methodology provided in Building America Research Benchmark Definition, updated December 2009. Pg.19-20. http://www.nrel.gov/docs/fy10osti/47246.pdf; average annual and monthly temperature data inputs came from Monthly Station Normals, 1971–2000—CLIM81. http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormals.htm
1,000,000	Unit conversion	1,000,000	1,000,000	1,000,000	1,000,000	Assumed
RE	Recovery energy	0.98	0.98	0.98	0.98	Air-Conditioning, Heating and Refrigeration Institute (AHRI) Directory.
0.003412	MMBtuh to kWh	0.003412	0.003412	0.003412	0.003412	2010 Ohio TRM Assumption

Efficient Showerheads

Cadmus used the following equations outlined in the Ohio TRM and the assumptions presented in Table 25 to calculate adjusted gross energy-savings and demand reductions for showerheads:

$$\Delta kWh = ISR * (GPM_{Base} - GPM_{Low}) * \frac{People}{Home} * \frac{min}{shower} * \frac{shower}{days} * \frac{days}{year} * \frac{1}{\frac{F}{home}} * 8.33 * (T_{FT} - T_{MAINS}) * \frac{1}{1{,}000{,}000} * \frac{1}{RE} * \frac{1}{0.003412}$$

$$\Delta kW = \frac{\Delta kWh}{\frac{People}{Home} * \frac{min}{shower} * \frac{shower}{days} * \frac{days}{year} * \frac{1}{\frac{F}{home}}} * CF$$

As with faucet aerators, Cadmus updated Ohio TRM assumptions for the average number of people per household using the ARP participant survey. In calculating savings, Cadmus accounted for an electric water heater saturation of 48.29%, as determined from OEP's Family Home Installation Survey.

The evaluators also updated assumptions on the minutes-of-use per person, per shower, showers per day, and assumed temperature of water used at the showerhead, based on a water metering study Cadmus conducted for Consumers Energy and DTE Energy in Michigan.[11]

Table 25. Efficient Showerhead Energy and Demand Savings Calculation Inputs

Variable	Variable Definition	*Ex Ante* Input	Adjusted Input	Cadmus Source
ISR	ISR or fraction of units installed	20%	24%	2017 ARP participant survey (n=80)
GPM_{BASE}	Gallons per minute of baseline faucet	2.5	2.5	Maximum federal GPM allowed
GPM_{LOW}	Gallons per minute of low-flow faucet	1.25	1.25	Showerhead 1.25 GPM Niagara N2912
#people	Average number of people per household	2.31	2.59	2017 ARP participant survey
min/shower	Minutes of use per person per shower	7.83	7.83	2012 Cadmus Showerhead and Faucet Aerator Meter Study
days/yr.	Days faucet used per year	365	365	2010 Ohio TRM Assumption
shower/day	Showers per day	0.61	0.61	2012 Cadmus Showerhead and Faucet Aerator Meter Study
F/home	Average number of showers in the home	2.1	1.7	2017 Follow Up Parent Survey
8.33	Constant to convert gals to lbs.	8.33	8.33	Adjusted 2010 Ohio TRM Assumption

[11] Cadmus and Opinion Dynamics. Memorandum regarding Showerhead and Faucet Aerator Meter Study. June 2012.

Variable	Variable Definition	*Ex Ante* Input	Adjusted Input	Cadmus Source
1	Constant to convert lbs. and of water to BTU	1	1	2010 Ohio TRM Assumption
T_{FT}	Assumed temperature of water used	101	101	2012 Cadmus Showerhead and Faucet Aerator Meter Study
T_{MAINS}	Assumed temperature of water entering house	57.7	57.7	Averaged monthly water main temperature calculated using the methodology provided in Building America Research Benchmark Definition, updated December 2009. Pg.19-20. http://www.nrel.gov/docs/fy10osti/47246.pdf; Average annual and monthly temperature data inputs come from Monthly Station Normals, 1971-2000 - CLIM81. http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormals.htm
1,000,000	Conversion	1,000,000	1,000,000	Assumed
RE	Recovery Energy	0.98	0.98	Review of AHRI Directory
0.003412	MMBtuh to kWh	0.003412	0.003412	2010 Ohio TRM Assumption

Using the above inputs, Cadmus calculated per-unit, annual energy savings of 40.0 kWh, resulting in total adjusted gross energy savings of 176,983 kWh. The peak demand reduction equated to 0.0005 kW per unit installed, for a total demand reduction of 2.43 kW.

Part-Use Factor

The "part-use" adjustment factor, specific to appliance recycling, is used to convert UECs into average per-unit, gross savings values. For the following reasons, a UEC itself does not equal the gross savings value:

- The UEC model yields an estimate of annual consumption
- Not all recycled refrigerators would have operated year-round had they not been decommissioned through the program

The part-use methodology relies on information from surveyed customers regarding pre-program usage patterns: that is, prior to recycling, how many months of the year the appliance remained plugged in and running.

The final estimate of part-use reflects how appliances would likely have operated had they not been recycled (rather than how they previously operated). For example, a primary refrigerator, operated year-round, could have become a secondary appliance and operated part-time.

The methodology accounts for such potential shifts in usage types. Specifically, it calculates part-use using a weighted average of the following prospective part-use categories and factors:

- Appliances that would have run full-time (part-use = 1.0)
- Appliances that would not have run at all (part-use = 0.0)
- Appliances that would have operated for a portion of the year (part-use is between 0.0 and 1.0)

Cadmus calculated a weighted average part-use factor, representing the three participant usage categories defined by the appliance's operational status during the year before recycling. For example, the evaluators assigned participants who did not use their appliance at all during the year prior to its recycling a part-use factor of zero (as no immediate savings were generated by the appliance's retirement). Final part-use adjusted gross savings resulted from the weighted average of these three usage scenarios and of participants' estimates of how the unit would have been used in the program's absence.

Table 26 illustrates how Cadmus applied part-use factors for each of the three categories to determine the historical average, per-unit, gross, and annual energy savings for refrigerators and freezers.

Table 26. Historical Part-Use Adjusted Gross Per-UES for Refrigerators and Freezers

Operational Status	Recycled Refrigerators			Recycled Freezers		
	Percent of Total Units	Average Part-Use Factor	Part-Use Adjusted Per unit UEC (kWh/Year)	Percent of Total Units	Average Part-Use Factor	Part-Use Adjusted Per Unit UEC (kWh/Year)
Primary and Secondary						
Not Running	3%	0	0			
Running Part Time	7%	0.31	349			
Running All Time	90%	1.00	1,131			
Weighted Average		**0.92**	**1,041**			
Secondary Only						
Not Running	7%	0	0	13%	0	0
Running Part Time	17%	0.31	349	7%	0.24	210
Running All Time	77%	1.00	1,131	80%	1.00	869
Weighted Average		**0.82**	**925**		**0.81**	**708**

In many cases, the way an appliance was used historically (prior to recycling) did not indicate how the appliance would have been used had it not been recycled. To account for this potential discrepancy, Cadmus asked surveyed participants how they would have likely operated their appliances had they not been recycled. For example, if surveyed participants indicated they would have kept a primary refrigerator in the program's absence, Cadmus asked if they would have continued to use the appliance as their primary refrigerator or would have relocated it and used it as a secondary refrigerator.

Participants who said they would have discarded their appliances independently of the program were not asked about future usage of that appliance. As the future usage type of discarded refrigerators

remained unknown, Cadmus applied the weighted part-use average of all units (0.92) for all refrigerators that would have been discarded independently of the program. Using this approach, the evaluators acknowledged that discarded appliances might be used as primary or secondary units in a would-be recipient's home.

Cadmus combined the part-use factors shown in Table 26 with participants' self-reported actions had the program *not* been available. This resulted in the distribution of likely future usage scenarios and corresponding part-use estimates. The weighted average of these future scenarios, shown in Table 27, produced the part-use factor for refrigerators (0.91) and freezers (0.81).

Table 27. Prospective Use Part-Use Factors

Use Prior to Recycling	Likely Use Independent of Recycling	Part-Use Factor	Percentage of Participants
Primary Refrigerators	Kept (as primary unit)	1	6%
	Kept (as secondary unit)	0.82	8%
	Discarded	0.92	42%
Secondary Refrigerators	Kept	0.82	8%
	Discarded	0.92	36%
Overall		**0.91**	**100%**
Freezers	Kept	0.89	29%
	Discarded	0.89	71%
Overall		**0.89**	**100%**

Based on the part-use, adjusted, per-unit, gross annual energy savings presented in Table 28, Cadmus determined program-wide, annual, gross energy savings generated by participation in DP&L's program in 2017 (also shown in Table 28).

Table 28. 2017 Adjusted, Part-Use, Gross, Annual Energy Savings

Appliance	Adjusted Gross Energy Savings Per Appliance (kWh/Year)	Adjusted Gross Demand Reduction Per Appliance (kW/Year)*	2017 Unit Counts	Total Adjusted Gross Savings (kWh/Year)	Total Adjusted Gross Demand (kW/Year)	Precision**
Refrigerator	1,029	0.16	4,297	4,421,858	688	11.0%
Freezer	708	0.11	952	673,631	105	24.7%
Total			**5,249**	**5,095,490**	**792**	**10.1%**

*Cadmus derived refrigerator and freezer summer coincident peak demand reduction by applying the 2010 Ohio TRM formula. Results from this evaluation determined the change in kWh input.

**Precision at 90% confidence.

Recommendations

Drawing upon the preceding findings, Cadmus offers the following recommendations:

- **Expand data collection for room ACs and dehumidifiers.** If dehumidifiers and room ACs continue to be part of the ARP Program measure mix, expand data collected for them to include the dehumidifier's capacity, year of manufacture, and energy factor; and the room AC's size in BTUs, and efficiency factor. These data serve as key inputs to the energy savings algorithm, and tracking these equipment characteristics will allow the program to more accurately estimate energy savings resulting from dehumidifier and room AC retirement.
- **Consider reducing marketing resources for the program, due to its high performance.** The ARP Program exceeded its goals for units collected in 2017. Furthermore, most participants heard about the program through bill inserts or word-of-mouth, rather than online or print advertising. DP&L might consider reducing the resources devoted to marketing this program and devote them to future programs or pilots.

Residential Income Eligible Efficiency Program

This chapter describes the evaluation approach, detailed findings, and conclusions and recommendations for the Residential Income Eligible Efficiency program, implemented by Ohio Partners for Affordable Energy (OPAE).

Evaluation Overview

Cadmus' evaluation of the Residential Income Eligible Efficiency program implemented by OPAE followed the evaluation activities and researchable questions outlined in Table 29.

Table 29. Key Researchable Questions

Researchable Question	Activity Used to Address Question
What are the estimated gross electric savings and demand reductions generated by the program?	• Engineering analysis • Billing analysis • Program database review
Is this program cost-effective?	• Cost-effectiveness analysis

Detailed Evaluation Findings

DP&L fell short of its 1,083,240 kWh energy savings and 162 kW demand reduction goals, achieving 925,681 kWh 126 kW in ex ante savings. A total of 568 unique sites received measures through the Income Eligible program implemented by OPAE. Verified gross savings represent realization rates of 100% and 100% against *ex ante*-claimed energy savings and demand reduction, respectively. It should be noted the contract for this program was executed at the end of June 2017, resulting in a shortened period of time in which customers were served. OPAE's community action agencies installed measures July to December 2017.

Table 30 presents *ex ante* claimed, verified gross, and adjusted gross savings for energy and demand. As adjusted savings use the billing analysis' program-level realization rate, results are presented at the program level. Key impact evaluation findings follow.

Table 30. Income Eligible Efficiency Program Claimed and Achieved Energy Savings

	Ex Ante Claimed Savings*		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision**
Program Savings	925,681	126	925,681	126	814,597	110	± 6.9%

*Cadmus calculated the 2017 energy and demand savings, which factored in ISRs and other adjustments. DP&L used these adjusted gross estimates for *ex ante* savings.

**Precision at 90% confidence.

- Cadmus found no differences between DP&L's reported *ex ante* savings and evaluated verified savings. DP&L requested that Cadmus calculate *ex ante* savings for the Residential Income

Eligible Efficiency program, and used quantity and measure details from the program tracking database (CC-System) as inputs to calculate *ex ante* savings (rather than using the savings field from the database).

- When applying the billing analysis results, the program achieved a realization rate of 88% in adjusted gross savings against *ex ante*-claimed energy savings and demand reduction.

Evaluation Data Collection Methods

To calculate program energy saving impacts, Cadmus' billing analysis primarily relied on DP&L's participant tracking data to calculate modeled savings, while savings algorithms provided in the Ohio TRM were used to calculated *ex ante* savings.

Billing Analysis

Starting in July 2014, Cadmus worked with DP&L to collect billing data for Residential Income Eligible Efficiency program participants. A billing analysis requires two to four years of electric bills for each customer: bills must cover pre-installation, installation, and post-installation periods for each home. As DP&L's billing data management system retains billing records for just two years, DP&L provided Cadmus with these records on a rolling basis so Cadmus could gather more than two years' worth of electric bills for each home.

As data collection began in 2014, DP&L provided electric billing records each month for program participants for that specific month. In February 2018, DP&L provided billing data for all participants (included in the monthly batches of billing records). This final dataset provided up-to-date billing information for billing records collected each month.

Engineering Analysis

Cadmus performed an engineering review incorporating the Ohio TRM and including additional primary and secondary sources as needed to supplement the TRM guidelines. Cadmus used engineering calculations to evaluate savings for the measures delivered as part of program.

Process Evaluation Methodology and Findings

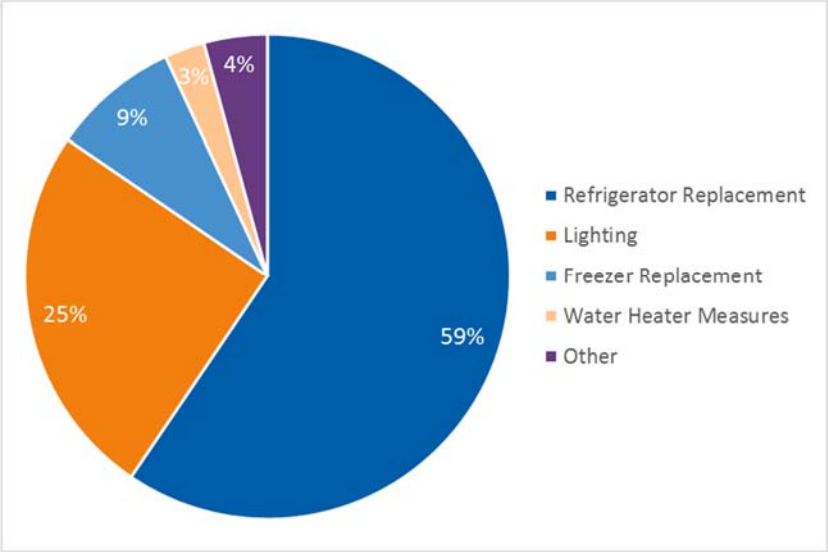
For the 2017 program year, Cadmus did not conduct a full process evaluation for the program. In summer 2017, Cadmus spoke with DP&L staff to gather information about program changes, and staff confirmed that program design, delivery, and implementation remained the same as in prior years.

Impact Evaluation Methodology and Findings

CC-System Database Review

Cadmus reviewed the CC-system database to summarize the program's *ex ante* savings. Refrigerator replacements, freezer replacements, and lighting measures provided 93% of the program's *ex ante* energy savings as shown in Figure 8. The remaining measures combined for 7% of the total savings with no other individual measures providing more than 2% of the total.

Figure 8. *Ex Ante* Energy Savings Distribution



Water heater measures include measures which reduce hot water usage, such as faucet aerators and showerheads, as well as measures which increase the efficiency of the hot water heater, such as pipe insulation and water heater tank wrap. The "other" category includes air sealing, attic insulation, foundation wall insulation, heat pumps, and smart strips.

Cadmus found these issues within the CC system when evaluating savings:

- Missing protocol savings
- Missing protocol quantity
- Inconsistent units for heating and cooling efficiencies
- Inconsistent units heat pump and central AC capacity

Cadmus was able to use invoiced amounts and other data to determine quantities, and used best judgement to determine the most realistic HVAC efficiencies and capacities.

DP&L, along with OPAE, has proposed a list of new measures which may be implemented in 2018 -- 2020 program years. Cadmus reviewed and advised on future savings values for the following measures:

- Band joist insulation
- Duct insulation
- 11w LED
- 3-way LED
- Heat pump water heater
- Replace furnace with air source heat pump

- Replace sump pump or well pump
- Replace dehumidifier
- Remove 1500w space heater

Engineering Analysis

Cadmus used the methodologies and inputs prescribed by the Ohio TRM to calculate *ex ante* and verified savings. Some measures required updating the methodology and inputs for the following reasons:

- Inaccurate inputs provided by the CC-System database
- Outdated methodology and inputs

For air-sealing and insulation measures, Cadmus applied thresholds on specific input assumptions to limit unreasonably high savings estimates. Without applying thresholds on these assumptions, savings calculations would estimate energy savings to be higher than the energy consumption of the entire house. This is due to the TRM algorithms' over estimation of savings past certain thresholds. Specifically, this limited air-sealing measure improvements to 30% (i.e., some cases experienced leakage improvements greater than 50%). For attic and wall insulation measures, Cadmus set respective savings thresholds at 50% and 20% of total home heating energy usage. Adjustments to pre- and post-R-values accounted for the insulating effect of roof and wall structures, as shown in Table 31, which are not accounted for in the data recorded by the contractors. These R-value adjustments drew upon modeling assumptions Cadmus used in the 2012 DP&L Potential Study.[12]

Table 31. R-Value Adjustments to Account for a Structure's Insulating Effect

Insulation	R-Value Adjustment
Ceiling	5.00
Wall	4.37
Foundation Wall	2.32

Table 32 summarizes additional updates and provides a complete source list for measure-level savings.

[12] The 2012 DP&L Potential Study can be found in the DP&L 2013–2015 Portfolio Plan Filing.

Table 32. Savings Sources and Updates

Measure	Source and Update
LED	2017 Residential Lighting program methodology: lumens equivalence and EISA baselines. 2013 Residential Income Eligible Efficiency program evaluation: ISR of 97%.
Energy-Efficient Showerhead	2012 Cadmus Showerhead and Faucet Aerator Meter Study: engineering algorithms and inputs.
Faucet Aerator	2012 Cadmus Showerhead and Faucet Aerator Meter Study: engineering algorithms and inputs.
Freezer Replacement	Cadmus replacement appliance savings calculator: ENERGY STAR UEC.
Refrigerator Replacement	Ohio TRM Joint Objections and Comments: updated existing UEC.
Water Heater Pipe Insulation	ACEEE Report Number E093, p. 117, April 2009: energy savings factor.
Smart Strip	Mid-Atlantic TRM V5.0: ISR.

Billing Analysis

Methodology

Cadmus implemented the PRISM and fixed-effect modeling techniques to verify kWh savings. The team chose to present PRISM results for the OPAE program to provide comparable results at the program level as well as at the measure-group level. Appendix J provides further descriptions of PRISM and fixed-effect modeling.

Energy Savings Summaries

Table 33 presents overall average savings, estimated using the PRISM models, adjusted gross savings realization rates, and associated confidence intervals around savings estimates. Overall, the average OPAE program participant's usage changed by 1,455 kWh or 12% from the pre-period to the post-period.

The nonparticipant group, however, experienced increased usage of 310 kWh over the same period (a 3.4% increase). This resulted in adjusted gross participant savings of 1,874 kWh. Compared to the 2,139 kWh *ex ante* savings estimate, this represented an 88% adjusted gross savings realization rate. *Ex ante* savings were contained within the confidence interval of the PRISM estimate; therefore, the two values were not considered statistically different at the 90% confidence level. With average pre-installation period usage of 12,419 kWh, the savings represent a 15% reduction in home energy usage.

Table 33. OPAE Overall Billing Analysis Results

Group	n	Model Savings (kWh/yr)*	*Ex Ante* Savings (kWh/yr)	Relative Precision 90% Confidence Level	Pre Period NAC (kWh)**	Adjusted Gross % Savings	*Ex Ante* % Savings
Participant	285	1,455*** [1,238, 1,671]	2,139	15%	12,419	11.7%	19.1%
Nonparticipant	113	-310 [-555, -65]	-	79%	9,181	-3.4%	-
Participant Adjusted Gross	**285**	**1,874 [1,479, 2,270]**	**2,139**	**22%**	**12,419**	**15.1%**	**17.2%**

*The brackets contain the lower and upper bound of each savings estimate at the 90% confidence level.
**Pre-Period NAC is the average normalized annual energy consumption of customers before participating in the OPAE program, representing the baseline against which Cadmus measured percent savings.
***As a check, the monthly, fixed-effects, CSA modeling approach yielded a similar result: 1,370 kWh savings with a 90% relative precision of 15%. These results can be found in Appendix J. As discussed, only PRISM estimates were used to derive model savings.

Table 34 compares results between the 2016 billing analysis and the 2017 billing analysis. The adjusted gross savings realization rates remained constant at 88% between the two program years; however, the model savings between program years fell by 322 kWh. Pre-period usage decreased between program years; the percent savings fell from 16.7% in 2016 to 15.1% in 2017. The decrease in average savings per site can be partially attributed to fewer installations of large savings measures such as heat pumps, air sealing, and attic insulation. These three measures provided the largest per unit savings in the program.

Table 34. Comparison of 2015 and 2016 Billing Analysis Results

Analysis Year	n	Model Savings (kWh/yr)	*Ex Ante* Savings (kWh/yr)	Relative Precision 90% Confidence Level	Pre Period NAC (kWh)*	Modeled Percent Savings	*Ex Ante* Percent Savings
2016	546	2,155	2,461	19%	12,877	16.7%	19.1%
2017	546	1,874	2,139	22%	12,419	15.1%	17.2%

*Pre-Period NAC is the average normalized annual energy consumption of customers before participating in the OPAE program, representing the baseline against which Cadmus measured percent savings.

Although sample sizes did not permit obtaining isolated measure-level savings estimates, Cadmus estimated measure group savings. These measure group savings are not the estimate of that specific measure, rather the average total program savings of all customers who receive that measure as customers in these groups did not only receive one type of measure. These savings should not be summed together or viewed as savings estimates for each measure; rather, the results are meant to be viewed anecdotally as the effects of each measure could not be separated.

Table 35 presents participation rates for each measure, by account of participants from 2016 and 2017, as observed from the billing analysis sample.

Table 35. Participation Rate by Review

Measure	Percentage of Participants Who Installed Each Measure
Efficient Refrigerators/Freezers	79%
Efficient HVAC Equipment	1%
Air Sealing	4%
Insulation	4%
Efficient Lighting	95%
Efficient Water Heating	15%
Other Efficient Equipment	1%

While most customers received lighting measures and refrigerators and/or freezers, Cadmus identified six participants who *only* installed refrigerators and/or freezers. Therefore, Cadmus was able to identify savings achieved by the installation of these measures only. These participants obtained a savings average of 778 kWh (a 46% adjusted gross savings realization rate) compared to the 1,685 kWh *ex ante* estimate. This suggested lower refrigerator and freezer savings than expected. It should be noted, however, that the precision around this estimate was low at 136%.

The analysis found that participants installing lighting measures, refrigerator/freezer measures, and water heating measures, achieved adjusted gross savings realization rates within 5% to 10% of the average, indicating *ex ante* estimates for these measures remained fairly accurate.

Table 36 provides adjusted gross measure group results (i.e., adjusted for the nonparticipant group's usage change). It also shows that participants receiving air sealing and insulation measure groups achieved lower average adjusted gross savings. Thus, although participants receiving air sealing and insulation measures saved a considerable amount (over 5,000 kWh), savings did not achieve the expected 8,000 kWh, despite applying thresholds to the inputs for the *ex ante* savings. Pre-period usage for participants receiving air sealing and insulation also nearly doubled the average, indicating electric heat usage. They did not, however, save in the expected 27% range (saving more in the 16% range). Similarly, it seems HVAC measures did not save as much as expected: participants expecting to save 20% achieved -4% savings.

Although not measure-specific results, these findings indicate water-heating and lighting *ex ante* savings estimates appeared reasonable, while air sealing, insulation, refrigerators, and freezers billing analysis savings appeared high (and HVAC appeared low).

Table 36. OPAE Adjusted Gross Measure Group Energy Savings from Billing Analysis

Measure Group	n	Model Savings (kWh/yr)	*Ex Ante* Savings (kWh/yr)	Relative Precision 90% Confidence Level	Pre Period NAC (kWh)*	Modeled Percent Savings	*Ex Ante* Percent Savings
Overall	**285**	**1,874**	**2,139**	**21%**	**12,419**	**15.1%**	**17.2%**
Refrigerators/Freezers	226	1,845	2,263	22%	12,032	15.3%	18.8%
Refrigerators/Freezers Only	6	778	1,685	136%	8,841	8.8%	19.1%
HVAC	2	-619	3,156	105%	15,567	-4.0%	20.3%
Air Sealing	10	5,083	8,094	34%	30,595	16.6%	26.5%
Insulation	10	5,083	8,094	34%	30,595	16.6%	26.5%
Lighting	272	1,836	2,093	21%	12,281	15.0%	17.0%
Water Heating	43	2,253	5,089	33%	17,465	12.9%	13.7%
Other	2	1,002	1,462	197%	25,401	3.9%	3.7%

*Pre-Period NAC is the average normalized annual energy consumption of customers before participating in the OPAE program, representing the baseline against which Cadmus measured percent savings.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Continue to perform measure-by-measure reviews of the system to replace the CC-System**. Development is underway for a database to replace the CC-System. Continuing to work in concert with the database administrator and the Community Action Agencies will help address any future database issues. Data tracking has improved throughout each program year, with all critical inputs for savings calculations present. Some of these inputs, however, continue to be entered inconsistently, and checking the database at set intervals throughout the year for common issues will help identify future mistakes as quickly as possible. Cadmus recommends checking the system to ensure the following are entered accurately:
    - Protocol quantities and savings associated with all measures are included
    - Consistent units for heating and cooling efficiencies are used (SEER and EER for cooling efficiencies, and COP for heating efficiency).
    - Consistent units for heat pump and central AC capacities are used (BTU).
- **Continue to collect monthly billing data for Income Eligible Efficiency program participants.** Continuing to collect and store these billing data will create a more robust dataset for future billing analysis, including more participants and longer data periods for each participant. In subsequent years, performing a billing analysis using a more robust dataset will allow estimating results with improved accuracy and precision.
- **Incorporate new measures into the program while maintaining the consistency in the program tracking databases**. DP&L—along with OPAE—proposed a list of new measures to be included in

program years 2018–2020. Cadmus reviewed savings values for these new measures and provided recommendations. Using the same data tracking and reporting systems as are currently in place will help to ease the transition between this program year and subsequent years.

Residential Income Eligible Efficiency Pilot

This chapter presents the evaluation approach, detailed findings, and conclusions and recommendations for the Residential Income Eligible Efficiency Pilot, implemented by People Working Cooperatively (PWC). The pilot installs energy efficiency measures in customers' homes as part of a broader mission to help low-income, elderly, and disabled homeowners stay in their homes. Despite offering similar measures, the pilot operates independently from DP&L's Residential Income Eligible Efficiency program.

Evaluation Overview

Cadmus' evaluation of the 2017 Residential Income Eligible Efficiency Pilot followed the evaluation activities and researchable questions outlined in Table 37.

Table 37. Key Researchable Questions

Researchable Question	Activity Used to Address Question
What gross electric savings and demand reductions did the pilot generate?	• Engineering analysis • Program database review
Is the pilot cost-effective?	• Cost-effectiveness analysis

Detailed Evaluation Findings

DP&L achieved *ex ante* savings of 306,988 kWh and 165 kW at a total of 186 unique sites. As DP&L requested calculated *ex ante* savings for the program, Cadmus used all current and available information to inform *ex ante* savings and adjusted gross savings. Verified gross savings represent realization rates of 100% and 100% against *ex ante*-claimed energy savings and demand reduction, respectively. It should be noted the contract for this pilot was executed at the end of June 2017, resulting in a shortened period of time in which customers were served. PWC staff installed measures July to December 2017.

Table 38 presents pilot *ex ante* claimed, verified gross, and adjusted gross savings for energy and demand. Key impact evaluation findings follow.

Table 38. Residential Income Eligible Efficiency Pilot Claimed and Achieved Energy Savings

Measure	*Ex Ante* Claimed Savings*		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision**
Air Sealing	19,508	0.17	19,508	0.17	19,508	0.17	± 10.0%
Attic Insulation	9,741	0.10	9,741	0.10	9,741	0.10	± 10.0%
Bathroom Faucet Aerator	1,637	0.46	1,637	0.46	1,637	0.46	± 14.3%
Floor Insulation	15,902	0.49	15,902	0.49	15,902	0.49	± 14.3%
Freezer Replacement	11,272	1.71	11,272	1.71	11,272	1.71	± 14.3%
Heat Pump	3,359	0.45	3,359	0.45	3,359	0.45	± 10.0%
Kitchen Faucet Aerator	247	0.07	247	0.07	247	0.07	± 10.0%
Lighting	155,943	149.91	155,943	149.91	155,943	149.91	± 14.3%
Pipe Insulation	2,743	0.31	2,743	0.31	2,743	0.31	± 14.6%
Refrigerator Replacement	68,805	10.58	68,805	10.58	68,805	10.58	± 14.3%
Showerhead	7,147	0.53	7,147	0.53	7,147	0.53	± 10.0%
Wall Insulation	5,263	0.08	5,263	0.08	5,263	0.08	± 10.0%
Water heater Wrap	158	0.018	158	0.02	158	0.02	± 14.3%
Total* **	**301,725**	**165**	**301,725**	**165**	**301,725**	**165**	**± 8.5%**

*Cadmus calculated the 2017 energy and demand savings, which factored in ISRs and other adjustments. DP&L used these adjusted gross estimates for its *ex ante* savings.

**Precision at 90% confidence.

*** Values in table may not sum exactly to total due to rounding.

- Lighting and refrigerator replacement provided 73% of the pilot's *ex ante* energy savings. Shell measures included air sealing, attic insulation, floor insulation, and wall insulation. Water heating measures included showerheads, kitchen aerators, bathroom aerators, pipe insulation, and water heater wrap.

Process Evaluation Methodology and Findings

During the 2017 program year, Cadmus did not conduct a full process evaluation for the program. Rather, Cadmus spoke with DP&L staff in summer 2017, gathering information about program changes; staff confirmed that the program's design, delivery, and implementation remained the same as in prior years.

Evaluation Data Collection Methods

Program Database Review

In collaboration with DP&L, Cadmus reviewed PWC's tracking database to assess if it accurately and consistently collected key assumptions used in Ohio TRM savings algorithms. At the program year's beginning, DP&L created a new form for collecting data which was sent to Cadmus for review and comment. At the fiscal year's end, DP&L sent Cadmus year-end data utilizing the updated collection form which included modifications based on feedback Cadmus provided earlier in the year.

Engineering Analysis

Cadmus used the same inputs and methods as in the 2016 program year to calculate *ex ante*, verified, and adjusted gross savings for measures in the database. Whenever possible, these included methodologies and inputs that the Ohio TRM prescribed for calculating savings.

Impact Evaluation Methodology and Findings

Engineering Analysis

Cadmus used inputs and methods from the Ohio TRM to calculate *ex ante*, verified, and adjusted gross savings for measures in the database. In all cases, Cadmus calculated *ex ante* and verified savings using methodologies and inputs consistent with the Income Eligible Efficiency Program implemented by OPAE. Table 39 summarizes all updates to the Ohio TRM methodologies:

Table 39. Savings Sources and Updates

Measure	Source and Update
Lighting	Residential Lighting program methodology: baseline wattages were the recorded wattages of bulbs being replaced, data provided by PWC in tracking data. 2013 Income Eligible Efficiency program Evaluation: ISR of 97%.
Energy-Efficient Showerhead	2012 Cadmus Showerhead and Faucet Aerator Meter Study: engineering algorithms and inputs.
Faucet Aerator	2012 Cadmus Showerhead and Faucet Aerator Meter Study: engineering algorithms and inputs.
Freezer Replacements	Cadmus replacement appliance savings calculator: ENERGY STAR UEC.
Refrigerator Replacements	Ohio TRM Joint Objections and Comments: updated existing UEC.
Water Heater Pipe Insulations	ACEEE Report Number E093, p. 117; April 2009: energy-savings factor.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Continue to hold meetings with PWC to discuss the database and data collection**. Cadmus recommends continuing to hold meetings with PWC to ensure both parties continue to understand the data collection tool. This will increase the likelihood that issues such as multiple data formats or missing data fields, which occurred in prior years but not in 2017, are addressed as quickly as possible. DP&L may consider periodically conducting “spot checks” of the database, screening for incomplete or faulty information.

Residential Heating and Cooling Rebate Program

This chapter describes Cadmus' evaluation approach, detailed findings, conclusions, and recommendations for the Residential Heating and Cooling Rebate program (called the Residential HVAC Rebates program in DP&L's 2013–2015 portfolio plan).

Evaluation Overview

To evaluate the 2017 program, Cadmus followed the evaluation activities and researchable questions outlined in Table 40.

Table 40. Key Researchable Questions

Researchable Question	Activity Used to Address Question
What are the program's gross electric savings and peak demand reductions?	• Program database review • Participant billing analysis • Engineering analysis
What changes to the program's design and delivery would improve performance?	• Program and implementation staff interviews • Program database review
Is this program cost-effective?	• Cost-effectiveness analysis

Consistent with impact methods employed in previous years, the 2017 impact evaluation focused on a regression analysis of billing data from 2016 program participants. As no significant program changes were planned for measures included for 2017, Cadmus applied UES estimates calculated during the billing analysis to 2017 participant data.

The program did not experience major changes in the 2017 program year. The only program modification allowed participants to apply for a smart thermostat rebate without installing other equipment (previously, smart thermostats could only be paired with purchases of other heating or cooling equipment).

Detailed Evaluation Findings

DP&L fell slightly short of its energy savings goal of 8,814,339, achieving 7,421,781 kWh in *ex ante* savings through 7,609 rebated measures. The 2017 program fell short of the 2,712 kW demand reduction goal, achieving 1,590 kW in *ex ante* demand reduction. Verified gross savings were 7,454,385 kWh and 1,594 kW. Verified gross savings, compared to *ex ante* savings, represented realization rates of 100% for energy and 100% for demand.

Table 41 presents program *ex ante* claimed, verified gross, and adjusted gross savings and demand reduction. Key impact evaluation findings follow.

Table 41. Residential Heating and Cooling Rebate Program Claimed and Achieved Energy Savings

Measure	*Ex Ante* Claimed		Verified Gross		Adjusted Gross		
	kWh	kW	kWh	kW	kWh	kW	Precision
ER AC 14/15 SEER	1,004,001	408	1,004,001	408	1,041,749	357	9.9%
ER AC 16+ SEER	1,645,407	669	1,645,407	669	1,902,121	652	7.7%
NC AC 14/15 SEER	8,510	4	8,510	4	11,192	5	10.0%
NC AC 16+ SEER	20,221	8	20,221	8	19,285	8	10.0%
RP AC 14/15 SEER	22,747	15	22,747	15	42,009	11	39.8%
RP AC 16+ SEER	34,549	14	34,549	14	48,381	14	31.3%
ER HP 14/15 SEER	553,705	72	553,705	72	611,224	64	12.5%
ER HP 16+ SEER	1,541,587	208	1,541,587	208	1,370,005	217	10.8%
NC HP 14/15 SEER	8,899	1	8,899	1	4,462	1	10.0%
NC HP 16+ SEER	42,797	6	42,797	6	28,753	5	10.0%
RP HP 14/15 SEER	17,344	3	17,344	3	12,276	1	27.8%
RP HP 16+ SEER	63,975	8	63,975	8	64,486	8	27.4%
ER GSHP 16/18 EER	85,100	4	85,100	4	55,324	2	10.0%
ER GSHP 19+ EER	162,540	11	162,540	11	105,157	9	10.0%
NC GSHP 16/18 EER	43,783	2	43,783	2	28,596	1	10.0%
NC GSHP 19+ SEER	25,409	2	25,409	2	20,320	1	10.0%
RP GSHP 19+ EER	33,565	3	33,565	3	26,980	2	0.0%
NC MS AC 16+ SEER	1,709	2	1,709	2	1,284	1	10.0%
NC MS HP 16+ SEER	366,745	20	366,745	20	386,899	16	0.0%
RP MS HP 16+ SEER	2,517	0	2,517	0	3,257	0	10.0%
ECM	241,818	57	241,818	57	227,788	56	0.0%
ECM with New AC****	674,626	0	674,626	0	0	0	0.0%
ECM with New HP****	33,060	0	33,060	0	0	0	0.0%

Measure	*Ex Ante* Claimed		Verified Gross		Adjusted Gross		
	kWh	kW	kWh	kW	kWh	kW	Precision
Programmable Thermostat with AC	197,881	0	197,315	0	270,433	0	10.0%
Programmable Thermostat with HP	321,394	0	320,724	0	263,629	0	10.0%
Programmable Thermostat with GSHP	20,757	0	20,757	0	11,721	0	10.0%
Smart Thermostat with AC	946	0	946	0	1,088	0	10.0%
Smart Thermostat with HP or GSHP	3729	0	3,729	0	3,768	0	10.0%
Heat Pump Water Heater - Gas Home	4,152	1	4,152	1	4,152	1	10.0%
Heat Pump Water Heater - Electric Home	24,643	3	24,643	3	24,643	3	10.0%
Air Sealing	31,556	0	31,556	0	31,556	0	10.0%
Wall Insulation	33,389	1	33,389	1	33,389	1	10.0%
Attic Insulation	43,549	0.96	43,549	1	43,549	1	10.0%
Multi-Family New Construction	105,169	68	139,010	72	112,890	52	10.0%
Total**	**7,421,781**	**1,590**	**7,454,386**	**1,594**	**6,807,414**	**1,489**	**± 8.0%**

*Adjusted gross savings for qualifying AC and HP units accounted for ECM savings with new AC and HP units.

**Values in table may not sum exactly due to rounding.

- One change between the 2016 and 2017 program years was the use of a higher baseline efficiency value for new construction and regular replacement air-source heat pump HVAC measures in 2017. In the 2016 program year, a higher efficiency baseline was used (SEER 14) for the second half of the year, with a lower baseline being used for the first half of the year. In 2017, the higher efficiency (SEER 14) value was used for the entire year. This contributed to slightly lower adjusted gross savings realization rates in the 2017 program year
- *Ex ante* savings from central air conditioners and air-source heat pumps accounted for two-thirds of total *ex ante* heating and cooling program savings, contributing 30% and 26% of *ex ante* savings, respectively.
- Envelope measures in this program (air sealing, wall insulation, and attic insulation) accounted for less than 2% of *ex ante* savings.
- For the billing analysis portion of the HVAC measures, the adjusted gross savings realization rate was 104% when ignoring the ECM with air conditioner (ECMA) measures and 91% when including ECMA measures. Since realization rates involve *ex ante* savings, considering ECMA and ECMH as *ex ante* measures can skew data.

Evaluation Data Collection Methods

In evaluating the 2017 program, Cadmus used the approaches detailed below.

Program Participant Utility Bill Regression Analysis and Engineering Review

For this evaluation, Cadmus conducted a billing analysis of 2016 program participants, comparing equipment characteristics from the billing analysis sample against 2017 program data. As the comparison found good agreement, Cadmus used the billing analysis results to evaluate measure-level kWh estimates.

For unavailable billing analysis results, Cadmus performed an engineering review, based on the Ohio TRM, including additional primary and secondary sources as needed to supplement the TRM guidelines. Cadmus used engineering calculations to evaluate measure-level kWh savings for ground source heat pumps (GSHP), mini-split HPs, and thermostat measures. The evaluation also relied on engineering calculations in evaluating all measure-level kW savings. Cadmus used deemed savings values to evaluate measure-level savings for air sealing and insulation measures.

Program Database Review

Cadmus reviewed the final 2017 program tracking database for input, accuracy, and completeness of data tracked, and to determine whether the database contained the following:

- Data necessary to calculate collected savings
- Reported savings estimates that matched the measure types
- Existing and installed equipment types that met the measure requirements

Process Evaluation Findings

Cadmus did not conduct a full process evaluation for the 2017 program year. Rather, Cadmus spoke with DP&L staff in summer 2017 to gather information about program changes. Staff reported that the program experienced no substantial changes in the 2017 program year. CLEAResult continued to implement the program. The program's design changed only in that participants could apply for a rebate for a smart thermostat without installing other equipment; previously, smart thermostats could only be paired with purchases of other heating or cooling equipment.

Impact Evaluation Methodology and Findings

This section first presents program energy savings, including results for the various measures, organized by the evaluation method used. It then outlines demand reduction results, also organized by evaluation method.

Participant Utility Billing Analysis UES Estimates

Table 42 summarizes the UES estimates calculated using a participant billing analysis.[13] Generally, per-unit, adjusted gross savings estimates compared fairly well to *ex ante* estimates provided by DP&L and the program implementer. UES estimates also proved comparable to the 2016 billing analysis results, apart from the SEER 14/15 standard replacement air source heat pumps (ASHP).

Table 42. Measure Savings Estimates (kWh)

Measure	Number of Measures Analyzed	*Ex Ante* UES Estimate	Adjusted Gross UES Estimate	Precision at 90% Confidence
ER AC 14/15 SEER	922	1,089	1,130	5.7%
ER AC 16+ SEER	1,321	1,246	1,440	6.7%
RP AC 14/15 SEER	116	196	362	29.4%
RP AC 16+ SEER	67	516	722	27.5%
ER HP 14/15 SEER	179	3,093	3,415	8.3%
ER HP 16+ SEER	467	3,301	2,934	7.9%
RP HP 14/15 SEER	18	964	682	32.8%
RP HP 16+ SEER	44	1,454	1,466	41.0%
ECM	319	758	714	16.9%

The adjusted gross savings realization rates shown in Table 42 for AC units exceed 100%, indicating that the 2017 gross unit energy savings were greater than those from the 2013 billing analysis. The primary reason for this is how savings of ECM blowers are reported and calculated. Table 43 shows total evaluated savings for early replacement AC units and ECMs with New AC. Overall, when considering

[13] Consistent with the previous evaluation, Cadmus used a pre- and post-fixed-effects modeling approach. Cadmus. "Evaluation 2013 EM&V Report." Filed May 15, 2014. Case No. 14-738-EL-POR. Available online: http://dis.puc.state.oh.us/DocumentRecord.aspx?DocID=fb8f219b-4024-4694-9908-1b2731540eb5

total savings across AC measures and the ECM with New AC measures, the adjusted gross savings realization rate for these measures combined was 89%.[14]

Table 43. Early Replacement AC Savings with ECM Savings Included

Measure	Incented Measures	*Ex Ante* UES Estimate	Adjusted Gross UES Estimate	Total Ex Ante Savings	Total Adjusted Gross Savings
ACER-14/15	922	1,089	1,130	1,004,058	1,041,749
ACER-16+	1,321	1,246	1,440	1,645,966	1,902,121
ECMA	1,618	417	-	674,706	-
Total	**3,861**	**--**	**--**	**3,324,730**	**2,943,870**

Another difference between the 2017 billing analysis and the 2013 billing analysis was the savings estimation for standard replacement air-source heat pumps. For the 2017 evaluation, Cadmus adjusted the baseline SEER and HSPF values used to calculate UES estimates to the current minimum federal standard values of SEER 14 and 8.2 HSPF[15]. The 2013 billing analysis used the prior federal baseline value of SEER 13 to estimate savings. This adjustment had a large effect on estimated savings, decreasing estimated savings from 1,152 kWh when using SEER 13 as the baseline to 682 kWh when using SEER 14 as the baseline.

To verify that including participants from previous program years did not introduce bias and that the billing analysis sample population remained comparable to the overall 2017 program population for these measure categories, Cadmus compared the two groups for the following:

- Average SEER rating of incented equipment
- Average size (tons) of incented equipment
- Average SEER rating of replaced equipment
- Average size (tons) of replaced equipment

Table 44 and Table 45 show the resulting comparisons.

[14] The 2017 billing analysis for AC and HP units includes all savings from ECM measures; savings are not disaggregated between the ECM blowers and the actual HVAC units themselves. This was also true in the 2013 billing analysis, but a lower percentage of installed systems used ECM blowers in the 2013 billing analysis so the effect was not as significant (for example, for ER AC 14/15 units, 9% used ECM air handlers in the 2013 analysis, compared with 42% in the current analysis). To avoid double counting savings associated to the ECM blowers, Cadmus omitted savings for ECM with New AC and ECM with New HP measures.

[15] DOE. *Explaining Central Air & Heat Pump Standards.* 2015. Available online:

https://www.energy.gov/sites/prod/files/2015/11/f27/CAC%20Brochure.pdf

Table 44. Comparison of Billing Analysis Sample to Program Population: Incented Equipment

Measure	Average SEER		Average Size (Tons)	
	Sample	Population	Sample	Population
ER AC 14/15 SEER	14.6	14.5	2.7	2.7
ER AC 16+ SEER	16.6	16.7	2.8	2.8
RP AC 14/15 SEER	14.4	14.4	2.4	2.7
RP AC 16+ SEER	17.0	16.7	3.0	2.6
ER HP 14/15 SEER	14.8	15.2	2.6	2.7
ER HP 16+ SEER	17.2	17.3	3.1	2.9
RP HP 14/15 SEER	14.6	15.2	2.5	2.7
RP HP 16+ SEER	17.3	17.2	4.2	3.0

Table 45. Comparison of Billing Analysis Sample to Program Population: Replaced Equipment

Measure	Average SEER		Average Size (Tons)	
	Sample	Population	Sample	Population
ER AC 14/15 SEER	10.1	9.9	2.6	2.6
ER AC 16+ SEER	10.2	10.2	2.7	2.7
RP AC 14/15 SEER	9.9	10.1	2.4	2.7
RP AC 16+ SEER	10.6	10.6	2.8	2.5
ER HP 14/15 SEER	10.6	10.6	2.5	2.7
ER HP 16+ SEER	11.2	10.6	2.8	2.7
RP HP 14/15 SEER	10.5	10.5	2.4	2.6
RP HP 16+ SEER	11.0	11.0	2.9	2.9

This comparison revealed several minor differences in the characteristics of incented versus replaced equipment. While some differences proved statistically significant, these tended to be small, with limited impacts on UES estimates. Therefore, Cadmus concluded that the populations were sufficiently similar to justify applying UES estimates (identified through the billing analysis) to the 2017 population.

Cadmus applied the UES estimates to the program population to derive adjusted gross savings for the selected measures, with the results shown in Table 46.

Table 46. Adjusted Gross Energy Savings (kWh) from Participant Billing Analysis

Measure	Incented Measures	Adjusted Gross UES Estimate	Total Adjusted Gross Savings
ER AC 14/15 SEER	922	1,130	1,041,749
ER AC 16+ SEER	1,321	1,440	1,902,121
RP AC 14/15 SEER	116	362	42,009
RP AC 16+ SEER	67	722	48,381
ER HP 14/15 SEER	179	3,415	611,224
ER HP 16+ SEER	467	2,934	1,370,005
RP HP 14/15 SEER	18	682	12,276
RP HP 16+ SEER	44	1,466	64,486
ECM	319	714	227,788
Total	**3,453**	**--**	**5,320,040**

*Values in table may not sum exactly due to rounding.

UES Estimates from Ohio TRM Calculations

Cadmus deferred to the Ohio TRM when calculating adjusted gross UES estimates for all measures, except for the following:

- Heating savings from mini-split ASHPs (not included in the TRM)
- Programmable and smart thermostats (not included in the TRM)
- Air sealing and insulation measures
- Measures included in the participant billing analysis (shown in Table 46)

By applying the Ohio TRM energy savings equations and assumptions to 2017 program participants, Cadmus determined the annual energy savings estimates shown in Table 47.

Table 47. Adjusted Gross Energy Savings from Ohio TRM Calculations

Measure	Incented Measures	Adjusted Gross UES Estimate	Total Adjusted Gross Savings*
NC AC 14/15 SEER	53	211	11,192
NC AC 16+ SEER	45	429	19,285
NC HP 14/15 SEER	10	446	4,462
NC HP 16+ SEER	30	958	28,753
ER GSHP 16/18 EER	12	4,610	55,324
ER GSHP 19+ EER	24	4,382	105,157
NC GSHP 16/18 EER	7	4,085	28,596
NC GSHP 19+ SEER	4	5,080	20,320
RP GSHP 16/18 EER	0	0	0
RP GSHP 19+ EER	5	5,396	26,980
NC MS AC 14/15 SEER	0	0	0
NC MS AC 16+ SEER	19	107	2,024
RP MS AC 14/15 SEER	0	0	0
RP MS AC 16+ SEER	0	0	0
RP MS HP 14/15 SEER	0	0	0
RP MS HP 16+ SEER	1	3,338	3,338
Heat Pump Water Heater - Gas Home	2	2,076	4,152
Heat Pump Water Heater - Electric Home	19	1,297	24,643
Total	**231**	**--**	**334,226**

*Values in table may not sum exactly due to rounding.

When calculating energy savings, Cadmus typically adhered to all savings equations and assumptions articulated in the Ohio TRM, with the exceptions discussed below.

Air Conditioners and Air Source Heat Pumps

The Ohio TRM listed 631 full-load cooling hours for the Dayton, Ohio, area. This estimate included a 33% reduction for oversizing newly installed equipment. Cadmus found this oversizing correction not applicable for the program, based on discussions with participating contractors and program staff. Therefore, Cadmus used full-load cooling hours from the ENERGY STAR calculator (947). Participant customer billing analysis supported this decision.

The Ohio TRM did not include early replacement ASHP measures. Consequently, to calculate energy savings and demand reductions for these measures, Cadmus adapted the appropriate time-of-sale, ASHP calculations to include the size and efficiency of equipment replaced.

Ground Source Heat Pumps

In 2017, according to program tracking data and the AHRI-certified products directory, approximately 83% of ground source heat pumps (GSHP) incented through the DP&L Residential Heating and Cooling Rebate program were multistage units. Therefore, consistent with the previous evaluation, Cadmus

adapted the algorithm provided in the Ohio TRM to capture savings from part- and full-load equipment operations.

Cadmus also deviated from the Ohio TRM in the following areas:

- As with the AC and ASHP calculations described above, Cadmus used full-load cooling hours from the ENERGY STAR calculator (947).
- The Ohio TRM did not include early replacement GSHP measures. To calculate energy savings and demand reductions, Cadmus adapted appropriate GSHP and time-of-sale calculations to include the replaced equipment size and efficiency.
- The Ohio TRM energy-savings algorithm for replace-on-burnout GSHP measures lacked a required "/1,000" component.
- Cadmus adjusted the baseline SEER and HPSF values for new construction and standard replacement units to meet current minimum federal standard values of SEER 14 and 8.2 HPSF.
- Ground source HPs tend to be sized for heating rather than cooling. In an area such as Dayton, this generally leads to oversized equipment on the cooling side. The Ohio TRM uses the overall unit capacity to determine savings, which could overstate a unit's cooling savings. To correct for oversizing when calculating cooling savings for early replacement and replace-on-burnout units, Cadmus used the capacity of the replaced unit. This adjustment could not be made for new construction; for these measures, Cadmus used the capacity of the newly installed unit.

Mini-Split Air Conditioners

The Ohio TRM did not provide savings equations or assumptions for mini-split ACs, and too few participants could be included in the billing analysis to provide precise savings estimates. However, a review of 2013 participant customer survey data, along with implementation staff interviews, confirmed that most of these measures were used for space cooling—much like window or portable ACs. Therefore, Cadmus applied the minimum federal standard SEER value of 13, which appeared most appropriate for split-system AC.

Heat Pump Water Heaters

Due to the relatively small number of rebated HP water heaters (n=21), Cadmus employed the same methodology as that used to calculate *ex ante* savings. Savings calculations for heat pump domestic water heaters are based on the Ohio TRM, and are a function of the type of heating system in the home. Implementer tracking data did not indicate the type of heating system in homes that installed hot water heat pumps. As with *ex ante* estimates, Cadmus assumed that ASHPs were used to heat these homes. However, if the homes had electric resistance heating, electrical savings would be reduced. If the homes used fossil fuel heating, electrical savings would increase, based on the TRM values.

Unit Energy Saving Estimates from Ohio TRM and Engineering Calculations

Mini-Split Heat Pumps

As with mini-split ACs, the Ohio TRM did not provide savings equations and assumptions for mini-split HPs, and too few participants could be included in the billing analysis to provide precise savings estimates. Therefore, in determining adjusted gross energy savings for these measures, Cadmus followed the same approach used for 2010 through 2014: relying on engineering calculations, informed by the Ohio TRM, and on primary and secondary source data.

To determine energy savings that these measures achieved while cooling, Cadmus adopted the minimum federal standard SEER value of 14, which appeared most appropriate for all split-system HPs.

To calculate energy savings produced by ASHPs, mini-split measures used for heating, Cadmus used the following equation and assumptions:

$$\Delta kWh = Hcap * \left(\frac{1}{3.413} - \frac{1}{Installed\ HSPF}\right) * \frac{1}{A} * Heating\ Savings * Adjustment\ Factor$$

Where:

Hcap	=	Size of the installed unit in tons, multiplied by 12
A	=	0.171 (identified in KEMA's mini-split study)[16]
Heating Savings	=	135.0 (identified in KEMA's mini-split study)[17]
Adjustment Factor	=	69.7%[18]

Table 48 presents annual savings estimates produced using this approach.

Table 48. Adjusted Gross Energy Savings from Engineering Calculations Based on Secondary Sources

Measure	Incented Measures	Adjusted Gross UES Estimate	Total Adjusted Gross Savings
NC MS HP 16+ SEER	165	2,345	386,899
RP MS HP 16+ SEER	1	3,257	3,257
Total	**166**	**--**	**390,157**

[16] KEMA. *Ductless Mini Pilot Study.* 2009. Available online: https://library.cee1.org/system/files/library/8723/CEE_Eval_2009DuctlessMiniPilotStudyFinalReport_1Jun2009.pdf

[17] Ibid.

[18] Cadmus determined the percentage of mini-split HPs installed to replace electric resistance space heating by using survey results from participants with mini-split, ASHPs, conducted by CSG staff in 2010 and Cadmus in 2013.

Programmable and Smart Thermostats

In addition to the HVAC Rebates program, the Smart Thermostats Rebate pilot provided four additional delivery channels for thermostats. Overall, 1,909 programmable thermostats and 11 smart thermostats were delivered as part of the HVAC Rebates program and received a $20 or $40 rebate. These 1,920 measures were accounted for in the HVAC Rebates program. There were also 356 smart thermostats delivered through the HVAC Rebates program that received a $75 rebate, and 4,685 thermostats delivered through the four Smart Thermostats Rebate pilot channels. These 5,041 smart thermostats were accounted for in the Smart Thermostats pilot.

The Smart Thermostats Rebate pilot data contained more information on heating and cooling systems than data provided through the HVAC Rebates program did, allowing for a more in-depth analysis of thermostat savings. Cadmus calculated savings for both programmable and smart thermostats together, in the HVAC Rebates program and the Smart Thermostats Rebate pilot. This methodology is described fully in the Smart Thermostats Rebate pilot chapter.

The Smart Thermostats Rebate pilot chapter also presents detailed savings for the 11 smart thermostats and 1,909 programmable thermostats that were accounted for in the HVAC Rebates program. Savings for these measures are summarized in Table 70 in that chapter. Table 41, above, also includes savings for these thermostats.

Weatherization Measures

In 2017, the Residential Heating and Cooling Rebate program included rebates for three weatherization measures—air sealing, wall insulation, and attic insulation. Table 49 shows the number of incented measures and adjusted gross savings. Due to the relatively small number of measures (n=102), Cadmus employed the same deemed values used to determine *ex ante* savings.

Table 49. Adjusted Gross Energy Savings (kWh) from Secondary Sources: Weatherization Measures

Measure	Incented Measures	Adjusted Gross UES Estimate	Total Adjusted Gross Savings
Air Sealing	47	671	31,556
Wall Insulation	13	2,568	33,389
Attic Insulation	42	1,037	43,549
Total	**102**	**--**	**108,495**

Demand Reduction Estimates from Ohio TRM Calculations

Cadmus used the Ohio TRM to calculate adjusted, gross, demand reduction estimates for most measures in the 2017 participant database (except ECM, thermostat, and weatherization measures). This did not deviate from the Ohio TRM's equations or assumptions for these measures, except for the following:

- To determine EER ratings for all incented and replaced equipment, Cadmus identified equipment in the AHRI-certified products directory using AHRI-certified reference numbers

(provided in program tracking data). If measures could not be located in the directory, Cadmus applied the following algorithm to the measure SEER rating:[19]

$$EER = -0.02 \times SEER^2 + 1.12 \times SEER$$

- The Ohio TRM did not include early replacement ASHP or GSHP measures. To calculate energy savings and demand reductions for these measures, Cadmus adapted the appropriate time-of-sale calculations to include the size and efficiency of replaced equipment.
- To calculate demand reductions for mini-split ACs and ASHPs, Cadmus applied the Ohio TRM demand reduction equation for time-of-sale, ENERGY STAR room ACs to 2017 program participants

Table 50 provides the resulting annual demand reduction, identified using Ohio TRM algorithms and assumptions.

[19] U.S. Department of Energy. *Building America House Simulation Protocols*. pp. 31. Revised October 2010. Available online: http://www.nrel.gov/docs/fy11osti/49246.pdf

Table 50. Adjusted Gross Demand Reduction (kW) from Ohio TRM Calculations

Measure	Incented Measures	Adjusted Gross UDR Estimate	Total Adjusted Gross Demand Reduction
ER AC 14/15 SEER	922	0.39	359.92
ER AC 16+ SEER	1,321	0.49	651.71
NC AC 14/15 SEER	53	0.09	4.72
NC AC 16+ SEER	45	0.18	7.93
RP AC 14/15 SEER	116	0.10	11.34
RP AC 16+ SEER	67	0.21	13.75
ER HP 14/15 SEER	179	0.36	63.68
ER HP 16+ SEER	467	0.72	337.51
NC HP 14/15 SEER	10	0.07	0.68
NC HP 16+ SEER	30	0.15	4.52
RP HP 14/15 SEER	18	0.07	1.25
RP HP 16+ SEER	44	0.18	7.79
ER GSHP 16/18 EER	12	0.20	2.42
ER GSHP 19+ EER	24	0.36	8.72
NC GSHP 16/18 EER	7	0.19	1.33
NC GSHP 19+ SEER	4	0.33	1.31
RP GSHP 19+ EER	5	0.44	2.20
NC MS AC 16+ SEER	19	0.11	2.07
NC MS HP 16+ SEER	165	0.58	95.31
RP MS HP 16+ SEER	1	0.18	0.18
Heat Pump Water Heater - Gas Home	2	0.28	0.56
Heat Pump Water Heater - Electric Home	19	0.18	3.42
Total	**3,530**	**--**	**1,582**

*Values in table may not sum exactly due to rounding.

Demand Reduction from Engineering Estimates

To calculate demand reductions from ECM measures, Cadmus used engineering estimates that accounted for the estimated capacity and airflow of the installed systems and the estimated difference in power draw of ECM motors per cubic feet per minute (CFM) airflow. Cadmus applied the 0.5 CF from the Ohio TRM to arrive at the adjusted gross demand reduction.

Demand reduction for ECM with New AC and ECM with New HP measures should be accounted for in demand reduction for the incented AC and HP units as SEER ratings account for ECM savings.

For air sealing, wall insulation, and attic insulation measures, Cadmus employed the same deemed values used to determine *ex ante* demand reduction, as shown in Table 51.

Table 51. Adjusted Gross Demand Reduction (kW) from Engineering Estimates

Measure	Incented Measures	Adjusted Gross Unit Demand Reduction Estimate	Total Adjusted Gross Demand Reduction
ECM	319	0.18	58.17
Air Sealing	47	0.01	0.36
Wall Insulation	13	0.06	0.73
Attic Insulation	42	0.02	0.96
Total	**421**	**--**	**60**

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Adjust *ex ante* savings for 2017 to omit separate savings for the ECM with New Air Conditioner and ECM with New Heat Pump measures.** The percentage of incented AC units installed with ECM furnaces has increased dramatically in the previous few years, increasing the impact of ECM blowers on savings of incented AC and HP units. As it is not practical to disaggregate these savings for each AC and HP measure, Cadmus recommends allowing the ECM with New AC and ECM with New HP measures to include savings from the ECM air handler. This would result in zero *ex ante* savings for ECM with New AC and ECM with New HP measures and avoids double-counting those savings.
- **Collect information about the home heating system for participants installing heat pump water heaters.** Heat pump water heaters installed in conditioned or partially conditioned spaces (such as basements) typically increase a home's heating load somewhat, which can offset energy savings. *Ex ante* and adjusted gross savings currently assume that a heat pump provides space heating in electrically heated homes Implementer tracking data did not indicate the type of electric heating system type in homes that installed domestic hot water heat pump. Cadmus recommends that DP&L instruct implementers to collect data on the types of heating systems present in homes. This information will inform savings calculations and may help identify educational needs for contractors and/or customers.

Residential Smart Thermostats Rebate Pilot

This chapter describes Cadmus' evaluation approach, detailed findings, conclusions, and recommendations for the Residential Smart Thermostats Rebate Pilot. The methodology used to calculate savings for all thermostats is described in this chapter. This methodology was used for the 1,909 programmable and 11 smart thermostats counted in the HVAC Rebates program as well as the 356 smart thermostats that were delivered via the HVAC Rebates program but whose savings were counted in the Smart Thermostats Rebate Pilot.

Evaluation Overview

To evaluate the 2017 Residential Smart Thermostat Rebate Pilot and thermostats delivered via the HVAC Rebates Program, Cadmus followed the evaluation activities and researchable questions outlined in Table 52.

Table 52. Key Researchable Questions

Researchable Question	Activity Used to Address Question
What are the pilot's gross electric savings and peak demand reductions?	• Program database review • Engineering calculations
What changes to pilot design and delivery would improve performance?	• Program and implementation staff interviews • Participant customer surveys • Program database review
What is customer satisfaction with the pilot?	• Participant customer surveys
Is this pilot cost-effective?	• Cost-effectiveness analysis

During the 2016 program year, all thermostats in the DP&L portfolio were delivered through the Residential Heating and Cooling Rebate program (HVAC Rebate). Each thermostat, installed with an AC or HP, was evaluated using known characteristics of equipment installed at each site in the HVAC Rebates program. The 2017 program year introduced four additional channels for smart thermostats: Rebates for Retail; DP&L Online Store; Nest Online Store; and Interstate Gas Supply, Inc. (IGS Energy). The Pilot Design section below reviews delivery mechanism details for all five channels.

Detailed Evaluation Findings

The Smart Thermostats Rebate Pilot achieved 1,722,140 kWh in verified gross savings through 5,041 rebated measures. *Ex ante* savings were 1,727,141 kWh. Verified gross savings, compared to *ex ante* savings, represented a realization rate of 99.7% for energy. Cadmus did not calculate demand savings for smart thermostats.

Table 53 presents pilot *ex ante* claimed, verified gross, and adjusted gross savings and demand reduction. These are divided by channel for the Smart Thermostats Rebate Pilot (including HVAC Rebates thermostats receiving the $75 pilot rebate). Key evaluation findings follow.

Savings for the 1,909 programmable and 11 smart thermostat measures delivered as part of the HVAC Rebates program are presented in the HVAC Rebates program chapter, Table 41.

Table 53. Smart Thermostat Pilot Claimed and Achieved Energy Savings

Measure	*Ex Ante* Claimed		Verified Gross		Adjusted Gross		
	kWh	kW	kWh	kW	kWh	kW	Precision
Nest Online	1,270,512	181.03	1,269,474	180.88	959,449	0	78.7%
Rebates for Retail	304,134	43.33	301,366	42.94	295,052	0	2.4%
DP&L Online Store	32,524	4.63	31,486	4.49	24,291		78.7%
IGS Energy	13,840	1.97	13,840	1.97	5,439	0	78.7%
Smart Thermostat with AC (Smart Thermostats Pilot rebate)	42,731	13.36	42,573	13.31	76,148	0	3.0%
Smart Thermostat with HP or GSHP (Smart Thermostats Pilot rebate)	63,400	4.19	63,400	4.19	60,231	0	4.1%
Smart Thermostats Rebate Total*	**1,727,141**	**249**	**1,722,140**	**248**	**1,420,611**	**0**	**53.2%**

*Values in table may not sum exactly due to rounding.

- Average verified gross savings per site for thermostats from the Smart Thermostat Rebate channels ranged from 136 kWh for the IGS Energy channel to 336 kWh for the Rebates for Retail channel. The Nest Online Store channel delivered the greatest savings, achieving 959,449 kWh and rebating 3,672 smart thermostats in 2017.
- Average savings per site for thermostats from the HVAC Rebates program ranged more widely, from 281 kWh to 709 kWh. This greater disparity existed because these measures were split out by HVAC system type, rather than averaged together across the channel as was the case with the Smart Thermostat Rebate channels.
- The online survey conducted with 315 participants showed that respondents most commonly reported learning about the Residential Smart Thermostat Rebate Pilot from a DP&L email (42%) or Nest promotion (28%).
- Surveyed participants gave the pilot high average satisfaction scores. They rated the program overall, the rebates they received, and the smart thermostats they received an average of 9.5, 9.4, and 9.3, respectively, on a scale of 0 to 10.

Evaluation Data Collection Methods

In evaluating the 2017 pilot, Cadmus used the approaches detailed below.

Stakeholder Interviews

Cadmus conducted two stakeholder interviews with the program implementer and DP&L staff to understand program design, goals, implementation and delivery, and marketing.

Participant Survey

Cadmus conducted an online participant survey with 311 recipients of a smart thermostat through four channels: Rebates for Retail, DP&L's Online Store, Nest Online, and the Heating and Cooling Rebates program. Cadmus gathered information in the following categories to use for the impact and process evaluations:

- Baseline thermostat type
- Smart thermostat installation
- Heating and cooling equipment and home characteristics
- Usage patterns for previous and existing thermostats
- Program awareness and motivation for making an upgrade
- Experience with smart thermostat installation
- Satisfaction with the program, rebates, and measures

Engineering Analysis

Cadmus performed an engineering review incorporating the Ohio TRM and including additional primary and secondary sources as needed to supplement the TRM guidelines. Cadmus used engineering calculations to evaluate savings for each individual thermostat delivered as part of the Smart Thermostat Rebate Pilot, often using data from some channels to calculate savings in other channels.

Program Database Review

Cadmus reviewed the final 2017 tracking database for input, accuracy, and completeness of data tracked, and to determine whether the database contained the following:

- Data necessary to calculate collected savings
- Reported savings estimates that matched the measure types
- Existing and installed equipment types that met the measure requirements
- Home addresses that received thermostats in DP&L territory
- Accurate categorization of thermostat types

Process Evaluation Methodology and Findings

Cadmus conducted the following process evaluation activities to assess the Residential Smart Thermostat Rebate Pilot:

- Stakeholder interviews (n=2)
- Participant online surveys (n=311)

Stakeholder Interview Findings

Pilot Design

The pilot offered five channels for obtaining a smart thermostat: Rebates for Retail; DP&L's Online Store; Nest; IGS Energy; and through the Heating and Cooling Rebates program. Descriptions of the channels follow:

- **Rebates for Retail:** Customers could purchase qualifying thermostats through participating retailers (either in-store or online), then complete rebate applications in paper or online. EFI processed the applications and sent the customer a rebate check or pre-paid Visa® card for $75.
- **DP&L Online Store:** Customers were directed through the DP&L website to set up an account and receive an instant $75 rebate for qualifying thermostats.
- **Nest:** The Nest channel offered two rebates: for electric-only DP&L customers; and for electric and gas DP&L and Vectren Ohio customers. Electric customers received a coupon code in their email from Nest and DP&L. They followed the link to receive an instant $75 off qualifying thermostats. Dual-fuel customers could receive an instant rebate of $150 from both DP&L and Vectren Ohio by going to the Nest website and entering their Vectren account number (validated by Vectren).
- **IGS Energy:** IGS Energy, an independent retail energy supplier, offered free smart thermostats as a promotional item to customers signing up for their services in DP&L territory. IGS Energy purchased and distributed the thermostats to customers, and DP&L reimbursed IGS Energy the $75 rebate amount.
- **Residential Heating and Cooling Rebate Program:** Participants in the Residential Heating and Cooling Program could purchase smart thermostats through a contractor and apply for a rebate. The contractor validated that the smart thermostat model was on the list of eligible products, installed the thermostat for the customer, and submitted the rebate application. The customer received the rebate.

A qualifying product list (QPL) developed by DP&L and Vectren Ohio, containing 19 models, dictated which thermostats were eligible for distribution through the above channels. The QPL was the same for all channels, except Nest offered only Nest thermostats. For the 2018 program year, the QPL will be updated to include only ENERGY STAR® smart thermostat models, and customers will be limited to purchasing one thermostat.

In the 2018 program year, DP&L plans to reduce the rebate from $75 to $50 (and from $150 to $100 for dual-fuel customers). The IGS Energy channel probably will not be offered again due to low participation.

Pilot Goals and Outcomes

DP&L and CLEAResult reported that the main objective of the Residential Smart Thermostat Rebate Pilot was to reduce the price of smart thermostats and increase their adoption within DP&L's territory.

Pilot Implementation and Delivery

CLEAResult implemented the pilot, overseeing sales, merchandising, incentive processing, and invoicing for all the channels, except IGS Energy (e.g., Rebates for Retail, DP&L's Online Store, Nest, and Heating and Cooling Rebates). EFI served as the incentive processer, handling rebate processing for the Rebates for Retail channel, and running the DP&L Online Store. EFI sent CLEAResult weekly invoices, and CLEAResult could access an online portal for customer data.

Vectren Ohio and DP&L offered a joint rebate for thermostats purchased through the Nest channel. Vectren validated customers' account numbers, and CLEAResult processed the Nest rebates. CLEAResult reported frequent interactions with Nest to review sales and promotions, ensure up-to-date customer files, and validate customer account numbers. CLEAResult could access an online portal for the Nest channel, which provided real-time sales reporting. CLEAResult reported that Nest invoices were slow to process, and they would prefer more timely invoicing. CLEAResult also reported that, due to the quantity of models on the QPL, they faced difficulty in determining which thermostats qualified; a simplified list would make this easier.

DP&L and CLEAResult maintained regular communications, holding biweekly meetings to discuss program updates, sales, and goals. CLEAResult invoiced DP&L weekly. Neither DP&L nor CLEAResult reported issues with communications.

Pilot Marketing

DP&L was largely responsible for marketing smart thermostats, using email blasts, social media, banner ads on its website, bill inserts, and promotional flyers. CLEAResult assisted with promotional materials in stores (for the Rebates for Retail channel) and some social media content in the beginning of the pilot year. DP&L and CLEAResult slowed down marketing activities once high participation through the Nest channel proved sufficient for achieving pilot goals.

DP&L and CLEAResult did not have specific customer segment or demographic goals for the pilot. CLEAResult believed awareness was very high, as seen from robust participation in 2017. Email was a major focus for marketing: after sending out promotional emails, sales increased.

Participant Survey Findings

Cadmus fielded online surveys from 315 DP&L residential customers who received a rebate for installing smart thermostats through the pilot as of January 30, 2018. Cadmus grouped survey responses by the

channel through which respondents received rebates, evaluating and comparing customer experiences. Cadmus surveyed participants from the following four channels:

- Rebates for Retail
- DP&L Online Store
- Nest
- Residential Heating and Cooling Rebate Program (HVAC Program)

Customers participating through the IGS Energy channel were not surveyed as smart thermostat distribution through this channel was completed after launching the participant survey.

Cadmus sought to achieve the following objectives through the surveys:

- Gauge participant awareness of and motivation to purchase smart thermostats
- Evaluate participant satisfaction with smart thermostats and installation experiences
- Understand participants' usage of their previous and current thermostats
- Assess how participation affected participants' satisfaction with DP&L

Table 54 shows the numbers of customers contacted and surveys completed through each smart thermostat distribution channel.

Table 54. Participant Survey Respondent Distribution by Channel

Channel	Customers Contacted	Surveys Completed
Nest	1,556	213
Rebates for Retail	393	66
DP&L Online Store	100	24
HVAC Program	103	12
Total		**315**

Due to the limited numbers of responses for the DP&L Online Store and HVAC Program channels, these results did not prove statistically significant for these channels, and results should be interpreted anecdotally.

Participant Awareness and Motivation

Survey respondents heard about the Residential Smart Thermostat Rebate Pilot through a variety of marketing and outreach channels, depending on their purchase channels:

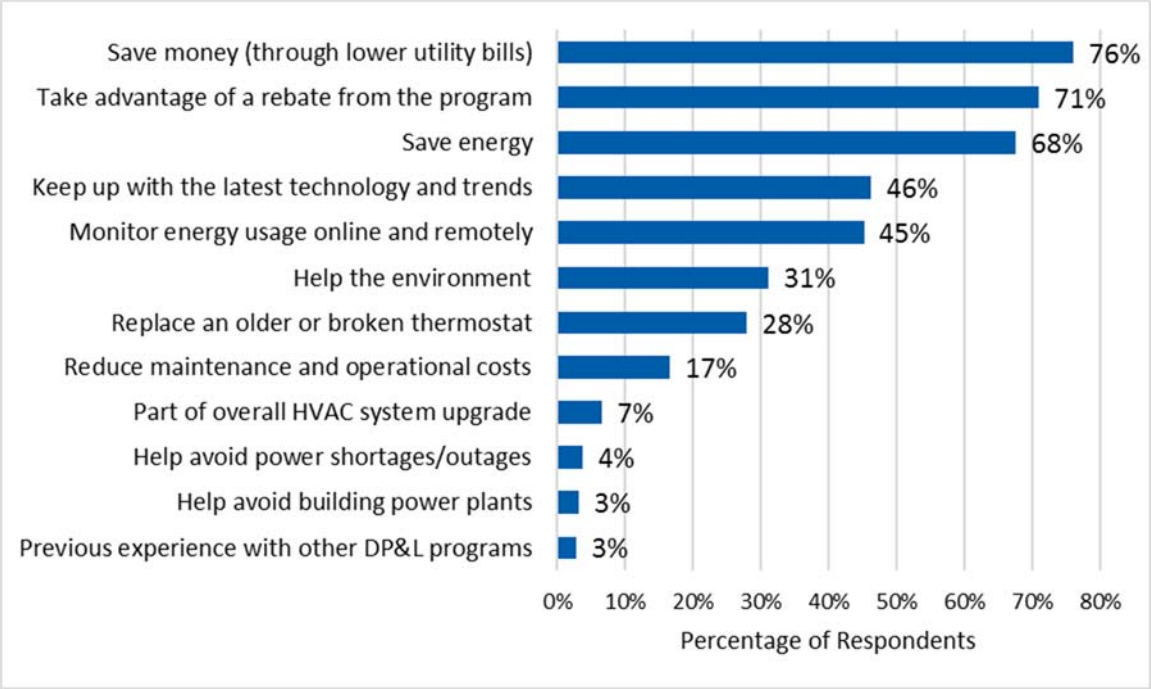
- 75% of Nest respondents (n=212) heard about the pilot via a DP&L promotional email or through a Nest promotion
- 52% of Rebates for Retail respondents (n=64) heard about the pilot via a Nest promotion or word of mouth
- 65% of DP&L Online Store respondents (n=23) heard about the pilot via DP&L's website or a DP&L email

- 92% of HVAC program respondents (n=12) heard about the program from their contractors

Overall, survey respondents most commonly reported that they heard about the Residential Smart Thermostat Rebate Pilot from a DP&L email (42%) or Nest promotion (28%) (n=311).

As shown in Figure 9, respondents were motivated to purchase a new smart thermostat primarily as they wanted to save money through lower utility bills (76%), take advantage of the rebate (71%), or save energy (68%). Almost one-half of respondents also liked keeping up with the latest technology and trends (46%) or monitoring their energy usage online and remotely (45%).

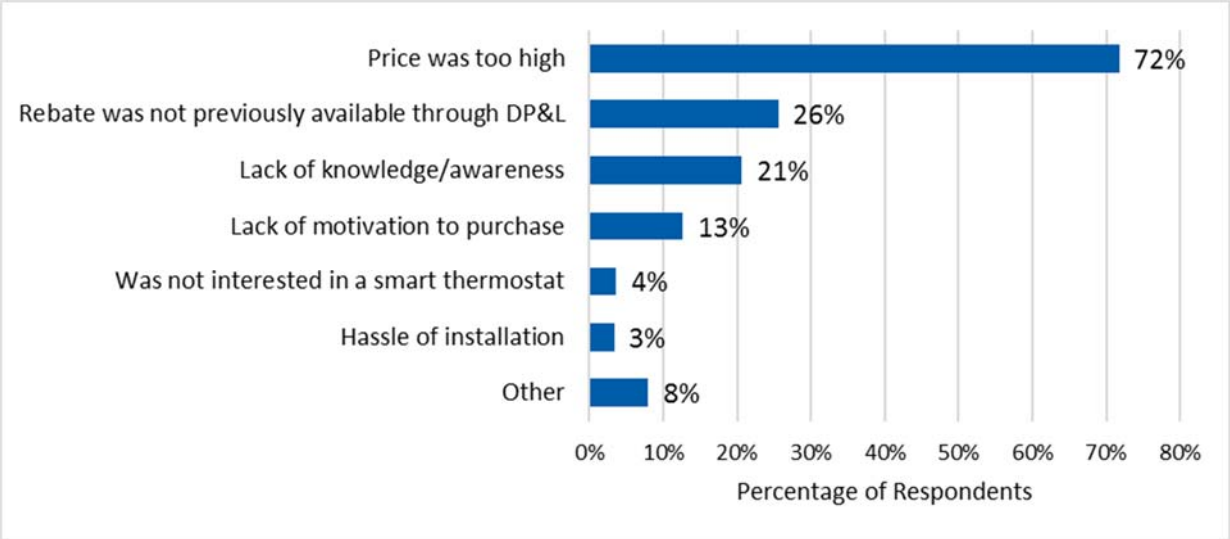
Figure 9. Motivation to Purchase Smart Thermostats



Source: 2017 Smart Thermostat Rebates Program Participant Online Survey, Question C2: "What factors motivated you to purchase a smart thermostat through Dayton Power and Light's Residential Smart Thermostat Rebate Program?" Multiple responses allowed (n=314)

Figure 10 shows that most respondents had not previously purchased a smart thermostat as prices were too high (72%) and/or a rebate was not previously available through DP&L (26%). Nearly one-fourth of respondents (24%) indicated they did not know about, were not aware of, or were not previously interested in smart thermostat technology.

Figure 10. Reasons for Not Previously Purchasing Smart Thermostats



Source: 2017 Smart Thermostat Rebates Program Participant Online Survey, Question C3: "What prevented you from purchasing a smart thermostat until now?"
Multiple responses allowed (n=301)

Thermostat Installation Experience

Of smart thermostats purchased by survey respondents, 96% were reported as installed. The remaining thermostats not installed were given away as gifts (2%) or stored for later use (1%). One respondent returned a thermostat to Nest as it originally sent the incorrect model. Eleven percent of respondents purchased two smart thermostats through the pilot, and all installed at least one thermostat, either in their homes or in other homes or locations.

Nineteen percent of respondents (n=300) reported encountering challenges while installing their thermostats—a trend reported whether the respondents installed their thermostats themselves or had contractors install them. Among respondents encountering challenges, 72% had trouble with wiring, including being unable to connect units to existing furnaces or heat pumps. The remaining challenges consisted primarily of receiving a faulty unit or addressing cosmetic issues with walls on which thermostats were installed.

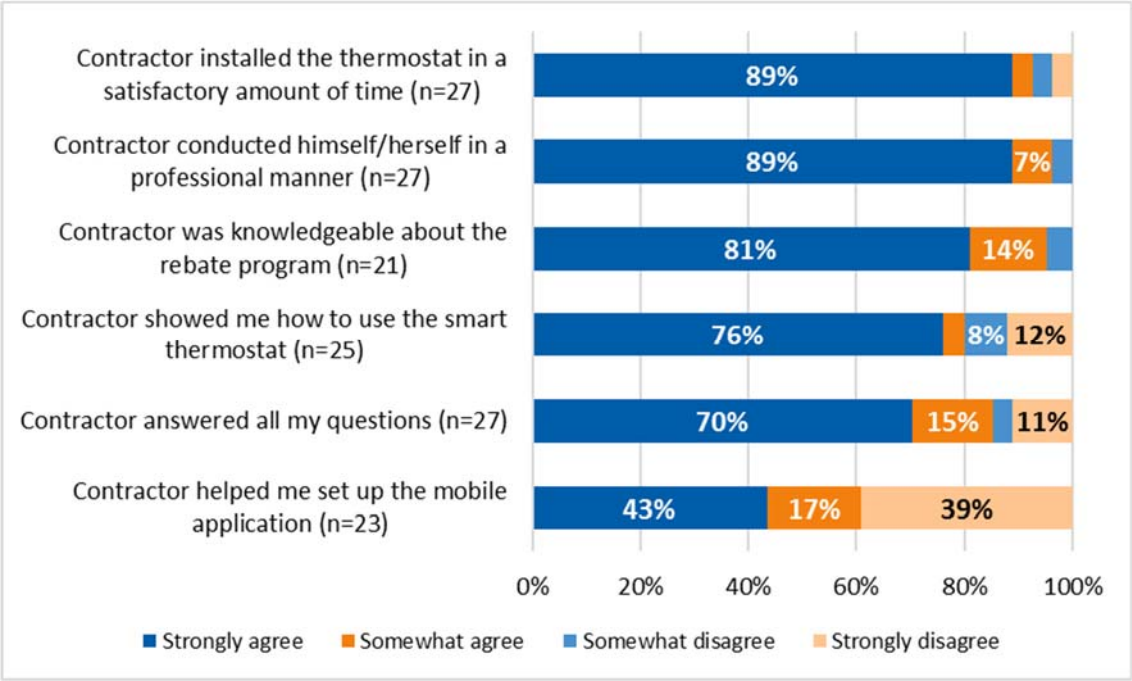
Among the 34 respondents having contractors install their new smart thermostats, 12 participated in the HVAC program. Two of these respondents reported experiencing challenges during installation, both related to their smart thermostats not working properly. Nine HVAC program respondents were home while their contractors installed their smart thermostats, and all strongly agreed that their contractors were knowledgeable, conducted themselves professionally, showed the respondents how to use their smart thermostats, answered all questions, and installed the smart thermostats in a satisfactory amount of time. Four respondents strongly agreed that their contractors helped them set up their mobile applications, though two agreed somewhat, and three did not know or preferred not to answer. Overall,

12 HVAC program respondents with contractors installing their smart thermostats gave their installation experience an average satisfaction rating of 9.5.[20]

Among respondents purchasing and installing a smart thermostat through a channel other than the HVAC program (n=301), 89% installed new smart thermostats on their own (or had someone in their household install them), and 7% had contractors install them.[21] Survey data suggests that respondents installing thermostats on their own did so more quickly than contractors: 54% of those installing thermostats themselves said it took less than 30 minutes, compared to 45% for those using contractors.[22]

Cadmus asked respondents with thermostats installed by contractors how much they agreed with a series of statements about their contractors; Figure 11 shows the results.

Figure 11. Participant Satisfaction with Installation Contractors



Source: 2017 Smart Thermostat Rebates Program Participant Online Survey, Question D12: "Please select a rating for the following elements of the installation process. The contractor who installed the smart thermostat…"

[20] On a scale of 1 to 10, where 1 was "not at all satisfied" and 10 was "very satisfied."

[21] Contractors installed new smart thermostats for all respondents participating through the HVAC Program.

[22] The limited number of respondents with contractors installing their thermostats suggests conclusions for this subset should be interpreted anecdotally.

Respondents generally agreed that contractors who installed their thermostats did so in a satisfactory amount of time, conducted themselves in a professional manner, and were knowledgeable about the program. Most respondents also said their contractors showed them how to use their smart thermostats and answered all the questions they had, although a larger portion of respondents (15% to 20%) somewhat or strongly disagreed with these statements specifically. Finally, less than one-half of respondents (n=23) strongly agreed that their contractors helped them set up their mobile applications. Among six respondents from the HVAC channel, only one strongly disagreed with the statement.

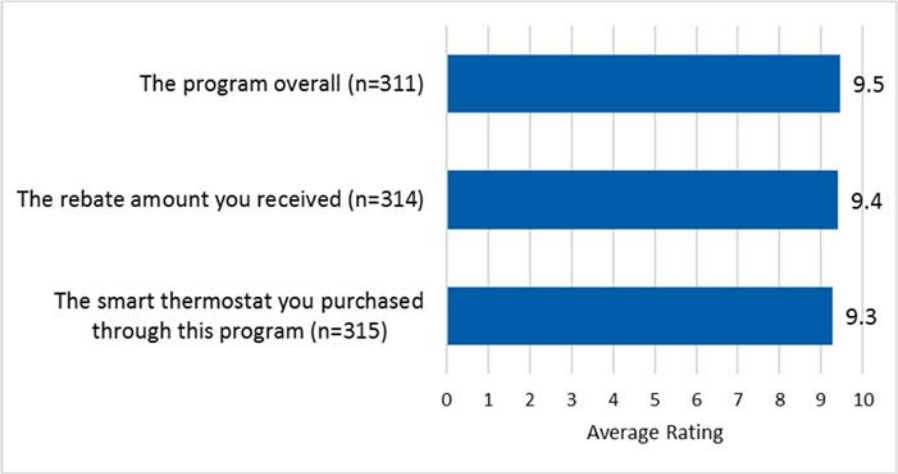
On a scale of 1 to 10, where 1 meant "not at all satisfied" and 10 meant "very satisfied," all respondents with smart thermostats installed by a contractor gave an average satisfaction rating of 9.0 to the process of scheduling an appointment with the contractor and an average satisfaction rating of 8.9 to their overall satisfaction with their contractors. Twelve HVAC channel participants offered average satisfaction ratings of 9.6 and 9.5, respectively. Respondents not satisfied with the installation experience offered the following feedback:

- "Unhappy we had to schedule service versus doing it ourselves."
- "Contractor had to look it up online."
- "They were able to wire it, but didn't know how to program it."

Participant Satisfaction

Cadmus asked respondents about their satisfaction with various elements, using a scale of 1 to 10. Respondents were satisfied with their smart thermostats, rebate levels, and the overall offering, as shown in Figure 12.

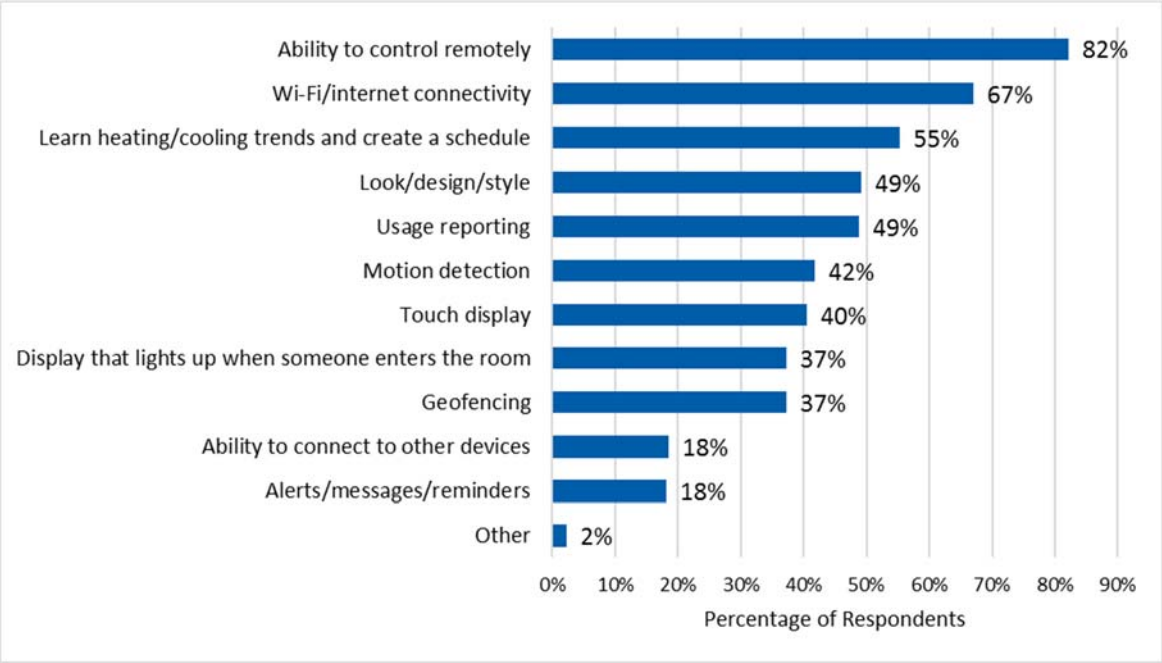
Figure 12. Satisfaction with Elements of Pilot



Source: 2017 Smart Thermostat Rebates Program Participant Online Survey, Question E1: "On a scale of 0 to 10, where 0 means 'not at all satisfied' and 10 means 'very satisfied,' how satisfied are you with…"

Cadmus also asked respondents for their favorite features of their new smart thermostats. As shown in Figure 13, respondents mostly highly favored the ability to control their smart thermostats using a mobile application's web browser (82%), the smart thermostat's Wi-Fi/Internet connectivity (67%), and the smart thermostat's ability to learn home heating/cooling trends and create a heating/cooling schedule (55%). Respondents least frequently cited the smart thermostat's ability to connect to other devices (18%) and to deliver alerts/messages/reminders (18%) as their favorite features.

Figure 13. Favorite Features of Smart Thermostats



Source: 2017 Smart Thermostat Rebates Program Participant Online Survey, Question E3: "What are your favorite features in your new smart thermostat(s)?" Multiple responses allowed (n=309)

Almost all respondents indicated they were more satisfied (56%) or just as satisfied (43%) with DP&L after participating in the pilot, while less than 1% of respondents said they were less satisfied. Dissatisfied respondents provided the following feedback:

- "Wouldn't work with our furnace."
- "It randomly changes the set temperature, and we don't know why."
- "I'm not that interested in all of the technology. It isn't very user friendly."
- "Would have liked to see a higher-value rebate or a lower-priced item."

Similarly, almost all respondents were very likely (90%) or somewhat likely (9%) to recommend the pilot to a friend, neighbor, or coworker, while less than 1% were very unlikely to do so.

Impact Evaluation Methodology and Findings

Pilot Database Review

The Smart Thermostat Rebate Pilot channels contained different types of data about sites receiving thermostats and their associated HVAC equipment. Table 55 shows what types of data fields were available across the channels' tracking data files, and shows the number of smart thermostats delivered through each channel. In total there were 5,052 smart thermostats delivered, including the 11 smart thermostats delivered through and accounted for in the HVAC Rebates program, and the 356 smart thermostats also delivered through the HVAC Rebates program but accounted for in the Smart Thermostats Pilot program. Table 55 also notes the 1,909 programmable thermostat measures delivered through the HVAC Rebates program.

Table 55. Data Available for Smart Thermostat Delivery Channels

Tracking Data Field		HVAC Rebates	Rebates for Retail	IGS Energy	Nest Online Store	DP&L Online Store
Smart Thermostat Count		367	879	40	3,672	94
Percent of Total Smart Thermostats Rebated		7.3%	17.4%	0.8%	72.7%	1.9%
Programmable Thermostat Count		1,909				
Address		X	X	X	X	X
Home Size			X	X		
Previous Thermostat Type		X	X			
CAC	Presence	X	X	X		
	Capacity	X*	X**			
	SEER	X*	X**			
Electric Resistance Heat	Presence		X	X		
ASHP	Presence	X	X			
	Capacity	X*				
	SEER	X*				
	HSPF	X*				
GSHP	Presence	X	X			
	Capacity	X				
	EER	X				
	COP	X				

*32 HVAC sites with CACs or ASHPs only received thermostats, so their HVAC system information is unknown.
**Only 318 of 724 Retail Rebate sites with CACs also had CAC capacity and SEER indicated in the tracking data

The HVAC Rebates and Rebates for Retail channels contained a wide variety of participant data on home characteristics and HVAC system for sites receiving a thermostat. The IGS Energy channel also contained data on site locations, home size, the presence of a CAC, and the presence of electric resistance heat.

The Nest Online Store and DP&L Online Store channels, which comprised 60% of all smart thermostats delivered, did not include participant data other than home address.

Engineering Calculations

The Ohio TRM does not provide savings values or equations for programmable and smart thermostats. Cadmus based savings calculations on the equations and assumptions discussed below. Each equation was designed to calculate estimated baseline energy use for heating or cooling, and then apply the appropriate energy savings factor (ESF) to estimate savings. The estimated baseline energy use for a given site is equal to its HVAC system peak load (in kW) multiplied by the full load hours for its region. The ESF represents the percentage of heating or cooling energy use that the thermostat would be expected to save, and is based on empirical data.

A given site's estimated peak load is dependent on its HVAC system type, size, and efficiencies. As noted, this information was generally available only for the HVAC Rebates channel, somewhat less available for the Rebates for Retail and IGS Energy channels, and generally unavailable for the Nest and DP&L Online Store channels. Therefore, peak loads often were averaged and applied across channels using various methods. The sections below detail general savings equations and then methods used to apply data across channels to calculate savings for each channel.

Electric Heating Savings

Cadmus calculated electric heating savings using the following equation for sites with electric resistance heat:

$$\Delta kWh = \frac{Hcap}{3.412} * FLHheating * ESFheating$$

Where:

Hcap	=	Heating capacity of system, in kBtu/h
3.412	=	Conversion from kBtu/h to watts, in (kBtu/h)/kW
FLHheating	=	Full-load heating hours, in hr
ESFheating	=	Heating ESF

Cadmus calculated electric heating savings using the following equation for sites with ASHPs:

$$\Delta kWh = \frac{Hcap}{HSPF} * FLHheating * ESFheating$$

Where:

HSPF = HSPF of heating system, in kBtu/h

Cadmus calculated electric heating savings using the following equation for sites with GSHPs:

$$\Delta kWh = \frac{Hcap}{COP * 3.412} * FLHheating * ESFheating$$

Where:

COP = HSPF of heating system

Cooling Savings

Cadmus calculated cooling using the following equation for CACs and ASHPs:

$$\Delta kWh = \frac{Ccap}{SEER} * FLHcooling * ESFcooling$$

Where:

Ccap = Cooling capacity of the system, in kBtu/h

SEER = SEER of the cooling system, in (kBtu/h)/kW

FLHcooling = Full-load cooling hours, in hr

ESFcooling = Cooling ESF

Cadmus calculated cooling using the following equation for GSHPs:

$$\Delta kWh = \frac{Ccap}{SEER} * FLHcooling * ESFcooling$$

Where:

EER = SEER of the GSHP

Full Load Heating and Cooling Hours

Full load heating and cooling hours (FLH) depend on local weather and, therefore, on the system location. The Ohio TRM provides a table of these values for various locations across Ohio, listing a value of 631 cooling hours and 1,438 heating hours for Dayton. However, the same adjustments to cooling hours discussed in the Residential Heating and Cooling Rebate Program section were made. In addition, 153 sites were located closer to Cincinnati or Columbus than to Dayton, and these sites used FLH corresponding to those cities. Table 56 presents values for FLH.

Table 56. Full Load Heating and Cooling Hours

City	$FLH_{HEATING}$	$FLH_{COOLING}$
Cincinnati	1,394	996
Columbus	1,272	828
Dayton	1,438	947

Energy Savings Factor Values

Savings factors depend on the type of thermostat upgrade. The initial thermostat type (manual, programmable, or smart) was an available data field for the HVAC Rebates and Rebates for Retail channels, but was not available for the other three channels. Therefore, seven upgrade scenarios are possible. Table 57 outlines these scenarios and their prevalence in the tracking data.

Table 57. Thermostat Upgrade Scenarios and Prevalence

Upgrade Thermostat	Baseline Thermostat	HVAC	Rebates for Retail	IGS	Nest	DPL Store
Smart	Manual	696	330	-	-	-
	Programmable	1,091	384	-	-	-
	Smart	-	152	-	-	-
	Unknown	23	13	40	3,672	94
Programmable	Manual	254	-	-	-	-
	Programmable	206	-	-	-	-
	Unknown	6	-	-	-	-

Each of these upgrade scenarios has its own ESF, as detailed below.

Cadmus examined ESF values from two studies, based on billing analyses, metering, and participant surveys Cadmus conducted outside of its work for DP&L. The first three rows of Table 58 display these ESFs (for upgrading from manual to smart and manual to programmable thermostats). Cadmus used an average of the two ESF heating values, as shown in the table's fourth row. For upgrades from programmable thermostats to smart thermostats, Cadmus used the difference between the two other upgrade scenarios, as shown in the table's fifth row.

Table 58. ESF Values for Programmable and Smart Thermostats

Row Reference	Thermostat Replacement	Source / Note	$ESF_{HEATING}$	$ESF_{COOLING}$
A	**Manual to Smart**	Cadmus, 2015* Tables 14 and 16	**12.5%**	**13.9%**
B	Manual to Programmable		5.0%	13.1%
C	Manual to Programmable	RLW Analytics, 2007** Table Ex 1	6.8%	N/A
D	**Average Manual to Programmable**	Average of rows B and C	**5.9%**	**13.1%**
E	**Programmable to Smart**	Difference between manual to programmable and manual to smart	**6.6%**	**0.8%**

*Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. Prepared for Vectren Corporation. January 29, 2015.

**RLW Analytics. *Validating the Impact of Programmable Thermostats.* January 2007.

Boldface values in Table 58—in rows A, D, and E—indicate the ESFs used in the savings analysis for smart thermostats. They apply to delivered thermostats with a known baseline thermostat type—all thermostats from the Rebates for Retail channel and nearly all from the HVAC Rebates channel. The remaining 57% of 2017 thermostat upgrades, however, came from sites with unknown baseline thermostat types. To calculate ESFs for these sites, Cadmus used weighted averages based on program data and participant survey results, as shown in Table 59.

Table 59. Weighted Average ESFs for Sites with Unknown Baseline Thermostats

Count Source	New Thermostat	Baseline Thermostat			$ESF_{HEATING}$	$ESF_{COOLING}$
		Type	Count	%		
Participant Survey	Smart	Manual	124	39.6%	12.5%	13.9%
		Programmable	183	58.5%	6.6%	0.8%
		Smart	6	1.9%	0.0%	0.0%
HVAC Rebates Program Data	Programmable	Manual	254	55.2%	5.9%	13.1%
		Programmable	206	44.8%	0.0%	0.0%

Cadmus used these weightings to derive the final ESFs for sites with unknown baseline thermostats, as shown in Table 60. For all upgrades from a programmable thermostat to a programmable thermostat, or from a smart thermostat to a smart thermostat, Cadmus applied ESF values of 0.0%.

Table 60. ESF Values for Sites with Unknown Baseline Thermostats

Thermostat Replacement	Source / Note	$ESF_{HEATING}$	$ESF_{COOLING}$
Unknown Thermostat to Smart Thermostat	Average of ESFs for manual and programmable to smart weighted by participant survey results	8.8%	6.0%
Unknown Thermostat to Programmable Thermostat	Average of ESFs for manual and programmable to programmable weighted by HVAC Rebates program data	3.3%	7.2%

Baseline Load Calculation Overview

When calculating baseline heating and cooling consumption for each site, Cadmus required information on each site's HVAC system. As discussed previously and shown in Table 55, however, most sites receiving thermostats did not contain a complete set of information. Consequently, Cadmus averaged available data and applied it across channels using the methods described below. These methods were used to calculate peak loads for each site, which were then multiplied by EFLH values to produce estimated baseline consumption values.

Six relevant HVAC system scenarios had to be referenced when discussing baseline consumptions for these sites, as shown in Table 61. The table includes population splits for the Rebates for Retail channel, derived from program data, and for the rest of the channels, derived from 2017 participant surveys.

Table 61. Baseline Consumption Scenarios and Population Splits

Cooling	Heating	Rebates for Retail Data		2017 Participant Survey*	
		Count	%	Count	%
CAC	Non-electric	664	79.2%	208	84.2%
ASHP	ASHP	87	10.4%	9	3.6%
CAC	Electric resistance	60	7.2%	18	7.3%
None	Non-electric	9	1.1%	6	2.4%
GSHP	GSHP	11	1.3%	4	1.6%
None	Electric resistance	7	0.8%	2	0.8%

*Excludes the Rebates for Retail channel

HVAC Rebates Channel Peak Load Calculation

The HVAC Rebates channel included all the information required to calculate cooling loads for all but 32 sites with CACs, ASHPs, and GSHPs. The remaining 32 sites received thermostats but no HVAC equipment; while their HVAC equipment types were known from their assigned measure name, their capacities and efficiencies (e.g., SEER, HSPF) remained unknown. The methods used to fill in data gaps for these sites are described in Table 62.

The HVAC Rebates sites that received ASHPs or GSHPs included most information required to calculate heating loads. It was assumed that the heat pumps at these sites provided all heating, and the methods used to fill in data gaps for these sites are also described in Table 62. Note that in cases where the heat

pumps were not upgraded as part of the HVAC Rebates program, average existing efficiencies were used.

Heating systems for HVAC Rebates sites with CACs remained unknown. In particular, it was not known if a given site had ERH or not, and if so what the capacity of that system was. To address the first issue, Cadmus used 2017 participant survey results (Table 61) indicating that 8.0% of surveyed sites with CACs also had ERH. To address the second issue, Cadmus assumed that the ERH system's heating capacity equaled the heating capacity of an average HVAC Rebates site with an ASHP.

Table 62. Base Load Approaches for HVAC Rebates Channel

System	Capacity & Efficiency	Base Load Calculation Approach		Thermostat Count
		Cooling	Heating	
CAC	Known	Used known information	Per participant survey, assume 8% of sites have ERH. Assume ERH capacity is equal to average ASHP capacity.	1,613
	Unknown*	Used average HVAC Rebates CAC size, average Rebates for Retail CAC SEER		27
ASHP	Known	Used known information		562
	Unknown*	Used average HVAC Rebates ASHP size and existing SEER	Used average HVAC Rebates ASHP size. Used average HVAC Rebates installed HSPF, normalized by existing and installed SEER.	5
GSHP	Known	Used known information		34
ASHP + CAC	Known	One site received two thermostats, a CAC, and an ASHP. Assumed one thermostat controls each unit, and used the above assumptions.		2
Second thermostat at sites with two		See In Service Rates and Multi-Thermostat Sites section		33

*Sites with unknown HVAC system information received only a thermostat, and therefore the efficiency values chosen reflect non-upgraded equipment

Rebates for Retail Channel Peak Load Calculation

Some sites from the Rebates for Retail channel (i.e., 318 out of 879) included complete information on their CAC unit. Cadmus used this information to calculate their baseline cooling loads. The other sites with CACs and all sites with HPs did not contain capacity or efficiency information. Consequently, Cadmus pulled average capacities and efficiencies for these sites from the HVAC Rebates program. Details for these methods can be seen in Table 63.

Unlike the HVAC Rebates program, it was known if each Rebates for Retail site with a CAC had ERH or non-electric heat. For sites with ERH, it was again assumed that the ERH capacity matched the heating capacity of the average HVAC Rebates site with an ASHP.

Table 63. Base Load Approaches for Rebates for Retail Channel

System	Capacity & Efficiency	Load Calculation Approach		Thermostat Count
		Cooling	Heating	
CAC, non-electric heat	CAC info known	Used known information	No heating	298
	Unknown	Used average Rebates for Retail CAC capacity and SEER		366
CAC + ERH	CAC info known	Used known information	Assumed ERH capacity was equal to average Rebates for Retail ASHP capacity	20
	Unknown	Used average Rebates for Retail CAC capacity and SEER		40
ERH only	Unknown	No cooling		7
ASHP	Unknown	Used average HVAC Rebates ASHP capacity* & existing SEER	Used average capacity* and installed HSPF of ASHPs from HVAC Rebates sites. HSPF was normalized by average existing and installed SEER, from same.	87
GSHP	Unknown	Used average capacity,* SEER, and HSPF from HVAC Rebates sites		11
No CAC, non-electric heat		No electric HVAC load		9
No system info		Average of other scenarios		13
Second thermostat at sites with two		See In Service Rates and Multi-Thermostat Sites section		28

*Capacities were normalized by average home size for the HVAC Rebates (1,861 sq ft, from participant survey) and Rebates for Retail (2,064 sq ft, from program data) channels

Table 64 shows average peak loads for the Rebates for Retail channel for all six HVAC system scenarios outlined in Table 61. The table illustrates how much higher the peak heating load was than the peak cooling load for sites with HPs or ERH. Heating consumption was higher still since full load heating hours were much higher than full load cooling hours. Overall heating consumption, however, approximately equaled overall cooling consumption as only 20% of Rebates for Retail sites had HP or ERH for heating.

Table 64. Average Peak Loads for Rebates for Retail Channel

Cooling	Heating	Average Cooling Peak Load (kW)	Average Heating Peak Load (kW)
CAC	Non-Electric	2.565	0.000
ASHP	ASHP	3.813	7.051
CAC	Electric Resistance	2.488	11.633
None	Non-Electric	0.000	0.000
GSHP	GSHP	4.383	4.961
None	Electric Resistance	0.000	11.633

IGS Energy Channel Peak Load Calculation

For the IGS channel, the known data included the following: whether or not each site had a CAC; each site's heating fuel (39 gas and one electric), and the site size. Table 65 shows details for peak load calculations for the IGS Energy channel.

Table 65. Base Load Approaches for IGS Energy Channel

System	Capacity & Efficiency	Load Calculation Approach		Thermostat Count
		Cooling	Heating	
CAC, non-electric heat	Unknown	Used average capacity* and SEER of Rebates for Retail sites with CAC and no ERH	No electric heating	38
CAC + ERH		Used average capacity* and SEER of Rebates for Retail sites with CAC and ERH	Assumed ERH capacity* was equal to average Rebates for Retail ASHP capacity	1
No cooling, non-electric heat	Unknown	No cooling	No electric heating	1

*Capacities were normalized by average home size for the IGS Energy (1,585 sq ft) and Rebates for Retail (2,064 sq ft) channels, both from program data

Nest and DP&L Store Channel Peak Load Calculation

The Nest and DP&L channels offered only a known location, with no other information on HVAC systems or home sizes. Cadmus inferred the sites' average heating and cooling peak loads from the loads and HVAC system distributions discussed above. Average loads for each HVAC system scenario presented in Table 64 could be applied to the Nest and DP&L Store channels, normalized for home areas. These normalized average loads for each of the six HVAC system scenarios could be averaged using the population weights from the participant surveys (in the rightmost column of Table 61).

This process produced an average peak cooling load of 2.300 kW and an average peak heating load of 1.153 kW for these sites.

In Service Rates and Multi-Thermostat Sites

While 5,052 smart thermostat measures were delivered in 2017, only 4,606 sites received thermostats: 898 (19.5%) sites received two thermostats, and four (0.1%) received three. The 2017 participant survey asked questions pertaining to thermostat usage behavior, and this was used to determine in service rates (ISR) for primary and secondary thermostats, as described below.

Table 66 shows results for sites with data showing they received one thermostat. Some sites with program data showing they received one thermostat—six (2.1%)—actually received two thermostats according to their survey responses, both of which were included in the evaluated totals. Some thermostats—four (1.4%)—were given to other sites. It was deemed that 70% of thermostats given

away were installed in DP&L's service territory, and the other 30% were either not installed or not installed in DP&L territory.

Given these assumptions, 98.0% of primary thermostats were installed in homes receiving them, and 0.9% were installed elsewhere in DP&L territory, for an overall primary thermostat ISR of 98.9%. This ISR was applied to the first thermostat that each site received (i.e., the only thermostat for sites with data showing they received only one, and one of the thermostats for sites receiving more than one). As only a small fraction of these thermostats was given away, it was simply assumed that the site receiving those thermostats had the same HVAC systems as those listed in the program data.

Table 66. Installation Behavior for Sites that Received One Thermostat

Behavior	Site Count	Thermostat Count				
		Total	Installed at Home	Given Away		Not In Use
				Installed In DP&L Territory*	Not Installed In DP&L Territory*	
Installed	279	279	279			
Gave away	2	2		1.4	0.6	
Put in storage	2	2				2
Received two, installed both	5	10	10			
Received two, gave both away	1	2		1.4	0.6	
Total Count	289	295	289	2.8	1.2	2
Total %			**98.0%**	**0.9%**	**0.4%**	**0.7%**

*70% of thermostats given away were deemed to be installed in DP&L's territory.

Cadmus approached the ISR and peak load assumptions for extra thermostats differently. The survey received complete behavioral results for 28 sites with data showing they received two thermostats, as shown in Table 67. With only 28 sites, results were not statistically significant, but represented values better than deemed assumptions. Making the same 70% in-territory assumption for thermostats given away, 46.4% of second thermostats were installed in the same home as the first, an additional 30.0% were installed in homes within DP&L's territory, and 12.9% + 10.7% = 23.6% were uninstalled or installed outside of DP&L's territory.

Table 67. Installation Behavior for Sites Receiving Two Thermostats

Behavior	Status of Second Thermostat	Second Thermostat Count				
		Total	Installed at Home	Given Away		Not In Use
				Installed In DP&L Territory*	Not Installed In DP&L Territory*	
Installed both	Installed	13	13			
Installed one, gave away other	Given away	11		7.7	3.3	
Installed one, not using other	Uninstalled	1				1
Gave both away	Given away	1		0.7	0.3	
Both uninstalled	Uninstalled	1				1
Got one, installed	Not delivered	1				1
Total Count		28	13	8.4	3.6	3
Total %			**46.4%**	**30.0%**	**12.9%**	**10.7%**

*70% of thermostats given away were deemed to be installed in DP&L's territory.

HVAC systems controlled by a second thermostat in a home also received special consideration. The second thermostat in a single home might control the same system as the first, using zoned control,[23] but the second thermostat in a single home might instead control an entirely separate system. It was assumed that 50% of second thermostats in the same home as the first controlled the same system (and therefore did not provide additional savings), and the other 50% controlled an equivalent system. Therefore, weighting presented in Table 68 was used to calculate peak loads for sites receiving two thermostats. The 23.2% values in this table represented 50% of 46.4%.

Second and third thermostats at sites from the Nest and DP&L Store channels received a simple 53.2% ISR. As illustrated in Table 68, this value represents the sum fraction of homes where the second thermostat was installed on an equivalent system as the first, and homes where the second thermostat was given away but remained in DP&L's territory—23.2% + 30.0% = 53.2%.

[23] Nest. "Does the Nest Thermostat work with zoned systems?" Accessed March 12, 2018. https://nest.com/support/article/Does-Nest-work-with-zoned-systems

Table 68. Weighting Used to Calculate Peak Loads for Second Thermostats

Cooling	Peak Load	Weighting	Used for Nest and DP&L Store ISR
Installed on same HVAC system	None – no additional savings	23.2%	
Installed on equivalent HVAC system	Same as for primary thermostat	23.2%	X
Given away and installed in DP&L territory	Average load for that channel	30.0%	X
Not installed, or not installed in DP&L territory	None – no savings	23.6%	

Twenty sites receiving thermostats were known to fall outside of DP&L's territory, per an examination of mailing addresses for the Rebates for Retail channel and the contact addresses for the other channels. Of these sites, 16 were nearby (Ohio or Indiana). The other four sites (from the Rebates for Retail channel) were further away—in Florida, North Carolina, Virginia, and Illinois. These 20 sites were not deemed to receive savings.

Smart Thermostat Savings Totals

Table 69 summarizes final savings values for smart thermostats, including thermostats delivered, average savings per site, and total savings for each channel.

Table 69. Smart Thermostat Adjusted Gross Savings (kWh) Across Pilot Delivery Channels

Channel	Count	Average Cooling Savings per Site	Average Heating Savings per Site	Average Total Savings Per Site	Total Savings
HVAC Rebates*	356	159.1	224.0	383.1**	136,379
Rebates for Retail	648	139.1	196.5	335.7	295,052
IGS Energy	40	107.7	28.3	136.0	5,439
Nest Online Store	3,639	123.0	138.1	261.2	950,346
DP&L Online Store	94	121.7	136.7	258.4	24,291
Total/Average	**5,041**	**128.3**	**153.5**	**371.7**	**1,420,611**

*These values represent savings for smart thermostat measures delivered via the HVAC Rebates program but associated with the $75 Smart Thermostat Pilot rebate.

**Average per-site savings for HVAC Rebates smart thermostats were 281.0 for those installed with a CAC (271 units) and 708.6 kWh for those installed with a HP (85 units).

Many factors influenced the average savings per site across channels. The Rebates for Retail channel had higher cooling and heating consumption than the HVAC Rebates channel. This was because the former channel generally had higher peak loads than the latter, largely due to a difference in efficiency—for instance, average Rebates for Retail CAC SEER was 12.9, but it was 16.4 for the HVAC channel because nearly all CACs for that channel were upgraded units. However, program tracking data shows that 17% of Rebates for Retail smart thermostats replaced smart thermostats. This brought the average savings fractions for the Rebates for Retail channel below those of the HVAC Rebates channel. The net effect is that the HVAC Rebates channel has a slightly higher per-unit savings.

The Nest and DP&L store channels had average savings values below those of the Rebates for Retail and HVAC Rebates channels. This was driven largely by differences in average peak loads for the channels due to varying distributions of HVAC systems—13% of Nest and DP&L store sites had electric heat, while 20% of Rebates for Retail sites did (see Table 61). These channels also had an average home size of 1,861 square feet, rather than 2,064 square feet for the Rebates for Retail channel.

The IGS Energy channel had smaller savings because it also had smaller peak loads than the other channels, due to both notably smaller average home size (1,585 square feet) and a much smaller portion of sites with electric heat (3%).

Programmable Thermostat Savings Totals

Table 70 shows savings for HVAC Rebates programmable thermostats, and smart thermostats that received a $20 or $40 rebate. Programmable thermostat measures had, on average, heating and cooling peak loads and consumption similar to those of HVAC Rebates smart thermostats accounted for in the pilot (Table 69). However, average savings per thermostat are less than those because of a difference in savings factors. Average savings values in Table 70 differ from those in Table 69 due to differences in average system size and efficiency that exist largely because the 11-unit sample is small and not representative of the broader population.

Table 70. Programmable and Smart Thermostat Savings (kWh) for the HVAC Rebates Channel

HVAC Rebates Measure	Count	Average Cooling Savings Per Site	Average Heating Savings Per Site	Average Total Savings Per Site	Total Savings
Programmable Thermostat with AC	1,398	107.3	86.1	193.44	270,433
Programmable Thermostat with HP	480	126.9	422.3	549.23	263,629
Programmable Thermostat with GSHP	31	143.8	234.3	378.11	11,721
Programmable Thermostat Total	**1,909**	**149.3**	**228.9**	**285.9**	**545,783**
Smart Thermostat with AC*	6	78.4	102.9	181.34	1,088
Smart Thermostat with HP or GSHP*	5	165.2	588.5	753.70	3,768
Smart Thermostat Total	**11**	**117.9**	**323.6**	**441.5**	**4,857**

* These values represent savings for smart thermostat measures delivered via the HVAC Rebates program and associated with the $20 or $40 HVAC Rebates rebate.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Provide additional resources to contractors and participants regarding installations to increase satisfaction of program participants.** Respondents reported challenges with installing the

thermostats, particularly regarding setting up the mobile application for the smart thermostat on their smart devices, and the contractor's ability to answer all of their questions. Training contractors on smart thermostat installations and the latest technology features will ensure they can provide expedient and satisfactory support to participants (whether or not the contractors are participants in DP&L's contractor network). Specific workshops or lunch-and-learn sessions focused on smart thermostats could be offered to DP&L participating contractors installing the measures. Additionally, links to manufacturer websites and videos explaining installations could be disseminated to contractors and linked on DP&L's smart thermostats webpage. These could be accessible to those outside of DP&L's participating contractor network, ensuring that even if an installer is not affiliated with DP&L, program participants experience a satisfactory installation process. For customers choosing to install the thermostats themselves, DP&L could provide resource sheets and links to videos with instructions and FAQs to educate and support customers during installation. As DP&L moves to a smaller quantity of qualifying thermostat models, the volume of educational resources required will reduce.

- **Standardize data tracking and outputs for different smart thermostat rebate channels.** The individual rebate channels had different tracking systems due to varied implementers and delivery mechanisms. Inputs resulting from the tracking systems for each channel were slightly different, making it difficult for Cadmus to analyze all channels together. Streamlining data tracking systems would enable evaluators to combine channels' data more effectively. It would also be useful to collect more data for the Nest Online channel, if possible.

Residential Energy Education (Be E³ Smart) Program

This chapter describes the evaluation approach, detailed findings, and conclusions and recommendations for the Residential Energy Education Program (Be E³ Smart).

Evaluation Overview

Cadmus' evaluation of the 2017 Be E³ Smart program followed the evaluation activities and researchable questions outlined in Table 71. Table 72 lists evaluated measures included in the Be E³ Smart home energy efficiency kit.

Table 71. Key Researchable Questions

Researchable Questions	Activity Used to Address Question
How many schools, teachers, and students participated in the program?	• Database review
What are the program's gross savings?	• Family home installation survey • Parent follow-up survey • Engineering analysis
What were the ISRs for kit measures?	• Parent follow-up survey
Are families satisfied with the program? What are the sources of satisfaction and dissatisfaction with the program?	• Parent follow-up survey
Is the program cost-effective?	• Cost-effectiveness analysis

Table 72. Be E³ Smart Evaluated Kit Measures

Kit Measures	Quantity in Kit
LED (9 W)	2
LED night light (0.5 W)	1
Bathroom faucet aerator (1.0 GPM)	2
Kitchen faucet aerator (1.5 GPM)	1
Showerhead (1.25 GPM)	1

In 2017, the kit contained two LEDs. The previous year's kit contained one CFL and one LED. The kit also contained other educational measures (though not evaluated by Cadmus): weather-stripping, a door sweep, and a furnace filter whistle. DP&L did not claim savings for these educational measures.

Detailed Evaluation Findings

With 9,102 kits sent to teachers, DP&L met its participation goal of distributing 9,000 kits. The program achieved 3,602,458 kWh in *ex ante*, verified gross, and adjusted gross savings and 188 kW in *ex ante,* verified gross, and adjusted gross demand reduction, surpassing the program's goals of 2,376,762 kWh and 20 kW. Verified savings represented 100% realization rates for energy savings and demand

reduction.[24] Overall, per-kit savings increased from 2016 with the replacement of the single 13-watt CFL with a second 9-watt LED.

Table 73 presents program *ex ante* claimed and adjusted gross savings and demand reduction. Key evaluation findings follow.

Table 73. Residential Be E³ Smart Program Claimed and Achieved Energy Savings

Measure	*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision*
LEDs (2)	627,928	66	627,928	66	627,928	66	± 15.3%
LED night light	43,163	--	43,163	--	43,163	--	± 12.1%
Bathroom faucet aerators (2)	352,355	51	352,355	51	352,355	51	± 21.1%
Kitchen faucet aerator	1,071,229	24	1,071,229	24	1,071,229	24	± 37.8%
Showerhead	1,507,783	47	1,507,783	47	1,507,783	47	± 27.7%
Total**	**3,602,458**	**188**	**3,602,458**	**188**	**3,602,458**	**188**	**± 14.0%**

*Precision at 90% confidence.

**Values in table may not sum to exactly 100% due to rounding.

- Cadmus calculated that each Be E³ Smart home energy efficiency kit generated 396 kWh of energy savings and 0.021 kW of demand reduction. ISRs for kit measures ranged from 36% for bathroom faucet aerators to 92% for LEDs.
- The family home installation survey (n=7,445) showed most participants (69%) reported satisfaction with the program, although satisfaction decreased slightly from the 2016 program year (73%). In addition, 64% of respondents reported changing thermostat heating settings in their homes, but 54% changed the cooling settings.

Evaluation Data Collection Methods

In evaluating the 2017 program, Cadmus used the approaches discussed below.

Program Database Review

The program relied on family home installation survey responses to estimate the number of measures installed from kits provided by OEP, the program implementer. After presenting the energy education lesson, teachers provided students with instructions on how to complete an online survey and encouraged them to complete the survey after one to two weeks.

Through the survey, students reported how many kit measures they installed and whether they adopted recommended behavioral changes (e.g., adjusting thermostat settings) since receiving the kits and lessons. The survey also collected basic household and demographic information, such as heating and

[24] Cadmus calculated the 2017 measure and kit savings, which accounted for installation rates and other adjustments. DP&L used these adjusted gross estimates for its *ex ante* savings.

cooling system types, family size, and home type (e.g., single-family, multifamily). The survey achieved an 82% response rate (7,445 responses of 9,102 kits distributed).

Follow-Up Parent Survey

In 2017, Cadmus fielded a parent follow-up survey (n=70) to gather feedback on program satisfaction, installation of kit measures, adoption of kit recommendations, and household characteristics.

Process Evaluation Methodology and Findings

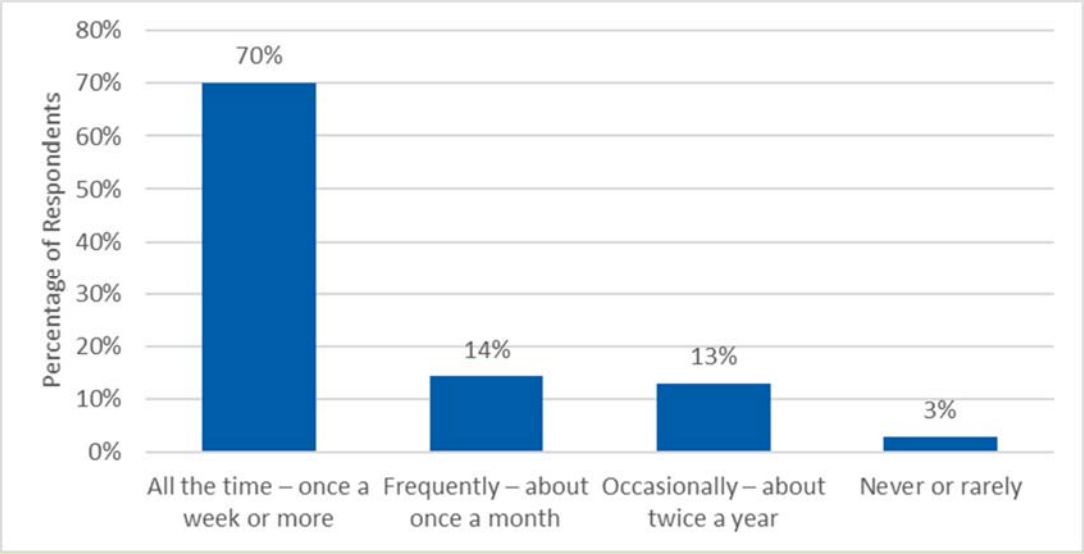
Cadmus did not conduct stakeholder interviews for the program in the 2017 program year, but the evaluation team did speak with DP&L staff in summer 2017 to gather information about program changes, and staff confirmed that the program's design, delivery, and implementation remained the same as in prior years. The only minor change came from replacing the CFL in the kit with a 9-watt LED bulb, for a total of two LED bulbs.

The following sections describe the process evaluation's high-level findings, derived from follow-up surveys administered to parents of participating students.

Energy Education Promotion and Energy Conservation Behaviors

Parent survey results indicate that student involvement in the program increased energy-related conversations, as shown in Figure 14. Seventy percent of respondents discussed energy topics all the time (once a week or more), and 14% of respondents discussed energy topics frequently (about once a month). From 2015 to 2017, the total percentage of respondents who discussed energy topics at least once a month increased from 74% to 84%.

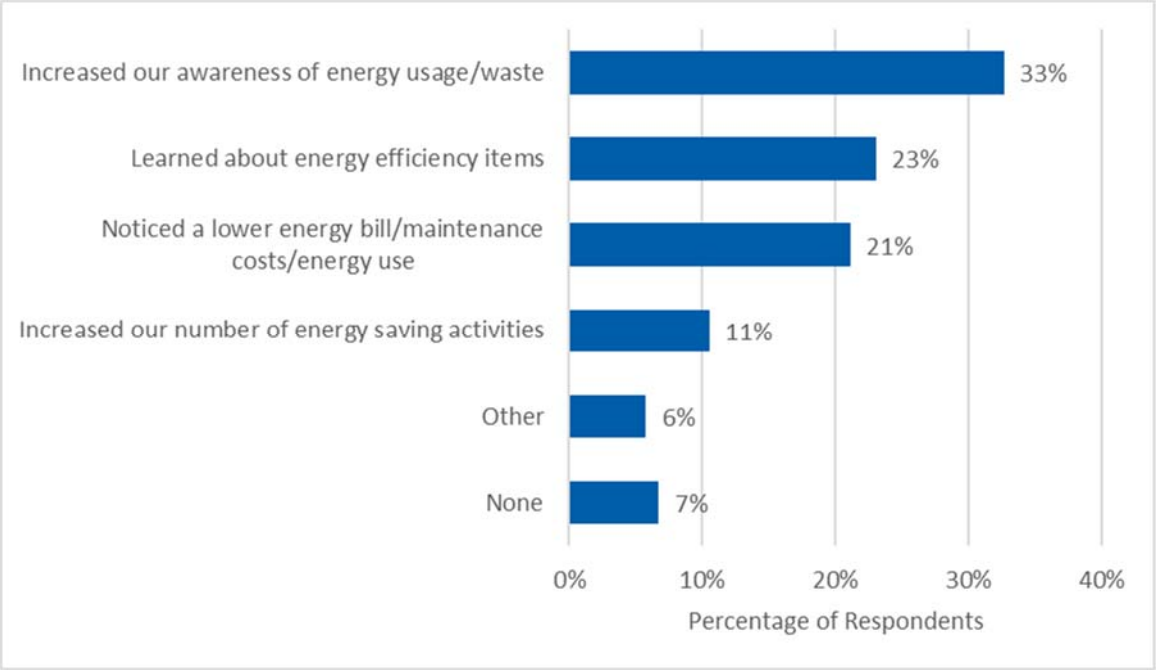
Figure 14. Frequency of Household Energy Conservation Discussions



Source: 2017 Cadmus Follow-Up Parent Survey. Question L2: "Since your child participated in this program, how often do you and your family talk about saving energy around the house?" (n=70)

Figure 15 shows that households reported energy-related benefits after participating in the program (including increased awareness, learning about energy-efficient products, decreased bills, and an increase in other energy-saving activities). Only 7% of respondents did not report benefits from their children participating in the program.

Figure 15. Benefits of Participating in the Be E^3 Smart Program



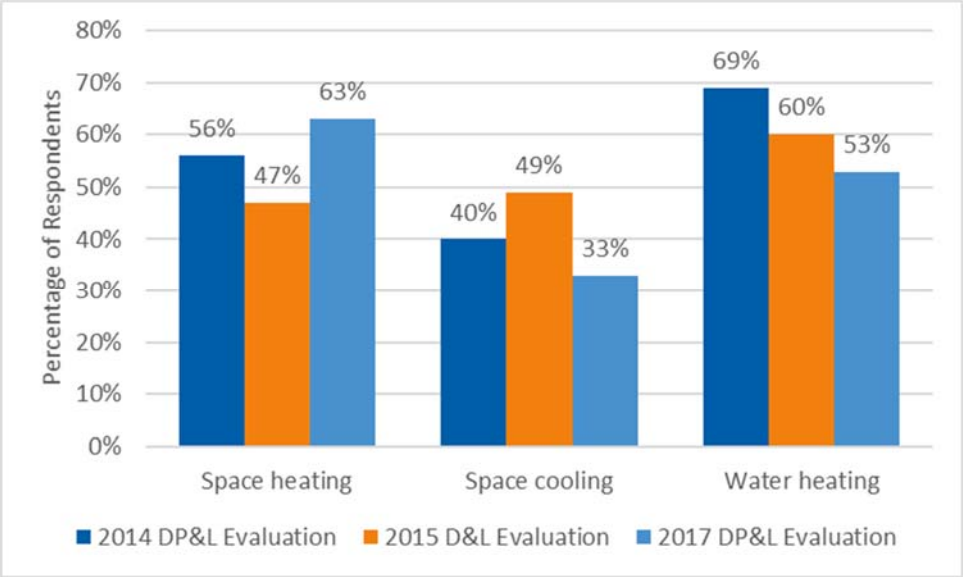
Source: 2017 Cadmus Follow-Up Parent Survey. Question L1: "What benefits, if any, have you seen in your home as a result of your child taking part in the program?" Multiple responses allowed; percentages sum to more than 100%. (n=65)

To evaluate the program's effectiveness in promoting energy conservation beyond the evaluated kit measures, Cadmus asked participants two questions that addressed energy-saving behaviors they adopted after program participation:

- Whether households adjusted temperature settings to DOE-recommended levels for several end-uses, including heating, cooling, and water heating
- Whether participants used the kit's weather-stripping, door sweep, or furnace filter whistle

Program kit and curriculum material recommended setting certain temperature levels for HVAC systems and water heaters. Figure 16 shows the percentage of surveyed participants who appropriately adjusted (or had already set) their temperature settings to recommended levels.

Figure 16. Energy-Saving Behaviors: Temperature Adjustments



Source: 2017 Cadmus Follow-Up Parent Survey. Questions K1-K4: "Did your family change your home's [heating/refrigerator/water heater/cooling] temperature to the setting recommended through the kit program?" (n=70)

In 2017, fewer participants reported adjusting (or had already appropriately set) their space cooling and water heating temperatures compared to previous program years. More participants, however, reported adjusting their space heating temperatures than in previous years. Cadmus also asked respondents if they adjusted their refrigerator cooling temperatures. A small percentage of respondents (4%) increased their refrigerator temperatures, as recommended in the program materials, although 23% of respondents reported their units were already set at the appropriate temperatures.

Participants reportedly installed or used kit weather-stripping, door sweeps, and furnace filter whistles at rates relatively consistent with previous evaluations, 17% of respondents did not know if they had used the furnace filter whistle, indicating they may not have known what it was. Cadmus asked respondents who installed or used the measures to rate their satisfaction with each measure on a scale of 0 to 10, where 0 meant "not at all satisfied" and 10 meant "very satisfied." Overall, the measures received high average ratings: 8.9 for weather-stripping (n=44), 8.4 for the door sweep (n=37), and 9.6 for the furnace filter whistle (n=11). Table 80 compares installation rates for additional measures between 2017 and previous program years when parent surveys were conducted.

Table 74. Secondary Kit Measures Installation Rates

Kit Measures	2014	2015	2017*
Weather-Stripping	70%	59%	65%
Door Sweep	60%	53%	59%
Furnace Filter Whistle	36%	14%	19%

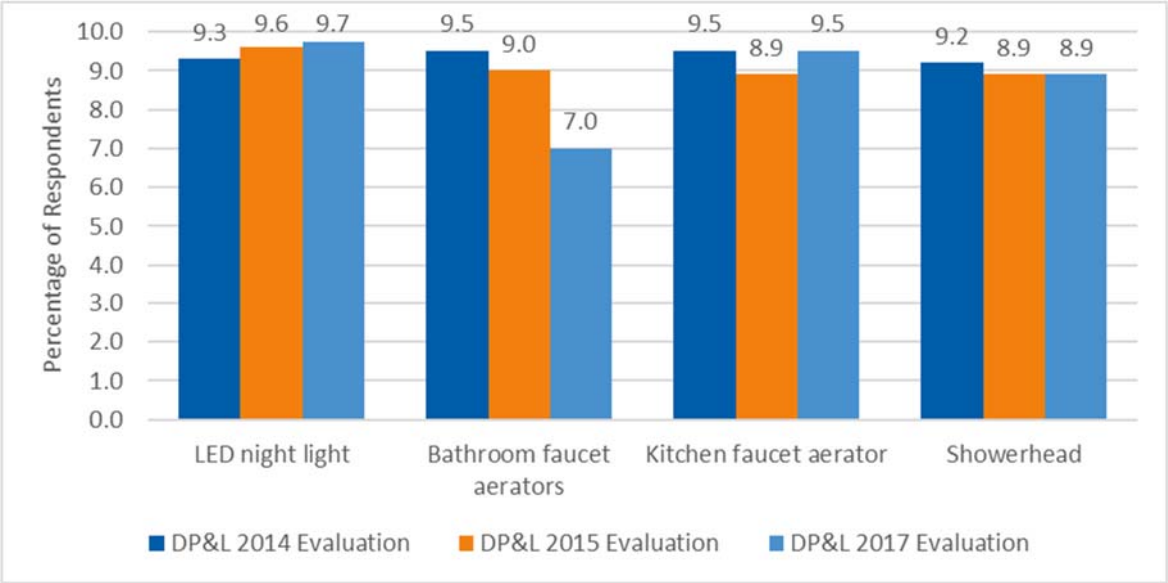
Despite collecting installation rate information for weather-stripping, door sweeps, and furnace filter whistles, Cadmus did not evaluate savings for these secondary kit measures.

Customer Satisfaction

Satisfaction with Kit Measures

When asked to rate their satisfaction with each kit measure on a scale from 0 to 10, where 0 meant "not at all satisfied" and 10 meant "extremely satisfied," participants reported satisfaction levels consistent with previous program years. Figure 17 shows the results.

Figure 17. Primary Kit Measure Satisfaction Ratings, 2014–2017



Source: 2017 Cadmus Follow-Up Parent Survey. Questions B3, C3, D3, E3, F3: "On a scale of 0 to 10, where 0 means "not at all satisfied" and 10 means "very satisfied," how satisfied are you with [kit measure name]?" DP&L transitioned away from CFLs to LEDs in 2017. (n=70)

LED Bulbs

Five of the seven respondents who did not install both LED bulbs provided in their kits either preferred their current light bulbs, had light bulbs of similar efficiency already installed, did not have time to install the lights, or stored them for later. The remaining two respondents said the LEDs "blew out" and they removed them.

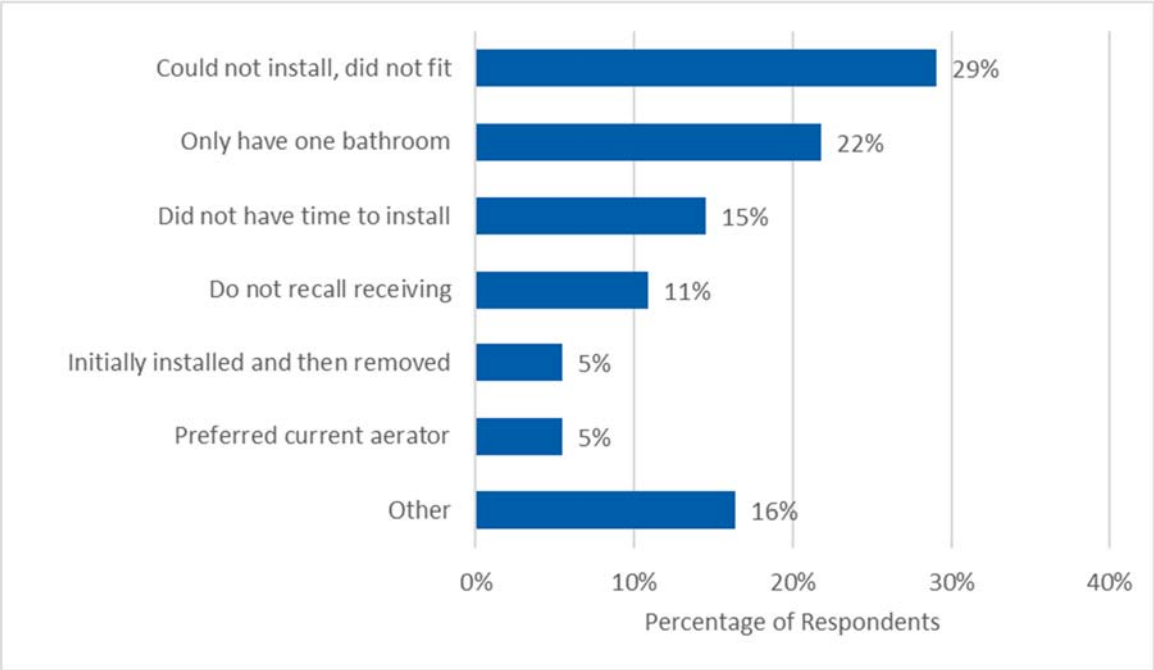
LED Night Light

Six participants did not install their LED night lights for the following reasons: they did not like the product, they did not recall receiving it, they did not have time to install it, or they installed it and later removed it (either because it broke or it was too bright).

Bathroom Faucet Aerators

Despite stable installation rates over the last couple of years, respondents rated bathroom faucet aerators less positively than in previous program years. Figure 18 details respondents' reasons for not installing one or both of their bathroom faucet aerators.

Figure 18. Reasons for Not Installing Bathroom Faucet Aerators



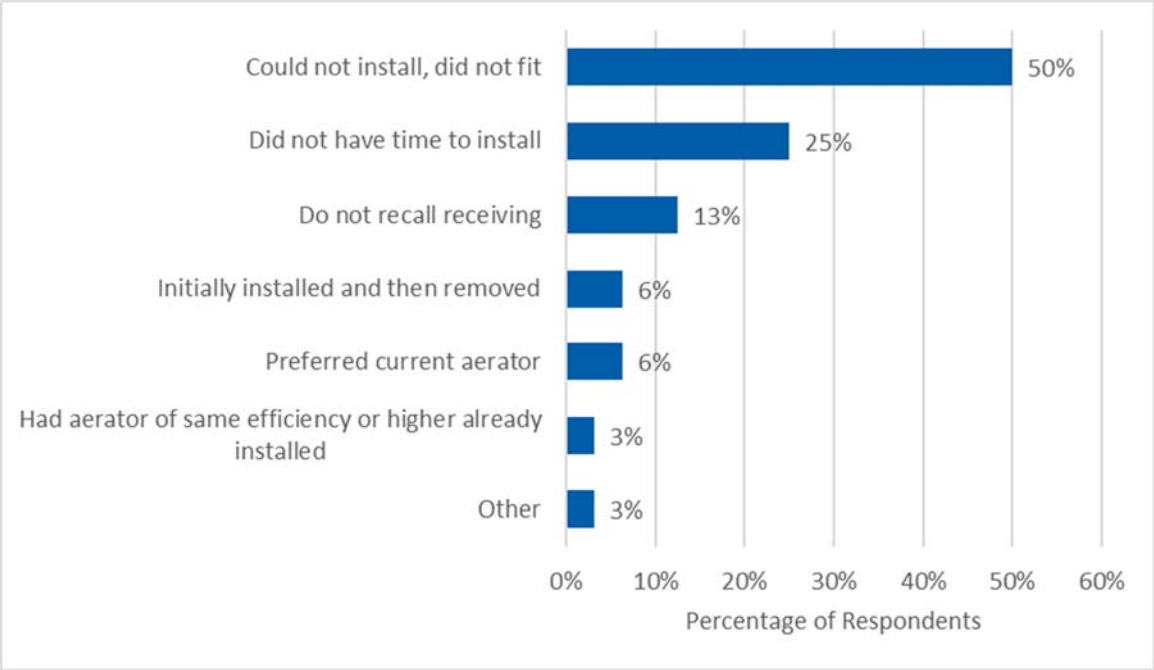
Source: 2017 Cadmus Follow-Up Parent Survey. Question E2: "Why isn't the bathroom aerator currently installed?" Multiple responses allowed; percentages sum to more than 100%. (n=55)

Most respondents (29%) could not install the bathroom faucet aerator and/or the bathroom faucet aerator did not fit. An additional 21% of respondents did not recall receiving it (11%), installed then later removed it (5%), or preferred their current faucet aerators (5%). "Other" responses included respondents having aerators of similar efficiency already installed (4%), having difficulties in installing the kit faucet aerator (2%), or being renters without the authority to make the installation (4%).

Kitchen Faucet Aerator

Figure 19 shows respondents' reasons for not installing their kitchen faucet aerators. As with bathroom faucet aerators, most of these respondents (50%) could not install the kitchen faucet aerator and/or the kitchen faucet aerator did not fit. An additional 25% of respondents did not have time to install the units, and 13% did not recall receiving the aerators.

Figure 19. Reasons for Not Installing Kitchen Faucet Aerators

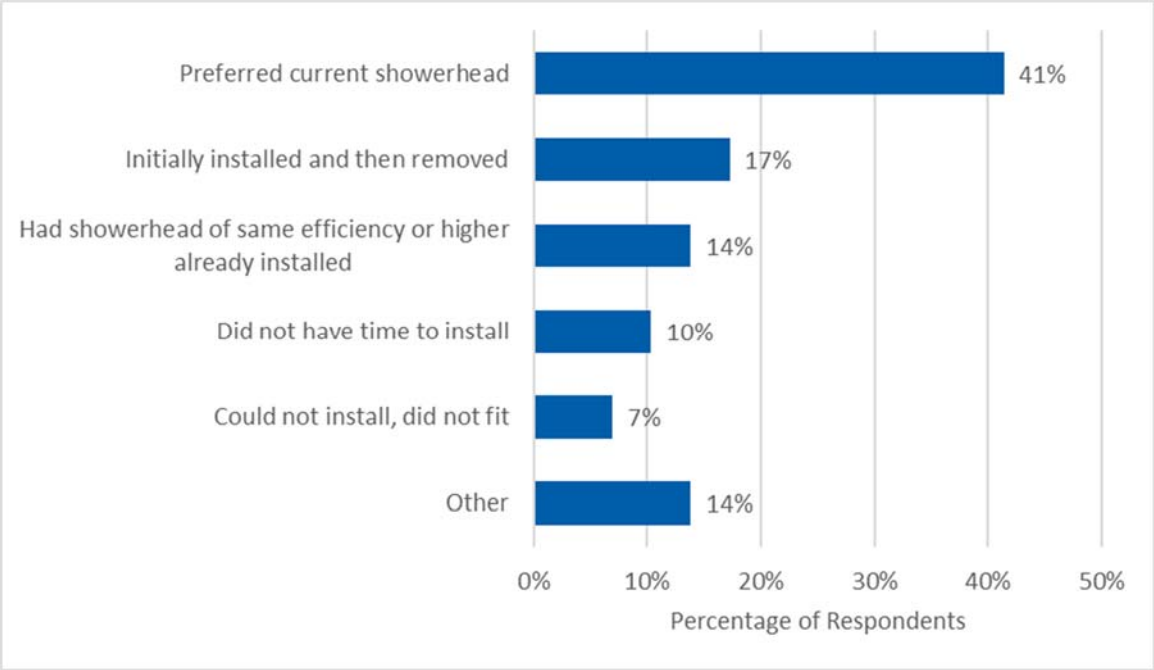


Source: 2017 Cadmus Follow-Up Parent Survey. Question D2: "Why isn't the kitchen aerator currently installed?" Multiple responses allowed; percentages sum to more than 100%. (n=32)

Showerhead

Figure 20 breaks down respondents' reasons for not installing their efficient showerheads. Unlike the faucet aerators, fewer of these respondents (7%) could not install the showerhead and/or the showerhead did not fit. Instead, most respondents (41%) preferred their current showerheads. An additional 17% of respondents initially installed and later removed the units, and 17% had a showerhead of similar efficiency already installed.

Figure 20. Reasons for Not Installing Showerheads

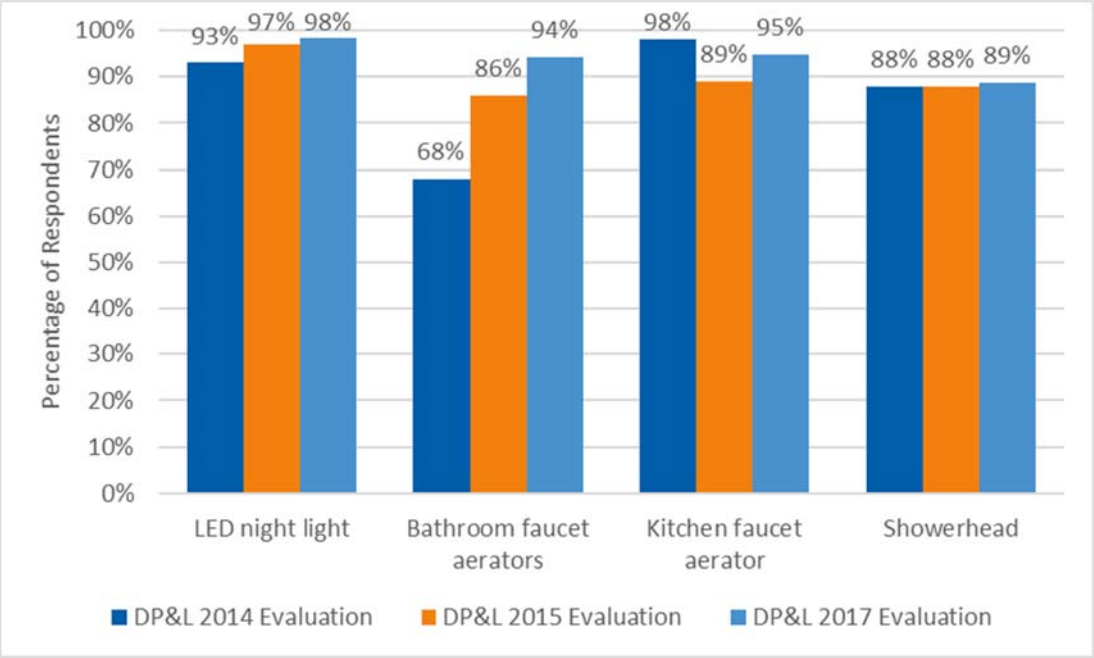


Source: 2017 Cadmus Follow-Up Parent Survey. Question C2: "Why isn't the showerhead currently installed?" Multiple responses allowed; percentages sum to more than 100%. (n=29)

Measure Persistence

To capture measure persistence, Cadmus asked participants whether they installed and later removed a measure. Figure 21 compares measure persistence across the 2014–2017 DP&L Be E^3 Smart program parent survey results. Except for bathroom faucet aerators (which exhibited lower persistence rates in 2014), DP&L's persistence rates have not varied greatly from year to year.

Figure 21. Reported Measure Persistence



Source: 2017 Cadmus Follow-Up Parent Survey. Questions B1, B2, C1, C2, D1, D2, E1, E2: "How many [measures] are currently installed in your home?", "Why isn't [one or both of the measures] currently installed?"

Overall Program Satisfaction

Ninety percent of respondents (n=69) reported being "very satisfied" (78%) or "somewhat satisfied" (19%) with the program, up seven percentage points overall from the 2015 program year evaluation. One respondent expressing dissatisfaction claimed he or she "did not receive anything." Table 75 provides additional details. All respondents, however, reported being "just as satisfied" (69%) or "more satisfied" (31%) with DP&L after participating to the program (n=68).

Table 75. Overall Satisfaction with the Be E^3 Smart Program

Satisfaction Category	Count	Percentage
Very satisfied	54	78%
Somewhat satisfied	13	19%
Neither satisfied nor dissatisfied	1	1%
Somewhat dissatisfied	1	1%
Very dissatisfied	0	0%

Source: 2017 Cadmus Follow-Up Parent Survey. Question M1: "Overall, how satisfied are you with the Be E3 Smart program?" Multiple responses allowed; percentages sum to more than 100%. (n=69)

Energy Efficiency Program Promotion

The Be E^3 kit contained a list of DP&L energy efficiency programs and, where possible, DP&L-branded materials. The company, however, did not officially monitor whether participation in the school education program increased participation in DP&L's overall energy efficiency portfolio.

In assessing this, Cadmus asked survey respondents whether they participated in other DP&L energy efficiency programs since participating in the Be E^3 Smart Program. Most respondents (92%, n=69) said their participation in Be E^3 Smart did not influence them to participate in other programs. However, the reported impact on participation was greater in 2017 than in 2015: the percentage of respondents reporting having participated in other programs increased from 3% in 2015 to 8%. Moreover, each respondent indicated participating in the following programs (rather than selecting "I don't know"): Appliance Recycling (n=2), Smart Thermostat Rebates (n=1), Lighting Rebates (n=2), and Heating and Cooling Rebates (n=1).

Impact Evaluation Methodology and Findings

DP&L requested that Cadmus calculate *ex ante* claimed savings alongside verified and adjusted gross savings. *Ex ante,* verified, and adjusted gross savings calculations primarily relied on the following sources:

- Ohio TRM
- 2017 Be E^3 Smart program family home installation survey
- 2017 Be E^3 Smart program parent follow-up survey
- Engineering algorithms from other Cadmus evaluation work

Table 76 summarizes adjusted gross savings. Adjusted gross savings included electric water heater saturation rates and ISRs, derived from the 2017 family home installation and 2017 parent follow-up surveys, respectively. On average, Cadmus calculated that each kit generated 396 kWh of energy savings and 0.021 kW of demand savings.

Table 76. Adjusted Gross Savings

Measure	Units Distributed	ISR	Percent Electric*	Per-Unit Savings**		Adjusted Gross Savings	
				kWh	kW	kWh	kW
LEDs (2)	18,204	92%	100%	34	0.0036	627,928	66
LED night light	9,102	36%	100%	5	--	43,163	--
Bathroom faucet aerators (2)	18,204	43%	50%	19	0.0028	352,355	51
Kitchen faucet aerator	9,102	54%	50%	118	0.0026	1,071,229	24
Showerhead	9,102	57%	50%	166	0.0052	1,507,783	47
Total	**63,714**			**396**	**0.021**	**3,602,458**	**188**

*For aerators and showerheads, percent electric represents the saturation of electric water heaters, calculated using results from OEP's family home installation survey.

**Per-unit savings include adjustments for ISRs and electric fuel types. LEDs and bathroom faucet aerators reflect savings per unit rather than per pack.

Measure In-Service Rates

For the 2017 evaluation, Cadmus conducted a parent follow-up survey and used survey results to verify installation. While ISRs can be derived from the family home installation survey, Cadmus typically observes different ISRs from the parent follow-up survey. The different and often higher ISRs occur because parent follow-up surveys are completed months after student participation, providing families with more time to install kit measures. Due to the additional time to install kit measures, Cadmus used ISRs from the parent survey to evaluate savings. Table 77 compares ISRs from the 2017 family home installation and parent follow-up surveys.

Table 77. Comparison of Family Survey and Verified ISRs

Measure	2017 Family Home Installation Survey (n=7,445)	Verified ISRs from 2017 Follow-Up Parent Survey (n=70)
LEDs (2)	60%	92%
LED night light	23%	36%
Bathroom faucet aerators (2)	32%	43%
Kitchen faucet aerator	38%	54%
Showerhead	42%	57%

Benchmarking

Cadmus compared ISRs for each kit measure to ISRs from evaluations of similar, utility-sponsored, school kit programs in the Midwest and Northeast. DP&L's LED night light ISR fell below the benchmarked ISR range (72% to 94%); however, most other programs did do not control for the percentage of LED night lights that replaced incandescent night lights, as shown in Table 78. DP&L's unadjusted 91% LED night light ISR would—akin to the ISRs of other kit measures—fall toward the upper ISR end of the range for LED night lights. Table 78 presents ISR benchmarking results, along with ISRs from the 2016 Be E³ Smart program (which, as noted above, relied on 2015 program data).

Table 78. ISR Benchmarking

Measure	DP&L Be E³ Smart (2017)	DP&L Be E³ Smart (2016)	Midwest Utility 1 (2015)	Midwest Utility 2 (2016)	Midwest Utility 3 (2016)	Midwest Utility 4 (2015)	Northeast Utility 1 (2016)
LEDs (2)	**92%**	**90%**	64%	53%	65%	--	89%
LED Night Light*	**36%**	**39%**	94%	72%	80%	86%	79%
Bathroom Faucet Aerators (2)	**43%**	**42%**	--	35%	41%	--	27%
Kitchen Faucet Aerator	**54%**	**43%**	59%	34%	50%	47%	32%
Showerhead	**57%**	**63%**	74%	45%	50%	52%	27%
ISR Data Source	**Follow-Up Survey**	**Follow-Up Survey**	Follow-Up Survey	Student Survey	Student Survey	Average**	Student Survey

* The DP&L kit's LED night light ISR is adjusted to reflect the percentage that replaced incandescent night lights. Unadjusted, the DP&L LED night light ISR is 91%, before the application of a 40% incandescent replacement factor derived from the family home installation survey.

**Average of student and follow-up surveys conducted by the administrator and evaluator, respectively.

TRM Deemed Savings Review

Table 79 lists the 2017 Be E³ Smart program's per-unit and per-kit adjusted gross electric and demand savings. Table 80 lists total adjusted gross electric and demand savings. Savings included all adjustments for water heater fuel-type saturation rates and ISRs.

Table 79. 2017 Be E³ Smart Program Per-Unit Adjusted Gross Savings

Measure	Per-Unit Adjusted Gross Savings (kWh)*	Per-Unit Adjusted Gross Savings (Coincident Peak kW)*
LEDs (2)	34.5	0.0036
LED night light	4.7	--
Bathroom faucet aerators (2)	19.4	0.0028
Kitchen faucet aerator	117.7	0.0026
Showerhead	165.7	0.0052
Kit Total	**395.8**	**0.021**

*Per-unit savings include adjustments for ISRs and electric fuel types. LEDs and bathroom faucet aerators reflect savings per unit.

Table 80. 2017 Be E³ Smart Program Total Adjusted Gross Savings

Measure	Adjusted Gross Savings (kWh)	Adjusted Gross Savings (Coincident Peak kW)
LEDs (2)	627,928	66.4
LED night light	45,753	-
Bathroom faucet aerators (2)	352,355	51.5
Kitchen faucet aerator	1,071,229	23.5
Showerhead	1,145,915	58.4
Total	**3,241,421**	**199.8**

*Per-unit savings include adjustments for ISRs and electric fuel types. LEDs and bathroom faucet aerators reflect savings per unit rather than per pack.

To calculate per-unit energy savings, Cadmus used inputs such as the number of people per home and the electric water heater saturation rates calculated using the family home installation survey results. Cadmus applied these inputs, along with inputs from the Ohio TRM, to determine savings for each measure. Detailed findings from this assessment follow, accompanied by engineering assumptions informing the calculations for LED bulbs, LED night lights, faucet aerators, and showerheads. The calculations include ISRs and electric water heater saturation rates.

LEDs

Cadmus used the following equations (outlined in the Ohio TRM) to calculate adjusted gross energy savings and demand reduction for LEDs:

$$\Delta kWh = \frac{(W_{efficient} - W_{baseline}) * ISR * HOURS * WHF_e}{1{,}000}$$

$$\Delta kW = \frac{(W_{efficient} - W_{baseline}) * ISR * HOURS * WHF_d * CF}{1{,}000}$$

Table 81 shows inputs and assumptions for LED bulb savings calculations. Using these inputs, Cadmus determined that the LED saved 34.5 kWh and 0.0036 kW per unit annually after adjusting for ISR and electric water heater saturation rates. The team estimated adjusted gross savings of 627,928 kWh and summer coincident peak savings of 66 kW for LEDs.

Table 81. LED Energy and Demand Savings Calculation Inputs

Input	Assumption	Source
Baseline wattage	43	DOE UMP, Chapter 21 Residential Lighting Evaluation Protocol
Efficient wattage	9	Program data provided by OEP
ISR	92%	2017 Be E³ Smart parent follow-up survey
Hours	1,040	2010 Ohio TRM
WHF_e	1.06	2010 Ohio TRM; adjustment made for outdoor installations
WHF_d	1.06	2010 Ohio TRM; adjustment made for outdoor installations
Summer Peak CF	0.11	2010 Ohio TRM

LED Night Lights

Cadmus used the following equations to calculate adjusted gross energy savings and demand reduction for LED night lights:

$$\Delta kWh = \frac{(W_{efficient} - W_{baseline}) * ISR * HOURS}{1{,}000}$$

Table 82 shows inputs and assumptions employed in the LED night light savings calculations. Using these inputs, Cadmus determined that each LED night light saved 4.7 kWh per unit annually. Using family home installation survey results, the 36% ISR estimates the percentage of LED night lights that replaced incandescent night lights. Cadmus estimated adjusted gross energy savings of 43,163 kWh for LED night lights and no demand reduction, as night light operation hours did not coincide with Ohio's definition of peak hours.

Table 82. LED Night Light Energy Savings Calculation Inputs

Input	Assumption	Source
Baseline wattage	5	2015 Indiana TRM v2.2 (not in 2010 Ohio TRM)
Efficient wattage	0.5	Program data provided by OEP
ISR	36%	2017 Be E^3 Smart parent follow-up and family home installation surveys
Hours	2,920	2015 Indiana TRM v2.2 (not in 2010 Ohio TRM)

Bathroom and Kitchen Faucet Aerators

Cadmus used the following equations (outlined in the Ohio TRM) to calculate energy savings and demand reductions for faucet aerators:

$$\Delta kWh = (GPM_{Base} - GPM_{Low}) * \frac{people}{home} * \frac{min}{day} * \frac{days}{year} * \frac{1}{\frac{F}{home}} * 8.33 * (T_{FT} - T_{MAINS}) * \frac{1}{1{,}000{,}000} * \frac{1}{EF} * \frac{1}{0.003412} * \%electric * ISR$$

$$\Delta kW = \frac{\Delta kWh}{hours} * CF * \%electric * ISR$$

Table 83 lists the inputs used to calculate savings for bathroom and kitchen faucet aerators. Employing these inputs, Cadmus estimated that bathroom faucet aerators saved 19.4 kWh per unit annually and kitchen faucet aerators saved 117.7 kWh per unit annually, after adjusting for ISRs and electric water heater saturation rates. Cadmus calculated peak demand savings of 0.0028 kW per bathroom faucet aerator and 0.0026 kW per kitchen faucet aerator. Bathroom faucet aerators achieved 352,355 kWh in energy savings and 51 kW in demand savings, and kitchen faucet aerators achieved 1,071,229 kWh in energy savings and 24 kW in demand savings. A higher ISR for kitchen faucet aerators in 2017 than 2016 (54% versus 43%) resulted in higher savings.

Cadmus updated Ohio TRM assumptions for the average number of people per household using family home installation survey results and the number of bathroom faucets per home using parent follow-up survey results. The team retained water use assumptions used in previous program year evaluations,

including minutes of use per person and assumed water temperatures at the point of use, originally derived from a Cadmus water metering study conducted for Consumers Energy and DTE Energy in Michigan.[25] Cadmus updated its assumed water main temperature (entering the house, prior to use), adhering to the methodology described in the Building America Research Benchmark Definition and using Monthly Station Normals weather data. [26,27]

Table 83. Bathroom and Kitchen Faucet Aerator Energy and Demand Savings Calculation Inputs

Variable	Definition	Bathroom Faucet Aerator	Kitchen Faucet Aerator	Source
GPM_{BASE}	GPM of baseline faucet	2.2	2.2	2012 Cadmus Water Metering Study
GPM_{LOW}	GPM of low-flow faucet	1.0	1.5	Program data provided by OEP
#people	Number of people per household	4.34	4.34	2017 Be E^3 Smart family home installation survey
min/day	Minutes of use per person per day	1.65	4.51	2012 Cadmus Water Metering Study
days/year	Days of use per year	365	365	2010 Ohio TRM
F/home	Number of faucets per home	2.43	1.00*	2017 Be E^3 Smart parent follow-up survey (*assumed)
8.33	Gallons of water to pounds	8.33	8.33	Adjusted 2010 Ohio TRM assumption
1	Pounds of water to Btu	1	1	2010 Ohio TRM
T_{FT}	Water temperature (°F) at point of use	86	93	2012 Cadmus Water Metering Study
T_{MAINS}	Water main temperature (°F) (upon entering house)	57.5	57.5	See footnotes 26 and 27, page 105
EF	Efficiency Factor (recovery efficiency of water heater)	0.98	0.98	2010 Ohio TRM
0.003412	MMBtuh to kWh	0.003412	0.003412	2010 Ohio TRM assumption
Hours	Hours of use per year per faucet	17.9	119.2	(#people*min/day*365)/60/F/home
CF	Summer Peak CF	0.00262	0.00262	2010 Ohio TRM
% Electric	Electric water heater saturation	49.5%	49.5%	2017 Be E^3 Smart family home installation survey

25 Cadmus and Opinion Dynamics. Memorandum regarding Showerhead and Faucet Aerator Meter Study. June 2012.

26 Building America Research Benchmark Definition, updated December 2009. Pg.19–20. http://www.nrel.gov/docs/fy10osti/47246.pdf

27 Monthly Station Normals, 1971–2000–CLIM81. ftp://ftp.ncdc.noaa.gov/pub/data/extremeevents/specialreports/US-Climate-Normals-1971-2000-Products.pdf

Energy-Efficient Showerheads

Cadmus used the following equations outlined in the Ohio TRM to calculate adjusted gross energy savings and demand reductions for showerheads:

$$\Delta kWh = (GPM_{Base} - GPM_{Low}) * \frac{people}{home} * \frac{min}{shower} * \frac{shower}{days} * \frac{days}{year} * \frac{1}{\frac{F}{home}} * 8.33 * (T_{FT} - T_{MAINS}) * \frac{1}{1{,}000{,}000} * \frac{1}{EF} * \frac{1}{0.003412} * \%electric * ISR$$

$$\Delta kW = \frac{\Delta kWh}{hours} * CF * \%electric * ISR$$

Table 84 lists the inputs and assumptions used for calculating efficient showerhead savings. Incorporating these inputs, Cadmus calculated 165.7 kWh of energy savings and 0.0052 kW of demand savings per unit annually, after adjusting for ISRs and electric water heater saturation rates. Efficient showerheads achieved adjusted gross savings of 1,507,783 kWh in energy and 47 kW in demand. A lower ISR for showerheads in 2017 than 2016 (57% versus 63%) resulted in lower savings.

As with faucet aerators, Cadmus updated Ohio TRM assumptions for the average number of people per household using family home installation survey results and the number of showerheads per home using parent follow-up survey results. The team retained water use assumptions used in previous program year evaluations that were originally derived from a Cadmus water metering study. Cadmus also updated its assumed water main temperature, adhering to the methodology described in Building America Research Benchmark Definition using Monthly Station Normals weather data.

Table 84. Efficient Showerhead Energy and Demand Savings Calculation Inputs

Variable	Variable Definition	Input	Cadmus Source
GPM_{BASE}	GPM of baseline faucet	2.5	Minimum federal GPM allowed
GPM_{LOW}	GPM of low-flow faucet	1.25	Program data provided by OEP
#people	Number of people per household	4.34	2017 Be E^3 Smart family home installation survey
min/day	Minutes of use per person per day	7.83	2012 Cadmus Water Metering Study
days/year	Days of use per year	365	2010 Ohio TRM
shower/day	Showers per person per day	0.61	2012 Cadmus Water Metering Study
F/home	Number of faucets per home	1.74	2017 Be E^3 Smart parent follow-up survey
8.33	Gallons of water to pounds	8.33	Adjusted 2010 Ohio TRM assumption
1	Pounds of water to Btu	1	2010 Ohio TRM
T_{FT}	Water temperature (°F) at point of use	101	2012 Cadmus Showerhead and Faucet Aerator Meter Study
T_{MAINS}	Water main temperature (°F) (upon entering house)	57.5	See footnotes 26 and 27, page 105
EF	Efficiency Factor (recovery efficiency of electric water heater)	0.98	2010 Ohio TRM
0.003412	MMBtuh to kWh	0.003412	Ohio TRM assumption
Hours	Hours of use per year per showerhead	72.7	[#people]*[min/day]*(365/60)/[F/home]
CF	Summer Peak CF	0.00371	Ohio TRM assumption
% Electric	Electric water heater saturation	49.5%	2017 Be E^3 Smart family home installation survey

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Expand the recommendations included in program materials for other energy-saving activities in which participants can engage.** Parent survey results show that 11% of participants reported increasing the number of energy-saving activities that took place in their home as a result of participating in the Be E^3 Smart program. DP&L and OEP could work together to emphasize different energy-saving behaviors and upgrades available to participants, and cross-promote other DP&L programs in materials sent to students and parents. For example, the kit materials could include a chart with average savings that can be expected from various behaviors and activities could be included in kit materials. DP&L might consider including a list of residential behaviors on the Simple Energy Marketplace, and refer Be E^3 Smart program participants to the links to this online platform.
- **Increase the availability of instructional materials to help with installations of bathroom and kitchen faucet aerators or offer an additional model of kitchen and bathroom faucet aerators.** In the 2017 parent survey, 29% of respondents said they could not install their bathroom faucet

aerators because they did not fit; 50% of respondents said the same for kitchen faucet aerators. DP&L and OEP might consider providing two types of faucet aerators to participants, in case one model does not fit. This would increase the installation of and satisfaction with the faucet aerators. Parents and students might be given the option of returning the non-working model to their schools for OEP to collect and reuse, or to give to families that would like an additional aerator. Additionally, providing a short, simple installation guide with each kit, which includes pictures and easy-to-follow steps, would increase participants' ease of use.

Nonresidential Prescriptive Rebate Program

This section describes the evaluation approach, detailed findings, and conclusions and recommendations for the Nonresidential Prescriptive Rebate program. Total program savings include those from four groups of measures:

- Rapid Rebate measures incented through the Nonresidential Prescriptive Rebate program
- Residential Lighting program bulbs installed in commercial allocations
- Measures from the Midstream Incentive channel
- Measures from the Residential ARP program, collected from nonresidential sites

This section includes savings for all four groups, though details related to the latter three may be found in their respective report sections.

Evaluation Overview

Cadmus' evaluation of the 2017 Nonresidential Prescriptive Rebate program followed the researchable questions and evaluation activities outlined in Table 85.

Table 85. Key Researchable Questions

Researchable Question	Activity Used to Address Question
How do Ohio TRM-deemed savings compare with validated program savings?	• Site visits • Engineering analysis • Database review
What gross electric savings and demand reductions does the program achieve?	• Engineering analysis • Database review • Meter installations
What experiences do program administrators have with program processes?	• Program staff interviews
Is the program cost-effective?	• Cost-effectiveness analysis

Detailed Evaluation Findings

DP&L exceeded its energy savings goal of 55,446,000 kWh, achieving 93,401,034 kWh in *ex ante* savings.[28] The program also achieved its 9,600 kW demand saving goal, with 14,560 kW in *ex ante* demand reduction. Verified savings represented 97% and 96% realization rates for *ex ante* energy and demand savings, respectively.

[28] Savings include those from the Nonresidential Prescriptive Rebate, Midstream Lighting, Residential Lighting, and ARP at nonresidential sites.

In addition to the typical Rapid Rebates measures (e.g., efficient commercial lighting, motors), DP&L offered prescriptive incentives through a midstream incentive channel in 2017.

Table 86 presents claimed and achieved program savings. Key impact evaluation findings follow.

Table 86. Nonresidential Prescriptive Rebate Program Claimed and Achieved Energy Savings

Measure	*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision*
P-Lighting-Large	12,631,182	1,056.2	12,631,184	1,056.2	13,413,661	1,323.7	9.5%
P-Lighting-Medium	21,516,997	2,625.9	21,480,099	2,641.6	18,456,970	2,807.1	12.7%
P-Lighting-Small	17,668,675	2,958.2	17,507,593	2,919.7	17,807,324	2,732.8	4.2%
P-Compressed Air	1,679,635	101.9	1,679,635	101.9	1,005,219	127.0	15.6%
P-Motors	4,406,913	771.1	3,950,429	729	4,333,529	737.1	8.7%
Census-P-Motors	15,052,406	2,596.1	15,052,406	2,596.1	12,359,621	2,320.3	0%
P-HVAC	4,646,953	1,059.8	4,403,798	1,029.6	6,026,064	1,428.6	25.6%
Midstream Incentives	7,569,785	1,451	7,130,572	1,369	6,581,394	1,179	12.5%
Residential Lighting Bulbs**	7,999,923	1,890	6,559,937	1,550	4,738,372	1,119	3.9%
Appliance Recycling at Nonresidential Sites	228,564	49.4	228,564	49.4	156,058	38.8	7.6%
Total* **	**93,401,031**	**14,560**	**90,624,217**	**14,043**	**84,878,212**	**13,814**	**4.7%**

*Precision at 90% confidence.

**Bulbs sold through the residential lighting program and allocated to the commercial program. For *ex ante* savings, 5% of upstream residential lighting bulbs were allocated to commercial applications. Verified and adjusted savings used 4.1%.

***Values in table may not sum to 100% due to rounding.

- Cadmus expected project-level adjusted gross savings realization rates above and below 100%, given the use of deemed assumptions for *ex ante* calculations and site-specific parameters for adjusted gross calculations. *Ex ante* values and assumptions derived from the Ohio TRM represented average, expected savings. Using site-specific parameters to calculate adjusted gross savings lead to some projects achieving greater savings and some projects achieving lower savings than predicted by the Ohio TRM.
- Similar to previous years, lighting projects exhibited the greatest variability in adjusted gross savings realization rates, with variability typically inversely proportional to claimed energy savings. In general, installed lighting fixtures were found as expected on site, and rebate documentation matched site findings. Cadmus, however, installed light loggers on 18 of 35

lighting projects, and updated the HOU used to calculate energy savings, based on analysis of light logging data. Variability in adjusted gross savings realization rates largely resulted from changes in HOU, based on the light logger data analysis.

- HVAC Measures exhibited the highest adjusted gross savings realization rate, at 130% for energy and 135% for demand savings. Among incentivized HVAC projects, 77% claimed less than 10,000 kWh in energy savings. For these relatively small projects, the evaluated energy and demand savings were found to vary substantially when findings deviated from the reported values. Three evaluated, sampled projects saved greater than 200% of claimed energy savings. Most large variations resulted from metered performance, analyzed to save more energy than prescriptive savings associated with HVAC projects.
- One large project accounted for 77% of the Motors *ex ante* energy savings. This project involved VFD installations on over 2,000 motors serving a glass manufacturing facility. Cadmus evaluated this project, with results indicating an adjusted gross savings realization rate of 82% for energy and 89% for demand. Cadmus installed power meters on 19 motors serving this facility. Analysis of meter data indicated lower maximum demand than expected and lower load profiles for the majority of sampled motors, resulting in reduced energy and demand savings.

Baseline Assumptions

Baseline assumptions typically address data obtained on site and include replaced fixture types and quantities as well as parameters (e.g., original operation hours and temperature setpoints). Where data could not be obtained on site (e.g., HVAC equivalent full load hours [EFLH], baseline motor efficiency), Cadmus used assumptions provided in the Ohio TRM.

Impact Evaluation Methodology

Cadmus collected baseline data through interviews with facility staff at each site, program implementation data, and tracking data. On-site visits verified measure installations and identified changes in operating parameters occurring since those installations. On-site data served to inform the savings impact calculations.

Sampling and Extrapolation Methodology

Through the Rapid Rebate program, DP&L provided incentives for 112 measure types. Cadmus stratified these 112 measure types into six strata: Large Lighting; Medium Lighting; Small Lighting; Compressed Air; Motors; and HVAC. Cadmus stratified the lighting projects based on total *ex ante* energy savings associated with each project. Large lighting projects' *ex ante* energy savings were greater than or equaled 500,000 kWh. Medium lighting projects had *ex ante* energy savings greater than or equal to 100,000 kWh and less than 500,000 kWh. Small lighting projects had *ex ante* energy savings less than 100,000 kWh.

Cadmus designed the sampling plan to achieve approximately 20% precision at 80% confidence per strata, and 10% precision at 90% confidence at the program level. Table 87 shows total project counts and energy savings reported in DP&L's tracking database. Table 88 summarizes project sampling.

Table 87. Prescriptive Program Sampling

Strata	Total Measures	Unique Projects	*Ex Ante* Energy Savings (kWh)	*Ex Ante* Demand Savings (kW)	Unique Sampled Projects
Large Lighting	95	17	12,631,182	1,056.2	6
Medium Lighting	419	104	21,516,997	2,625.9	10
Small Lighting	2,170	1,032	17,668,675	2,958.2	19
Compressed Air	34	34	1,679,635	101.9	13
Motors	46	27	2,237,804	460.6	14
Census-P-Motors	1	1	15,052,406	2,596.1	1
HVAC	224	130	4,646,953	1,059.8	16
Total	**2,989**	**1,345**	**77,602,762**	**11,169.3**	**78**

Table 88. Prescriptive Program Sampling Summary

Strata	Sampled Projects	Sampled Projects *Ex Ante* Energy Savings (kWh)	Energy Savings Percentage of Strata	Sampled Projects *Ex Ante* Demand Savings (kW)	Demand Savings Percentage of Strata
Large Lighting	6	3,892,718	31%	398.3	38%
Medium Lighting	10	2,025,988	9%	231.3	9%
Small Lighting	19	393,301	2%	43.2	1%
Compressed Air	13	522,010	31%	32.7	32%
Motors	13	2,237,804	51%	460.6	60%
Census-P-Motors	1	15,052,406	100%	2,596.1	100%
HVAC	16	81,790	2%	48.4	5%
Total	**78**	**24,206,017**	**31%**	**3,810.6**	**34%**

Site Verification Visits and Engineering Measurements

After selecting projects to verify through on-site verification activities, Cadmus downloaded project documentation from DP&L's administrative website. In preparation for each site visit, the evaluation team reviewed documentation and other relevant program information. The review focused on calculation procedures and energy savings estimate documentation.

Cadmus also reviewed DP&L's tracking spreadsheet and online application data, comparing entries to original application materials for consistency and accuracy.

On-site visits enabled Cadmus to conduct the following primary tasks:

- Verify implementation, installation, and characteristics of incented equipment
- Collect additional, detailed data (e.g., ballast factors) needed to calculate energy savings
- Install light meters on selected projects to determine HOU
- Install power metering equipment

Appendix G. summarizes Cadmus' metering process and findings. Appendix H. provides detailed site visit findings.

Engineering Analysis and Savings Verification

For each project in the site visit sample, Cadmus performed an engineering analysis using data verified on site and supplemented by project documentation and, in some instances, metered data. This analysis validated energy savings and demand reductions.

Procedures used to validate savings depended on the measure type analyzed. Major measure groups including the following:

- Lighting Measures
- HVAC Measures
- Motors and VFDs
- Air Compressors

Generally, the review methodology relied on industry-standard algorithms, the Ohio TRM, secondary research, meter and trend data, and engineering experience. The following sections describe procedures used to validate savings from the four measure categories.

Lighting Measures

Lighting measures included retrofits of existing fixtures, lamps, and/or ballasts with energy-efficient models as well as lighting control technologies. Cadmus generally assumed fixtures operated in the same way (i.e., the same duration of time), pre- and post- retrofit.

Analyzing lighting fixtures' measure savings required specific fixture data, including the following:

- Wattage before and after the retrofit
- HOU after the retrofit
- Number of fixtures affected by the measure

Cadmus used two sources to calculate HOU for lighting fixtures:

- Cadmus engineers verifying lighting HOU during site visits installed light meters in a representative manner, or confirmed HOU from site contact interviews
- Where hours could not be verified, Cadmus employed the Ohio TRM

For 18 projects, Cadmus installed 69 light meters to determine HOU. These 18 projects were selected randomly based on strata (medium, small, and large projects) and fixture locations (interior fixture locations). Metered sites represented a variety of building types (e.g., schools, manufacturing facilities, offices, churches, universities, retail spaces). As the reported HOU in DP&L's database only reflected fixture types and not space types, Cadmus installed meters on lighting fixtures in different space types (e.g., retail, manufacturing floor, break rooms, storage, office space).

Cadmus analyzed HOU for each fixture by day type (e.g., weekday, Saturday, Sunday, holiday). When the metering period did not include a public holiday, Cadmus assumed six federal holidays for businesses. For buildings following a special schedule (e.g., schools, universities), Cadmus discussed annual holidays with site contacts. To ensure redundancy, Cadmus field staff installed at least two meters for large spaces. When installing multiple meters in the same space, Cadmus averaged the hours recorded by the meters. Appendix G. Nonresidential Metering Summary provides a summary of the memo Cadmus issued to inform DP&L about light meter installations and retrieval protocols.

In addition to lighting fixture retrofit measures, Cadmus analyzed savings for wall, ceiling, and fixture-mounted occupancy sensors using the following data:

- Total connected lighting loads
- Space types
- Facility operating hours (light metering where applicable), with any operational characteristics identified through on-site surveys

Calculations used wattage values reported on applications, unless those deviated significantly from published databases or manufacturers' claims.

During on-site visits, Cadmus verified the parameters discussed above, and conducted interviews with facility personnel to verify operating hours and to determine locations where measures had been applied. When on site, field engineers collected lamp information (e.g., actual fixture and ballast details) and performed a fixture count.

As the Ohio TRM provided a specific baseline for fixtures, based on high-efficiency replacements for lighting measures, Cadmus used (where applicable) baseline wattage values in the TRM for the savings calculations. For LED fixtures and bulb replacements, Cadmus used the baseline fixture and bulb information provided by the customer.

For additional upstream lighting savings, achieved when customers purchased LEDs from retailers and installed the lamps in commercial applications, Cadmus conducted analysis as part of the Residential Lighting program, and attributed savings to the Nonresidential Prescriptive Rebate program's lighting measure category. Analysis used the Ohio TRM to account for differences between sectors. Cadmus adjusted HOU, WHFs, and demand CFs for small commercial applications, using the commercial lighting inputs shown in Table 7 of the Residential Lighting program chapter.

Compressed Air Systems

DP&L incentivized three types of compressed air projects: 1–100 HP air compressors with load/no-load controls; 1–100 HP air compressors with variable speed controls; and no-loss drains. Similar to motors, load factors served as critical parameters for air compressor systems. Cadmus calculated savings using load factor estimates, based on TRM values and engineering experience.

Cadmus installed power metering equipment on air compressors associated with seven compressed air projects. For each air compressor project, the meters measured energy use at two-minute intervals for a

minimum of three months. Cadmus retrieved the power metering equipment in October and analyzed the data to determine the compressor load profile, efficiency, and HOU. The team updated the energy saving calculations using the metering results.

HVAC Measures

DP&L provided incentives for 25 unique measure types in 2017, grouped into the following technology categories:

- Unitary and Split-System ACs
- Packaged Terminal ACs
- Air-Cooled Chillers
- Water-Cooled Chillers
- Air Source HPs
- Ground Source HP
- HP Water Heaters
- Variable Refrigerant Flow (VRF) Systems
- Smart Thermostats
- HVAC Variable Frequency Drives
- HVAC Occupancy Sensors
- Window Film
- Outside Air Economizer with Two Enthalpy Sensors

Using the Ohio TRM as a guide, Cadmus analyzed each measure and verified HVAC savings through site verification results and reviews of application materials.

To quantify loads controlled by the devices, Cadmus used values based on the Ohio TRM and on engineering experience. This analysis accepted the Ohio TRM values for EFLH, as these had been reviewed by various evaluation contractors supporting development of the Ohio TRM. For 10 non-VFD HVAC projects, Cadmus installed power metering equipment and used the data to update the energy savings calculations.

Motors and HVAC VFDs

DP&L incentivized four unique project types in 2017, including the following motor measures:

- 15 HP premium-efficiency motors
- 75 HP premium-efficiency motors
- 100 HP premium-efficiency motors

- VFDs[29] less than 250 HP

Cadmus analyzed each measure using the methodology defined in the Ohio TRM, and verified motor and VFD gross savings through site-verification results and reviews of application materials.

For high-efficiency motor replacements, parameters included the following:

- Efficiency of the old and new motors
- Load factors[30]
- Usage factors

As Cadmus engineers conducted a site visit of a motor project, they collected information such as nameplates and motor applications (e.g., pump, fan, process). Where applicable, the evaluation team also verified motor operating hours by interviewing facility contacts. When data could not be obtained, Cadmus estimated these parameters, based on professional experience, deemed values from the Ohio TRM, and an internet search of equipment specification data. Additionally, Cadmus installed power metering equipment for VFDs incentivized on 10 projects. The team analyzed the metering data to determine annual HOU and associated VFD speeds. When calculating energy savings for VFD projects, these two metrics represented the most important variables.

Calculating Realization Rates

Cadmus derived program-level, end-use savings, and demand reductions through adjusted gross savings realization rates, calculated for each major measure type (e.g., HVAC, lighting, motors, compressed air). As with the sample selection process, the study broke lighting measure types into three categories: large, medium, and small lighting projects. This method included the following:

- Calculating adjusted gross savings for the sample of site visit projects.
- Calculating a realization rate, based on *ex ante* and adjusted gross savings, for the total sample within each measure group.
- Applying sample realization rates to the program lighting population for each measure group to calculate total program verified and adjusted gross savings. Cadmus divided lighting into the following kWh strata:
  - Small (0–100,000 kWh)
  - Medium (100,000–500,000 kWh)
  - Large (500,000 plus kWh)

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29 In some cases, this category included HVAC VFDs.

30 The load factor—serving as a critical parameter for air compressor and VFD installations—often can be determined through pre- and post-installation metering. Due to time and cost involved, however, metering may not be feasible for prescriptive programs. Therefore, Cadmus calculated savings using load factor estimates, based on Ohio TRM values and engineering experience.

- Applying adjusted gross savings realization rates, developed for each stratum, across that population subgroup. One large prescriptive motors project was selected due to the magnitude of claimed savings. As the project was selected individually (not randomly), the evaluated results and adjusted gross savings realization rates from this project were not applied to the stratum population.
- Including 4.1% kWh in adjusted savings from the Residential Lighting program to the Nonresidential Prescriptive Rebate program.

Cadmus acknowledged several limitations resulting from this approach. For example, applying adjusted gross savings realization rates to a heterogeneous population of measures using small samples can present issues. Lighting measures, however, dominated *ex ante* program savings (67%).[31] Cadmus determined that the size, variability, confidence, and precision associated with the lighting sample provided the most significant influence on overall adjusted gross savings realization rates, reducing impacts of small sample sizes in other measure groups.

Detailed Impact Findings

Gross Savings Results

Table 89 and Table 90 summarize sample-verified and adjusted results by major prescriptive measure groups (the Midstream Incentive section discusses in-depth midstream incentive details).

Table 89. Sample Gross *Ex Ante* and Adjusted Gross Energy Savings

Measure	Number of Projects	*Ex Ante* Gross Energy Savings (kWh)	Verified Energy Savings (kWh)	Adjusted Energy Savings (kWh)
Large Lighting	6	3,892,718	3,892,718	4,133,865
Medium Lighting	10	2,025,988	2,025,988	1,737,863
Small Lighting	19	393,301	393,301	396,387
Compressed Air	13	522,010	522,010	516,392
Motors	13	2,237,804	2,237,804	2,200,541
Census-P-Motors	1	15,052,406	15,052,406	12,359,621
HVAC	16	81,790	81,790	106,063
Total	**78**	**24,206,017**	**24,206,017**	**21,450,732**

[31] This percentage did not include the transfer of upstream Residential Lighting program savings to the Nonresidential Lighting program.

Table 90. Sample Gross *Ex Ante* and Adjusted Gross Demand Savings

Measure	Number of Projects	*Ex Ante* Gross Demand Savings (kW)	Verified Demand Savings (kW)	Adjusted Demand Savings (kW)
Large Lighting	6	398.3	398.3	499.1
Medium Lighting	10	231.3	231.3	247.3
Small Lighting	19	43.2	43.2	39.9
Compressed Air	13	32.7	32.7	40.8
Motors	13	460.6	460.6	440.3
Census-P-Motors	1	2,596.1	2,596.1	2,320.3
HVAC	16	48.4	48.4	65.2
Total	**78**	**3,810.6**	**3,810.6**	**3,652.9**

Lighting Savings

Figure 22 and Figure 23 show adjusted gross savings realization rates and associated *ex ante* energy savings for each sampled lighting project.

Figure 22. Prescriptive Lighting Energy Savings Sample Results

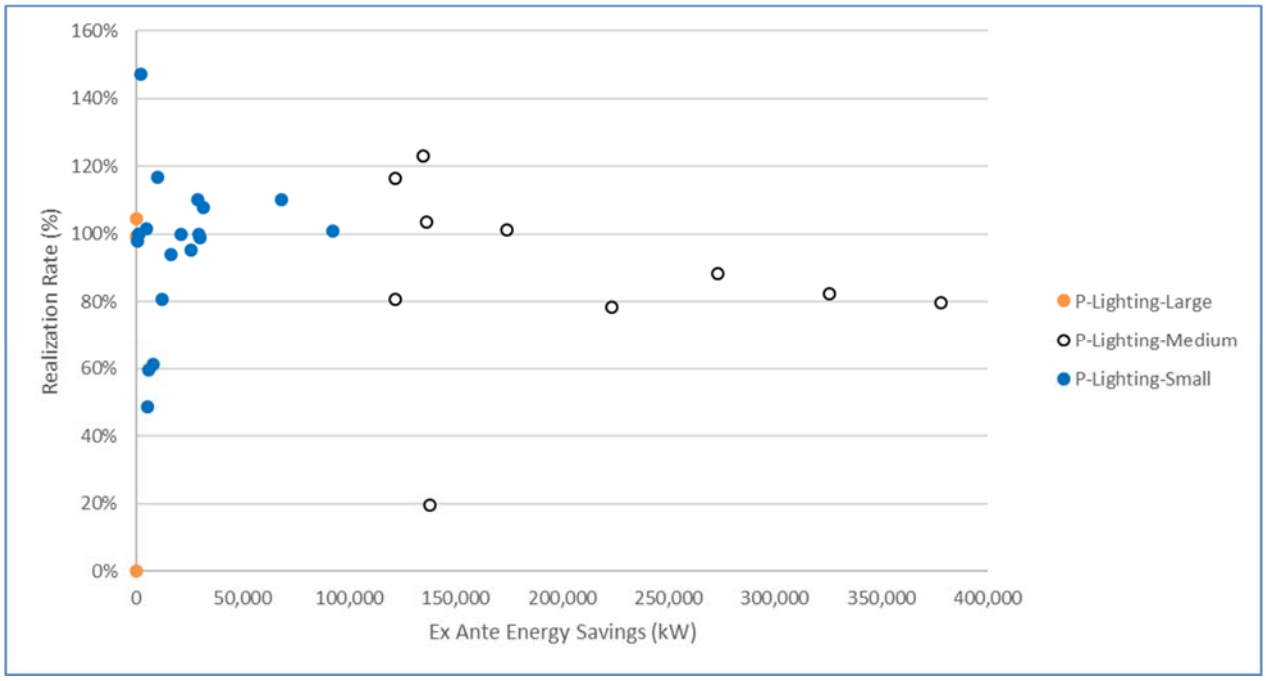
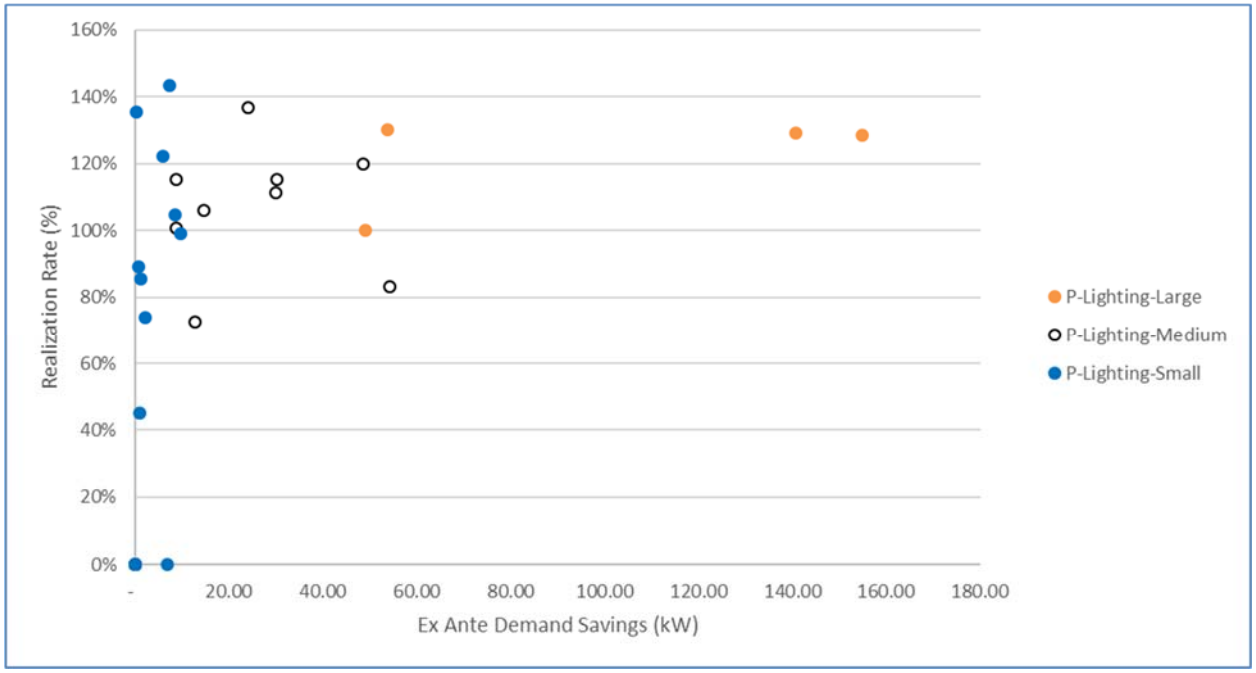


Figure 23. Prescriptive Lighting Demand Reduction Sample Results



For many sampled lighting projects, Cadmus calculated lower or higher energy savings than those reported. The primary differences between reported and adjusted values resulted from differences in operating hours, based on light logger data, light fixture locations, fixture quantities, fixture types, and CF calculations. Table 91 provides details regarding sampled projects evaluated to exhibit lower than 80% or higher than 120% adjusted gross savings realization rates for demand savings.

Table 91. Lighting—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
4GXUFGKF	300+ LED fixtures at healthcare facility	137,782	12.62	27,116	9.15	Lower HOU than claimed: 8,760 HOU claimed; 600–2,600 HOU measured.
M9E07CY3	Seven screw-in LEDs; LED relamping	5,177	0.94	2,513	0.43	Lower HOU than claimed: 4,380 HOU claimed. 357–3,085 HOU measured.
V0PYX1R3	125 high-bay LEDs at automotive facility	223,433	23.94	175,601	32.70	Lights ran continuously during the peak period, but did not run as long as expected during all other hours.

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
J1S5GZ9T	48 10 W LED lamps	12,299	2.11	1.56	1.58	Eleven fewer fixtures found on site than rebated; 37 vs 48.
UTOW2NXB	Very large LED lighting project	587,148	53.77	525,045	69.87	Higher peak coincident factor than claimed, based on light logger data.
SCPSOAK9	Eight 100 W LED fixtures at a retail facility	31,249	6.89	33,759	0.00	The eight LED fixtures were installed on exteriors and controlled by photocells; claimed savings based on interior installations.
ZD99Y3K0	70 18 W LED fixtures; 25 9W LED bulbs	29,072	5.78	32,057	7.07	Higher HOU than claimed, based on light logger data.
DU7SCTTD	448 12 W linear LED fixtures	68,301	7.32	75,379	10.50	Higher HOU than claimed, based on light logger data.
OKXZUUKV	25,000+ ft of linear LEDs	592,702	140.67	678,836	181.50	Calculated kWh and kW savings greater than claimed kWh savings due to longer annual operation hours and higher CFs, determined by light logger analysis.
QN4OGZ42	Very large LED lighting project	665,658	154.88	882,773	198.80	Higher HOU than claimed, based on light logger data.
YJ42S07D	21 127 W LED fixtures	1,829	0.31	2,692	0.42	Higher HOU than claimed, based on light logger data.

Cadmus evaluated six large lighting projects projects(>500,000 kWh savings) and installed light loggers at three facilities. Where loggers were installed, Cadmus observed higher HOU and higher coincident factors during peak periods than claimed in the rebate documentation.

Cadmus installed light loggers on nine of 10 evaluated medium lighting projects (<= 500,000 kWh and > 100,000 kWh savings). One project, Confirmation ID: 4GXUFGKF, involved an LED upgrade at a healthcare facility and claimed 8,760 HOU. Cadmus installed light loggers at four different suites and measured HOU varying between 600 to 2,600 per year. Cadmus applied evaluated HOU to the lighting

calculation, resulting in a 20% energy consumption realization rate. Another project, Confirmation ID: V0PYX1R3, involved installation of high-efficiency lighting. Cadmus installed light loggers and the analyzed data indicated the lights operate for more time than expected during the peak period (137% realization rate) but fewer annual hours than claimed (79% realization rate).

Cadmus deployed light loggers at seven of 19 evaluated facilities within the small lighting projects strata (<= 100,000 kWh savings). One project, Confirmation ID: SCPSOAK9, involved LED installations at a retail facility. The rebate documentation indicated these 100-watt LED fixtures were intended for installation in a retail facility. Cadmus discovered fixtures installed on parking lot poles and controlled by photocells. Due to the photocell control, these fixtures did not operate during peak hours, resulting in no demand savings (6.9 kW demand savings claimed). Twelve of 19 small lighting projects evaluated involved exterior lighting and claimed no demand savings. In general, most small lighting projects exhibited small discrepancies between rebate documentation and site observations.

Compressed Air

Cadmus evaluated 13 compressed air projects. Sampled projects included high-efficiency screw air compressors and no-loss condensate drains. Figure 24 and Figure 25 show realization rates and associated *ex ante* energy savings for each sampled compressed air project.

Figure 24. Prescriptive Compressed Air Energy Savings Sample Results

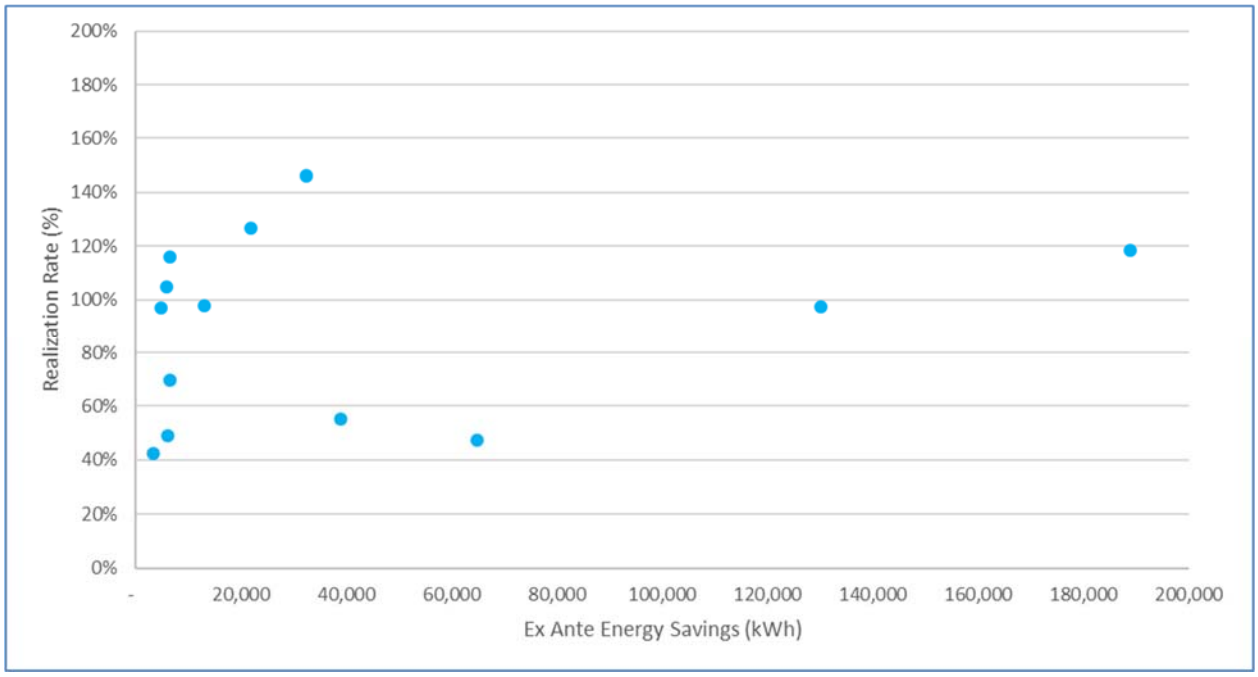
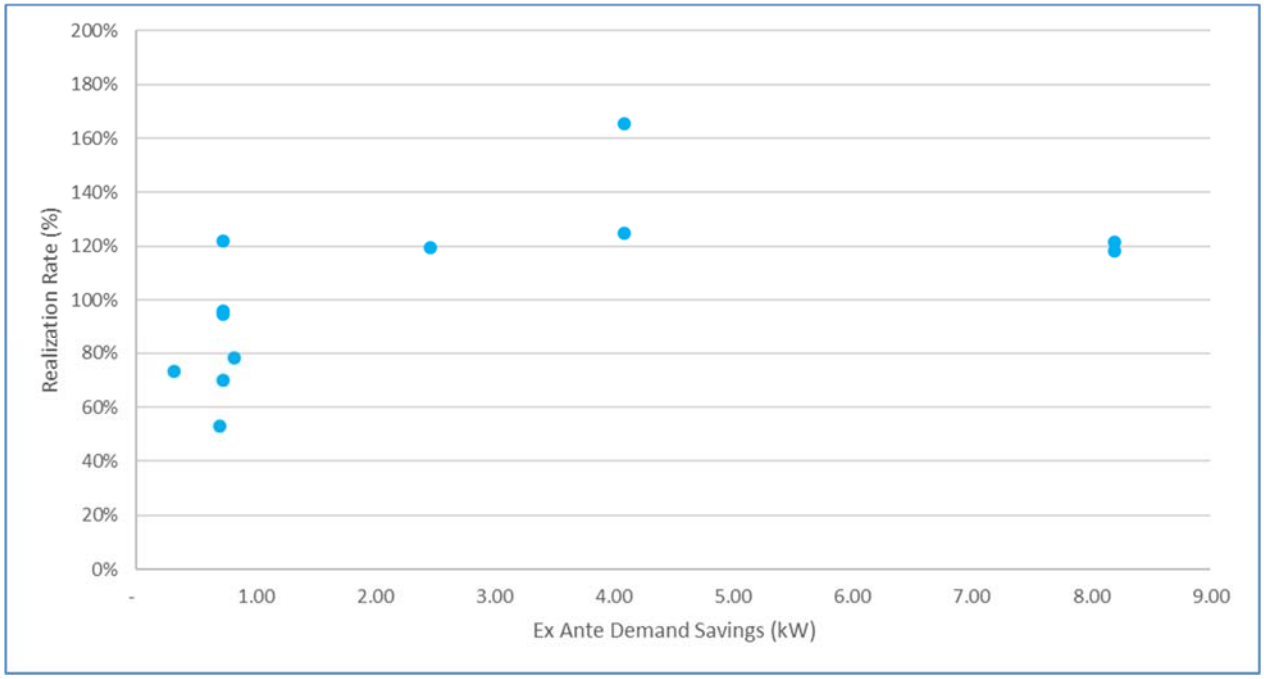


Figure 25. Prescriptive Compressed Air Demand Sample Results



Cadmus installed power metering equipment for seven of eight projects involving new screw air compressors and analyzed the performance period (from June 2017 through September 2017). Metered projects showed high variability in energy consumption and energy demand savings. As compressed air systems and usage varied, depending on the industry, manufacturing process, and end-use requirements, compressed air load profiles varied from case to case. Table 92 provides details regarding sampled projects, evaluated to exhibit lower than 80% or higher than 120% realization rates for demand savings.

Table 92. Compressed Air—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
3QEJVWXW	One 10 HP screw air compressor	3,316	0.31	1,410	0.23	Meter data indicated lower total HOU than expected.
F6NITK4C	One 50 HP screw air compressor	64,653	4.09	30,617	6.76	Meter data indicated lower total HOU than expected (3,396 hours vs 6,000 hours); Metered CF was higher than TRM default (75% vs 38%).

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
3QM145UI	Two no-loss condensate drains	6,114	0.70	3,007	0.37	One of two no-loss drains installed on a compressor that only ran during weekend shifts.
ZQYRWNG5	Two no-loss condensate drains	6,359	0.73	4,437	0.51	Rebate documentation assumed a lower-efficiency air compressor than observed on a system served by drains.
TO2VD8Z7	One 100 HP screw air compressor	130,083	8.19	126,616	9.95	Meter data indicated higher-efficiency performance during peak periods than assumed by the TRM.
WTP06EU3	One 10 HP screw air compressor	12,931	0.82	12,664	0.64	Meter data indicated lower HOU than expected.
1DWUY072	Two no-loss condensate drains	6,359	0.73	7,380	0.89	Lower-efficiency air compressor observed on system than assumed in the application documentation.
ZSIF2JY9	One 30 HP screw air compressor	21,783	0.94	27,582	2.29	Meter data indicated a load profile with a higher-efficiency performance than assumed by the TRM.
IN0BS87N	One 50 HP screw air compressor installed	32,327	4.09	47,270	5.11	Meter data indicated a load profile with higher-efficiency performance than assumed by the TRM.

The evaluation indicated three of the five compressed air projects, involving the installation of a no-loss condensate drain, had low adjusted gross savings realization rates for energy consumption data. DP&L determined energy savings for no-loss condensate drains, based on assumptions for equipment specifications and performance. DP&L collected applicant data inputs for quantity, system pressure, and HOU, but not collect data inputs for all equipment specifications and performance. DP&L used all applicant data inputs and assumptions to calculate energy consumption and demand savings. For three projects realizing low adjusted gross savings realization rates for energy consumption, Cadmus observed

higher-efficiency rated output from air compressors for two projects and lower system pressures than claimed in the documentation. DP&L assumes air compressor performance and system pressures when calculating energy savings for no-loss condensate drain projects.

Cadmus installed power meters for seven of eight compressed air projects that involved installation of new or replacement high-efficiency screw air compressors. DP&L claimed energy savings based on the Ohio TRM, with applicant inputs for quantity and horsepower. Assumptions included motor efficiency, energy saving factors, and coincident factors. For most metered projects, HOU were lower than expected, based on applicant inputs resulting in low energy consumption adjusted gross savings realization rates. For nearly all projects, metered data indicated air compressors operated at a higher efficiency during peak hours, resulting in greater energy demand savings than expected by the Ohio TRM.

HVAC Savings

Cadmus evaluated 16 HVAC projects including VRF systems, AC units, HPs, and a water heater. Cadmus installed power metering equipment on 11 of the 16 projects. Figure 26 and Figure 27 show adjusted gross savings realization rates and associated *ex ante* energy savings for each sampled HVAC project.

Figure 26. Prescriptive HVAC Energy Savings Sample Results

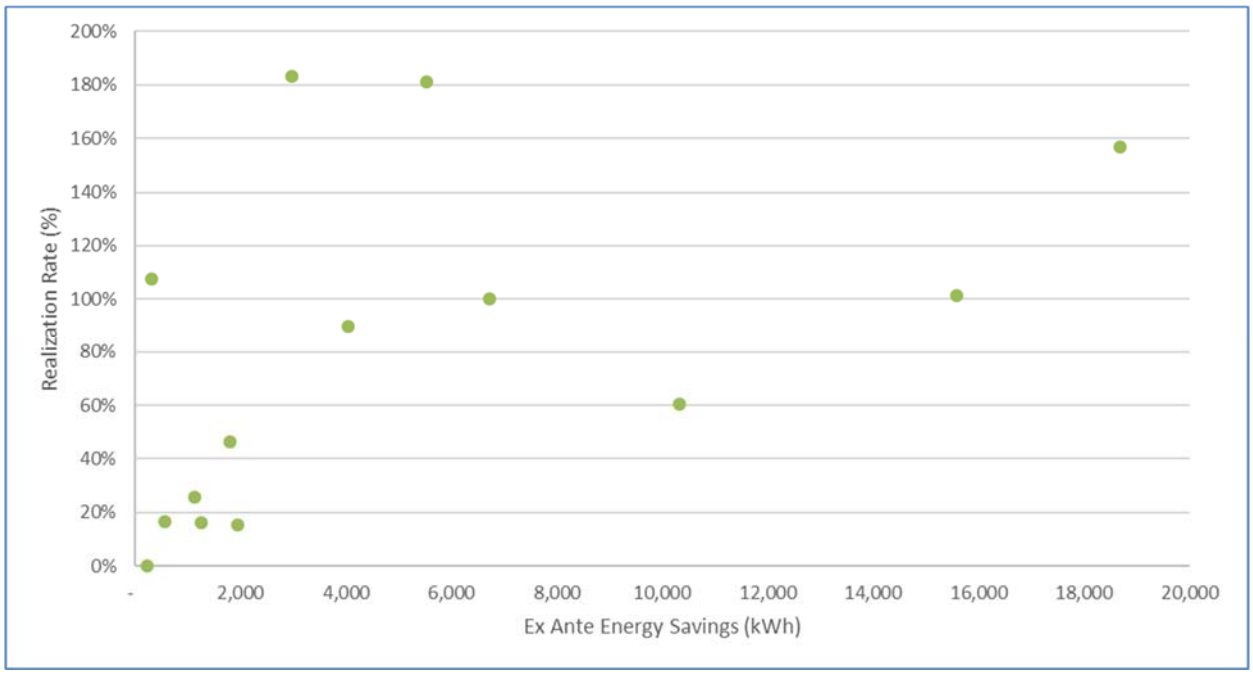
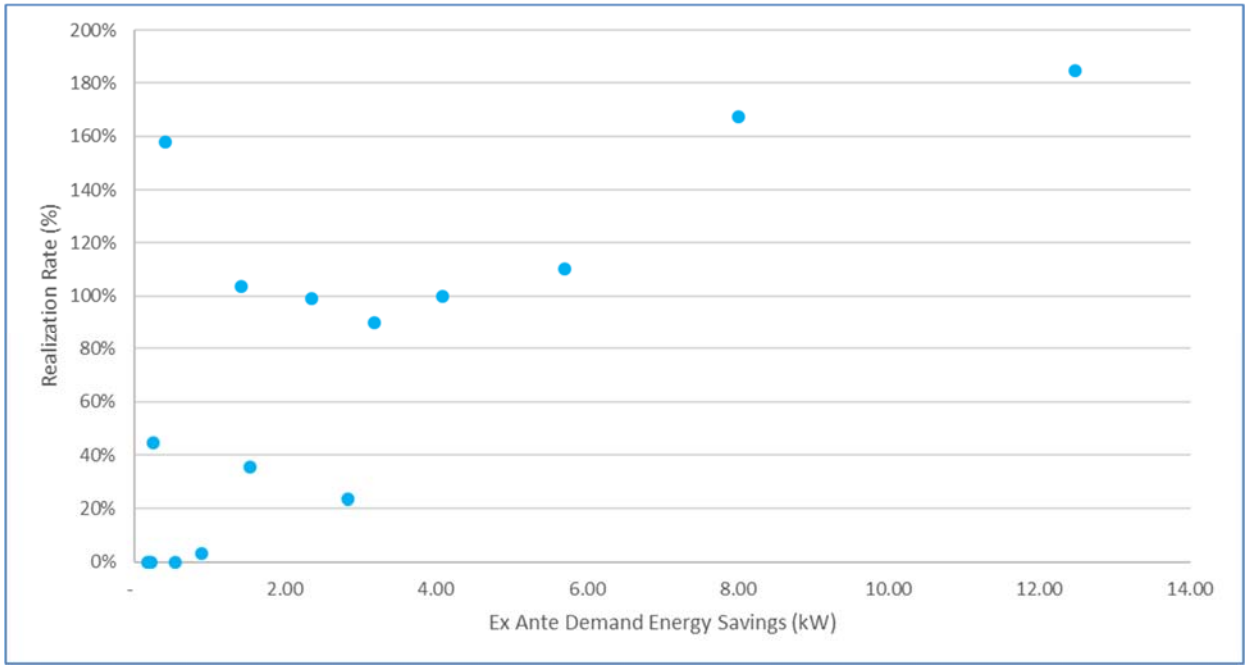


Figure 27. Prescriptive HVAC Sample Results



Cadmus installed power metering equipment for 11 of 16 sampled HVAC projects. Metered data indicated variances in EFLH and CF. Table 93 provides details regarding sampled projects evaluated to exhibit lower than 80% or higher than the 120% realization rate for demand savings.

Table 93. HVAC—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
BA2QALKG	One 12.5-ton packaged A/C unit	1,951	1.53	299	0.54	Meter data indicated low EFLH due to a unit installed at a golf course clubhouse facility.
S7O50HMH	One 7.5-ton ASHP	1,259	0.54	202	0.00	Unit only used for heating. Savings associated with a heat pump of 3.3 COP vs baseline equipment of 3.2 COP. Unit serves a warehouse.
AKD6199S	One 4-ton ASHP	556	0.22	92.72	0.00	Business ended operations shortly after the rebate was incentivized, and the facility no longer remains in use. Energy savings pro-rated, based on the time business was open in 2017

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
MP0D285W	Three 3-ton split system A/C unit	1,130	0.89	348	0.03	Evaluation calculations based on a code minimum baseline of SEER 13 instead of the SEER 10 indicated in rebate documentation
NKZY3I3A	One 80-gallon heat pump water heater	10,327	2.83	6,249	0.66	Installed water heater capacity was lower than indicated on rebate application. Power metering data indicated lower energy use than expected.
G4HLGWDE	Two 2.5-ton split system A/C units	311	0.24	334.54	0.11	Average load during the metering period was 40% of unit capacity. Lower EFLH than expected.
6Y64ZXD4	Nine VRF systems, two packaged A/C units	18,686	12.47	29,888	23.01	Higher-efficiency unit observed on site than indicated in rebate documentation.
EZ2OOEDZ	Four A/C units: one 5-ton; one 7.5-ton, two 15-ton A/C units	5,517	4.33	9,989	9.58	Metered data indicated higher EFLH and CF than expected, based on the Ohio TRM.
Q952Y6BU	Three 50-ton packaged A/C units; one 21.5-ton packaged A/C unit	10,203	8.01	24,640	13.40	Metered data indicated higher EFLH and CF than expected, based on the Ohio TRM.
7SJKL4VA	One 7.5-ton packaged A/C unit	524	0.41	1,751	0.65	Metered data indicated higher EFLH and CF than expected, based on the Ohio TRM.

One project, Confirmation ID: BA2QALKG, involved the installation of a new 12.5-ton packaged air conditioning unit at a golf course facility. Because the unit served a golf course facility clubhouse, the facility HOU and associated cooling load were observed as very low. Typically, the facility was occupied for 48 hours per week, and meter data indicated a maximum cooling load at only 55% of the total unit capacity during the performance period.

One project, Confirmation ID: S7O50HMH, involved the installation of a new 7.5-ton ASHP serving a warehouse. While on site, Cadmus observed the thermostat controlling the HP only provided heating control for the warehouse. The cooling capability was not used. Energy savings for heat pumps are based on high-efficiency performance in heating and cooling modes. As the heat pump was not used for cooling, no summer demand savings were realized and low energy consumption savings were observed.

Rebate documentation calculated energy savings for project Confirmation ID: MP0D285W using 10.0 SEER as the baseline unit and installed equipment with a 15.0 SEER. Cadmus observed the installed equipment to match the rebate documentation, but the Ohio TRM mandated a minimum 13.0 SEER for air conditioners less than 65,000 Btu/h. Due to changes in the baseline equipment efficiency, energy savings for consumption and demand decreased.

Cadmus installed power meters on multiple projects, where installed equipment exhibited higher EFLH and CFs than expected. The Ohio TRM indicated a default value of 942 EFLH Cooling for Dayton. In many cases, observed metered equipment ran at higher cooling capacities and for longer periods than expected, resulting in EFLH values exceeding the default value by as much as 296%. In these cases, high use may have resulted from undersized equipment for spaces served or very low temperature thermostat settings.

Motor Savings

Cadmus' evaluation of 14 motors projects including VFDs and premium efficiency motors. One large prescriptive motors project accounted for 87% of all claimed energy savings within the prescriptive Motors strata. Figure 28 and Figure 29 show adjusted gross savings realization rates and associated *ex ante* energy savings for each sampled Motors project.

Figure 28. Prescriptive Motor Energy Savings Sample Results

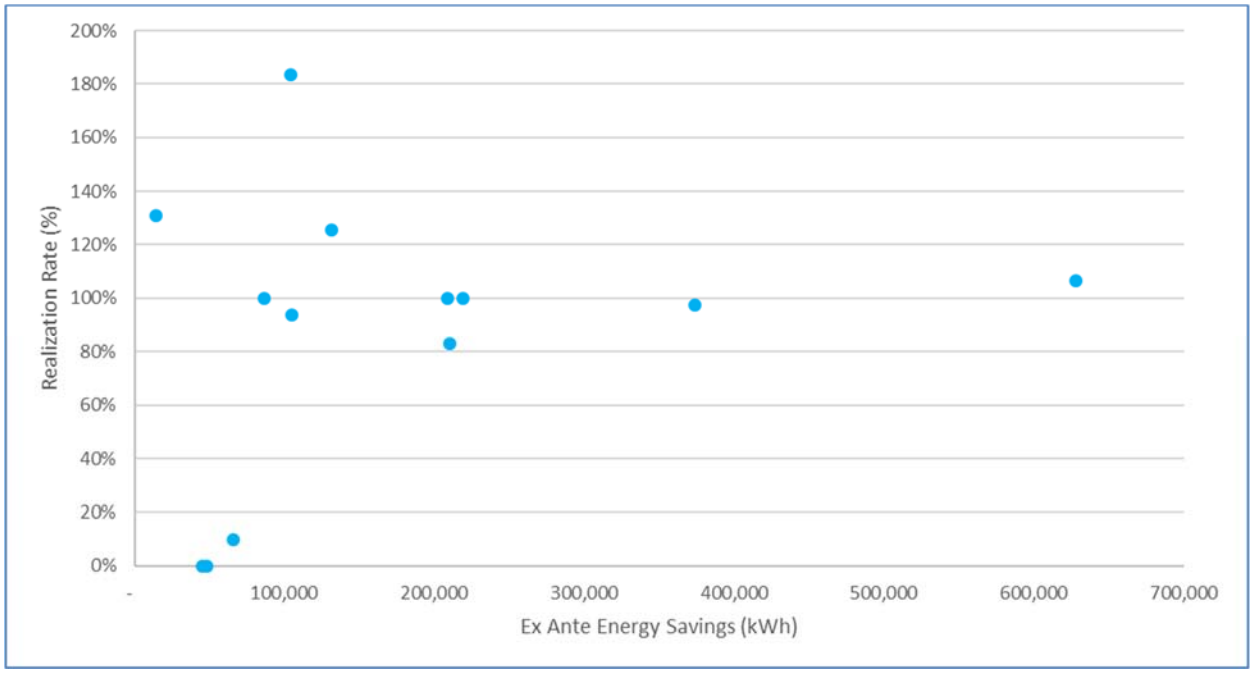
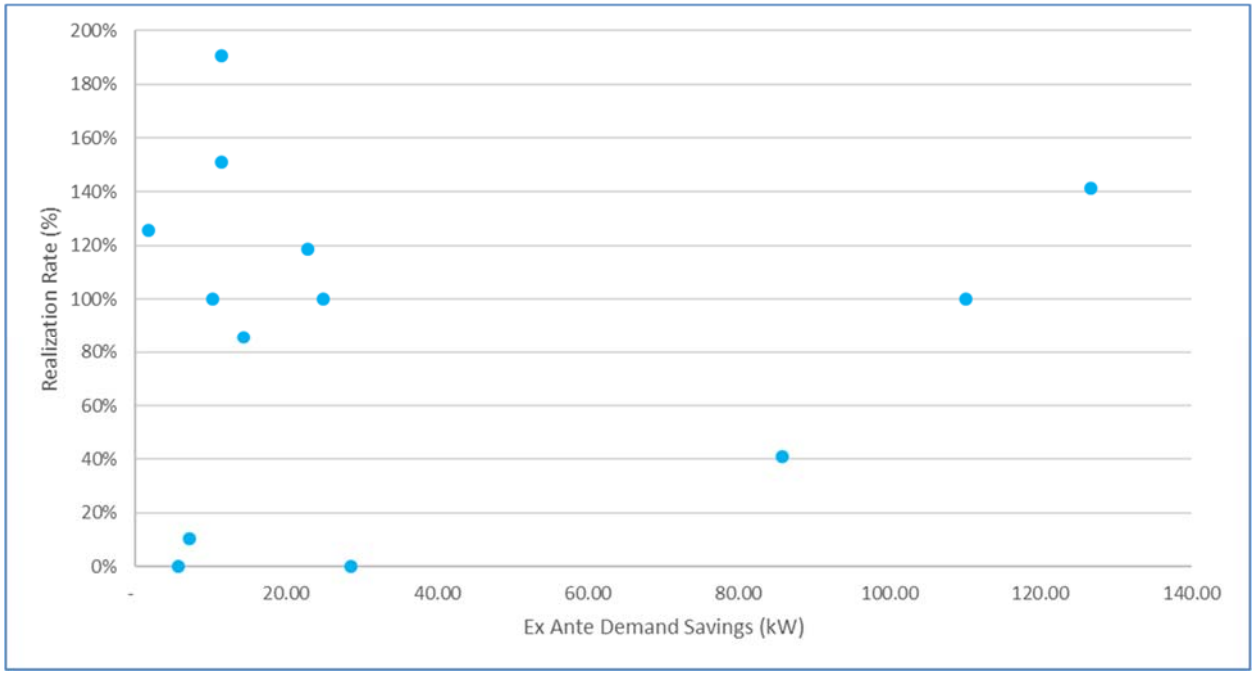


Figure 29. Prescriptive Motor Demand Reduction Sample Results



The figures above do not show one project—Project ID: R793CO9R—with 15,052,406 kWh and 2,596.1 kW savings, due to the magnitude of savings relative to the other projects within the Motors strata.

Cadmus installed power metering equipment for ten of 14 sampled motors projects. Table 94 provides details regarding the sampled projects evaluated to exhibit lower-than-80% or higher-than-120% adjusted gross savings realization rates for demand savings.

Table 94. Motors—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
MAMPN4T5	One VFD serving a 20-HP motor	47,941	5.71	0	0.00	VFD used as a soft start for an elevator motor. Elevator runs at full speed at all times except when starting and stopping.
VIB2R5S1	One VFD serving a 100-HP motor	44,944	28.57	0	0.00	VFD runs at 100% speed to serve the water plant motor. Shaft vibration symptoms prevent motor from reducing speed.

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
8OKS9TQP	One VFD serving a 25-HP motor	65,619	7.14			VFD runs at near 100% speed to serve a wastewater treatment plant motor.
KAH97BOS	Two VFDs serving 150 HP motors	373,938	85.71	6,374	0.73	VFD serves process exhaust fans. Energy use during peak period was observed to be 83% of maximum power draw.
F3L4WIDN	One VFD serving a 40-HP water pump	104,703	11.43	97,955	17.25	Meter data indicated operating hours lower than expected (5,400 vs. 8760). When running, low average speeds were observed resulting in high average kW reduction
AT5WJ5T4	Seven VFDs and four high-efficiency motors	627,616	126.64	669,238	178.90	Meter data indicated low total run hours and low average power consumption for the metered equipment
Y237IBKM	Six VFDs serving 1-HP motors.	14,382	1.71	18,860	2.15	Meter data indicated motors run continuously and operate at an average speed of 70%.
VUPCL2HX	One VFD serving two 20-HP motors	103,912	11.43	190,803	21.78	Meter data indicated motors operate between 30% and 60% of maximum speed during trend period

Cadmus metered nine projects involving VFD installations. DP&L claimed energy savings for these projects, based on the Ohio TRM measure "Variable Frequency Drives for HVAC Applications" by collecting the following applicant inputs: quantity; HOU; and motor horsepower. DP&L calculations assumed motor efficiency (0.91), load factors (0.85), ESF (0.41), and demand savings factors (0.43). Based on meter data analysis and site observations, Cadmus observed or measured all inputs used in the Ohio TRM calculation methodology. The observed or measured inputs for motor efficiency, load factors, and load profile (ESF and DSF were derived from load profiles) often deviated from the assumptions used in DP&L's calculations and could result in increased or decreased savings.

Meter data and site observations from three projects—Confirmation IDs: MAMPN4T5, VIB2R5S1, and 8OKS9TQP—indicated VFDs operating at or near 100% during the entire trend period. Energy savings were achieved only when VFDs operated at part-load speeds. These projects realized minimal or no energy savings. Two VFDs controlled pumps at water treatment plants, and one VFD controlled an elevator motor.

The largest project incentivized within the Motors strata, Confirmation ID: R793CO9R, involved the installation of over 800 VFDs serving process motors at a glass manufacturing facility. The VFDs served a variety of end use equipment types including pumps, fans, conveyors, autoclaves, bending machines, lamination machines, packing machines, and other process equipment. Cadmus recorded spot power measurements and installed 19 power meters on a representative sample of the motors to determine performance characteristics over a period of five weeks. DP&L's calculations for VFDs utilize metered data for hours of use. The other calculation components within DP&L's VFD calculations utilize the Ohio TRM and an energy savings factor and demand saving factors based on the average composition of VFDs serving process and hvac applications. Within this project, the majority of VFDs serve process equipment and on average, the maximum demand and load profile was lower than expected for motors serving HVAC equipment, resulting in lower energy and demand savings than claimed.

Meter data from five projects indicated HOU, load factors, ESFs, and demand savings factors, all measured as higher or lower than expected in the application data. Variations for each input were expected due to the wide range of applications.

Recommendations

Based on the preceding findings, Cadmus offers the following recommendations for prescriptive program improvements:

- **Cadmus recommends modifying the energy savings calculation methodology for prescriptive VFD rebates serving large non-HVAC applications.** The Ohio TRM provides guidance on how to calculate energy savings for VFDs, with the energy savings based on motor applications for HVAC applications (e.g., air handling unit supply fans, return fans, exhaust fans, boiler or chiller pump applications). Many VFDs incentivized through DP&L's prescriptive program were observed as applied to process applications. As process applications do not have typical or regularly established load profiles, they will likely achieve lower or higher energy savings than typical HVAC applications. For process VFD applications, Cadmus recommends monitoring the end use load profile and modifying the energy savings analysis to account for a modified load profile and associated energy savings factor and demand savings factor.

Midstream Incentive Channel

This section describes the evaluation approach, detailed findings, and conclusions and recommendations for the Midstream Incentive Channel. The Midstream Incentive Channel is a component of the Non-Residential Prescriptive program, and as such, Midstream savings are ultimately attributed to the Nonresidential Prescriptive Rebate program.

Evaluation Overview

Cadmus' evaluation of the 2017 Midstream Incentive Channel followed the evaluation activities and researchable questions outlined in Table 95.

Table 95. Key Researchable Questions

Researchable Question	Activity Used to Address Question
How do Ohio TRM-deemed savings compare with validated program savings?	• The program uses Ohio TRM-deemed values for future reported savings, which may differ from actual savings achieved. The impact evaluation characterized any differences.
What gross electric savings and demand reductions does the program achieve?	• Determining the amount of gross electric savings and demand reductions will help in creating a business case for continuing the program and will be useful for planning future program designs.
Is the program cost-effective?	• Cost-effectiveness analysis

For specific technologies (e.g., VFDs, LEDs, T8s), the Midstream Incentive Channel provided time-of-sale markdowns through commercial distributor locations. Implementation staff worked with distributors located within DP&L's service territory to promote efficient, nonresidential, commercial lighting and VFD measures by offering midstream incentives. Incented lighting measures included screw-in LED lamps, linear fluorescent and linear LED lamps, and LED fixtures.

CLEAResult developed and implemented this effort. The participation was entirely distributor-driven in 2017.

Detailed Evaluation Findings

Table 96 presents *ex ante* and verified gross savings included in the Nonresidential Prescriptive Rebate program's roll-up. Overall, the Midstream Incentive channel achieved 94.2% verified gross energy savings realization rate and a 94.3% verified gross demand savings realization rate. Key impact evaluation findings follow.

Table 96. Midstream Incentive Program *Ex ante* and Adjusted Gross Energy Savings

Program	*Ex Ante* Claimed Savings		Verified Gross Savings		Adjusted Gross Savings		
	Gross kWh	Gross kW	Gross kWh	Gross kW	Gross kWh	Gross kW	Precision*
Midstream Lighting Measures	6,461,694	1,251	6,040,654	1,178	5,491,476	988	14.9%
VFD Measures	1,108,090	200	1,089,918	191	1,089,918	191	10.0%
Total	**7,569,785**	**1,451**	**7,130,572**	**1,369**	**6,581,394**	**1,179**	**12.5%**

* Precision at 90% confidence.

Incented VFD measures accounted for roughly 15% of the Midstream channel's *ex ante* energy savings and 14% of the channel's *ex ante* demand savings. Lighting measures accounted for approximately 85% of the Midstream Incentive Channel's *ex ante* savings. Table 97 compares claimed and verified savings inputs as well as these inputs' overall impacts on the evaluation results.

Table 97. *Ex Ante* vs. Adjusted Gross Lighting Inputs and Overall Impact on Adjusted Gross Realization Rates

Weighted Input Value	HOU	ISR	IEF_e *	IEF_d *	CF	Delta Watts
Ex Ante Inputs	3,957	100%	1.09	1.20	0.73	24.80
Adjusted Inputs	3,926	98%	1.09	1.19	0.68	21.68
Overall Impact	**-1%**	**-2%**	**0%**	**-1%**	**-7%**	**-13%**

*The Interactive effects factor (IEF) for energy and demand, respectively. This factor represents reduced electric space cooling requirements due to reduction of waste heat rejected by efficient lighting.

The delta watts savings input had the largest impact on 2017 adjusted gross savings realization rates. For midstream lighting, the delta watts value remains entirely dependent on the estimated baseline wattage. Cadmus found that claimed savings did not appropriately reflect current Federal standards for lighting efficiency, specifically for screw-base LEDs sold through the Midstream Incentive channel. This measure accounted for approximately 31% of the channel's energy savings, overestimating delta watts by approximately 13%.

For example, *ex ante* savings for a 10-watt LED A-lamp are based on a 60-watt incandescent baseline lamp. Although LED packaging may state the bulb is a "60-watt equivalent," it has been unlawful since 2014 to manufacture 60-watt incandescent lamps due to more stringent lighting efficiency standards. Based on current Federal regulations, the baseline wattage for "60-watt equivalent" lamps is 43 watts. The Baseline Wattage section provides further details.

Evaluation Data Collection Methods

In evaluating the 2017 Midstream Incentive Channel, Cadmus used the approaches discussed below.

Program Database Review

Cadmus reviewed data provided by CLEAResult, verifying each measure included model numbers and reported savings. The evaluation team verified wattages, lumen outputs, and other defining

characteristics for the majority of bulbs by cross-checking equipment model numbers against the implementer-provided QPL.

Impact Evaluation Methodology and Findings

Variable Frequency Drives

Introduced to the Midstream Incentive Channel in 2015, the VFD measure served as a successful addition in 2017. Cadmus did not perform site visits to verify installations or determine equipment operations specifically for the Midstream Incentive Channel, but, in past years, several VFD projects have been reviewed as part of the Nonresidential Prescriptive Rebate program evaluation. Since 2014, Cadmus has sampled and reviewed—either through power metering or engineering desk reviews—a total of 45 VFD projects, encompassing a number of end uses. The average adjusted gross savings realization rates for the 2017 projects—98.4% for energy and 95.8% for demand—were applied to VFD measures incented through the Midstream Incentive Channel.

The Nonresidential Prescriptive Rebate Program chapter provides additional details on Cadmus' power metering and engineering review processes.

Lighting

Cadmus used the following approaches and algorithms in evaluating the Midstream Incentive Channel's lighting measures:

$$\Delta kWh = \frac{\Delta W}{1{,}000} * ISR * HOU * WHF_e$$

$$\Delta kW = \frac{\Delta W}{1{,}000} * ISR * WHF_d * CF$$

Where:

ΔW	= Delta watts = baseline watts – efficient watts
ISR	= In-service rate
HOU	= Hours of use in hours per year
IEF_e	= Interactive effects factor for energy
IEF_d	= Interactive effects factor for demand
CF	= Summer peak coincidence factor

Table 98 shows input values used to calculate energy savings and demand reductions for *ex ante*, verified, and adjusted gross savings for lighting measures. Additional details on the inputs follow.

Table 98. LED Energy and Demand Savings Calculation Inputs

Savings Algorithm Input	*Ex Ante* Inputs*	Verified Inputs	Adjusted Inputs*
HOU	3,957	3,957	3,926
IEF_e	1.09	1.09	1.09
IEF_d	1.20	1.20	1.19
ISR	1.00	0.98	0.98
ΔW **	24.93	24.80	21.68
CF	0.73	0.73	0.68

*Cadmus calculated overall averages using inputs supplied by the implementation team and data derived from the channel's tracking data. These values represented a weighted average for all rebated bulbs.

**This value reflects a weighted average of delta watts for all rebated bulbs. Cadmus' baselines were calculated using the lumen equivalency method, outlined in the UMP Residential Lighting Evaluation Protocol.

Installation Rate

A challenge arises in evaluating programs employing midstream delivery: not knowing the final installation locations of purchased bulbs, or whether those bulbs were installed immediately or kept in storage for future installation. During the 2015 program year, Cadmus performed a participant survey (described below) to develop a multiyear installation rate, based on the percentage of lamps installed within set times from the date of purchase.

For the 2015 program year, Cadmus and CLEAResult worked with distributors to field an online survey, intending to identify a DP&L-specific ISR for the Midstream Incentive Channel. The evaluation team fielded the survey from late October 2015 through the end of February 2016 at six distributor locations.[32] Each time a customer made a qualifying purchase, whether in-store or through a distributor's outside sales staff, they were prompted to complete an online survey in exchange for a $10 gift card. Cadmus used the survey results to develop a 98.2% multiyear installation rate, based on the UMP Residential Lighting Evaluation Protocol. This multiyear ISR accounted for lamps not installed immediately following purchase. In the 2017 evaluation, Cadmus applied the 98.2% multiyear installation rate to all lighting measures.

Hours of Use

As with installation rate, HOU depend on a bulb's installed location. Cadmus used a combination of previous DP&L Nonresidential Prescriptive program data and a literature review to identify building types where bulbs were likely installed after purchase. The Nonresidential Prescriptive Rebate program database allowed Cadmus to identify the percentage of lighting projects performed for each building type, weighted by the number of rebates submitted. Database records were omitted if they lacked a specific building type.

[32] Selected by CLEAResult for their high participation rates in the Midstream Incentive Channel, these locations cumulatively represented nearly one-half of all bulbs sold through the channel in 2015.

Cadmus supplemented this information with data from the 2015 Lighting Market Characterization Study, which provided an estimate for the number of bulbs installed on building exteriors.[33]

Table 99 shows building-type distributions for commercial lighting.

Table 99. Commercial Lighting Building Type Distribution

Building Type	Project Percentage by Rebate Quantity*	Estimated Building Type Weight (Incl. Exterior)**	HOU	CF
College	2%	1%	3,900	0.68
Food Sales	3%	3%	5,544	0.92
Food Service	3%	2%	4,482	0.83
Garage	3%	2%	8,760	1.00
Health Care	4%	4%	3,677	0.78
Hotel/Motel	3%	2%	3,356	0.37
Industrial	11%	11%	4,739	0.76
Office	8%	7%	3,526	0.76
Other	34%	32%	3,672	0.65
Public Assembly	4%	4%	2,729	0.65
Public Services (non-food)	3%	3%	3,425	0.64
Retail	13%	13%	4,226	0.84
School	5%	5%	2,302	0.50
Warehouse	4%	4%	3,464	0.79
Exterior		5%	3,833	0.00
Total / Average	**100%**	**100%**	**3,931**	**0.68**

*Rebate percentage calculated from the number of rebates recorded in the Nonresidential Prescriptive Rebate Program database at the end of the 2014 program year.

**Estimated building type weight, based on the number of rebates recorded in the Nonresidential Prescriptive Rebate Program database, with an added assumption that 5% of lamps would be installed outdoors; based on the 2010 Lighting Market Characterization Study.

Cadmus used the Ohio TRM's annual hours of operation for each building type to develop overall commercial building annual operating hours. The team evaluated savings using an average of 3,931 hours for all non-exterior lighting products and 3,833 for all exterior products. This resulted in an overall, channel-average HOU value of 3,926. Overall, the program-average HOU used by the implementation and evaluation teams were very similar, with less than a 1% difference between the two values.

[33] *2015 U.S. Lighting Market Characterization.* U.S. Department of Energy. December 2017. Available online: https://www.energy.gov/eere/ssl/2015-us-lighting-market-characterization

Interactive Effects Factor

Cadmus used building-type weightings developed for the HOU input to determine IEF values for energy and demand. The team evaluated an energy interactive effects factor (IEF_e) of 1.09 and a demand interactive effects factor (IEF_d) of 1.19, and applied these values to purchases made through the Midstream channel, with the following exceptions:

- LED wall packs were evaluated with an IEF_e and an IEF_d of 1.0
- LED exterior flood lamps were evaluated with an IEF_e and an IEF_d of 1.0

In both cases, equipment was installed outdoors and should not affect the energy consumption of heating or cooling equipment in the building. Although the LED exterior flood lamps were installed outdoors, the implementation team assigned savings using a 1.095 IEF_e. The LED exterior flood measure accounted for a small percentage of overall program savings; so the difference in IEF_e had a minimal impact on program savings.

Coincidence Factor

Cadmus evaluated the summer peaking CF using the same approach adopted in estimating annual operating hours. Building-type distributions resulted in a 0.69 overall commercial CF. LED wall packs and exterior flood lamps were evaluated with a CF of 0, consistent with the *ex ante* savings approach.

Baseline Wattage

A challenge arose with the Midstream Incentive Channel's delivery method as, based solely on the rebated equipment, it's not possible to know the type of equipment that participants replaced when purchasing new lighting equipment. Upstream lighting programs, which offer a similar delivery method, also present this challenge.

The lumen equivalence method, outlined in Chapter 21 of the UMP, offers the best-practices method for determining the wattage of replaced equipment (and therefore savings). Wherever possible, Cadmus used the lumen equivalence method to determine baseline lamp wattages, based on lumen outputs of purchased lamps. This methodology is most appropriate for common and well-studied lighting types, such as screw-based LEDs, and assumes customers will purchase lamps possessing similar lighting characteristics to those already installed.

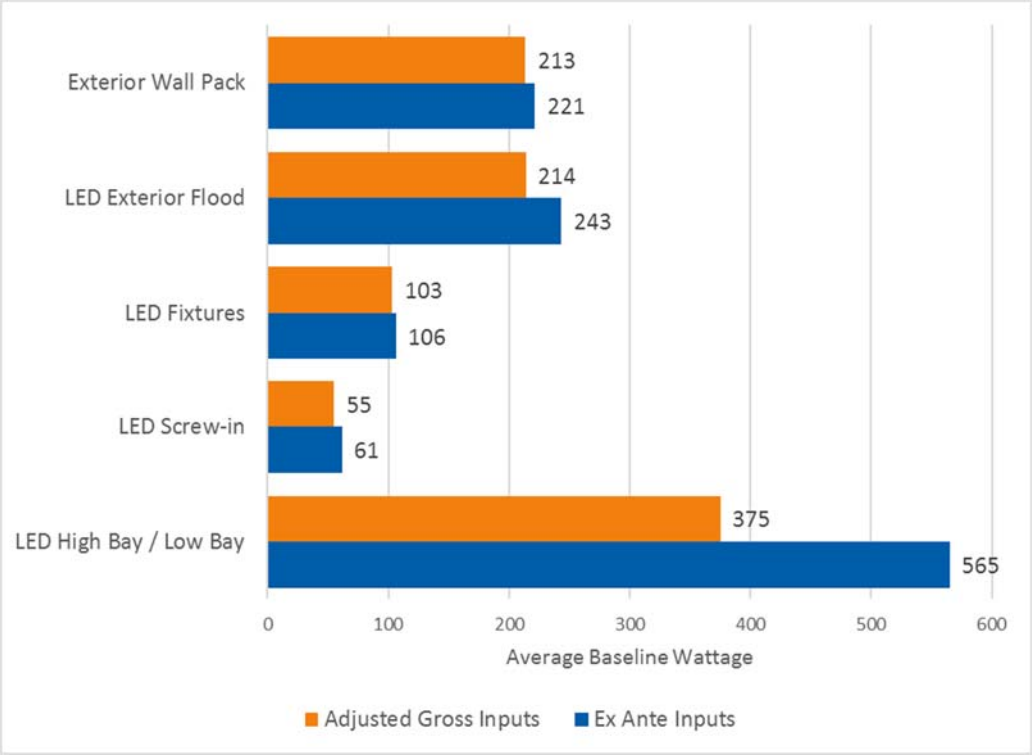
Cadmus used the lumen equivalence method to evaluate baseline wattages for each lamp sold through the channel, except for LED wall packs, exterior LED flood lamps, and LED high-bay lighting. Due to the relatively small amount of available data comparing traditional HID products and emerging LED products, no well-established lumen bins or lumen equivalency maps exist. While attempts have been made to create an equivalency map, these efforts remain in early stages and may not fully capture the intricacies involved in comparing these dissimilar technologies. An example of limitations presented by the lumen bin approach for these technologies is discussed later in this section. For exterior and high-

bay lighting products, Cadmus referred to the Wisconsin TRM to determine baseline wattages based on wattages of purchased equipment.[34]

For screw- and pin-based LEDs, Cadmus assigned baseline wattages using the lumen equivalence approach in conjunction with ENERGY STAR lumen bins

Though linear fluorescent and linear LED lamps are evaluated similarly, ENERGY STAR does not supply a lumen bin framework for linear fluorescent lamps; so baseline assignments are made directly, based on the purchased lamp's lumen output rather than on a set of equivalency bins. Figure 30 compares baseline wattages used by the implementation and evaluation teams by measure type. The figure does not show linear fluorescent measures as very little difference between *ex ante* and adjusted values.

Figure 30. Comparison of *Ex Ante* and Adjusted Baseline Wattages by Measure Type



For most measures, the *ex ante* and adjusted baselines were very similar, though there are exceptions: exterior wall packs and LED exterior flood lights, screw-based LED lamps, and high-bay/low-bay LED replacements were evaluated with a much lower baseline wattage. The difference in baseline wattage assignments resulted in 5%, 15%, 36%, and 45% decreases in evaluated connected load reductions, respectively, for each of these measures. The evaluation team compared *ex ante* baselines against other

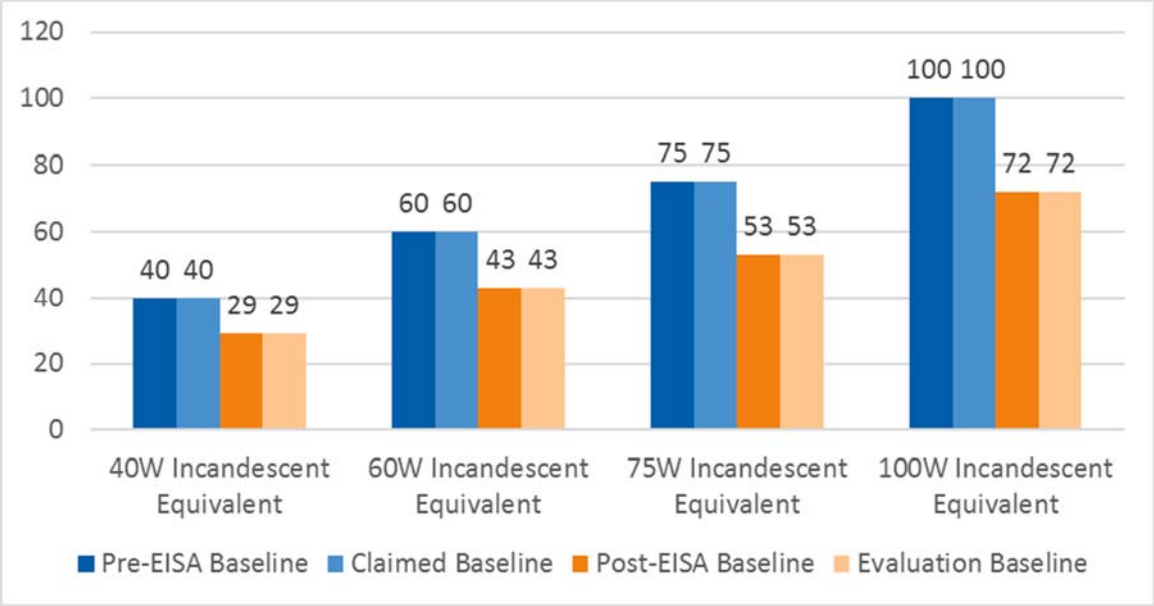
[34] Focus on Energy. *Wisconsin Focus on Energy 2017 Technical Reference Manual*. Prepared by Public Service Commission of Wisconsin. Available online: https://www.focusonenergy.com/sites/default/files/TRM%202018%20Final%20Version%20Dec%202017.pdf

TRMs with similar measures, and by looking up manufacturer specifications for rebated LED products. Manufacturer specifications often include an "equivalent wattage" so consumers can compare LED products against an existing fixture or fixtures.

In an extreme example, one product accounted for 50% of *ex ante* high-bay energy savings, based on a baseline of 843 watts. Upon review of manufacturer specifications, the equivalent product was identified as a 400-watt metal halide fixture. Especially for high-bay/low-bay lighting, the baseline wattage reduction served as a major driver of the measure's adjusted gross savings realization rate. Though the measure accounted for 14% of *ex ante* energy savings, it had a reduction in delta watts of 45%. This resulted in a 51% measure-level adjusted gross savings realization rate. Ultimately, the evaluation team assigned a baseline wattage for exterior and high-bay LED measures using the Wisconsin TRM, which provided baseline wattages that more closely reflected manufacturer-recommended replacement equipment.

For screw-based LED lamps, the baseline wattage difference results from the shift to an as-found baseline in combination with *ex ante* savings that do not account for federally mandated baselines or the as-found baseline. These differences apply to all classes of screw-based LEDs: globes, reflectors, and general service lamps. Figure 31 shows how *ex ante* and as-found baselines compared to pre- and post-EISA baseline standards for general service screw-based lamps.

Figure 31. Comparison of Claimed and Evaluated Baseline Wattages to Pre- and Post-EISA Standards for General Service Screw-In LEDs



This difference in baseline wattages for standard LEDs presents one of the primary factors driving the 2017 adjusted gross savings realization rate. Standard LEDs represented approximately 31% of the Midstream Incentive Channel's lighting savings, and Cadmus' application of the as-found baseline wattages resulted in an approximately 13% savings reduction for these measures. Table 100 shows the

relative percentage of *ex ante* energy savings and the percent difference in savings input values for measures with large differences between *ex ante* and evaluated baseline wattages.

Table 100. *Ex Ante* Savings Percentage and Percent Difference in Input Assumptions by Measure

Measure	Percent of *Ex Ante* kWh	Energy RR	Percent Difference in Input Values			
			HOU	ISR	IEF_e	Delta Watts
LED Screw-In	31%	63%	13%	-2%	0%	-13%
High-Bay/Low-Bay	14%	51%	-6%	-2%	0%	-45%
Exterior Wall Pack	5%	83%	-7%	-2%	0%	-5%
LED Exterior Flood	1%	74%	-11%	-2%	-9%	-15%

Across the channel, differences in baseline wattage assignments accounted for the largest impacts on measure savings. The evaluated baseline wattage adjustment resulted in an approximately 13% reduction in lighting savings.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Implement a four-year, staged ISR, and adjust future savings back to their present values.** The 2015 survey found that by year four, 100% of the lamps sold through the midstream channel will be installed. Cadmus recommends claiming savings for all lamps sold through the channel, but netting back savings for lamps installed during the second, third, and fourth year after purchase to the present value using the utility discount rate. Using a four-year, staged ISR of 98.2% allows future savings to be claimed at their present value.
- **Assign baseline lamp wattages for screw-based lamps consistent with agreed upon, as-found baselines.** Cadmus and DP&L have agreed that 2017 will be the last year for which Cadmus will use the current methodology to determine the baseline wattage of replaced bulbs. For future evaluations Cadmus will use wattages more closely aligned with the wattage of the bulbs being replaced. This change aligns with Ohio Senate Bill 310 which allows utilities to claim savings based on as found conditions.
- **Consider including on-site data collection as part of the Midstream program evaluation.** On-site visits allow the evaluation team to assess inputs helpful for the evaluation, such as confirming hours of operation and working with facility staff to determine what equipment types were replaced. It may be possible to accomplish the same type of data collection through a phone survey with facility staff or possibly other secondary data.
- **Review measure-level HOU assumptions, especially for similar lighting technologies.** The implementation team assigns average HOU estimates by equipment type, based on information available in the Nonresidential Prescriptive Rebate program database. Based on this review, 28-watt linear fluorescent lamps were assigned a 5,960 average HOU, 25-watt linear fluorescent lamps were assigned a 4,145 average HOU, and LED T8 lamps were assigned a 4,103 average HOU. A similar discrepancy emerged with exterior lighting: wall packs used a 4,137 HOU, but

exterior floods used a 4,306 HOU. Cadmus recommends adopting the same HOU for similar technology types, given their similar characteristics and use in the same applications.

- **As part of the point-of-sale process, record the building or facility types in which the equipment will be installed.** The Ohio TRM provides lighting HOU and CF estimates for a number of different building types. Midstream tracking data already collects customer address information, but assigning building types based on address information remains challenging and subjective. Tracking building types in the program data would establish a common set of inputs that could be used by implementation and evaluation teams for determining savings inputs (e.g., HOU, CF, IEF), though retaining some measure-specific values may be prudent (e.g., 8,760 hours of operation for exit signs).

Nonresidential Custom Rebate Program

This section describes the evaluation approach, detailed findings, conclusions, and recommendations for the Nonresidential Custom Rebate program.

Evaluation Overview

Cadmus' evaluation of the 2017 Nonresidential Custom Rebate program followed the evaluation activities and researchable questions outlined in Table 101.

Table 101. Key Researchable Questions

Researchable Questions	Activity Used to Address Question
What are the program's gross electric savings and demand reductions?	• Engineering analysis • Database review • Site visit observations • Power and temperature metering
What are DP&L's experiences with the program processes?	• Program staff interviews
Is this program cost-effective?	• Cost-effectiveness analysis

Detailed Evaluation Findings

DP&L attained 27,542,177 kWh in *ex ante* energy savings and 4,455 kW in *ex ante* demand reduction, falling short of its 28,144,000 kWh energy savings and 5,200 kW demand reduction goals. Cadmus calculated 27,066,918 kWh and 4,357 kW in verified gross savings, representing verified gross savings realization rates of 98% and 98% for *ex ante* energy savings and demand reduction, respectively.

Table 102. Nonresidential Custom-Rebate Program *Ex Ante* and Achieved Energy Savings

Measure	*Ex Ante* Savings		Verified Gross Savings		Adjusted Gross Savings		
	kWh	kW	kWh	kW	kWh	kW	Precision*
Custom	6,268,656	419.4	6,268,656	419.4	6,316,920	393.4	9.9%
Census-Custom	12,409,931	2,170.5	12,409,931	2,170.5	4,271,462	725.5	0.0%
Retro-Commissioning	2,235,865	113.1	2,235,865	113.1	2,177,766	113.1	3.2%
New Construction	6,627,724	1,751.6	6,152,466	1653.8	5,252,660	1,281.9	30.9%
Total	**27,542,177**	**4,455**	**27,066,918**	**4,357**	**18,018,808**	**2,514**	**12.5%**

*Precision at 90% confidence.

DP&L divided the Custom Rebate offering into three separate categories: Custom, Retro-Commissioning, and New Construction. The following key findings applied for each category:

- Similar to the prescriptive program, one large project accounted for 66% of the Custom *ex ante* energy savings. This project involved installations of VFDs on 30 large motors serving a glass manufacturing facility. Cadmus' project evaluation results indicated adjusted gross savings realization rates of 34% for energy and 33% for demand with this project. Cadmus installed power meters on 10 motors serving the facility, meter data analysis indicated lower maximum

demand than expected and lower load profiles for all motors, resulting in reduced energy and demand savings. When excluding this large custom project, the remaining custom projects indicated adjusted gross savings realization rates of 92% for energy and 76% for demand.

- Custom projects exhibited few variations in comparison to claimed documentation. Given the additional investigation and documentation DP&L performed for custom projects, site observations typically validated the rebate documentation, and variations typically only occurred where light loggers were installed.
- DP&L introduced retro-commissioning projects for the Custom program in 2017. The Retro-Commissioning incentive process appeared well-run for its first year. On-site investigation activities yielded minimal differences in the performance of implemented measures for the five sampled projects. The evaluated projects appeared to possess sufficient documentation, with measures implemented within incentivized projects that claimed energy savings matching savings established through retro-commissioning studies.
- New construction projects exhibited higher variations than in previous years. One large project, evaluated to achieve no energy savings in 2017, remained unoccupied and will not be used until 2018. All sampled projects were lighting power reduction (LPD) efforts, with light logger data analyzed to determine findings similar to prescriptive lighting projects: HOU deviated from claimed performance, resulting in higher or lower evaluated energy savings.

Evaluation Data Collection Methods

Using the Nonresidential Custom Rebate program database, Cadmus selected a sample for on-site verification and metering activities. This required subdividing Custom projects into three populations, according to project type: Custom Rebate; Retro-Commissioning Rebate; and New Construction Rebate building performance projects.

Through site visits and metering, Cadmus evaluated a statistically valid sample of projects within the Custom and New Construction programs. The team determined a sample size based on an 80% confidence interval, with a 10% precision level for the program, employing a correction factor for a finite population.

Project and Site Review

In June 2017 and January 2018, Cadmus performed on-site visits and engineering analyses for 36 projects, representing 69% of the program's overall reported savings. Of 91 custom projects included in the 2017 program, 19 represented relatively large savings (i.e., greater than 100,000 kWh per year). Cadmus verified nine of these projects, performing site visits to 36 unique locations (by account number).

Baseline Assumptions

Typically, baseline assumptions involve using data obtained on site or identified through rebate documentation. When replacing equipment, baseline equipment is defined as equipment of equivalent performance and capacity.

Where an incentivized project involved improvements to controls, repairs, or other non-like-for-like equipment replacements, Cadmus determined baseline performance through field measurements, staff interviews, rebate documentation, and utility bills. Additionally, Cadmus collected parameters such as operating hours, setpoints, capacity, efficiency, and control strategies (if available) during site visits; these data were used to calculate baselines and efficient-condition energy consumption.

In many cases, DP&L's third-party engineering firms conducted monitoring to obtain baseline consumption. In these cases, Cadmus verified that operating conditions remained valid on site and used the same logged data to inform the baseline conditions. When data could not be obtained on site or through project documentation (e.g., baseline motor efficiencies, fixture wattages), Cadmus used assumptions provided in the Ohio TRM. Baseline conditions for New Construction projects, derived from the 2009 International Building Code, which included references to the International Energy Conservation Code and ASHRAE 90.1-2007 and 90.1-2010 for projects applied for and paid in 2017.

Impact Evaluation Methodology and Findings

Site Verification Visits and Documentation Review

After selecting projects to verify through on-site activities, Cadmus downloaded project documentation from DP&L's administrative website. In preparation for each site visit, the team reviewed this documentation and other relevant program data. The review focused on calculation procedures and energy savings estimate documentation.

On-site visits enabled Cadmus to accomplish four primary tasks:

- Verify implementation, installation, and characteristics of incented equipment
- Collect additional detailed equipment data (e.g., ballast factors) needed to confirm and calculate energy savings
- If applicable, collect available energy management systems data to inform the savings analysis
- For New Construction projects, verify and collect additional building characteristics data to inform the building simulations

Appendix G. Nonresidential Metering Summary summarizes Cadmus' metering process and findings. Appendix H. Nonresidential Site Visit Summary provides detailed site visit findings.

Engineering Analysis and Savings Verification

For each project in the site visit sample, Cadmus performed an engineering analysis (using data verified on site and supplemented by project documentation) to validate energy savings and demand reductions.

Procedures used to validate savings depended on the measure types analyzed. The review methodology relied upon industry-standard algorithms, the Ohio TRM, secondary research, and engineering experience. The following sections describe procedures used to validate savings from these measure group categories: Custom, Retro-Commissioning, and New Construction.

Custom

Custom projects primarily fall into three types:

- Lighting
- HVAC
- Other Technologies

In general, the evaluation methodology followed the process identified in the prescriptive rebate program, related to prescriptive lighting and HVAC measures (for more details, see the Lighting Measures and HVAC Measure sections in the Prescriptive program chapter). Analyzing lighting fixture measure savings requires understanding installed fixture data, including energy consumption (watts), lumen output, fixture location, control methodology, reported HOU, and quantity of fixtures. The baseline fixture is identified based on equivalent performance in terms of lumen output or space lighting designs. Documentation provided with the rebate documentation identifying the baseline fixture also is considered when evaluating custom lighting projects.

Custom HVAC projects often involve process equipment replacement, comprehensive plant upgrades, controls projects, or building tune-ups and repairs. Rebate documentation for these projects often includes verification audits performed by DP&L's third-party engineering firms.

Due to the unique nature of these projects, the evaluation methodology involved a mixture of processes, including a rebate documentation review, site visit investigations, facility staff interviews, trend data collection and analysis, utility bill analysis, and custom spreadsheet calculations. With most projects, energy savings were determined by subtracting installed energy use from baseline energy use, with baseline performance determined through metered performance of baseline equipment or as minimum code-compliant efficiency equipment where metering proved unavailable.

Retro-Commissioning

DP&L introduced retro-commissioning incentives for 2017. Retro-commissioning is a process involving activities intended to improve the efficiency, performance, and control of an existing building's mechanical systems, digital controls, and lighting. For each retro-commissioning project, the retro-commissioning study provider completed an on-site investigation, identified energy-saving opportunities, and developed a retro-commissioning study report. Customers implemented the selected energy-saving opportunities, generally over a period of 12 weeks, and DP&L's subcontractor performed measurement and verification to confirm energy savings were achieved.

Nine projects successfully completed all activities involved in the retro-commissioning process. Of these, Cadmus randomly selected five projects for evaluation, which included reviewing project documentation and performing on-site investigations for the five sampled projects. For each energy conservation measure identified within the sampled projects, Cadmus identified control inputs, operating parameters, or installation characteristics with the greatest impact on energy savings. Table 103 shows typical measures and on-site investigation activities.

Table 103. Retro-commissioning: Typical Energy Conservation Measures and Verification Activities

Energy Conservation Measure	On-Site Verification Activity
Optimize Equipment Operation Schedule	• Review equipment control systems (typically the building management system) and document equipment schedules • Review trend data of equipment operations
Optimize Economizer Operation	• Review economizer mode enable and disable setpoints on building management systems • Review economizer mode programming on building management systems • Spot measure (via building management systems) economizer performance by calculating mixed-air conditions. based on outside air conditions, return air conditions, and economizer mode damper positions
Implement Supply Temperature or Pressure Reset	• Review reset controls programming on building management systems • Review trend data of supply pressures or supply temperatures • Spot measure (via building management system) temperatures or pressures, and compare to temperature or pressure setpoints
Optimize Equipment Sequencing	• Identify equipment controllers for each equipment affected by a measure • Review sequence control programming • Spot measure (via building management system) equipment performance

Retro-commissioning projects often involve multiple efficiency control measures, implemented simultaneously and resulting in high levels of interactive effects. Consequently, retro-commissioning projects are often evaluated through site visits to observe implemented changes as well as through reviewing a minimum of 12 months of utility data for a billing analysis. As the retro-commissioning projects were completed in the final months of 2017, evaluation of these projects could not be conducted through use of billing.

New Construction

New Construction projects fall into three types:

- Whole Building New Construction (NC-WB)
- New Construction as part of an existing building (NC)
- New Construction Lighting Power Reduction (NC-LPD)

NC and NC-WB projects involve construction of new facilities or large renovations of existing facilities. Due to numerous interactive effects from high-efficiency equipment, these projects require creating an energy simulation model, normalized to weather and utility data. The model simulates energy consumption for a baseline case, which revises all incentivized equipment to reflect baseline efficiency equipment, as defined in ASHRAE standard 90.1-2007, or applicable Ohio Building Code at the time of application. Additionally, the energy model simulates energy consumption for the installed case, reflecting a facility's actual equipment and energy consumption. Energy savings can be determined by subtracting installed case energy use from baseline case energy use. While DP&L's third-party

engineering firm already created an energy model, Cadmus reviewed and updated the existing energy model, based on site findings normalized to weather and utility data.

NC-LPD projects account for 82% of all new construction projects. These typically involve construction of new spaces. For these projects, energy savings are determined by quantifying the lighting fixtures, wattages, and areas (square feet) of incentivized spaces, and then comparing total energy use to minimum code lighting energy consumption requirements in terms of watts per square feet. The minimum code consumption for each space type is based on the ASHRAE standard 90.1-2007, or applicable Ohio Building Code at the time of application. Cadmus evaluated these sites by inspecting all installed fixtures within each incentivized space and updating calculations based on site findings.

Calculating Realization Rates

Cadmus derived program-level, end-use savings and demand reductions through adjusted gross savings realization rates, calculated for each strata. Similar to the sample selection process, the study broke custom projects into five strata: Large Custom, Medium Custom, Small Custom, Retro-Commissioning, and New Construction projects.

This method included the following:

- Calculating adjusted gross savings for the sample of site-visit projects and desk reviews.
- Calculating a realization rate, based on *ex ante* and adjusted gross savings, for the total sample within each measure group.
- Applying sample realization rates to the program population for each measure group to calculate total program verified and adjusted gross savings. Cadmus divided custom into the following kWh strata:
  - Small Custom (0–100,000)
  - Medium Custom (100,000–500,000)
  - Large Custom (500,000 plus)
  - Retro-Commissioning
  - New Construction
  - Realization rates, developed for each stratum, could then be applied across the population subgroup. One large custom project was selected due to the magnitude of claimed savings. Because this project was individually selected (not randomly), the project's evaluated results and realization rates were not applied to the stratum population.

Detailed Impact Findings

Gross Savings Results

By major measure groups, Table 104 and Table 105 summarize the sample's verified and adjusted results.

Table 104. Gross *Ex Ante* Claimed and Adjusted Gross Savings for Sampled Projects*

Measure	Number of Projects	*Ex Ante* Gross Energy Savings (kWh)	Verified Energy Savings (kWh)	Adjusted Energy Savings (kWh)
Custom	18	6,641,495	6,641,495	6,078,929
Census-Custom	1	12,409,931	12,409,931	4,271,462
Retro-Commissioning	5	1,289,900	1,289,900	1,256,382
New Construction	12	2,676,010	2,676,010	2,120,814
Total	**36**	**19,051,426**	**19,051,426**	**10,350,391**

Table 105. Gross *Ex Ante* and Adjusted Gross Demand Savings for Sampled Projects*

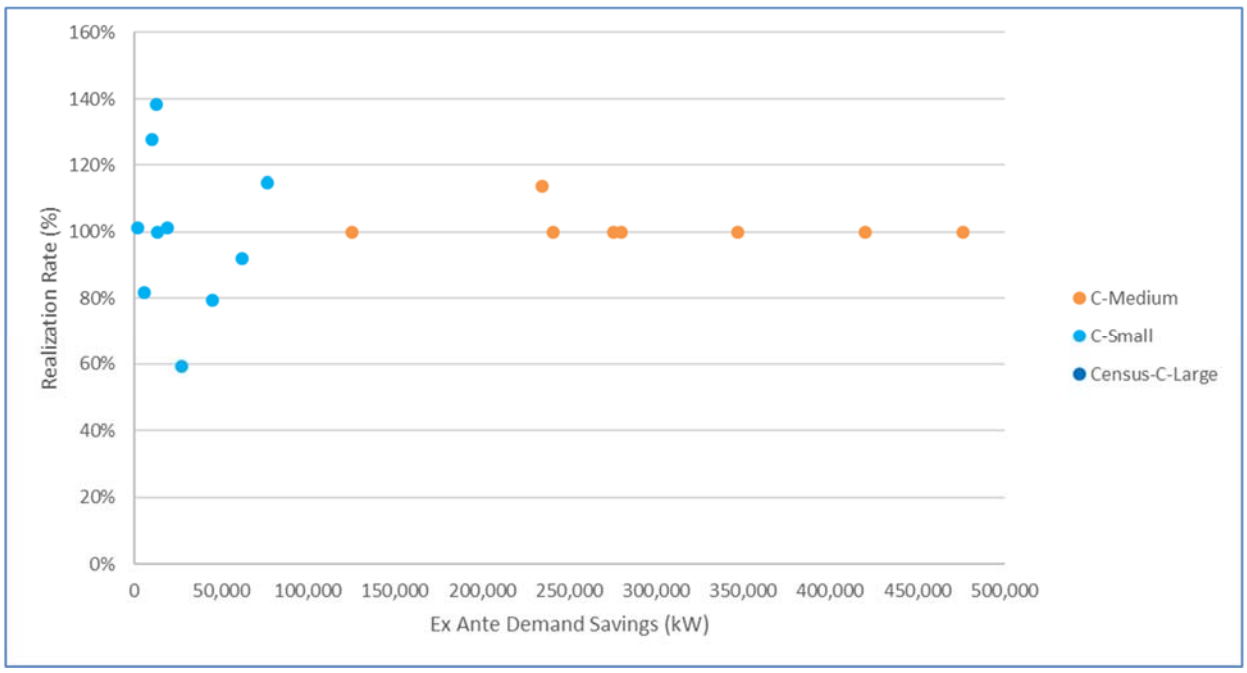
Measure	Number of Projects	*Ex Ante* Gross Demand Savings (kW)	Verified Demand Savings (kW)	Adjusted Demand Savings (kW)
Custom	18	127.6	127.6	107.2
Census-Custom	1	2,170.5	2,170.5	725.5
Retro-Commissioning	5	2.1	2.1	2.1
New Construction	12	446.8	446.8	327.0
Total	**36**	**2,747.0**	**2,747.0**	**1,161.8**

A summary follows of major differences (by measure category) between *ex ante* savings and adjusted savings.

Custom

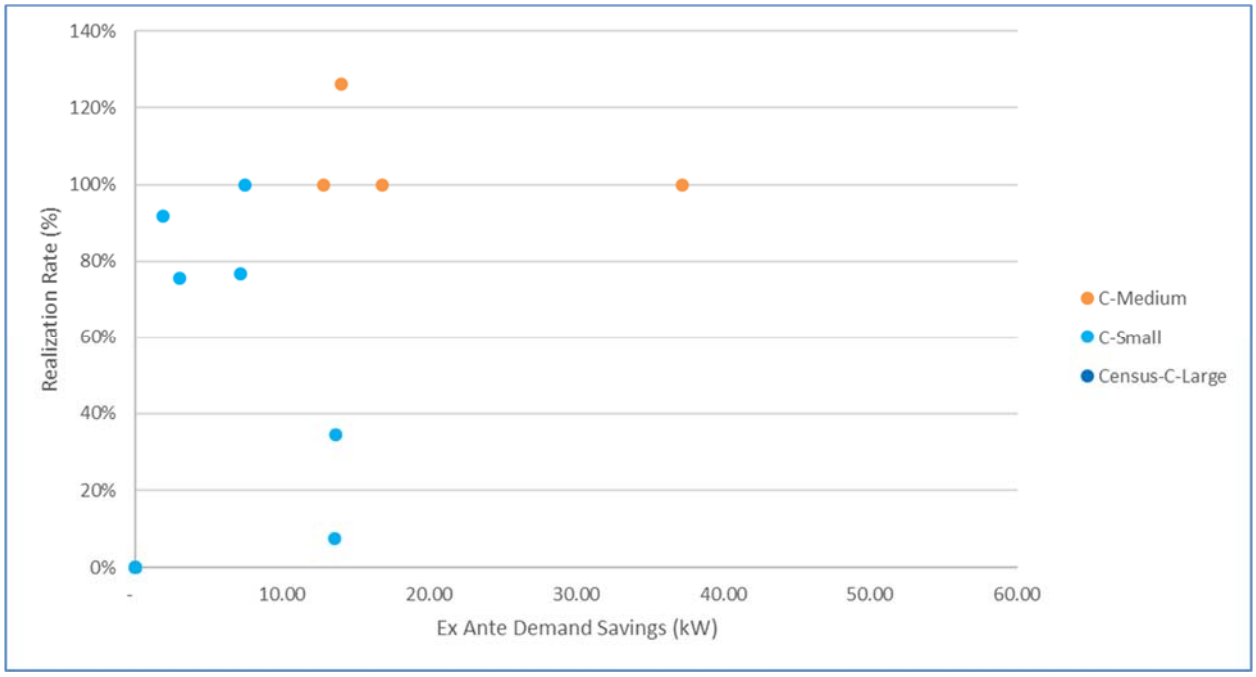
Figure 32 and Figure 33 provide adjusted gross savings for each sampled custom project.

Figure 32. Custom Energy Savings Sample Results*



*The graph does not include a large project, claiming 12,409,931 kWh in energy savings with a 34% realization rate.

Figure 33. Custom Demand Reduction Sample Results*



*The graph does not include a large project, claiming 2,170.5 kW in demand savings with a 33% realization rate.

Table 106 provides details regarding sampled projects evaluated to exhibit lower-than-80% or higher-than-120% adjusted gross savings realization rates for demand savings.

Table 106. Custom—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
XE5MB587	15 97 W LED high-bay fixtures	62,307	13.54	57,431	1.02	Light loggers indicated lower HOU, almost exclusively at nighttime (outside of the peak period).
GLCWV22Q	(30) VFDs serving large motors at a glass-	12,409,931	2,170.5	4,271,462	525.50	Power meters indicate low load profile

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
	manufacturing facility					
MZ64SGEN	34 40 W LED flat-panel ceiling fixtures	27,280	13.64	16,204	4.69	Light loggers indicate lower HOU than expected.
C2H6ZTQB	Eight 218 W, six-lamp T8 high-bay fixtures	10,489	3.06	13,412	2.31	Light loggers indicate higher HOU than expected, but lower operation hours during the peak period.
LZ2N0H27	32 30 W LED fixtures at a church	13,046	7.17	18,039	5.49	Calculations updated, based on CF assigned to public assembly building type.
XWBWXVYH	One 180 HP variable speed air compressor	234,495	14	267,270	17.67	Meter data indicated a load profile with higher-efficiency performance than assumed by the TRM.

Over 60% of the custom projects incentivized in 2017 involved implementation of high-efficiency lighting. Cadmus sampled 120 custom projects, with 12 including high-efficiency lighting fixtures. In addition to site visits to verify that installed fixtures matched rebate documentation, Cadmus installed light loggers at four sites.

One project, Confirmation ID: GLCWV22Q, involved the installation of 30 VFDs, serving large process motors at a glass manufacturing facility. DP&L performed M&V on this project by installing power metering equipment on six of the 30 incentivized VFDs and monitored VFD performance over a period of 5 weeks. The power metering data was used to generate load profiles and calculate energy savings for each VFD. For the baseline condition, the motors are assumed to run at 100% speed with no load control. Cadmus recorded spot power measurements and installed power meters on 10 motors to determine performance characteristics over five weeks. On average, maximum demand was typically less than one-half of the expected demand for a motor running at maximum capacity. Additionally, Cadmus assumed the motor output would be controlled in the baseline condition through the use of a

damper or valve control. Given the low load profiles observed and the reduce baseline energy use based on damper or valve control, reduced energy and demand savings were realized.

Custom lighting projects realized energy savings ranging from 59% to 128%, with an average of 96% from *ex ante* values. In general, discrepancies between claimed and evaluated energy savings arose as a variance between claimed HOU and measured HOU. The nine sampled, non-lighting, custom projects included compressed air system upgrades, variable speed air compressors, VSDs for process motors, and process system controls upgrades. Cadmus installed power metering equipment on one project that involved installing a 180-HP variable speed air compressor. Meter data for this project indicated it achieved higher efficiencies (based on the equipment load profile) than predicted (based on the TRM). No discrepancies appeared for four of the other seven non-lighting projects.

Retro-Commissioning

Cadmus evaluated five retro-commissioning projects incentivized in 2017. Figure 34 and Figure 35 provide adjusted gross savings realization rates and associated energy savings for each of these sampled projects.

Figure 34. Retro-Commissioning Energy Savings Sample Results

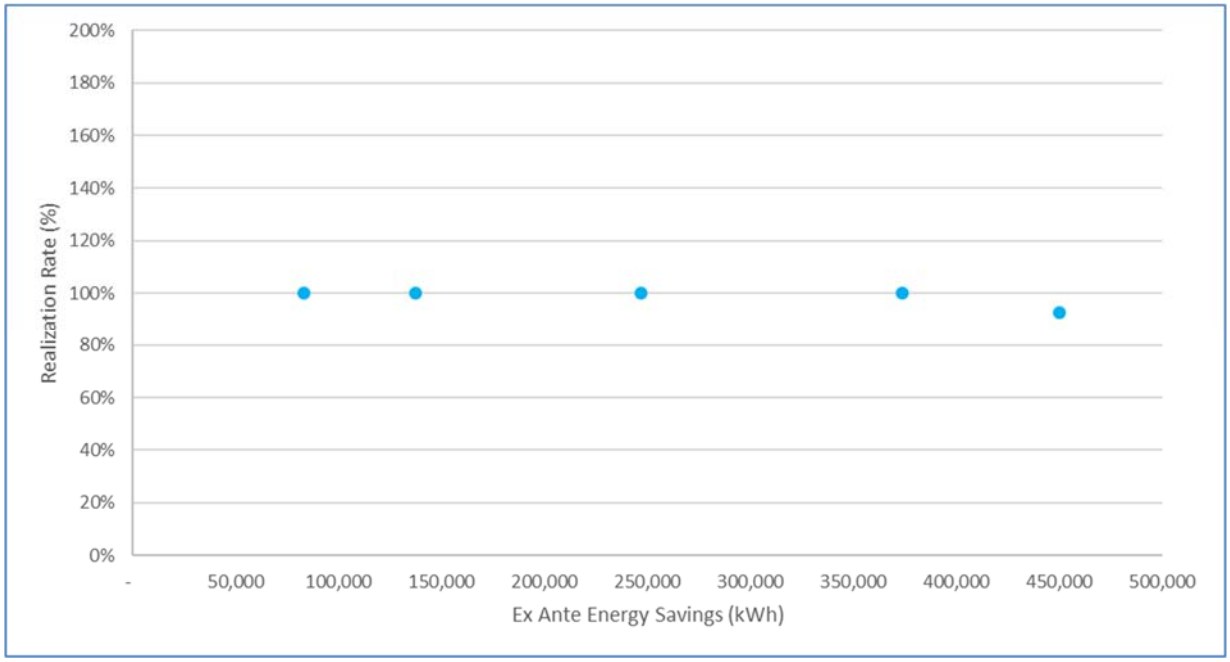
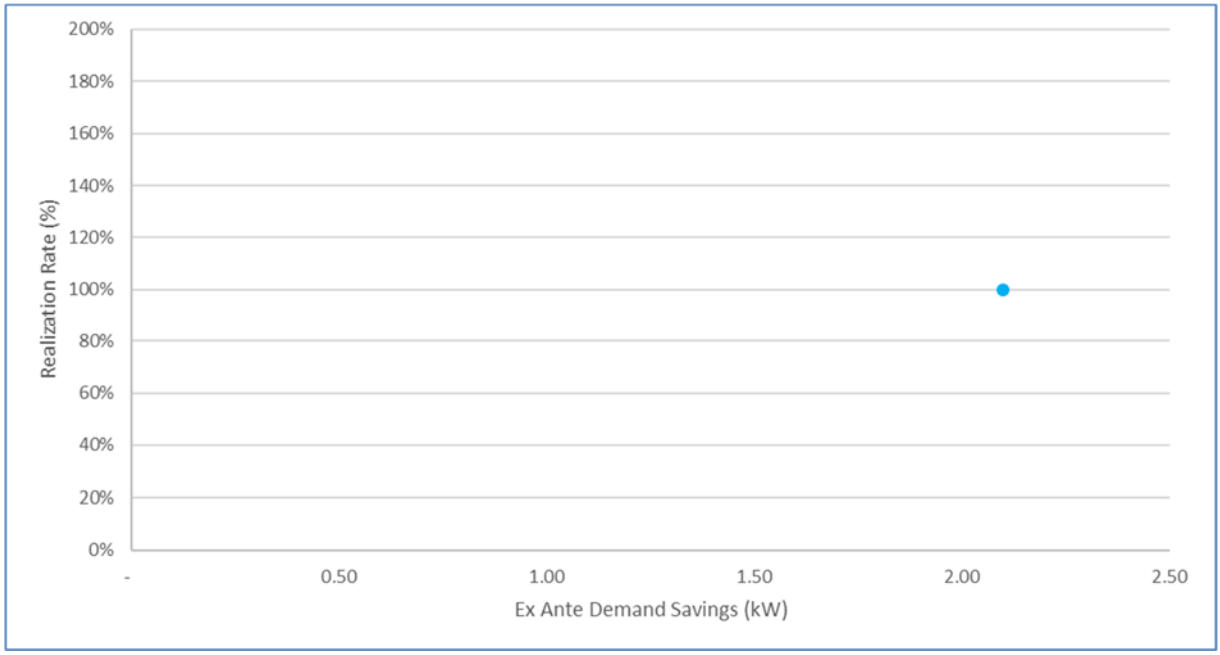


Figure 35. Retro-Commissioning Demand Reduction Sample Results



The majority of retro-commissioning projects were completed in the final months of 2017. Due to the late completion date, sufficient post-implementation operation data were unavailable for utility billing analysis. On-site investigation activities yielded minimal differences in implemented measures' performance for five sampled projects. Only one project identified a performance variation sufficiently large to impact total project evaluated savings.

New Construction

Cadmus sampled and evaluated 12 of the 44 incentivized new construction projects for 2017. Figure 36 and Figure 37 indicate adjusted gross savings realization rates and associated *ex ante* energy savings for each new construction project sampled.

Figure 36. New Construction Energy Saving Sample Results

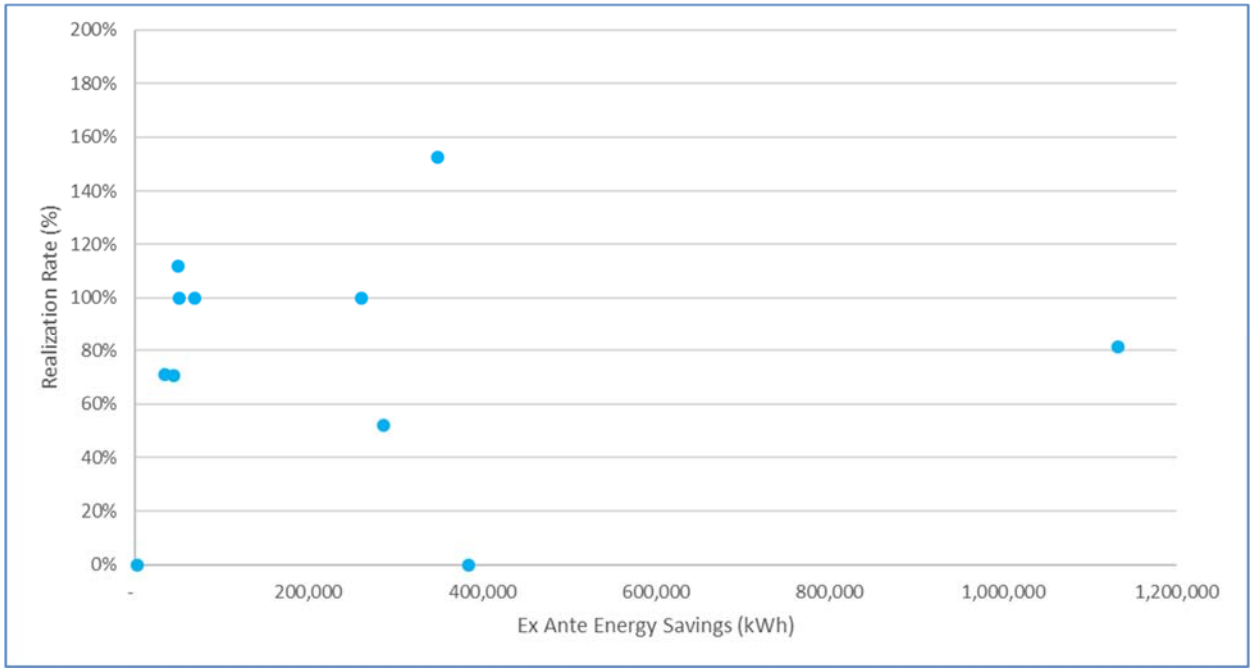


Figure 37. New Construction Demand Reduction Sample Results

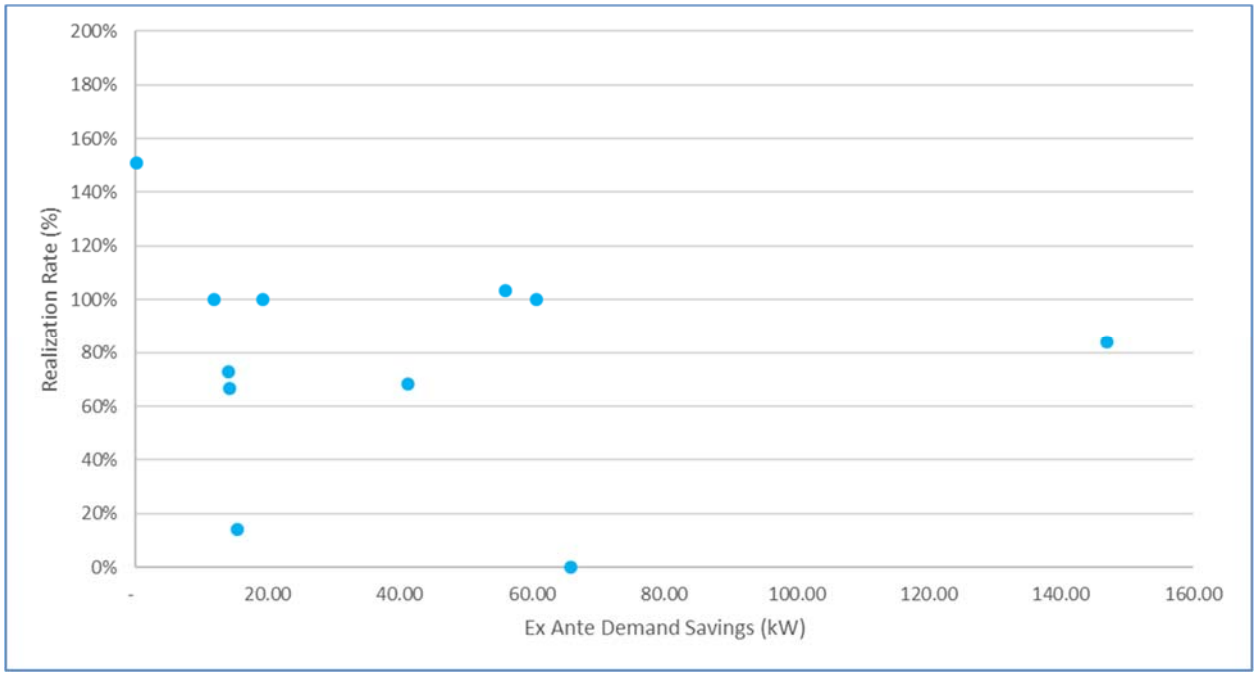


Table 107 provides details regarding evaluated sample projects exhibiting lower-than-80% or higher-than-120% adjusted gross savings realization rates for demand savings.

Table 107. New Construction—Sample Detailed Findings

Project	Project Measures	Reported kWh	Reported kW	Site Adjusted Gross Savings (kWh)	Site Adjusted Gross Savings (kW)	Notes
IYN30C88	Lighting remodel: LPD reduction	383,793	65.72	0	0.00	Fixtures installed, but facility not in use and unoccupied until 2018.
Y1SF1HXI	Lighting remodel: LPD reduction	1,592	0.18	0	0.27	Missing fixtures and a higher HOU measured during peak period with light loggers for a small lighting redesign.
R572MQIP	Lighting remodel: LPD reduction	286,643	41.14	148,986	28.10	Light loggers indicated lower HOU than reported.
13ZG22W0	Lighting remodel: LPD reduction	33,993	15.38	24,155	2.17	Lights installed in a space with a lower LPD allowance than indicated in rebate documentation.
CWPZNIIM	Lighting remodel: LPD reduction	44,226	14.18	31,242	9.46	Light loggers indicated lower HOU than reported.
0HANK5JX	Lighting remodel: LPD reduction	49,912	14.03	55,782	10.23	Observed parking lot lighting plan differed from that reported
2GVRCUPC	Lighting remodel: LPD reduction	13,838	1.58	29,201	4.15	Area calculated using a building area method instead of a space-by-space method.

All sampled projects were LPD reduction projects, involving high efficiency space lighting design, so new lighting power consumption exceeded efficiency requirements by code. Typically, these projects are calculated using the space-by-space method, with the maximum lighting wattage per floor area defined for each space type. Cadmus evaluated 12 LPD reduction projects and installed light loggers at seven of these. Seven new construction projects also showed high variability levels.

One large lighting project involved a newly constructed warehouse. Cadmus confirmed all fixtures were installed as reported, but the facility remained unused. In late fall 2017, Cadmus again contacted the facility, and the facility contact confirmed the facility was not in use and would remain so until 2018.

Cadmus inspected another project where lights were to be installed as a high-bay manufacturing application. Rather, the incentivized lights were installed in a storage area, more appropriately defined as "warehouse—medium/bulky material storage." The storage area lighting power allowance was lower than the manufacturing space types, resulting in decreased energy savings.

For three projects where Cadmus installed light loggers, measured lighting HOU were lower than reported at two projects and higher at one project. Decreased HOU resulted in lower energy savings.

Recommendations

Drawn from the preceding findings, Cadmus offers the following recommendations:

- **Where incentivizing large custom projects, implement short-term metering before and after installation of the new equipment.** This will determine baseline equipment performance. Historically, DP&L has performed power metering to determine equipment HOU for incentivized equipment. Where load profiles are known and understood, specifically metering for HOU may be appropriate. For projects, however, with unknown load profiles (e.g., process equipment), short-term power metering with a load profile analysis may prove critical to understanding equipment performance and associated energy savings.
- **For incentivized variable speed equipment, perform spot power measurements on incentivized equipment at maximum, part-load, and minimum speeds.** Based on this year's findings, metered performance of VFDs serving large motors found much lower than expected energy demand for the associated motor size. Energy savings may be reduced for oversized equipment, and spot power measurements of installed equipment will determine if oversizing has occurred and by how much.
- **Continue to operate the Nonresidential Custom Rebate Program using the approach used for the past several years.** Regarding the new construction and custom programs, the evaluation did not prompt substantial recommendations. While Cadmus found some variations in reported savings, the team found project and supporting documentation generally sufficient and in good order.

Cost-Effectiveness

Cost-Benefit Scenarios

The total resource cost (TRC) test, which serves as the primary method used to determine program and portfolio cost-effectiveness, derives from the portfolio's ratio of lifecycle benefits over lifecycle incremental costs. The TRC determines whether pursuing energy efficiency proves more cost-effective overall than supplying energy. The TRC does not, however, provide the information necessary to determine whether a portfolio or program proves cost-effective from the perspective of an individual program participant, DP&L, or ratepayers.

Therefore, Cadmus calculated the following additional tests, based on the California Standard Practice Manual for the portfolio of programs and for each individual program implemented in 2017:

- The Societal Cost Test (SCT)
- The Utility Cost Test (UCT) (i.e., the Program Administrator Cost Test [PAC])
- The Ratepayer Impact Measure Test (RIM)
- The Participant Cost Test (PCT)

As Cadmus did not include non-energy benefits in this analysis, the SCT can be only differentiated from the TRC by the discount rate: the SCT uses a 10-year Treasury bill (T-bill) rate (2.33%) to discount future benefits.[35] Applying this as a discount rate for the SCT recognizes that benefits accrue to society in general rather than solely to a utility or participants. Generally, utilities experience high, weighted-capital costs, reflecting the cost of borrowing money and its associated risks. For society as a whole, this presents a low or almost nonexistent risk level, making the T-bill rate more appropriate for a total resource perspective.

The UCT serves as a valuation of costs and benefits directly accrued by the utility. In some ways, this means the UCT provides a more even comparison between demand- and supply-side resources, as both include only the utility cost.

The RIM, a valuation of program net benefits as perceived by ratepayers, is measured using the following:

- Electric avoided costs
- Incentive costs (i.e., utility measure costs)
- Administrative costs associated with the program
- Lost revenues (equal to participant energy-savings benefits)

Table 108 shows the discount rate applied to each benefit-cost test.

[35] For program year 2016, the SCT discount rate was updated; 2015 and 2014 used discount rates of 2.13% and 2.51%, respectively.

Table 108. Discount Rates

Benefit-Cost Test	Discount Rate
TRC	7.86%
SCT	2.33%
UTC	7.86%
RIM	7.86%
PCT	10.00%

Program Benefit Components

The TRC, UCT, RIM, and SCT counted the following benefits:

- The full value of time and seasonally differentiated avoided generation costs
- Avoided capacity costs

For each energy efficiency measure included in a program, Cadmus adjusted the hourly (8,760), system-avoided costs using the hourly load shape of the end use affected by the measure, capturing the full value of time and the measure's seasonally differentiated impacts.[36]

Cadmus used adjusted gross energy and demand savings to perform the benefit-cost calculations. This did not factor in non-energy benefits (e.g., water savings), but it did apply line loss—the percentage of energy lost during transmission and distribution—to measure-level savings that reflected total savings from the point of generation. Table 109 specifies the line-loss assumptions.[37]

Table 109. Line Loss Assumptions Used in Cost-Effectiveness Calculations

Sector	Energy Line Losses	Demand Line Losses
Residential	7.05%	8.14%
Commercial/Industrial	3.9%	5.01%

Program Cost Components

For the analysis' cost component, Cadmus considered incremental measure costs or project costs, depending on the data available and the direct utility costs.

The evaluation defined incremental measure costs as follows: incremental expenses associated with installations of energy efficiency measures; and, where applicable, ongoing operation and maintenance costs. These costs included the incentive as well as the customer's contribution. Cadmus used data

[36] As hourly end-use load shapes were unavailable for DP&L's service area, Cadmus developed these using available data from similar regions (adjusting for weather conditions in DP&L's service territory).

[37] Line losses in Table 109 represent the percentage loss in energy and demand from the generation point to the meter.

provided by DP&L as well as secondary sources to calculate the incremental cost for each measure within each program.

Utility costs included customer payments and expenses associated with the following: program development; marketing; delivery; operation; and evaluation, monitoring, and verification (EM&V). Table 110 summarizes DP&L's implementation and administrative costs (with all utility costs provided by DP&L).

Table 110. Implementation and Administrative Costs

Cost Category	Level	Description
Implementation Vendor and Marketing Costs	Program Level	Incremental costs associated with performing program implementation tasks (e.g., customer service, application processing, marketing, customer outreach).
Incentive Costs	Program Level	Rebates and incentives paid to customers by DP&L.
Direct Measure Costs	Program Level	Costs associated with paying for program measures (e.g., measures installed through Appliance Recycling, Income Eligible Efficiency Program Weatherization, Be E³ Smart, and Small Business Direct Install).
DP&L Staff Costs	Program Level/ Portfolio Level	Costs to administer energy efficiency programs, including DP&L's fully loaded incremental personnel costs; activities associated with market research outside of EM&V.
External Vendor Evaluations	Portfolio Level	Activities associated with determining and evaluating current and potential energy efficiency programs (e.g., benefit-cost ratio analysis, impact and process analysis, cost per kWh analysis, customer research, all other analyses necessary for program evaluation).
Education, Awareness, and Building and Market Transformation	Portfolio Level	Cost to increase awareness of energy efficiency.

In programs where the DP&L funds measures' full costs, such costs are modeled as Direct Measure Costs (rather than incentives). These measures set the participant cost at zero and include direct-measure costs as a participant benefit. Modeling these programs this manner ensures including measure costs in the TRC and benefits in the PCT, while not showing participant costs incorrectly.

The following programs experienced direct-measure costs:

- Appliance Recycling
- Income Eligible Efficiency Weatherization (OPAE and PWC)
- Be E³ Smart

Some projects for the Custom and Nonresidential Prescriptive programs had missing incremental cost data. In such cases, Cadmus relied on the Ohio TRM and the Database for Energy Efficient Resources as well as on other secondary sources to calculate incremental costs for several measures (e.g., lighting,

HVAC units, motors). When secondary information proved unavailable, the ratio between reported gross kWh and incremental measure costs for projects *with* data was applied to projects without incremental costs; this determined total incremental costs for cost-effective reporting.

For the Nonresidential Custom Rebate program's new construction components as well as for the Self-Directed Mercantile program, Cadmus relied on secondary research to calculate incremental costs. Such secondary research confirmed the incremental cost of constructing a LEED-Certified school as 1.65% (and 2% for non-school "green" buildings). Thus, Cadmus applied these percentages to total project costs in calculating a proxy incremental cost for new construction projects.

Overall Portfolio Cost-Effectiveness Results

Full Portfolio Results

Utilizing adjusted gross savings, Table 234 summarizes *ex ante* energy savings, demand impacts, and costs for DP&L's entire energy efficiency portfolio. The portfolio includes the following:

- DP&L's five residential sector programs: Lighting, Appliance Recycling, Income Eligible Efficiency through OPAE, HVAC Equipment, and Be E³ Smart.
- Two Residential pilot programs, also included in the residential portfolio: Energy Saving Kits and Income Eligible Efficiency through PWC.
- DP&L's three nonresidential programs: Prescriptive Rebate; Custom Rebate; and Self-Directed Mercantile.
- Portfolio costs for education and awareness.
- EM&V costs.

Table 111. DP&L Energy Impacts and Costs: 2017 Portfolio

Benefit/Cost Component	2017 Values
Gross Savings (MWh)	200,759
Capacity Savings (kW)	30,566
Total TRC Costs	$57,719,899
Direct Participant Costs	$50,133,590
Direct Utility Costs	$19,553,446
Incentives	$11,967,137
Direct Measure Costs	$1,200,583
DP&L Staff Costs	$639,395
Implementation Vendor & Marketing	$4,462,771
External Vendor Evaluations	$819,375
Education, Awareness Building & Market Transformation	$464,184

The portfolio passed the TRC test with a 1.30 benefit-cost ratio. All other tests had benefit-cost ratios above 1.0, except for the RIM test. Table 112 shows benefits, costs, and benefit/cost ratios for each test.

Table 112. DP&L Cost-Effective Test Results: 2017 Portfolio

Cost-Effective Test	Present Value Benefits	Present Value Costs	Benefit-Cost Ratio
TRC	$75,114,484	$57,719,899	**1.30**
UCT	$70,061,035	$19,553,446	**3.58**
PCT	$133,888,107	$50,133,590	**2.67**
RIM	$70,061,035	$145,661,065	**0.48**
SCT	$98,909,950	$57,719,899	**1.71**

Residential Portfolio Results

Overall, the residential portfolio proved cost-effective, with a 1.42 TRC. The Lighting program—the most cost-effective program in the portfolio—exhibited a 4.61 benefit/cost ratio. The HVAC Equipment Program did not pass the TRC test as a standalone program. Additionally, the Residential Income Eligible Efficiency programs, and the Smart Thermostat pilot program did not pass the TRC test. These programs, however, provided numerous non-energy benefits, such as better health and safety for low-income customers.

All residential portfolio programs incorporating energy efficiency lighting included avoided replacement costs as a TRC, PCT, and SCT benefit.

Table 113 (below) summarizes energy savings, demand impacts, and costs for DP&L's residential programs.

Nonresidential Portfolio Results

Table 114 (below) summarizes energy savings, demand impacts, and costs for DP&L's commercial and industrial programs. Overall, the nonresidential portfolio proved cost-effective, with a 1.30 TRC. Furthermore, all programs proved cost-effective from the TRC perspective.

Table 113. Residential Portfolio

Benefit/Cost Component	Lighting	Heating and Cooling Rebate	Appliance Recycling	Be E³ Smart	Income Eligible Efficiency (OPAE)	Income Eligible Efficiency (PWC)	Smart Thermostats	Total
Gross Savings (MWh)	43,777	7,422	8,003	3,602	926	302	1,727	65,759
Capacity Savings (kW)	5,233	1,590	1639	188	126	165	249	9,190
Total TRC Costs	$2,662,404	$8,060,848	$1,024,637	$287,196	$724,706	$204,056	$1,330,873	$14,294,721
Direct Participant Costs	$1,713,360	$7,465,329	$0	$0	$0	$0	$1,175,167	$10,353,856
Direct Utility Costs	$2,556,209	$1,910,575	$1,024,637	$287,196	$724,706	$204,056	$534,063	$7,241,443
Incentives	$1,607,164	$1,315,057	$0	$0	$0	$0	$378,357	$3,300,578
Direct Measure Costs	$0	$0	$324,071	$134,413	$573,385	$168,714	$0	$1,200,583
DP&L Staff Costs	$59,943	$47,658	$46,101	$22,616	$33,257	$5,524	$5,524	$220,624
Implementation Vendor & Marketing	$889,101	$547,860	$654,465	$130,167	$118,064	$29,818	$150,182	$2,519,657
Benefit-Cost Ratios								
TRC								
Present Value Benefits	$12,280,256	$3,754,291	$2,529,898	$738,461	$307,306	$122,570	$568,395	$20,301,178
Present Value Costs	$2,662,404	$8,060,848	$1,024,637	$287,196	$724,706	$204,056	$1,330,873	$14,294,721
Benefit-Cost Ratio	**4.61**	**0.47**	**2.47**	**2.57**	**0.42**	**0.60**	**0.43**	**1.42**
Utility								
Present Value Benefits	$7,868,134	$3,754,291	$2,494,438	$662,274	$281,382	$110,642	$568,395	$15,739,557
Present Value Costs	$2,556,209	$1,910,575	$1,024,637	$287,196	$724,706	$204,056	$534,063	$7,241,443
Benefit-Cost Ratio	**3.08**	**1.97**	**2.43**	**2.31**	**0.39**	**0.54**	**1.06**	**2.17**
Participant								
Present Value Benefits	$25,613,669	$8,127,080	$6,024,646	$2,013,924	$694,346	$204,888	$1,766,440	$44,444,993
Present Value Costs	$1,713,360	$7,356,632	$0	$0	$0	$0	$1,022,252	$10,092,245
Benefit-Cost Ratio	**14.95**	**1.10**	**-**	**-**	**-**	**-**	**1.73**	**4.40**

Benefit/Cost Component	Lighting	Heating and Cooling Rebate	Appliance Recycling	Be E³ Smart	Income Eligible Efficiency (OPAE)	Income Eligible Efficiency (PWC)	Smart Thermostats	Total
RIM								
Present Value Benefits	$7,868,134	$3,754,291	$2,494,438	$662,274	$281,382	$110,642	$568,395	$15,739,557
Present Value Costs	$23,188,667	$9,613,315	$7,375,508	$2,304,375	$1,439,783	$413,318	$2,189,525	$46,524,491
Benefit-Cost Ratio	**0.34**	**0.39**	**0.34**	**0.29**	**0.20**	**0.27**	**0.26**	**0.34**
Societal								
Present Value Benefits	$14,476,713	$5,715,264	$3,016,450	$838,203	$385,195	$166,697	$725,384	$25,323,905
Present Value Costs	$2,662,404	$8,060,848	$1,024,637	$287,196	$724,706	$204,056	$1,330,873	$14,294,721
Benefit-Cost Ratio	**5.44**	**0.71**	**2.94**	**2.92**	**0.53**	**0.82**	**0.55**	**1.77**

Table 114. Nonresidential Portfolio

Benefit/Cost Component	Prescriptive Rebates	Custom Rebate	Self-Directed Mercantile	Total
Gross Savings (MWh)	93,401	27,542	14,057	135,000
Capacity Savings (kW)	14,560	4,455	2,362	21,376
Total TRC Costs	$29,054,827	$10,244,055	$2,842,737	42,141,619
Direct Participant Costs	$27,683,498	$9,325,711	$2,770,524	39,779,734
Direct Utility Costs	$7,631,154	$2,635,210	$762,079	11,028,444
Incentives	$6,259,825	$1,716,866	$689,867	8,666,558
Direct Measure Costs	$0	$0	$0	0
DP&L Staff Costs	$231,963	$139,142	$47,666	418,771
Implementation Vendor & Marketing	$1,139,366	$779,202	$24,546	1,943,114
Benefit-Cost Ratios				
TRC				
Present Value Benefits	$35,739,781	$13,449,848	$5,623,677	54,813,306
Present Value Costs	$29,054,827	$10,244,055	$2,842,737	42,141,619
Benefit-Cost Ratio	**1.23**	**1.31**	**1.98**	**1.30**
Utility				
Present Value Benefits	$35,247,953	$13,449,848	$5,623,677	54,321,479
Present Value Costs	$7,631,154	$2,635,210	$762,079	11,028,444
Benefit-Cost Ratio	**4.62**	**5.10**	**7.38**	**4.93**
Participant				
Present Value Benefits	$59,201,424	$20,659,093	$9,318,612	89,179,129
Present Value Costs	$27,683,498	$9,325,711	$2,770,524	39,779,734
Benefit-Cost Ratio	**2.14**	**2.22**	**3.36**	**2.24**
RIM				
Present Value Benefits	$35,247,953	$13,449,848	$5,623,677	54,321,479

Benefit/Cost Component	Prescriptive Rebates	Custom Rebate	Self-Directed Mercantile	Total
Present Value Costs	$64,397,773	$23,394,960	$10,060,282	97,853,015
Benefit-Cost Ratio	**0.55**	**0.57**	**0.56**	**0.56**
Societal				
Present Value Benefits	$47,851,216	$18,547,749	$7,187,080	73,586,045
Present Value Costs	$29,054,827	$10,244,055	$2,842,737	42,141,619
Benefit-Cost Ratio	**1.65**	**1.81**	**2.53**	**1.75**

Appendix A. Measure Level Savings

Program	Measure	Verified Gross Savings		Adjusted Gross Savings	
		kWh	kW	kWh	kW
Residential					
Lighting	LED	44,192,190	5,282	42,702,563	4,517
Appliance Recycling	Recycled Refrigerator	5,912,672	945	4,421,858	688
	Recycled Freezer	1,184,288	190	673,631	105
	Recycled Room AC	42,062	368	42,069	368
	Recycled Dehumidifier	277,636	73	277,636	73
	Energy Kit	586,445	62	624,568	35
Income Eligible Efficiency (OPAE)	Air Sealing	11,927	0	10,495	0
	Attic Insulation	18,167	0	15,987	0
	Central AC	701	0	617	0
	CFLs	11,661	1	10,262	1
	Faucet Aerator	6,881	1	6,055	1
	Foundation Wall Insulation	95	0	83	0
	Freezer Replacement	78,902	12	69,433	11
	Heat Pump	7,738	1	6,809	1
	LEDs	220,169	23	193,749	20
	Pipe Insulation	2,524	0	2,221	0
	Refrigerator Replacement	550,440	85	484,387	74
	Showerhead	10,058	1	8,851	1
	Smart Strip	1,222	0	1,076	0
	WH Tank Setback	92	0	81	0
	WH Wrap	5,104	1	4,491	1
Income Eligible Efficiency (PWC)	Air Sealing	19,508	0	19,508	0
	Attic Insulation	9,741	0	9,741	0
	Bathroom Faucet Aerator	1,637	0	1,637	0
	Central AC	0	0	0	0
	Floor Insulation	15,902	0	15,902	0
	Freezer Replacement	11,272	2	11,272	2
	Heat Pump	3,359	0	3,359	0
	Kitchen Faucet Aerator	247	0	247	0
	Lighting	155,943	150	155,943	150
	Pipe Insulation	2,743	0	2,743	0
	Refrigerator Replacement	68,805	11	68,805	11
	Showerhead	7,147	1	7,147	1

Program	Measure	Verified Gross Savings		Adjusted Gross Savings	
		kWh	kW	kWh	kW
	Wall Insulation	5,263	0	5,263	0
	WH Wrap	158	0	158	0
HVAC Rebates	ER AC 14/15 SEER	1,004,001	408	1,041,749	360
	ER AC 16+ SEER	1,645,407	669	1,902,121	652
	NC AC 14/15 SEER	8,510	4	11,192	5
	NC AC 16+ SEER	20,221	8	19,285	8
	RP AC 14/15 SEER	22,747	15	42,009	11
	RP AC 16+ SEER	34,549	14	48,381	14
	ER HP 14/15 SEER	553,705	72	611,224	64
	ER HP 16+ SEER	1,541,587	208	1,370,005	217
	NC HP 14/15 SEER	8,899	1	4,462	1
	NC HP 16+ SEER	42,797	6	28,753	5
	RP HP 14/15 SEER	17,344	3	7,320	1
	RP HP 16+ SEER	63,975	8	64,486	8
	ER GSHP 16/18 EER	85,100	4	55,324	2
	ER GSHP 19+ EER	162,540	11	105,157	9
	NC GSHP 16/18 EER	43,783	2	28,596	1
	NC GSHP 19+ SEER	25,409	2	20,320	1
	RP GSHP 19+ EER	33,565	3	26,980	2
	NC MS AC 16+ SEER	1,709	2	1,284	1
	NC MS HP 16+ SEER	366,745	20	386,899	16
	RP MS HP 16+ SEER	2,517	0	3,257	0
	ECM	241,818	57	227,788	56
	ECM with New AC**	674,626	0	0	0
	ECM with New HP**	33,060	0	0	0
	Programmable Thermostat with AC	197,315	0	270,433	0
	Programmable Thermostat with HP	320,724	0	263,629	0
	Programmable Thermostat with GSHP	20,757	0	11,721	0
	HVAC Channel: Smart Thermostat with AC	946	0	1,088	0
	HVAC Channel: Smart Thermostat with HP or GSHP	3,729	0	3,768	0
	Heat Pump Water Heater - Gas Home	4,152	1	4,152	1
	Heat Pump Water Heater - Electric Home	24,643	3	24,643	3

Program	Measure	Verified Gross Savings		Adjusted Gross Savings	
		kWh	kW	kWh	kW
	Air Sealing	31,556	0	31,556	0
	Wall Insulation	33,389	1	33,389	1
	Attic Insulation	43,549	1	43,549	1
Be E³ Smart	9W LED	627,928	66	627,928	66
	LED Night Light	43,163	0	43,163	0
	Bathroom Faucet Aerator (2 per kit)	352,355	51	352,355	51
	Kitchen Faucet Aerator	1,071,229	24	1,071,229	24
	Efficient Showerhead	1,507,783	47	1,507,783	47
Smart Thermostats	Pilot: Smart Thermostat with AC	42,573	13	76,148	0
	Pilot: Smart Thermostat with HP or GSHP	63,400	4	60,231	0
	Nest Online	1,269,474	181	959,449	0
	Rebates for Retail	301,366	43	295,052	0
	IGS Energy	13,840	2	5,439	0
	DP&L Online Store	31,486	4	24,291	0
Nonresidential					
Non-Residential Prescriptive	HVAC	4,403,798	1,030	6,026,064	1,429
	Lighting	51,618,876	6,617	49,677,956	6,864
	Motors	19,002,835	3,325	16,693,150	3,057
	Compressed Air	1,679,635	102	1,005,219	127
	Midstream Lighting	6,040,654	1,178	5,491,476	988
	Midstream VFDs	1,089,918	191	1,089,918	191
	Upstream Lighting	6,559,937	1,550	4,738,372	1,119
	Appliance Recycling	228,564	49	156,058	39
Non-Residential Custom	Custom	27,066,918	4,357	18,018,808	2,514
Total		**183,892,817**	**27,641**	**164,586,149**	**24,065**

Appendix B. *Ex Ante* Measure-Level Savings

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
Residential						
Lighting	LED	1,098,945	39.84	0.00	43,777,456	5,233
Appliance Recycling	Refrigerator Replacement	4,297	1,376.00	0.22	5,912,672	945
	Freezer Replacement	952	1,244.00	0.20	1,184,288	190
	Room Air Conditioner	406	103.60	0.91	42,062	368
	Dehumidifier	310	895.60	0.24	277,636	73
	Energy Kit	4,416	132.80	0.01	586,445	62
Income Eligible Efficiency (OPAE)*	Air Sealing	4	2,981.75	0.01	11,927	0
	Attic Insulation	8	2,270.88	0.02	18,167	0
	Central AC	3	233.67	0.15	701	0
	CFLs	365	31.95	0.00	11,661	1
	Faucet Aerator	155	44.39	0.01	6,881	1
	Foundation Wall Insulation	7	13.57	0.01	95	0
	Freezer Replacement	91	867.05	0.13	78,902	12
	Heat Pump	4	1,934.50	0.28	7,738	1
	LEDs	6,457	34.10	0.00	220,169	23
	Pipe Insulation	23	109.74	0.01	2,524	0
	Refrigerator Replacement	440	1,251.00	0.19	550,440	85
	Showerhead	56	179.61	0.01	10,058	1
	Smart Strip	26	47.00	0.01	1,222	0
	WH Tank Setback	1	92.00	0.01	92	0
	WH Wrap	60	85.07	0.01	5,104	1
Income Eligible Efficiency (PWC)	Air Sealing	16	1,219.27	0.01	19,508	0
	Attic Insulation	9	1,082.33	0.01	9,741	0
	Bathroom Faucet Aerator	46	35.58	0.01	1,637	0
	Central AC	0	0	0	0	0

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	Floor Insulation	9	1,766.90	0.05	15,902	0
	Freezer Replacement	13	867.05	0.13	11,272	2
	Heat Pump	2	1,679.66	0.23	3,359	0
	Kitchen Faucet Aerator	8	30.91	0.01	247	0
	Lighting	2,971	52.49	0.05	155,943	150
	Pipe Insulation	26	105.51	0.01	2,743	0
	Refrigerator Replacement	55	1,251.00	0.19	68,805	11
	Showerhead	20	357.36	0.03	7,147	1
	Wall Insulation	2	2,631.31	0.04	5,263	0
	WH Wrap	2	79.00	0.01	158	0
HVAC Rebate	ER AC 14/15 SEER	922	1,088.94	0.44	1,004,001	408
	ER AC 16+ SEER	1,321	1,245.58	0.51	1,645,407	669
	NC AC 14/15 SEER	53	160.56	0.08	8,510	4
	NC AC 16+ SEER	45	449.35	0.18	20,221	8
	RP AC 14/15 SEER	116	196.09	0.13	22,747	15
	RP AC 16+ SEER	67	515.66	0.21	34,549	14
	ER HP 14/15 SEER	179	3,093.32	0.40	553,705	72
	ER HP 16+ SEER	467	3,301.04	0.44	1,541,587	208
	NC HP 14/15 SEER	10	889.89	0.13	8,899	1
	NC HP 16+ SEER	30	1,426.58	0.18	42,797	6
	RP HP 14/15 SEER	18	963.53	0.14	17,344	3
	RP HP 16+ SEER	44	1,453.99	0.18	63,975	8
	ER GSHP 16/18 EER	12	7,091.68	0.36	85,100	4
	ER GSHP 19+ EER	24	6,772.51	0.45	162,540	11
	NC GSHP 16/18 EER	7	6,254.74	0.32	43,783	2
	NC GSHP 19+ SEER	4	6,352.28	0.48	25,409	2
	RP GSHP 19+ EER	5	6,712.98	0.51	33,565	3
	NC MS AC 16+ SEER	19	89.97	0.09	1,709	2

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	NC MS HP 16+ SEER	165	2,222.70	0.12	366,745	20
	RP MS HP 16+ SEER	1	2,517.16	0.28	2,517	0
	ECM	319	758.05	0.18	241,818	57
	ECM with New AC	1,618	416.95	0.00	674,626	0
	ECM with New HP	116	285.00	0.00	33,060	0
	Programmable Thermostat with AC	1,394	141.55	0.00	197,881	0
	Programmable Thermostat with HP	479	669.57	0.00	321,394	0
	Programmable Thermostat with GSHP	31	669.57	0.00	20,757	0
	HVAC Channel: Smart Thermostat with AC	6	157.68	0.05	946	0
	HVAC Channel: Smart Thermostat with HP or GSHP	5	745.89	0.05	3,729	0
	Heat Pump Water Heater - Gas Home	2	2,076.00	0.28	4,152	1
	Heat Pump Water Heater - Electric Home	19	1,297.00	0.18	24,643	3
	Air Sealing	47	671.41	0.01	31,556	0
	Wall Insulation	13	2,568.42	0.06	33,389	1
	Attic Insulation	42	1,036.89	0.02	43,549	1
Be E³ Smart	9W LED	18,204	34.49	0.0036	627,928	66
	LED Night Light	9,102	4.74	0.0000	43,163	0
	Bathroom Faucet Aerator (2 per kit)	18,204	19.36	0.0028	352,355	51
	Kitchen Faucet Aerator	9,102	117.69	0.0026	1,071,229	24
	Efficient Showerhead	9,102	165.65	0.0052	1,507,783	47
Smart Thermostats	Pilot: Smart Thermostat with AC	270	157.68	0.05	42,731	13
	Pilot: Smart Thermostat with HP or GSHP	85	745.89	0.05	63,400	4
	Nest Online	3,669	346.00	0.05	1,270,512	181
	Rebates for Retail	871	346.00	0.05	304,134	43
	IGS Energy	40	346.00	0.05	13,840	2
	DP&L Online Store	91	346.00	0.05	35,524	5
Nonresidential						

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
Nonresidential Prescriptive: HVAC	Air cooled chiller - any size	5	94,495	5.72	472,475	29
	Air cooled chiller <150 tons	4	31,083	1.44	124,333	6
	Air Cooled Chiller 150 tons or greater	4	162,680	7.51	650,719	30
	Air source heat pump < 65,000 BTUH	5	515	0.20	2,573	1
	Air source heat pump < 65,000 BTUH (single package)	1	278	0.11	278	0
	Air source heat pump < 65,000 BTUH (split)	3	464	0.18	1,391	1
	Air source heat pump 65,000 - 135,000 BTUH	1	1,259	0.54	1,259	1
	Heat pump water heater < 80 gallon tank	1	10,327	2.83	10,327	3
	HVAC occupancy sensor	1	595	0.47	595	0
	Outside air economizer with two enthalpy sensors	5	7,330	0.00	36,652	0
	Packaged terminal air conditioning	1	16,549	16.75	16,549	17
	Smart Thermostat - Honeywell Lyric T6 TH6220WF2006	3	461	0.07	1,384	0
	Smart Thermostat - Lennox - iComfort S30	1	346	0.05	346	0
	Unitary and split system A/C 65,000 - 135,000 BTUH (5.4-11.25 tons)	37	1,232	0.97	45,579	36
	Unitary and split system A/C < 65,000 BTUH (<5.4 tons)	47	547	0.43	25,691	20
	Unitary and split system A/C > 760,000 BTUH (>63.33 tons)	1	9,500	7.46	9,500	7
	Unitary and split system A/C 136,000 - 240,000 BTUH (11.33-20 tons)	29	4,765	3.74	138,188	109
	Unitary and split system A/C 241,000 - 760,000 BTUH (20-63.33 tons)	20	3,315	2.60	66,307	52
	Variable frequency drive up to 250 HP	32	89,957	20.86	2,878,626	668

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	Variable Refrigerant Flow System < 65,000 BTUH	2	1,390	0.84	2,779	2
	Variable Refrigerant Flow System > 240,000 BTUH	2	12,027	7.31	24,054	15
	Variable Refrigerant Flow System 136,000 - 240,000 BTUH	3	3,280	2.00	9,840	6
	Variable Refrigerant Flow System 65,000 - 135,000 BTUH	6	2,202	1.34	13,214	8
	Water cooled chiller > 300 tons	1	105,116	47.37	105,116	47
	Window film	9	1,020	0.40	9,179	4
Nonresidential Prescriptive: Lighting	Central lighting control	1	24	0.00	24	0
	CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	1	18,254	4.01	18,254	4
	CFL screw-in bulb or pin-based fixture 21W to 32W replacing incandescent	2	2,813	0.66	5,625	1
	CFL screw-in bulb or pin-based fixture up to 20W replacing incandescent	1	2,014	0.32	2,014	0
	De-lamping HID	8	43,079	12.51	344,633	100
	De-lamping T12 (# linear feet)	37	15,245	4.37	564,057	162
	De-lamping T8 (# linear feet)	24	19,036	4.53	456,867	109
	Energy Star CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	2	13,743	3.18	27,485	6
	Energy Star CFL screw-in bulb or pin-based fixture 21W to 32W replacing incandescent	2	3,724	0.91	7,447	2
	Energy Star CFL screw-in bulb or pin-based fixture up to 20W replacing incandescent	1	1,630	0.35	1,630	0
	Energy Star LED luminaires or screw-in base lamps (replacing incandescent)	214	7,171	1.80	1,534,631	384

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	Energy Star LED screw-in base lamps (replacing CFL)	61	2,077	0.35	126,681	21
	Exterior - LED replacing 175W or less	109	6,223	0.00	678,265	0
	Exterior - LED or Induction (8,760 operating hours) replacing 175 W or less	17	12,486	0.81	212,258	14
	Exterior - LED or Induction (8,760 operating hours) replacing 176W to 250W	6	3,938	0.51	23,630	3
	Exterior - LED or Induction (8,760 operating hours) replacing 251W or greater	3	5,925	0.68	17,775	2
	Exterior - LED or Induction (operating hours < 8,760) replacing 175W or less	153	6,056	0.04	926,497	7
	Exterior - LED or Induction (operating hours < 8,760) replacing 176W to 250W	72	34,220	0.08	2,463,833	5
	Exterior - LED or Induction (operating hours < 8,760) replacing 251W or greater	221	17,676	0.00	3,906,446	0
	Exterior - LED replacing 176W to 250W	64	38,508	0.00	2,464,517	0
	Exterior - LED replacing 251W or greater	218	20,422	0.00	4,452,068	0
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing CFL, Energy Star certified)	14	1,384	0.00	19,376	0
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing incandescent, ENERGY STAR certified)	19	5,726	0.00	108,791	0
	Exterior Re-Lamping LED Tube	1	864	0.00	864	0
	Fixture-mounted daylight sensor	3	5,009	0.59	15,026	2
	Fixture-mounted occupancy sensor	1	4,069	0.26	4,069	0
	LED 4-ft 1-lamp tube	2	3,053	0.96	6,106	2
	LED 4-ft 2-lamp tubes	4	10,735	1.03	42,942	4

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	LED 4-ft 3-lamp tubes	1	7,110	0.81	7,110	1
	LED 4-ft 3-lamp tubes 1	2	3,092	0.55	6,183	1
	LED 4-ft 4-lamp tubes	4	11,117	1.64	44,469	7
	LED case lighting sensor controls	1	989	0.00	989	0
	LED High Bay Replacing 150 W or less HID, T8 or T5	1	3,194	0.29	3,194	0
	LED High Bay Replacing 151 W to 200 W HID, T8 or T5	1	43,142	3.96	43,142	4
	LED High Bay Replacing 201 W to 350 W HID, T8 or T5	1	14,388	2.64	14,388	3
	LED High Bay Replacing 351 W to 500 W HID, T8 or T5	3	50,192	12.21	150,577	37
	LED High Bay Replacing 501 W or greater HID, T8 or T5	2	28,537	5.23	57,074	10
	LED lighting in reach-in freezer/cooler case	13	4,173	0.59	54,251	8
	LED or Electroluminescent exit sign	45	738	0.09	33,211	4
	LED or Induction (8,760 operating hours) replacing 175 W or less	1	624	0.00	624	0
	LED or Induction (operating hours < 8,760) replacing 175W or less	20	2,833	0.09	56,658	2
	LED or Induction (operating hours < 8,760) replacing 176W to 250W	5	6,501	0.36	32,506	2
	LED or Induction (operating hours < 8,760) replacing 251W or greater	21	7,986	0.04	167,705	1
	LED or Induction (operating hours < 8,760) replacing 251W to 400W	1	9,146	2.12	9,146	2
	LED Re-Lamping $1 per foot	318	29,710	5.16	9,447,815	1,642

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	LED Replacing 50 W or less HID or Fluorescent	60	6,466	1.75	387,966	105
	LED Replacing 51 W to 100 W HID or Fluorescent	247	17,137	3.58	4,232,791	883
	LED Replacing 101 W to 150 W HID or Fluorescent	219	20,979	3.84	4,594,349	841
	LED Replacing 151 W to 200 W HID or Fluorescent	46	12,697	2.67	584,054	123
	LED Replacing 201 W to 350 W HID or Fluorescent	72	32,755	4.22	2,358,338	304
	LED Replacing 351 W to 500 W HID or Fluorescent	126	48,787	8.83	6,147,176	1,113
	LED Replacing 501 W or greater HID or Fluorescent	17	129,189	21.70	2,196,217	369
	Lighting controls	16	4,162	0.62	66,585	10
	Low-watt T8 4-foot 1 lamp fixture replacing T12	1	395	0.11	395	0
	Low-watt T8 4-foot 2 lamp fixture replacing T12	5	3,260	0.79	16,298	4
	Low-watt T8 4-foot 2 lamp fixture replacing T8	2	5,725	1.78	11,450	4
	Low-watt T8 4-foot 3 lamp fixture replacing T8	4	27,396	7.44	109,584	30
	Low-watt T8 4-foot 4 lamp fixture replacing T12	6	3,771	1.38	22,626	8
	Low-watt T8 4-foot 4 lamp fixture replacing T8	4	1,475	0.39	5,901	2
	Occupancy sensor controlling 100 watts or more	47	20,538	0.54	965,279	26

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	Occupancy sensor controlling less than 100 watts	19	818	0.05	15,534	1
	Re-lamping 28 watt	5	19,641	3.07	98,203	15
Nonresidential Prescriptive: Lighting	T5 high-output high-bay 4 lamp fixture replacing HID	3	63,353	5.97	190,058	18
	T5 high-output high-bay 6 lamp fixture replacing HID	3	15,341	7.61	46,022	23
	T5 high-output high-bay 8 lamp fixture replacing HID	1	8,578	2.15	8,578	2
	T5 high-output high-bay 10 lamp fixture replacing HID	1	426,162	54.79	426,162	55
	T5 high-output high-bay 4 lamp fixture replacing HID	2	26,637	7.28	53,275	15
	T5 high-output high-bay 6 lamp fixture replacing HID	3	3,359	1.32	10,076	4
	T8 (BF < 0.78) 4-foot 2 lamp fixture replacing T12	8	1,391	0.34	11,126	3
	T8 (BF < 0.78) 4-foot 2 lamp fixture replacing T8	2	482	0.13	965	0
	T8 (BF < 0.78) 4-foot 3 lamp fixture replacing T12	1	1,196	0.18	1,196	0
	T8 (BF < 0.78) 4-foot 3 lamp fixture replacing T8	1	1,203	0.14	1,203	0
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T12	13	2,150	0.73	27,948	9
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T8	4	2,381	0.41	9,526	2
	T8 high-bay 4-foot 2 lamp fixture replacing HID	2	1,670	0.45	3,341	1

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
	T8 high-bay 4-foot 4 lamp fixture replacing HID	2	38,338	5.44	76,675	11
	T8 high-bay 4-foot 6 lamp fixture replacing HID	6	12,981	4.79	77,884	29
	T8 high-bay 4-foot 6 lamp fixture replacing HID	11	33,015	7.00	363,170	77
	Vending equipment controller	14	4,605	0.00	64,474	0
	Wall or Ceiling-mounted occupancy sensor	10	7,158	0.43	71,577	4
Nonresidential Prescriptive: Compressed Air	Air compressor 1 - 100 HP Load/No Load	4	11,210	0.94	44,839	4
	Air compressor 1 - 100 HP Variable Speed	24	66,836	3.92	1,604,062	94
	No-loss drain	6	5,122	0.66	30,735	4
Nonresidential Prescriptive: Motors	Premium Efficiency Motor 15HP	1	1,737	0.08	1,737	0
	Premium Efficiency Motor 100HP	1	7,098	0.62	7,098	1
	Premium Efficiency Motor 75HP	1	3,701	0.32	3,701	0
	Variable frequency drive up to 250 HP	44	441,972	76.50	19,446,783	3,366
Nonresidential Prescriptive: Midstream Incentives	Low Bay Hi Bay	484	1,918	0.37	928,450.18	178.82
	LED Screw-in	9,130	221	0.051	2,014,371	461
	LED Fixtures	904	279	0.054	252,580	49
	LED T8	40,955	66	0.013	2,682,845	523
	LED Exterior Flood	47	813	0.000	38,229	0
	Exterior Wall Pack	422	714	0.000	301,472	0
	Re-lamp 25 watt	3,486	32	0.006	110,750	21
	Re-lamp 28 watt	5,075	26	0.004	132,458	18
	T5	40	13	0.003	539	0
	Midstream VFDs	20	55,405	9.985	1,108,090	200
Nonresidential Prescriptive: Upstream Lighting	CFL Lamps	0	0	0.000	0.00	0.00
	LED Lamps	47,428	169	0.040	7,999,923	1,890

Program	Measure	Verified Participation Count	Ex Ante Per Unit kWh Impact	Ex Ante Per Unit kW Impact	Gross Ex Ante kWh Savings	Gross Ex Ante kW Savings
Nonresidential Appliance Recycling	Refrigerator Replacement	130	1,376.00	0.22	178,880.00	28.60
	Freezer Replacement	23	1,244.00	0.20	28,612.00	4.60
	Room Air Conditioner	15	103.60	0.91	1,554.00	13.59
	Dehumidifier	4	895.60	0.24	3,582.40	0.95
	Energy Kit	120	132.80	0.01	15,936.00	1.68
Total Nonresidential Prescriptive Rebate					**93,401,034**	**14,560**
Nonresidential Custom	Custom-Large	3	4,620,039	723.51	13,860,117	2,171
	Custom-Medium	16	272,066	21.19	4,353,056	339
	Custom-Small	19	24,496	4.23	465,415	80
	Retro-Commissioning	25	89,435	4.52	2,235,865	113
	Custom-New Construction	44	150,630	39.81	6,627,724	1,752
Total Nonresidential Custom Rebate					**27,542,177**	**4,455**
Total					**186,702,555**	**28,204**

*Participant count for the Income Eligible Efficiency program represents measure count. The exception to this is the insulation and air sealing measures where it represents participants.

Appendix C. Program Measure-Level Incentives

Program	Measure	Incentives
Residential		
Lighting	LEDs	$1.00 - $24.00 (Average: $5.16)
Appliance Recycling	Recycled Freezer	$50.00
	Recycled Refrigerator	$50.00
	Recycled Room AC	$30.00
	Recycled Dehumidifier	$30.00
	Energy Kit	Provided at no cost to customer
Income Eligible Efficiency (OPAE)	Air Sealing	Services provided at no cost to customer. Cap of $5,000 in measure costs per home. In addition, agencies can charge 15 percent of the admin cost for total installations.
	Attic Insulation	
	CFLs	
	Duct Sealing	
	Faucet Aerator	
	Foundation Wall Insulation	
	Freezer Replacement	
	Freezer Retire	
	Heat Pump	
	HVAC	
	LED Nightlight	
	Pipe Insulation	
	Refrigerator Replacement	
	Refrigerator Retire	
	Showerhead	
	Smart Strip	
	Wall Insulation	
	WH Tank Setback	
	WH Wrap	
Income Eligible Efficiency (PWC)	Air Sealing	Services provided at no cost to customer. Agencies can charge 15 percent of the admin cost for total installations.
	Attic Insulation	
	Bathroom Faucet Aerator	
	Central AC	
	Floor Insulation	
	Freezer Replacement	
	Heat Pump	
	Kitchen Faucet Aerator	
	Lighting	
	Pipe Insulation	
	Refrigerator Replacement	
	Showerhead	
	Wall Insulation	
	Water Heater Wrap	
HVAC Rebate	ER AC 14/15 SEER	$200
	ER AC 16+ SEER	$300
	NC AC 14/15 SEER	$100

Program	Measure	Incentives
	NC AC 16+ SEER	$150
	RP AC 14/15 SEER	$100
	RP AC 16+ SEER	$150
	ER HP 14/15 SEER	$300
	ER HP 16+ SEER	$450
	NC HP 14/15 SEER	$150
	NC HP 16+ SEER	$250
	RP HP 14/15 SEER	$150
	RP HP 16+ SEER	$250
	ER GSHP 16/18 EER	$1,000
	ER GSHP 19+ EER	$1,250
	NC GSHP 16/18 EER	$800
	NC GSHP 19+ SEER	$1,000
	RP GSHP 16/18 EER	$800
	RP GSHP 19+ EER	$1,000
	NC MS AC 14/15 SEER	$150
	NC MS AC 16+ SEER	$150
	RP MS AC 14/15 SEER	$150
	RP MS AC 16+ SEER	$150
	NC MS HP 14/15 SEER	$200
	NC MS HP 16+ SEER	$200
	RP MS HP 14/15 SEER	$200
	RP MS HP 16+ SEER	$200
	ECM	$50
	ECM with New AC	$50
	ECM with New HP	$25
	Programmable Thermostat with AC	$20
	Programmable Thermostat with HP	$40
	Programmable Thermostat with GSHP	$40
	Smart Thermostat with AC	$20
	Smart Thermostat with HP or GSHP	$40
	Air Sealing	$150
	Wall Insulation	$350
	Attic Insulation	$150
Be E3 Smart	9W LED	Services provided at no cost to customer
	LED Night Light	
	Bathroom Faucet Aerator (2 per kit)	
	Kitchen Faucet Aerator	
	Efficient Showerhead	
Smart Thermostats	HVAC - Smart Thermostat with AC	$75
	HVAC - Smart Thermostat with HP or GSHP	$75
	Nest Online	$75
	Rebates for Retail	$75
	IGS Energy	$75

Program	Measure	Incentives
	DP&L Online Store	$75
Commercial		
Nonresidential Prescriptive	Air cooled chiller - any size	40 $/Tons
	Air source heat pump < 65,000 BTUH (single package)	400 $/Tons
	Air source heat pump < 65,000 BTUH (split)	400 $/Tons
	Air source heat pump 65,000 - 135,000 BTUH	40 $/Ton
	Energy recovery ventilation > 450 CFM	1 $/Cubic Feet per Minute
	Heat pump water heater < 80 gallon tank	1000 $ / unit
	HVAC occupancy sensor	30 $/Tons
	Outside air economizer with two enthalpy sensors	250 $/ unit
	Packaged terminal air conditioning and heat pumps	$50 / unit
	Unitary and split system A/C 65,000 - 135,000 BTUH (5.4-11.25 tons)	40 $/Ton
	Unitary and split system A/C < 65,000 BTUH (<5.4 tons)	200 $/Tons
	Unitary and split system A/C 136,000 - 240,000 BTUH (11.33-20 tons)	40 $/Ton
	Unitary and split system A/C 241,000 - 760,000 BTUH (20-63.33 tons)	40 $/Ton
	Variable frequency drive up to 250 HP	40 /Horsepower
	Variable Refrigerant Flow System < 65,000 BTUH	400 $/Tons
	Variable Refrigerant Flow System 65,000 - 135,000 BTUH	50 $/Tons
	Water cooled chiller 150 - 300 tons	40 $/Ton
	Water source heat pump < 240,000 BTUH @ 85 degrees F	40 $/Ton
	Window film	2 $/Square Feet
	Central lighting control	0.04 $/Connected Watts
	CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	4 $ / unit
	CFL screw-in bulb or pin-based fixture up to 20W replacing incandescent	$1.50 / unit
	Delamping HID	0.05 $/rated fixture watt
	Delamping T12 (# linear feet)	2.25 $/linear foot
	Delamping T8 (# linear feet)	1.2 $/linear foot
	Energy Star CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	4 $/bulb
	Energy Star CFL screw-in bulb or pin-based fixture 21W to 32W replacing incandescent	$1.50 / unit
	Energy Star LED luminaires or screw-in base lamps (replacing incandescent)	6 $/unit
	Energy Star LED screw-in base lamps (replacing CFL)	3 $/ unit

Program	Measure	Incentives
	Exterior - LED or Induction (8,760 operating hours) replacing 175 W or less	100 $/ unit
	Exterior - LED or Induction (8,760 operating hours) replacing 176W to 250W	150 $/ unit
	Exterior - LED or Induction (8,760 operating hours) replacing 251W or greater	200 $/ unit
	Exterior - LED or Induction (operating hours < 8,760) replacing 175W or less	50 $ / unit
	Exterior - LED or Induction (operating hours < 8,760) replacing 176W to 250W	75 $/ unit
	Exterior - LED or Induction (operating hours < 8,760) replacing 251W or greater	120 $/ unit
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing CFL, Energy Star certified)	3 $/ unit
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing incandescent, ENERGY STAR certified)	6 $/ unit
	Fixture-mounted daylight sensor	30 $/ unit
	LED 4-ft 2-lamp tubes	12 $/ unit
	LED 4-ft 3-lamp tubes	20 $/ unit
	LED 4-ft 3-lamp tubes	21 $/ unit
	LED 4-ft 4-lamp tubes	24 $/ unit
	LED case lighting sensor controls	10 $/ unit
	LED lighting in reach-in freezer/cooler case	25 $/ tube
	LED lighting in reach-in freezer/cooler case (per tube)	25 $/ tube
	LED luminaires up to 18 watts (replacing incandescent)	N/A
	LED or Electroluminescent exit sign	10 $/ unit
	LED or Induction (operating hours < 8,760) replacing 175W or less	N/A
	LED or Induction (operating hours < 8,760) replacing 251W or greater	N/A
	LED Re-Lamping $1 per foot	1 $/ foot
	LED Replacing 50 W or less HID or Fluorescent	15 $ / unit
	LED Replacing 51 W to 100 W HID or Fluorescent	25 $ / unit
	LED Replacing 101 W to 150 W HID or Fluorescent	35 $/ unit
	LED Replacing 151 W to 200 W HID or Fluorescent	50 $/ unit
	LED Replacing 201 W to 350 W HID or Fluorescent	75 $/ unit
	LED Replacing 351 W to 500 W HID or Fluorescent	95 $/ unit
	LED Replacing 501 W or greater HID or Fluorescent	120 $/ unit
	LED traffic signal - green	25 $/ unit
	LED traffic signal - red	26 $/ unit
	Low-watt T8 4-foot 1 lamp fixture replacing T12	4.5 $/ unit
	Low-watt T8 4-foot 2 lamp fixture replacing T12	7 $/ unit
	Low-watt T8 4-foot 2 lamp fixture replacing T8	7 $/ unit

Program	Measure	Incentives
	Low-watt T8 4-foot 3 lamp fixture replacing T12	11.5 $/ unit
	Low-watt T8 4-foot 3 lamp fixture replacing T8	11.5 $/ unit
	Low-watt T8 4-foot 4 lamp fixture replacing T12	14 $/ unit
	Low-watt T8 4-foot 4 lamp fixture replacing T8	14 $/ unit
	Occupancy sensor controlling 100 watts or more	30 $/ unit
	Occupancy sensor controlling less than 100 watts	5 $/ unit
	Relamping 25 watt or less	1.5 $/ unit
	Relamping 28 watt	1 $/ unit
	T5 high-output high-bay 4 lamp fixture replacing HID	50 $ / unit
	T5 high-output high-bay 6 lamp fixture replacing HID	60 $ / unit
	T5 high-output high-bay 10 lamp fixture replacing HID	80 $/ unit
	T8 (BF < 0.78) 4-foot 1 lamp fixture replacing T12	4 $/ unit
	T8 (BF < 0.78) 4-foot 2 lamp fixture replacing T12	6 $/ unit
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T12	12 $/ unit
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T8	12 $/ unit
	T8 high-bay 4-foot 2 lamp fixture replacing HID	30$ /unit
	T8 high-bay 4-foot 4 lamp fixture replacing HID	40 $ / unit
	T8 high-bay 4-foot 6 lamp fixture replacing HID	50 $ / unit
	Vending equipment controller	50 $ / unit
	Air compressor 1 - 100 HP Load/No Load	45 $/ HP
	Air compressor 1 - 100 HP Variable Speed	125 $ / HP
	No-loss drain	100 $ unit
	VFDs on Air Compressors 1-100 HP	40 $ / HP
	Premium Efficiency Motor 20HP	15 $/HP
	Variable frequency drive up to 250 HP	40 $/ HP
Nonresidential Prescriptive: Midstream Incentives	Low Bay Hi Bay	$40.00 - $80.00 per unit
	LED Screw-in	$2.00 - $14.00 per unit
	LED Fixtures	$13.00 - $80.00 per unit
	LED T8	$4.00 - $6.00 per unit
	LED Exterior Flood	$25.00 - $70.00 per unit
	Exterior Wall Pack	$25.00 - $75.00 per unit
	Re-lamp 25 watt	$1.00 - $1.00 per unit
	Re-lamp 28 watt	$0.50 - $0.50 per unit
	T5	$1.00 - $1.00 per unit
	Midstream VFDs	$40.00 per horsepower

Program	Measure	Incentives
Nonresidential Custom	Custom NC	5-10% savings over baseline: $0.05 / kWh and $50 / kW
		> 10% savings over baseline: $0.08 / kWh and $75 / kW
		> 20% savings over baseline: $0.10 / kWh and $100 / kW
	Custom NC-LPD	(LPDbaseline - LPDactual) * gross lighted area * $0.30
	Custom-HVAC	$0.10 per kWh saved + $100 per kW saved.
	Custom-Lighting	$0.05 per kWh saved + $50 per kW saved.
	Custom-Other	$0.08 per kWh saved + $100 per kW saved.

Appendix D. Evaluated Energy Savings Calculation Sources

Program	Measure	Source
Residential		
Residential Lighting	LEDs	Draft Ohio TRM. Joint Utility Comments were used to update the waste heat factor for demand. Adjusted savings use weighted waste heat factors to account for 8% of bulbs installed outside. Evaluated savings reflect 95.9% of bulbs sold to account for 4.1% of the bulbs sold being installed in commercial applications. Baseline wattages account for EISA standards following the UMP. The LED ISR of 0.96 is based on benchmarking LED ISR values from five different studies.
Appliance Recycling	Refrigerator	Regression model and participant survey.
	Freezer	Regression model and participant survey.
	Room AC	Draft Ohio TRM. Updated with Unit Capacity from Tracking Data
	Dehumidifier	Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030
	Kit LEDs	Draft Ohio TRM. Joint Utility Comments were used to update the waste heat factor for demand. Delta Watts input was based on participant survey responses. Updated with ISR from Energy Saving Kits survey for adjusted gross calculations.
	Kit Bathroom Faucet Aerators	Draft Ohio TRM. Adjusted gross calculations were made using internal engineering algorithms, 2013 Cadmus water metering study data, and participant survey results. See Comment 2 below. Updated with ISR from participant survey for adjusted gross calculations.
	Kit Kitchen Faucet Aerators	Draft Ohio TRM. Adjusted gross calculations were made using internal engineering algorithms, 2013 Cadmus water metering study data, and participant survey results. See Comment 2 below. Updated with ISR from participant survey for adjusted gross calculations.
	Kit Showerhead	Draft Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms, participant survey results, and 2013

Program	Measure	Source
		Cadmus water metering study data. See Comment 2 below. Updated with ISR from participant survey for adjusted gross calculations.
Income Eligible Efficiency (OPAE)	All Measures	Billing analysis conducted using a final billing dataset of 546 customers that participated in the OPAE's Low-Income program between 2012 and 2016. The billing analysis employed a PRISM model to calculate the savings, analyzing weather-normalized pre- and post-installation annual usage for each account.
Income Eligible Efficiency (PWC)	Attic Insulation	Draft Ohio TRM. Used average square footage of insulation installed per house from 2016 OPAE program data
	Faucet Aerator	Draft Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms and 2013 Cadmus water metering study data. Flowrate inputs based on measured values. See Comment 2 below.
	Lighting	Draft Ohio TRM. Joint Utility Comments were used to update the waste heat factor for demand. Updated with ISR from participant surveys for verified and adjusted gross calculations. Delta Watts input was based on recorded wattage of bulbs removed. See Comment 1 below.
	Floor Insulation	Draft Ohio TRM. Used average square footage of insulation installed per house from 2016 OPAE program data
	Freezer Replacement	The calculation for freezer replacement savings is not included in the draft Ohio TRM. The TRM provided an algorithm for freezer early retirement, from which we took the baseline assumption for usage (1,244 kWh). This baseline consumption was scaled up to align with the Joint Utility Comments for the Refrigerator Replacement measure which adjusts the baseline consumption up to account for the unit being installed in a low income application and being the primary unit. The energy consumption of the replacement unit was determined by matching consumption estimates for the efficient freezer by size and type, assuming replacement with an ENERGY STAR® unit. We calculated a weighted average usage estimate for the efficient unit based on the distribution of installations through the program.

Program	Measure	Source
	Heat Pump	Average savings of the 97 heat pump installations in the 2016 Income Eligible Efficiency (OPAE) program. Savings for these 97 installations use algorithms and inputs from Draft Ohio TRM.
	Faucet Aerator	Draft Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms and 2013 Cadmus water metering study data. Flowrate inputs based on measured values. See Comment 2 below.
	Pipe Insulation	Draft Ohio TRM. Adjusted gross savings were calculated based on an internal engineering algorithm from other evaluations that is based on the number of people per home in the Income Eligible Efficiency program and the temperature of the ground water in Dayton.
	Refrigerator Replacement	The Joint Utility Comments on the Draft Ohio TRM presented alternative unit energy consumption measures for the existing unit part-use factor and for Energy Star refrigerators. The main assumption they make is that for low-income families, these refrigerators are primary units that are being replaced so they should be modeled as running full time. The adjusted gross calculations use these alternative inputs in the TRM deemed savings formula.
	Showerhead	Draft Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms and 2013 Cadmus water metering study data. Flowrate inputs based on measured values. See Comment 2 below.
HVAC Rebate	AC Early Retirement (all SEERs)	Participant billing analysis, kW calculated using draft Ohio TRM. See comment 3 below.
	AC Std Replacement (all SEERs)	Participant billing analysis, kW calculated using draft Ohio TRM. See comment 3 below.
	AC New Construction (all SEERs)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	GSHP Early Retirement/Std/New Construction (all EERs)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	HP Early Retirement (all SEERs)	Participant billing analysis, kW calculated using draft Ohio TRM. See comment 3 below.
	HP Std Replacement (all SEERs)	Participant billing analysis, kW calculated using draft Ohio TRM. See comment 3 below.

Program	Measure	Source
	HP New Construction (all SEERs)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	Mini-split AC Std Replacment (all SEERs)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	Mini-split AC New Construction (all SEERs)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	Mini-split HP New Construction (all SEERs)	kWh and kW calculated using draft Ohio TRM and secondary sources. See comment 4 below.
	ECM with furnace	Participant billing analysis, kW calculated using draft Ohio TRM. See comment 3 below.
	Heat pump water heaters (both heating fuels)	kWh and kW calculated using draft Ohio TRM. See comment 3 below.
	Air sealing and insulation	kWh and kW calculated using deemed values from secondary sources.
Be E³ Smart	9W LED	2010 Ohio TRM. DOE Uniform Methods Project, Ch. 21: Residential Lighting Evaluation Protocol. ISR from 2016-17 parent follow-up survey.
	LED Night Light	2015 Indiana TRM. ISR from 2016-17 family participant survey and parent follow-up survey.
	Bathroom Faucet Aerator (2 per kit)	2010 Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms, 2017 family installation survey results, and 2013 Cadmus water metering study data. See Comment 2 below. ISR from 2016-17 parent follow-up survey.
	Kitchen Faucet Aerator	2010 Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms, 2017 family installation survey results, and 2013 Cadmus water metering study data. See Comment 2 below. ISR from 2016-17 parent follow-up survey.
	Efficient Showerhead	2010 Ohio TRM. Adjusted gross calculations were calculated using internal engineering algorithms, 2017 family installation survey results, and 2013 Cadmus water metering study data. See Comment 2 below. ISR from 2016-17 parent follow-up survey.
Smart Thermostats	HVAC - Smart Thermostat with AC	EFLH values from 2010 Ohio TRM and program data w/ address

Program	Measure	Source
	HVAC - Smart Thermostat with HP or GSHP	ESF values from a 2015 Cadmus study and a 2007 RLW Analytics study HVAC system capacities and efficiencies from program data HVAC system types from program data and participant survey ISR values from participant survey Baseline thermostat distribution from program data and participant survey
	Nest Online	
	Rebates for Retail	
	IGS Energy	
	DP&L Online Store	
Commercial		
Non-Residential Prescriptive	HVAC	See comment 5 below.
	Lighting	See comment 5 below.
	Motors	See comment 5 below.
	Other	See comment 5 below.
	Midstream Incentives	Waste heat factor and hours of use were evaluated using the HOU by building type in the 2010 Ohio TRM, in conjunction with the building type distribution of commercial lighting projects from previous evaluation years and a 5% adjustment to account for the percentage of commercial lamps installed outside. In-service rate was evaluated based on an online survey of customers who participated through the distributor channel in 2015. Baseline wattages for screw-based LEDs are based on EISA 2007 and other legislation. Spring 2017 Wisconsin TRM was used to estimate baseline wattages for High-bay/Low-bay, Exterior Flood, LED Fixture, and LED Wall-pack measures.
	Midstream VFDs	Cadmus leveraged projects evaluated through the Commercial Prescriptive Program in PY2017. The cumulative realization rates of these projects—98.4% for energy and 95.8% for demand—were applied to the VFD measures incented through the Midstream Incentive Program.
Non-Residential Custom	Lighting	See comment 6 below.

Program	Measure	Source
	Other	See comment 7 below.

Comments

1. We used an algorithm that better accounts for DP&L specific variables, such as: number of people per home, number of faucets per home, and the temperature of the ground water. Other variables were taken from a Cadmus water metering study done in Michigan in 2012-2013 and include: baseline flow rates, length of showers and faucet usage, number of showers taken per day and shower and faucet point of use temperatures.
2. Minor adjustments were made to TRM equations and assumptions. See report section for details.
3. Mini-split HP kWh saving calculated using the draft Ohio TRM (for cooling) and engineering calculations informed by data from the following study: http://www.env.state.ma.us/dpu/docs/electric/09-64/12409nstrd2ac.pdf
4. We based our calculations on algorithms outlined in the draft Ohio TRM. We based our baseline conditions on the draft Ohio TRM, except when the site visit indicated a different baseline than deemed by measure type. Cadmus calculated the retrofit equipment wattage and operating parameters through site visit results and product specification sheets.
5. Cadmus calculated baseline and retrofit equipment wattage and operating parameters through site visit results and product specification sheets.
6. DP&L contracted with a third-party engineering firm to conduct pre- and post- installation metering to calculate energy savings. Cadmus reviewed the engineering reports and made revisions as necessary to evaluate savings.

Appendix E. Cost-Effectiveness Analysis Inputs

Utility Assumptions

Utility assumptions apply to all programs and measures, including the assumptions that follow.

Avoided Costs are the full value of time and seasonally differentiated generation and capacity costs. For each energy efficiency measure included in a program, hourly (8,760) system-avoided costs are adjusted by the hourly load shape of the end use affected by the measure, capturing the full value of time and seasonally differentiated impacts of the measure.

Line Loss is the percentage of energy lost during transmission and distribution. In DSM Portfolio Pro, energy and capacity line losses are applied to measure-level savings to reflect total savings from the point of generation. Table 115 presents line loss assumptions for the 2017 Evaluation Measurement and Verification Report.[38]

Table 115. Line Loss Assumptions Used in Cost-Effectiveness Calculations

Sector	Energy Line Losses	Demand Line Losses
Residential	7.05%	8.14%
Commercial/Industrial	3.90%	5.01%

Retail Rates, provided by DP&L, include electric rates for all customer classes eligible for DSM programs. Table 116 provides retail rate assumptions for the 2017 Evaluation Measurement and Verification Report.

Table 116. Retail Rates Used in Cost-Effectiveness Calculations

Sector	Retail Rate	Escalator
Residential	$0.130	0%
Residential Heating	$0.120	0%
Commercial	$0.097	0%
Industrial	$0.092	0%

Load Shapes show hourly energy use over a year for each end use included in DSM Portfolio Pro. Hourly end-use load shapes were unavailable for the 2017 cost-effectiveness analysis. Therefore, Cadmus developed load shapes using available data from similar regions and adjusting for weather conditions in DP&L's service territory.

Discount Rates **are used to determine the net present value of each program's benefits.** Table 117 shows discount rates used in 2017. The TRC, UTC, and RIM test discount rates are based on DP&L's weighted cost of capital; the SCT discount rate is based on a 10-year T-bill rate; the PCT rate represents a hurdle rate. Cadmus will update discount rates in subsequent years, as new data become available.

[38] Line losses in Table 109 represent the percentage loss in energy and demand from the point of generation to the meter.

Table 117. Discount Rates

Benefit-Cost Test	Discount Rate
TRC	7.86%
SCT	2.33%
UTC	7.86%
RIM	7.86%
PCT	10.00%

Peak Definitions are used to determine time or seasonal differentiations between rates and avoided costs. Additionally, to calculate peak load impacts from energy efficiency measures, end-use load shapes are used to identify the average reduction in demand over the DP&L system's top 100 peak demand hours.

Externalities and Indirect Benefits are additional, non-energy benefits associated with installing energy-efficiency measures. For the 2017 analysis, Cadmus only included Operation and Maintenance benefits for lighting measures to account for avoided replacement costs associated with lighting measures that have a longer estimated useful life than their baselines.

Program Assumptions

Sectors/Segments identify the customer class to which each program's participants belong. Sectors for DP&L include: residential, commercial, and industrial. Segments used in DSM Portfolio Pro include: single-family, multifamily, small office, large retail, and schools (tailored to DP&L's service territory). Sectors and segments dictate retail rates and load shapes used during analysis.

Utility Administrative Costs include expenses associated with program development, marketing, delivery, operation, and EM&V. Such non-t measure-specific costs are assessed at the program or portfolio levels. Costs categories used in the *2017 Evaluation Measurement and Verification Report*, shown in Table 118, will be updated in subsequent cycles.

Table 118. Implementation and Administrative Costs

Cost Category	Level	Description
Implementation Vendor and Marketing Costs	Program Level	Incremental costs associated with performing program implementation tasks (e.g., customer service, application processing, marketing, customer outreach).
Incentive Costs	Program Level	Rebates and incentives paid to customers by DP&L.
Direct Measure Costs	Program Level	Costs associated with paying for program measures (e.g., measures installed through the Appliance Recycling, Income Eligible Efficiency, BE³ Smart, Energy Efficiency Kits).
DP&L Staff Costs	Program Level/ Portfolio Level	Costs to administer energy efficiency programs, including DP&L's fully-loaded incremental personnel costs. Activities associated with market research outside of EM&V.
External Vendor Evaluations	Portfolio Level	Activities associated with the determination and evaluation of current and potential energy efficiency programs (e.g., benefit-cost ratio analysis, impact and process analysis,

Cost Category	Level	Description
		cost per kWh analysis, customer research, all other analyses necessary for program evaluation).
Education, Awareness, and Building and Market Transformation	Portfolio Level	Cost to increase awareness of energy efficiency.

Measure Assumptions

Measure Life is used during the calculation of total lifetime benefits for each measure. The life of each measure is based on information from the draft Ohio TRM, program-supported documentation, and secondary research.

End Use is used to assign each measure to a specific load shape. Examples of end uses in DSM Portfolio Pro include water heating, HVAC, and lighting.

Savings are annual kWh savings associated with the installation of each energy efficiency measure. Savings used in DSM Portfolio Pro are adjusted gross savings.

Incremental Cost is the expense associated with the installation of energy efficiency measures and ongoing operation and maintenance costs, where applicable. These costs include the entire cost of installing the measure and do not net out incentive payments to the customer. The incremental cost is based on data provided by DP&L and on secondary research.

Incentive Level is the dollar amount of the rebate paid to a customer by DP&L, which provided the incentive amount for each measure.

Freeridership is the percentage of participants who would have taken the same action/installed the same measure in the program's absence. Cadmus assumed a net-to-gross ratio of 1.0 for the 2016 analysis.

Spillover is the percentage of participants who installed additional energy-saving measures without incentives due to their participation in the program. Spillover was not calculated for the 2016 analysis.

Participation is the number of customers who participated in the program or the quantity of measures verified by Cadmus.

Appendix F. Energy and Demand Savings Confidence and Precision

Cadmus used a multifaceted approach to construct error bounds for final kWh savings estimates resulting from variations in methods across programs and, in some cases, within individual programs. To determine the uncertainty level, two types of error were considered: measurement (or modeling) errors and sampling errors. Measurement errors refer to uncertainty levels around engineering parameters derived from simulation or professional judgment. Sampling errors refer to uncertainty introduced by use of sampled data to infer characteristics of the overall population.

For engineering calculations using simulated or assumed parameters, measurement error was assumed to have a relative precision of ±10%. This accuracy level is regarded as a minimum for results in the evaluation industry, and results taken from outside evaluations or based on engineering analysis would likely be reliable within these bounds.

An example of this would be the effective full-load hours (EFLH), used in many of the HVAC savings calculations. These values come from simulations conducted by the U.S. Environmental Protection Agency and, as such, have no sampling error. They are not, however, deterministic (average EFLH presumable deviates from these values). Absent documentation on this uncertainty level, Cadmus assumed they were accurate within the industry standard threshold of ±10% relative precision with 90% confidence.

Sampling error was calculated for parameters estimated through some form of sampling. These data included survey results, meter data, and secondary sources. Sampled data were used in the evaluation of several programs to estimate parameters for use in per-unit savings calculations (such as installation rates) or in they consumption of specific equipment types (such as in billing analysis).

In some cases, uncertainty of estimates derived from multiple sources. For example, for summed estimates (such as those for total program savings), the root of the sum of the squared standard errors was calculated to estimate the confidence interval:[39]

$$Confidence\ Interval_{\bar{X}+\bar{Y}} = (\bar{X} + \bar{Y}) \pm 1.645 \cdot \sqrt{\left(\frac{s_{\bar{X}}^2}{n_{\bar{X}}}\right) + \left(\frac{s_{\bar{Y}}^2}{n_{\bar{Y}}}\right)}$$

In some cases, Cadmus computed an estimate as the product of two other estimates. For example, evaluating ARP gross per-unit savings calculations involved combining full-year gross estimates from a regression-based metering analysis, with average annual running times estimated from participant

[39] This approach to aggregation errors follows methods outlined in Appendix D from Schiller, Steven et. al. "National Action Plan for Energy Efficiency." *Model Energy Efficiency Program Impact Evaluation Guide.* 2007. Available online: www.epa.gov/eeactionplan.

surveys. For these results, Cadmus calculated combined standard errors for the final estimates. In cases where the relationship was multiplicative, Cadmus used the following formula:[40]

$$Confidence\ Interval_{\bar{X}\cdot\bar{Y}} = \bar{X}\cdot\bar{Y} \pm 1.645 \cdot \sqrt{\bar{Y}^2\left(\frac{s_{\bar{X}}^2}{n_{\bar{X}}}\right) + \bar{X}^2\left(\frac{s_{\bar{Y}}^2}{n_{\bar{Y}}}\right) + \left(\frac{s_{\bar{X}}^2}{n_{\bar{X}}}\right)\left(\frac{s_{\bar{Y}}^2}{n_{\bar{Y}}}\right)}$$

Table 119 reports precision estimates with associated uncertainty sources for each residential program.

Table 119. Residential Energy Savings Precision

Program	Precision at 90%	Sources of Uncertainty
Lighting	± 14.4%	TRM algorithms and assumptions, Non-Res allocation from 2015 survey, LED ISR based on benchmarking of ISR value from five different studies
Appliance Recycling	± 7.1%	Model analysis, 2014, 2015, 2016, 2017 participant survey part-use survey inputs, participant survey, TRM algorithms and assumptions
Income Eligible Efficiency (OPAE)	± 6.9%	Billing analysis, TRM algorithms and assumptions; CFL and LED ISR, showerhead and aerator measure inputs from Cadmus 2012 Michigan water study
Income Eligible Efficiency (PWC)	± 8.5%	TRM algorithms and assumptions; LEDISR, showerhead and aerator measure inputs from Cadmus 2012 Michigan water study
HVAC Rebate	± 8.0%	Secondary meter data, billing analysis, participant survey, and TRM algorithms and assumptions
Be E³ Smart	± 14.0%	2017 parent follow-up survey, family installation survey, and TRM algorithms and assumptions
Smart Thermostats	± 14.4%	2017 follow-up survey and TRM algorithms and assumptions, showerhead and aerator measure inputs from Cadmus 2012 Michigan water study

Nonresidential

For commercial and industrial programs, DP&L provided Cadmus with a project database that included calculated and deemed (*ex ante*) claimed savings values for each nonresidential project. Cadmus performed site visits and engineering desk reviews to calculate adjusted gross savings for a sample of projects. This included using these activities to estimate realization rates, which could then be applied to projects outside of the samples to obtain realized savings estimates. Cadmus divided projects selected for site visits and desk review samples into Prescriptive and Custom Rebate programs, and performed the analyses separately.

[40] Goodman, Leo. "The Variance of the Product of K Random Variables." *Journal of the American Statistical Association.* 1962.

For the Prescriptive Rebate program, Cadmus first estimated savings, standard errors, and precision levels by measure type, then aggregated these results into the program-level savings estimate, standard error, and precision. As lighting projects spanned an especially wide range of *ex ante* savings values (from 26 kWh to over 5 million kWh), Cadmus divided prescriptive lighting savings by strata, according to the aggregate reported *ex ante* claimed savings for each project, and then allocated each project to each stratum according to the proportional representation across the population.

Further, given the heterogeneity in measure-level energy savings for other prescriptive measures beyond lighting (e.g., HVAC, Motors), Cadmus designed two additional strata to capture variance for these measures, and finally one "Other" strata for the remaining prescriptive projects. Table 120 reports cut points and distribution of sites for each prescriptive strata.

Table 120. Prescriptive Lighting Stratification

Statistic	Small	Medium	Large
kWh Range	**<100,000**	**100,000-500,000**	**>500,000**
Number of Projects	1,032	104	17
Total *ex ante* kWh	17,668,675	21,516,997	12,631,182

Cadmus also separated custom projects into four strata: large custom, medium custom, small custom, and new construction. Table 121 reports cut points and distribution of sites for each custom strata.

Table 121. Custom Stratification

Statistic	Small	Medium	Large	NC	OnBoard
kWh Range	**<100,000**	**100,000-500,000**	**>500,000**	**N/A**	**N/A**
Number of Projects	19	16	4	44	9
Total *ex ante* kWh	465,415	4,353,056	13,860,117	6,627,724	2,235,865

The remaining project types were: prescriptive HVAC, prescriptive motors, and prescriptive other; Cadmus treated each as a single stratum.

Verification samples targeted projects in the large strata. This emphasis reduced uncertainty in overall savings estimates by directly verifying a large proportion of savings. Cadmus obtained total savings estimates and precision levels with 90% confidence, as shown in Table 122.

Table 122. Nonresidential Gross Energy Savings, Prescriptive and Custom

Prescriptive Program Savings		Custom Program Savings	
Total Estimated Savings (kWh)	Precision at 90% Confidence	Total Estimated Savings (kWh)	Precision at 90% Confidence
74,058,726	3.9%	18,018,808	8.3%

Energy-savings estimates for individual measure categories follow in Table 123. Precision at 90% confidence is provided for each estimate. Categories with large kWh savings totals have tighter precision than those with small savings totals as the team allocated evaluation resources with the goal of producing efficient, program-level estimates.

Table 123. Nonresidential Summary of Energy Savings Precision Estimates

Measure Type	Reported Savings (kWh)	Estimated Savings (kWh)	Realization Rate	Precision at 90% Confidence
P-Lighting-Large	12,631,182	13,413,661	106%	9.5%
P-Lighting-Medium	21,516,997	18,456,970	86%	12.7%
P-Lighting-Small	17,668,675	17,807,324	101%	4.2%
P-Compressed Air	1,679,635	1,661,556	99%	15.6%
P-Motors	19,459,319	16,693,150	86%	8.7%
P-HVAC	4,646,953	6,026,064	130%	25.6%
C-Large	13,860,117	5,721,648	41%	N/A
C-Medium	4,353,056	4,412,505	101%	1.9%
C-Small	465,415	454,229	98%	9.9%
C-Retrocommissioning	2,235,865	2,177,766	97%	3.2%
C-New Construction	6,627,724	5,252,660	79%	30.9%
Midstream Lighting	6,461,694	5,491,476	85%	14.9%
Midstream VFDs	1,108,090	1,089,918	98%	10.0%
Residential Lighting Bulbs**	7,999,923	4,738,372	59%	3.9%
Appliance Recycling at Nonresidential Sites	227,028	156,058	69%	7.6%
Total	**120,941,675**	**103,553,357**	**N/A**	**4.4%**

*Bulbs sold through the Residential Lighting Program and allocated to the Commercial Program. For *ex ante* savings, 5% of upstream residential lighting bulbs were allocated to commercial applications. Verified and adjusted savings used 4.1%.

Appendix G. Nonresidential Metering Summary

Introduction

Cadmus is currently evaluating Dayton Power & Light's (DP&L) 2017 Commercial and Industrial (C&I) rebate program. DP&L offers incentives to its customers for installing energy-efficient equipment categorized under: lighting, motors, HVAC, air compressors, custom projects. In order to evaluate the program savings, Cadmus conducted site visits in June 2017 to verify equipment installation, operating hours and other performance related system parameters. In addition to the C&I rebate program evaluation, Cadmus is also responsible for calculating peak demand savings as part of the PJM analysis. This memo summarizes the installation of light loggers at 30 customer sites to record fixture operating hours and power meters at 28 customer sites to record equipment demand and operating hours.

DP&L Database

DP&L provided Cadmus access to the rebate program database in order to select a sample for the site visits and review project documentation. The database provides information such as customer contact, confirmation number (project ID), claimed energy and demand savings, estimated lighting hours of use (HOU), project date of completion, rebate status, and vendor name. The database also contains supporting documentation such as invoices, rebate application forms, and new lighting specification.

Many projects are incentivized under the prescriptive program; therefore project specifics such as location of new fixtures, space types, and lighting controls may not be available.

Logger Installation Protocol

For selected lighting projects, Cadmus engineers determined the quantity and location of light logger installations based on installed fixture types and quantities and space types (locker room, office, restroom, etc.). For example, one of the selected sites was a school. While on site, we verified that the lighting fixture hours of use (HOU) reported for the project were not applicable to all the space types: classrooms, hallways, and auditorium. Since these spaces each had different lighting schedules, we installed light loggers in a sample of locations. At each site, we installed three to six HOBO light loggers (model # UX-90). Loggers were installed inside the lighting fixtures with direct exposure to the lamp and hidden from natural light.

For selected non-lighting projects, Cadmus installed Wattnode power meters with HOBO pulse loggers (model # UX-90) on the rebated equipment. Metering equipment was installed within the electrical enclosures where possible to eliminate incidental contact with energized parts by non-qualified personnel. In some cases, temperature sensors were also installed to support the power metering data.

Logger Retreival Protocol

Once the data collection period is over, the loggers will be retrieved and returned to Cadmus by DP&L. A detailed description of locations and special instructions to access each logger (site contact,

ladder/scissor lift required, etc.) is provided in Appendix A. Personnel retrieving the loggers should follow the following steps:

- Before scheduling the visit, identify loggers that need ladder/scissors lift/harness for access as indicated on the logger data collection form for that site. Any special equipment needed should be prearranged.
- Once on site, survey and locate all rooms/spaces where loggers are installed before starting retrieval procedure.
- Once logger locations have been identified, retrieve loggers and note the data and time in the data collection sheets.
- If logger(s) are missing/damaged/relocated, please notify the Cadmus contact before leaving the site.
- When loggers from all the sites are retrieved, mail them to Cadmus's Boulder office (Cadmus Group - RE: Ryan Hughes - 1426 Pearl Street, Suite 400, Boulder, CO 80302)

Analysis

Data from the loggers will be filtered and analyzed. Cadmus will determine the total project energy (kWh) savings using the collected data and information verified during the site visit. For lighting sites, the HOU for each space type will be determined. The recorded HOU will be extrapolated to annual HOU for each space type by considering whether the space is occupied on weekends and annual holidays. Cadmus will determine the total project energy savings using the calculated HOU and the number of fixtures and lamp wattages verified during the site visit.

For non-lighting sites, we will calculate demand (kW) savings by following the Ohio TRM's definition of the peak demand timeframe for the evaluation and we will use the PJM definition of the peak demand timeframe to calculate the kW reduction for the PJM auction. There is a one hour difference between the two definitions.

Table 124. June 2017 Sites Selected for Metering

#	Site Name	Confirmation #	Strata	Loggers Installed
1	Hood Packaging	000IFK1B	P-Lighting-Medium	Six Light Loggers
2	Dayton Metro Libraries Kettering/Moraine Branch	0HANK5JX	C-New Construction	Six Light Loggers
3	Electro Controls	13ZG22W0	C-New Construction	Three Light Loggers
4	Rookwood Properties	28FQBDQO	P-Lighting-Medium	Four Light Loggers
5	McDonalds	2GVRCUPC	C-New Construction	Three Light Loggers
6	Keller Grain and Feed	3QEJVWXW	P-Compressed Air	One Power Meter
7	Kettering HN Eaton	4GXUFGKF	P-Lighting-Medium	Four Light Loggers
8	YMCA of Dayton Preble County Branch	5INP5SGF	P-Lighting-Medium	Five Light Loggers
9	Speedway	7SJKL4VA	P-HVAC	One Power Meter
10	City of Sidney, Wastewater Treatment Plant	8OKS9TQP	P-Motors	One Power Meter

#	Site Name	Confirmation #	Strata	Loggers Installed
11	Heapy Engineering	ARQ3N71E	P-HVAC	Two Power Meters
12	Mahle Behr	AT5WJ5T4	P-Motors	Three Power Meters
13	Beavercreek Golf Course	BA2QALKG	P-HVAC	One Power Meter
14	Hull Brothers	C2H6ZTQB	C-Small	Three Light Loggers
15	Wreck-A-Mended	C6R0TWZY	C-Small	Four Light Loggers
16	Osi-Carrabba's	CSYS8HTV	P-HVAC	One Power Meter
17	Classic Carriers	CWPZNIIM	C-New Construction	One Light Logger
18	International Paper	DU7SCTTD	P-Lighting-Small	One Light Logger
19	Tom Smith Industries	DWPWMUAE	P-Lighting-Medium	Six Light Loggers
20	Venture Manufacturing Co	ERA5HMGM	P-Compressed Air	One Power Meter
21	Arch Polymers, Inc.	EL28OSYB	P-Motors	One Power Meter
22	Travelcenters Of America	EZ2OOEDZ	P-HVAC	Three Power Meters
23	City Of Greenville, Greenville Water Plant	F3L4WIDN	P-Motors	One Power Meter
24	Beach Manufacturing	F6NITK4C	P-Compressed Air	One Power Meter
25	Erwin Insurance Agency	G4HLGWDE	P-HVAC	One Power Meter (only temperature sensors installed)
26	Clopay Building Products	GJMTKSEY	C-New Construction	Nine Light Loggers
27	Greenville Technology, Inc.	GKDS0V66	P-Lighting-Small	One Light Logger
28	DM Tool and Plastics	IGZR4M5A	C-Small	Two Light Loggers
29	Crown Equipment	IN0BS87N	P-Compressed Air	One Power Meter
30	Sidney-Shelby County YMCA	J1S5GZ9T	P-Lighting-Small	Four Light Loggers
31	Barret Paving Materials	KAH97BOS	P-Motors	One Power Meter
32	Landes Fresh Meats	LUBEC7CF	P-Lighting-Small	Two Light Loggers
33	Turner Properties	M5N2JNQ8	P-Lighting-Medium	One Light Logger
34	Peace Evangelical Church	M9E07CY3	P-Lighting-Small	Three Light Loggers
35	Greenville Technology, Inc.	MGC5VF47	P-Lighting-Medium	Four Light Loggers
36	Salem Church of God	MZ64SGEN	C-Small	Three Light Loggers
37	Heapy Engineering	NKZY3I3A	P-HVAC	One Power Meter
38	Advanced Composites	NZMXR18B	C-New Construction	Two Light Loggers
39	Reynolds and Reynolds	OKXZUUKV	P-Lighting-Large	Eight Light Loggers
40	Perrigo	PM5QIWZZ	P-Compressed Air	One Power Meter
41	Clopay Building Products	Q952Y6BU	P-HVAC	Two Power Meters
42	Clinton Hills Equities Group	QN4OGZ42	P-Lighting-Large	Six Light Loggers
43	idX Dayton	R572MQIP	C-New Construction	Two Light Loggers
44	Ohio Department of Transportation District 7	RZZD6B0C	P-Motors	One Power Meter
45	Pro Line Fishing	TO2VD8Z7	P-Compressed Air	One Power Meter
46	Dayton Progress	UTOW2NXB	P-Lighting-Large	Six Light Loggers
47	Montgomery County Facilities Management	V0PLOO81	P-Motors	Two Power Meters

#	Site Name	Confirmation #	Strata	Loggers Installed
48	Honda East Liberty	V0PYX1R3	P-Lighting-Medium	Four Light Loggers
49	Ohio Water Plant	VIB2R5S1	P-Motors	One Power Meter
50	Cedarville University	VUPCL2HX	P-Motors	Two Power Meters
51	Miamisburg Moose Club	X5EWQQC3	P-HVAC	One Power Meter (Temperature Sensors only)
52	Twist, Inc.	XE5MB587	C-Small	Two Light Loggers
53	Stolle Machinery	XWBWXVYH	C-Medium	One Power Meter
54	Mike Sells Potato Company	Y3HR7X6M	P-HVAC	One Power Meter
55	PVS Plastic Corp	YJ42S07D	P-Lighting-Small	One Light Logger
56	Castilian and Company, Inc.	ZD99Y3K0	P-Lighting-Small	Three Light Loggers
57	Norwood Tool Company	ZEBA0EVB	P-HVAC	Two Power Meters
58	ISS America	ZSIF2JY9	P-Compressed Air	One Power Meter
Total				**109 Light Loggers, 35 Power Meters**

Appendix H. Nonresidential Site Visit Summary

Cadmus is currently evaluating Dayton Power & Light's (DP&L) 2017 Commercial & Industrial (C&I) rebate program. DP&L's C&I energy efficiency portfolio consists of: lighting, motors, air compressors, HVAC, and custom project categories. Cadmus conducted a first round of site visits in June 2017. A sample of 107 projects were selected from a list of 2017 program participants. In addition to the rebate program evaluation, Cadmus is responsible for calculating peak demand savings as part of the PJM analysis, so the sample was filtered for only PJM applicable projects. Each stratum was further classified as lighting (large, medium, and small), HVAC, motors, air compressor and custom.

Table 125. Site Visit Summary

Site Visits	Time Period	Sites Qty
Round 1	June 2017	107

This memo provides a summary of observations and findings for the sites Cadmus visited. For each site, we provide reported and verified quantities, comments regarding discrepancies, and measure operation observations. Cadmus conducted 107 site visits and metered 57 rebated projects. Table 126 shows the list of projects Cadmus engineers verified during round 1 site visits for FY 2017 program evaluation.

Table 126. June 2017 Round 1 Nonresidential FY17 Site Visit Summary

#	Site Name	Verified Sampled Project #	Strata
1	Hood Packaging	000IFK1B	P-Lighting-Medium
2	Dayton Metro Libraries Kettering/Moraine Branch	0HANK5JX	C-New Construction
3	Electro Controls	13ZG22W0	C-New Construction
4	Timken Steel	1DWUY072	P-Compressed Air
5	White Allen Chevrolet	1P6LLYOW	C-Medium
6	Rookwood Properties	28FQBDQO	P-Lighting-Medium
7	CPH Service LLC (McDonalds)	2GVRCUPC	C-New Construction
8	Creative World of Child Care	2MPFEGDT	C-New Construction
9	Timken Steel	3LS6RZXN	C-Medium
10	Keller Grain and Feed	3QEJVWXW	P-Compressed Air
11	Oerlikon	3QM145UI	P-Compressed Air
12	Aabel Exterminating	484MXIIO	P-Lighting-Small
13	Kettering HN Eaton	4GXUFGKF	P-Lighting-Medium
14	Lexus	4QFEBLBV	C-Medium
15	Dollar Tree Stores	4W3O9TC6	C-New Construction
16	YMCA of Dayton Preble County Branch	5INP5SGF	P-Lighting-Medium
17	Greeneview Schools	6Y64ZXD4	P-HVAC
18	Mahle Behr	7H4880OB	P-Lighting-Medium
19	Speedway	7SJKL4VA	P-HVAC
20	Outfront Media, LLC	8DMU5XHJ	P-Lighting-Large
21	City of Sidney, Wastewater Treatment Plant	8OKS9TQP	P-Motors

#	Site Name	Verified Sampled Project #	Strata
22	Stolle Machinery	8PO7GDH3	P-Compressed Air
23	Honda East Liberty Plant	8V0H74IW	C-Small
24	Mahle Behr	9OLUUQMS	P-Lighting-Small
25	Thomas Winemiller Assoc.	AKD6199S	P-HVAC
26	City of Troy	AO3T8EZ1	P-Lighting-Medium
27	Heapy Engineering	ARQ3N71E	P-HVAC
28	Mahle Behr	AT5WJ5T4	P-Motors
29	Beavercreek Golf Course	BA2QALKG	P-HVAC
30	Hull Brothers	C2H6ZTQB	C-Small
31	Wreck-A-Mended	C6R0TWZY	C-Small
32	OSI-Carrabba's	CSYS8HTV	P-HVAC
33	Sugarcreek	CVL7VBEU	P-Compressed Air
34	Classic Carriers	CWPZNIIM	C-New Construction
35	International Paper	DU7SCTTD	P-Lighting-Small
36	Tom Smith Industries	DWPWMUAE	P-Lighting-Medium
37	Arch Polymers Inc.	EL28OSYB	P-Motors
38	Venture Manufacturing Co	ERA5HMGM	P-Compressed Air
39	TravelCenters of America	EZ2OOEDZ	P-HVAC
40	City of Greenville, Greenville water plant	F3L4WIDN	P-Motors
41	Beach Manufacturing	F6NITK4C	P-Compressed Air
42	Erwin Insurance Agency	G4HLGWDE	P-HVAC
43	Clopay building products	GJMTKSEY	C-New Construction
44	Greenville Technology, Inc.	GKDS0V66	P-Lighting-Small
45	Hohman Plating	GVW0G078	P-Lighting-Large
46	White Allen P A S	I1ZUL8HE	C-Medium
47	DM Tool and Plastics	IGZR4M5A	C-Small
48	Crown Equipment	IN0BS87N	P-Compressed Air
49	Clopay Building Products	IYN30C88	C-New Construction
50	Sidney-Shelby County YMCA	J1S5GZ9T	P-Lighting-Small
51	Mad River Local Schools	JKH8WXB7	P-Lighting-Small
52	Barret Paving Materials	KAH97BOS	P-Motors
53	Landrum Oil	L1H79GIQ	P-Lighting-Small
54	Landes Fresh Meats	LUBEC7CF	P-Lighting-Small
55	Sacred Heart Catholic Church	LZ2N0H27	C-Small
56	Turner Properties	M5N2JNQ8	P-Lighting-Medium
57	Peace Evangelical Church	M9E07CY3	P-Lighting-Small
58	Plastipak	MAMPN4T5	P-Motors
59	Greenville Technology, Inc.	MGC5VF47	P-Lighting-Medium
60	Prairie Farms Dairy	MP0D285W	P-HVAC
61	Salem Church of God	MZ64SGEN	C-Small
62	R&R Takhar Operation	N93TAPC2	P-Lighting-Small

#	Site Name	Verified Sampled Project #	Strata
63	Clopay Building Products	NJ50KK1O	C-New Construction
64	Heapy Engineering	NKZY3I3A	P-HVAC
65	Norwood Tool Company	NNA0ALJY	P-Lighting-Small
66	Mahle Behr	NRN1ED40	P-Lighting-Medium
67	City Of Greenville Ohio	NZ2PJPBJ	P-Lighting-Small
68	Advanced Composites	NZMXR18B	C-New Construction
69	Reynolds and Reynolds	OKXZUUKV	P-Lighting-Large
70	Plastipak	PG5REW7U	C-Small
71	Perrigo	PM5QIWZZ	P-Compressed Air
72	Clopay Building Products	Q952Y6BU	P-HVAC
73	Clinton Hills Equities Group	QN4OGZ42	P-Lighting-Large
74	Plastipak	QRYHWACG	P-Motors
75	DAYTON OFFICE PROPERTIES	R1W48A7O	P-Lighting-Small
76	idX Dayton	R572MQIP	C-New Construction
77	Clinton County Courthouse	R5O232M9	P-HVAC
78	Ohio Department of Transportation District 7	RZZD6B0C	P-Motors
79	Bon Builders	S7O50HMH	P-HVAC
80	Vic Green realty	SCPSOAK9	P-Lighting-Small
81	AGC Automotive	SQ01K7WO	C-Medium
82	White Allen Chevrolet	SYRKSRRF	C-Medium
83	Pro Line Fishing	TO2VD8Z7	P-Compressed Air
84	Lefeld Welding & Steel Supplies Inc.	U5K8HC95	P-Lighting-Small
85	Dayton Progress	UTOW2NXB	P-Lighting-Large
86	Montgomery County Facilities Management	V0PLOO81	P-Motors
87	Honda East Liberty	V0PYX1R3	P-Lighting-Medium
88	Plastipak	VEFQ20K0	P-Motors
89	Ohio Water Plant	VIB2R5S1	P-Motors
90	Berkway Properties	VTYGE4DU	C-Small
91	Cedarville University	VUPCL2HX	P-Motors
92	Hobart Institute of Welding	WTP06EU3	P-Compressed Air
93	Miamisburg Moose Club	X5EWQQC3	P-HVAC
94	Twist, Inc.	XE5MB587	C-Small
95	Plastipak	XSMQZRY2	C-Medium
96	Christ United Methodist Church	XUVRK6NT	P-Lighting-Small
97	Stolle Machinery	XWBWXVYH	C-Medium
98	Wayne Hospital	Y1SF1HXI	C-New Construction
99	Plastipak	Y237IBKM	P-Motors
100	Mike Sells Potato Company	Y3HR7X6M	P-HVAC
101	Dollar General 13203	Y9HDA6XG	P-Lighting-Small
102	New Paris Car Wash	YDML5LRS	C-Small
103	PVS Plastic Corp	YJ42S07D	P-Lighting-Small

#	Site Name	Verified Sampled Project #	Strata
104	Castilian and Company, Inc.	ZD99Y3K0	P-Lighting-Small
105	Norwood Tool Company	ZEBA0EVB	P-HVAC
106	Mancor	ZQYRWNG5	P-Compressed Air
107	ISS America	ZSIF2JY9	P-Compressed Air

Site Specific Findings

Table 127. Hood Packaging (Project Number: 000IFK1B)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	Linear LED re-lamping (linear feet)	9,692	9,692	0

Notes: This is a facility that manufactures paper, plastic, and poly-woven products. The project involved the installation of 9,650 linear feet of LED replacement lamps for fluorescent lamps. The evaluation team confirmed these installations and did not identify any old fluorescents installed—the entire facility has been switched over to LED. The installed LED lamps were 18-watt lamps. The team installed six light loggers to record lighting fixture operating hours for two months: two in office spaces, two in low-bay fixtures on the manufacturing floor, and two in high-bay fixtures on the manufacturing floor.

Table 128. Dayton Metro Libraries Kettering Moraine Branch (Project Number: 0HANK5JX)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Active Storage	1,557 Sq Ft 742 W	1,625 Sq Ft 790 W	69 Sq Ft 48 W
C-New Construction	Conference/Meeting/Multipurpose	1,914 Sq Ft 1,741 W	1,880 Sq Ft 1741 W	-34 Sq Ft 0 W
C-New Construction	Corridor/Transition	403 Sq Ft 168 W	325 Sq Ft 120 W	-78 Sq Ft -48 W
C-New Construction	Electrical/Mechanical	937 Sq Ft 480 W	860 Sq Ft 480 W	-77 Sq Ft 0 W
C-New Construction	Library – Stacks	8,455 Sq Ft 6,621 W	8,390 Sq Ft 6613 W	-64 Sq Ft -8 W
C-New Construction	Lounge/Recreation	211 Sq Ft 194 W	205 Sq Ft 194 W	-6 Sq Ft 0 W
C-New Construction	Office – Enclosed	136 Sq Ft 164 W	140 Sq Ft 164 W	4 Sq Ft 0 W
C-New Construction	Office – Open Plan	1,088 Sq Ft 574 W	950 Sq Ft 574 W	-138 Sq Ft 0 W
C-New Construction	Restrooms	410 Sq Ft 388 W	455 Sq Ft 388 W	45 Sq Ft 0 W
C-New Construction	Building Facades - Each Illuminated wall or surface length	293 Ft 530 W	340 Ft 530 W	192 Ft 0 W
C-New Construction	Uncovered Parking Areas - Parking Lots and Drives	21,333 Sq Ft 810 W	26,500 Sq Ft 810 W	3,167 Sq Ft 0 W
C-New Construction	Canopies and Overhangs	175 Sq Ft	290 Sq Ft	125 Sq Ft

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
		120 W	120 W	0 W

Notes: This project is the major renovation of a library with a new lighting design characterized by LED fixtures and lower lighting power density than required by code. The scope includes interior and exterior lighting. Cadmus observed fixture types and counts throughout the building and measured space areas using the lighting plans. In the interior, fixture counts and space areas differed slightly from the project documentation in a few instances. On the exterior, fixture counts were consistent with project documentation, but Cadmus found the parking lot area, as measured on the exterior lighting plan, was significantly different from the reported value. Cadmus installed six light loggers in interior spaces at this site.

Table 129. Electro Controls (Project Number: 13ZG22W0)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Manufacturing - High Bay (>=25 ft Floor to Ceiling Height)	8,740 Sq Ft 2,700 W	9,150 Sq Ft 2,790 W	410 Sq Ft 90 W
C-New Construction	Active Storage	6,069 Sq Ft 1,800 W	6,100 Sq Ft 1,860 W	31 Sq Ft 60 W
C-New Construction	Restrooms	338 Sq Ft 136 W	300 Sq Ft 136 W	-38 Sq Ft 0 W

Notes: This project is a new addition to a manufacturing facility with a lower lighting power density than required by code. The new addition is divided into two main spaces plus a small restroom. The larger of the two main spaces was classified in the project documentation as Manufacturing—High Bay (≥25ft Floor to Ceiling Height). However, Cadmus observed while on site that this space is named "Shipping and Receiving" and appeared to be used as storage, and therefore the manufacturing space type does not seem appropriate; "Warehouse—Medium/Bulky Material Storage" would be a better classification. Revising the space type designation will not change the savings calculations as light loggers were installed and will be used to determine coincident factor and hours of use. Cadmus observed LED high-bay fixtures in the main spaces. The documented lighting power calculations use 180 watts/fixture for this fixture type, but, according to the product literature for the model number Cadmus observed, this fixture is rated at 186-watts. Cadmus observed 2'x4' LED troffers in the restrooms, consistent with project documentation. Cadmus measured the space areas while on site, and found them to be similar but slightly different to the documented values. Cadmus installed three light loggers at this site.

Table 130. Timken Steel (Project Number: 1DWUY072)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	No-loss condensate drains	2	2	0

Notes: This facility is a manufacturing plant for automotive transmissions. The facility operates 24/7, five to seven days a week, with reduced operating hours in the summer. The project involved the installation of two no-loss condensate drains on the air dryers for the compressed air system. The two Bekomat 33

drains were confirmed and in operation. These dryers service the main compressed air loop for the whole plant, which is maintained at a pressure setpoint of 95 psi.

Table 131. White Alan Chevrolet (Project Numbers: 1P6LLYOW)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	0-watt LED parking lot flood lights	23	23	0
	0-watt LED wall sconce	5	5	0

Notes: This project involved installing 320-watt and 110-watt LED exterior lights. No photocells were visible, but the project files reported photocells were installed as part of the project. Two of the 110-watt exterior wall sconce fixtures were on during the site visit, indicating a potential control problem. All other exterior fixtures were off. It is also possible that some of these were installed at other sites. The evaluation team visited four White Alan dealerships.

Table 132. Rookwood Properties (Project Number: 28FQBDQO)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	(17,600) rated watts of high bay HID delamping	17,600	17,600	0
	(640) linear feet of T12 delamping	640	640	0
	Install (88) 79-watt high bay LEDs with integral occupancy sensors	88	88	0
	Install (16) 138-watt high bay LEDs	16	16	0

Notes: This site is a medium-size warehouse being leased out to multiple tenants. The project involved the installation of 138-watt high-bay LED fixtures in the loading area and 79-watt high-bay LED fixtures with fixture-mounted occupancy sensors in the storage area. The evaluation team confirmed the quantity and models of occupancy sensors and both LED fixture types. The loading dock is open and used by all tenants, while the storage area is divided for each tenant by chain link fences. There are currently three tenants: a furniture supply company, a printing company, and a third company which appears to have vacated its space. There are 30 79-watt LED fixtures in this area, which may be used infrequently. The fixtures in the loading area are manually controlled, and the site contact claimed they are left on 24/7. All LED fixtures in the storage area have a fixture-mounted occupancy sensor and were assumed to operate 2,080 hours per year. The evaluation team installed four light loggers across the storage area to confirm the hours of operation. No loggers were installed in the loading area as fixtures were above an active loading dock.

Table 133. McDonalds (Project Number: 2GVRCUPC)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Warehouse - Medium/Bulky Material Storage	5,003 Sq Ft 2,923 W	4,600 Sq Ft 2,952 W	-403 Sq Ft 29 W

Notes: This new construction project installed a lighting system with a lower lighting power density than required by code for a fast food restaurant. The lighting power savings calculations for this project use

the “Building Area” method rather than the “Space-by-Space” method. Cadmus verified the floor area by measuring the lighting plan, and found the correct area to be less than the documented value. The original documented area includes the walk-in freezer/refrigerator, which was not included in the lighting scope. Cadmus observed fixture counts differed slightly from the lighting plan. Cadmus could not verify make/model numbers by observation, but observed that the LED fixtures matched the general fixture descriptions documented in the product submittals. However, Cadmus found the pendant fixtures observed to contain CFL lamps, not LEDs. Cadmus observed occupancy sensors throughout the facility, except in the main kitchen area. Cadmus installed three light loggers at this facility.

Table 134. Creative World of Child Care (Project Number: 2MPFEGDT)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Classroom/Lecture/Training	5,477 Sq Ft 2,610 W	5,477 Sq Ft 2,610 W	0 Sq Ft 0 W
C-New Construction	Conference/Meeting/Multi-Purpose	3,285 Sq Ft 2,183 W	3,285 Sq Ft 2,183 W	0 Sq Ft 0 W
C-New Construction	Lounge/Recreation	256 Sq Ft 46 W	256 Sq Ft 46 W	0 Sq Ft 0 W
C-New Construction	Lobby	339 Sq Ft 84 W	339 Sq Ft 84 W	0 Sq Ft 0 W
C-New Construction	Corridor/Transition	1,767 Sq Ft 796 W	1,767 Sq Ft 796 W	0 Sq Ft 0 W
C-New Construction	Office - Enclosed	118 Sq Ft 23 W	118 Sq Ft 23 W	0 Sq Ft 0 W
C-New Construction	Restrooms	502 Sq Ft 226 W	502 Sq Ft 226 W	0 Sq Ft 0 W
C-New Construction	Food Preparation	346 Sq Ft 288 W	346 Sq Ft 288 W	0 Sq Ft 0 W
C-New Construction	Gym/Exercise Center-Play Area	1,502 Sq Ft 1,140 W	1,502 Sq Ft 1,140 W	0 Sq Ft 0 W
C-New Construction	Library - Reading Area	739 Sq Ft 407 W	739 Sq Ft 407 W	0 Sq Ft 0 W
C-New Construction	Stairs - Active	101 Sq Ft 46 W	101 Sq Ft 46 W	0 Sq Ft 0 W
C-New Construction	Active Storage	1,746 Sq Ft 289 W	1,746 Sq Ft 289 W	0 Sq Ft 0 W
C-New Construction	Electrical/Mechanical	178 Sq Ft 119 W	178 Sq Ft 119 W	0 Sq Ft 0 W
C-New Construction	Canopies and Overhangs - Canopies	399 Sq Ft 29 W	399 Sq Ft 29 W	0 Sq Ft 0 W
C-New Construction	Building Facades	159 Ft 120 W	159 Ft 120 W	0 Sq Ft 0 W
C-New Construction	Building Grounds - Walkways <10 ft wide	338 Ft 50 W	338 Ft 50 W	0 Sq Ft 0 W
C-New Construction	Uncovered Parking Areas - Parking Lots and Drives	49,357 Sq Ft 636 W	49,357 Sq Ft 636 W	0 Sq Ft 0 W

Notes: This project is new construction of a child care facility with a lower lighting power density than required by code. The scope includes interior and exterior lighting. Cadmus counted fixtures and measured floor areas in a sample of the building spaces, and all findings were consistent with the project documentation. The site contact reported that interior lights were controlled by manual switches, and exterior lights were controlled by a timer. No ladder was available, so the fixtures were not accessible. Therefore, Cadmus was not able to verify fixture model numbers, but all observed fixture types were consistent with those described in the project documentation. Cadmus was not able to install any light loggers at this site.

Table 135. Timken Steel (Project Number: 3LS6RZXN)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	Compressor #2, model EBH99F (50 hp)	1	1	0
C-Medium	Compressor #3, model EBH99H (50 hp)	1	1	0
C-Medium	Compressor #4, model EBH999G09 (50 hp)	1	1	0
C-Medium	Compressor #6, model EBP99K (100 hp)	1	1	0
C-Medium	Compressor #7, model EBH99K (100 hp)	1	1	0

Notes: This facility is a manufacturing plant for automotive transmissions. The facility operates 24/7, five to seven days a week, with reduced operating hours in the summer. The project involved replacing two 50-hp air compressors with two 100-hp air compressors, removing a small reciprocating air compressor, and installing a sequencer to efficiently turn compressors on and off as compressed air demand fluctuates. The models of the installed air compressors were verified. The plant line pressure setpoint was observed to 95 psi, according to a screenshot of data for the past week. The air compressor discharge air pressures were 115 psig.

Table 136. Keller Grain & Feed (Project Number: 3QEJVWXW)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Air Compressor – 10 HP	1	1	0

Notes: This project involved the installation of a 10-hp air compressor for machinery used in various grain processes. Tank pressure was approximately 120 psi, which was combined with the compressor as a package. Compressor also served a space which was rented out; so the facilities manager was not entirely sure about the hours of operation. The primary facility operates 10 hours/day, 5 days/week. Power metering equipment was installed upstream of the compressor to determine power consumption during the peak summer period. The dryer was internal to the unit.

Table 137. Oerlikon (Project Number: 3QM145UI)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	No-loss drain	2	2	0

Notes: This project involved the installation of two no-loss drains on two separate air dryers. Cadmus verified the installation of one no-loss drain on an air dryer, matching the project documentation. However, the site contact stated that the other air dryer, where the second no-loss drain was installed, was recently replaced with a new unit that contained a no-loss drain of its own. The second no-loss drain was moved to the existing air compressor #3, and Cadmus verified its installation in the new location.

Table 138. Aabel Exterminating (Project Number: 484MXIIO)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	4-foot LED Lamps	494	488	6
P-Lighting-Small	De-lamping 112 T8 lamps	112	112	0

Notes: This was a re-lamping retrofit project in an office and garage. The removal of 112 T8 lamps was performed in the garage space. The new LED lamps re-used the existing fixtures. Cadmus verified 488 lamps. The discrepancy comes from a miscalculation in the number of lamps per fixture in some of the office areas.

Table 139. Kettering Health Network, Preble County (Project Number: 4GXUFGKF)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	36-watt LEDs	143	142	-1
P-Lighting-Medium	72-watt LEDs	185	181	-4

Notes: This is a medical services facility with several wings and with many doctors' offices, waiting rooms, and exam rooms. The project involved the installation of 143 36-watt, two-lamp linear LED fixtures and 185 72-watt, three-lamp linear LED fixtures. Cadmus identified all rebated fixtures and observed four bulbs were burned out and one had failed. The failed bulb had been replaced with a T8 fluorescent lamp. The evaluation team installed four light loggers to record operating hours for two months.

Table 140. Lexus of Dayton (Project Number: 4QFEBLBV)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	320-watt LED parking lot flood lights	32	32	0
C-Medium	110-watt LED wall sconce	6	6	0

Notes: All exterior fixtures were found on site and matched the rebate documentation. No controls were visible, but photocells were reported in the project documentation. The site visit was conducted during daytime hours, and none of the lights were observed to be on.

Table 141. Dollar Tree (Project Number: 4W3O9TC6)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Restrooms	122 Sq Ft 36 W	122 Sq Ft 36 W	0 Sq Ft 0 W
C-New Construction	Office – Enclosed	81 Sq Ft	81 Sq Ft	0 Sq Ft

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
		36 W	Watts not verified	0 W
C-New Construction	Retail – Sales Area	7,885 Sq Ft 4,050 W	7,885 Sq Ft 4,194 W	0 Sq Ft 144 W
C-New Construction	Corridor/Transition	44 Sq Ft 18 W	44 Sq Ft 18 W	0 Sq Ft 0 W
C-New Construction	Active Storage	1,366 Sq Ft 288 W	1,366 Sq Ft Watts not verified	0 Sq Ft 0 W
C-New Construction	Building Facades	410 Sq Ft 480 W	410 Sq Ft 480 W	0 Sq Ft 0 W

Notes: This new construction project involved installing a lighting system with a lower lighting power density than required by code. Cadmus could not obtain permission for a site visit from the parent corporation to enter the office or storage spaces, and therefore was only able to observe the fixtures in the public spaces. Cadmus observed 18-watt LED tube fixtures throughout the facility, which matched project documentation. The fixture counts that Cadmus did observe matched project documentation, except for a higher number of one-lamp fixtures in the retail space than indicated in the documentation. Cadmus measured space areas using the lighting plan and confirmed that they matched the reported values. Cadmus could not install light loggers at this site.

Table 142. YMCA of Dayton Preble County Branch (Project Number: 5INP5SGF)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	Linear LED re-lamping (linear feet)	4,648	4,648	0
P-Lighting-Medium	138 W LEDs	24	24	0
P-Lighting-Medium	9 W LEDs	56	56	0
P-Lighting-Medium	136 W LEDs	24	24	0
P-Lighting-Medium	155 W LEDs	32	32	0
P-Lighting-Medium	41 W LEDs	10	10	0
P-Lighting-Medium	44 W LEDs	14	14	0
P-Lighting-Medium	LED exit signs	7	7	0

Notes: This building consists of a YMCA and a community college. Several lighting measures were reported for this facility. The largest was the installation of 4,648 linear feet of LED replacement lamps for fluorescent lamps. The evaluation team reviewed the entire facility and verified the linear feet matched the reported quantity. No linear fluorescents were observed; all fixtures had been converted to LEDs. The evaluation team installed five light loggers to record fixture operating hours for two months: four in the YMCA building, and one in the community college.

Table 143. Greeneview Schools (Project Number: 6Y64ZXD4)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	9 Variable Refrigerant Flow Systems and 2 Package AC Units	9 VRF 2 AC	9 VRF 3 AC	0 VRF 0 AC

Notes: This measure was the installation of a VRF system and package AC units on a school. The VRF system was broken into four separate loops. The facilities manager was unaware of why the project changed from two to three package units. Set points had been turned up in all the classrooms to 73°F. No metering equipment was installed. The BAS interface had a column for cooling setback, populated with 77°F, but the facilities manager did not remember the schedule or if there was one. The units served approximately 64,000 ft^2 of conditioned space.

Table 144. Mahle Behr (Project Number: 7H4880OB)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	Interior LED fixtures 197-watt high bay	35	35	0

Notes: This facility manufactures and assembles specialty parts for automobiles. The project installed new LED lighting fixtures with onboard occupancy sensors in the manufacturing area. Cadmus verified the installation, counts, and nameplate data of the fixtures. We interviewed the site contact about the hours of operation and controls. The facility operates 24 hours/day, five days/week with occasional partial weekend use. The facility is closed for six holidays/year. Due to inaccessibility, we did not install light loggers.

Table 145. Speedway (Project Number: 7SJKL4VA)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	7.5 Ton RTU	1	1	0

Notes: This facility is a quick-stop gas station and convenience market. The project installed a new 7.5-ton Trane rooftop unit. Control was via a manual thermostat. Cadmus verified the installed equipment, hours of operation, and thermostat setpoints. The store operates 8,760 hours per year. The cooling setpoint was fixed at 60°F at the time of our visit, and the store operators said the heating setpoint is 70°F in the winter. The condenser coil was very dirty upon arrival. This was pointed out to the site contact, who cleaned the coil immediately. We installed a power meter and temperature logger on the rooftop unit to gather data about its operation.

Table 146. Outfront Media, LLC (Project Number: 8DMU5XHJ)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Large	LED street lights replacing HPS and MV	114	117	-3

Table 147. Location Breakdown

No.	Address	City	Reported Quantity	Verified Quantity	Difference
1	4015 Expermnt-Frm Rd	Troy	6	6	0
2	1900 Eldean Rd	Troy	2	6+	-4
3	1575 Expermnt-Frm Rd	Troy	6	6	0
4	844 Brookwood Dr	Troy	6	6	0
5	1001 Monroe-Cncrd Rd	Troy	2	3*+	-1
6	3401 Peters Rd	Troy	2	6	-4
7	3401 Peters Rd	Troy	10	4+	+6
8	9494 Dog-Leg Rd Unit A	Dayton	8	8	0
9	9494 Dog-Leg Rd Unit B	Dayton	4	4	0
10	9105 Peters Pke	Vandalia	-	8	n/a
11	3910 Mulberry Rd	Dayton	8	8	0
12	5136 Salem Ave	Dayton	8	8	0
13	4401 Salem Ave	Dayton	6	6	0
14	4175 Salem Ave	Dayton	8	8	0
15	Salem Ave & Wolf Rd	Dayton	4	4	0
16	1601 Needmore Rd	Dayton	8	8	0**
17	3175 Needmore Rd	Dayton	6	6	0
18	3701 Needmore Rd	Dayton	8	8	0
19	409 Woodman Drive	Dayton	4	4*	0
20	720 Hillrose Ave	Dayton	8	8	0

*Different fixtures than the rest of signs
**One side of sign was blank, so savings may be only half if unused side is not lit
+Count differs from audit report

Notes: This project involved the installation of 108-watt LED lights on billboards around Dayton and surrounding areas. All but two signs observed had identical lights, which appeared to match project documentation. The count on one of these two differed from the audit report, indicating that the fixtures were likely altered recently. Cadmus could not identify how the lights were controlled. Photocells were not visible from the vantage points available, indicating the cells were either not visible from the ground, or the lights were controlled by timers. There were three discrepancies between the audited and verified quantities, indicated with a (+) in

Table 147. There were three additional fixtures found in the audit report when compared to verified totals, after omitting fixtures which did not match.

Table 148. City of Sidney (Project Number: 8OKS9TQP)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Variable Frequency Drive for Pump	1	1	0

Notes: This project involved the replacement of an older VFD on a 15-hp, 86.5% efficient pump motor. Meters were installed in cabinet labeled "New Clean Water Pump." The facility had been shut down for construction, and the pump is planned to be moved. The facility manager claimed that he would make sure to run it for at least a week, so we could get data, but, for most of the metering period, we should expect to see no energy use. Once construction occurs, the equipment will be moved and set aside if Cadmus has not yet conducted removals. When in operation, the pump works most of the time, generally at 60 Hz. The VFD is primarily a control measure, and is used identically to the one that existed previously.

Table 149. Stolle Machinery (Project Number: 8PO7GDH3)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Installing (2) no loss condensate drains	2	2	0

Notes: This project involved the installation of two no-loss condensate drains, serving the compressed air for a specialty machinery manufacturer. Though the project documentation for this project only included two no loss drains, Cadmus found three units installed. One was installed at the base of the receiver, one directly on the older backup compressor, and one on the air filter at the discharge of the new unit. Since the older unit was only used as a backup, savings resulting from the no loss drain installed on it will be minimal. Thus, in evaluating the energy savings resulting from this project, two drains were appropriate. The new 177-hp air compressors was set to maintain a 105-psig discharge pressure and to shut off completely if the pressure reaches 115 psig. The air receiver was approximately 12' tall with a diameter of 4 feet.

Table 150. Honda East Liberty Plant—SEMI (Project Number: 8V0H74IW)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	Installing VFDs on 2 Process Fans	2	2	0

Notes: This facility is large automotive assembly plant. Cadmus observed two new VFDs installed on two existing 20-hp fans used in a paint-drying process. Cadmus observed that the VFDs were installed and that fans were set to a fixed 40 Hz, which cycle on and off based on temperature setpoints in the production line. Facility staff stated that this 40 Hz setpoint is constant, year-round. However, the runtimes of the fans vary, based on seasonal outside air temperatures. Though Cadmus intended to install power metering equipment on the fans, Cadmus and the facility staff decided that it was unsafe and impractical to install the equipment. Instead, Cadmus collected trend data of fan speeds and runtimes encompassing typical winter, spring, and summer operations of the system, and verified typical voltage and amperage of the system during stable operations. This multi-seasonal trend data will better inform the energy savings estimations for this project than any short-term power metering due to the seasonal sensitivity of the affected systems.

Table 151. Mahle Behr (Project Number: 9OLUUQMS)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Interior fluorescent T5 fixtures 216-watt high bay	43	43	0

Notes: This facility manufactures and assembles specialty parts for automobiles. The project installed new T5 fluorescent high-bay lighting fixtures with onboard occupancy sensors in the warehouse area. Cadmus verified the installation, counts, and nameplate data of the fixtures. We interviewed the site contact about the hours of operation and controls. The facility operates 24 hours per day, five days per week, with occasional partial weekend use. The facility is closed for six holidays/year. Due to inaccessibility, we did not install light loggers.

Table 152. Thomas Winemiller Associates (Project Number: AKD6199S)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	New 4-ton air source heat pump	1	1	0

Notes: This facility is an office building. The business was closed due to the death of the business owner. Cadmus verified the installation of the heat pump located on the roof from the ground. Due to the business being closed, no nameplate information or thermostat settings could be gathered from the heat pump. No meters were installed.

Table 153. City of Troy (Project Number: AO3T8EZ1)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	LED street lights replacing HPS and MV	92	98	+5

Notes: This project was the replacement of more than 1,200 high-pressure sodium and mercury vapor street lights with LED equivalents in the City of Troy, OH. The new LED fixtures were all either 53-, 90-, or 219-watts, except for a 183-watt LED fixture on a pole not included in the audit report. All installed fixtures were controlled by photocells. There were five LED fixtures found that were not in the audit report, and one LED had been recorded as HPS in the audit report. This change likely happened after the audit report was generated. Otherwise, there were no discrepancies between the audit report and the verified findings.

Table 154. Heapy Engineering (Project Number: ARQ3N71E)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	20 HP Circulating pump VFD	1	1	0

Notes: This facility is an office building that houses an engineering firm. The project installed two VFDs, serving 20 HP pump motors that circulate condenser water. The rebate is for one VFD, since only one motor runs at a time. Cadmus verified the motor and VFD installation and nameplate data. We installed power meters on both pumps since they alternate on a regular basis. The VFDs are controlled via a differential pressure sensor. The facility operates 10 hour per day, five days per week, with 10 holidays.

Table 155. Mahle Behr (Project Number: AT5WJ5T4)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Premium efficiency motors	4	4	0
P-Motors	Variable frequency drives on process cooling pumps	7	7	0

Notes: This facility manufactures and assembles specialty parts for automobiles. The project installed four new premium efficiency motors and seven variable frequency drives on process cooling pumps. Cadmus verified the equipment installation, hours of operation, and method of VFD control. The VFDs are controlled by differential pressure sensors in their respective cooling loops. The facility operates 24 hours per day, five days per week, with occasional partial weekend use. The facility is closed for six holidays per year. Cadmus installed power meters on Pumps 1, 4, and 6 to gather data about their energy use and demand.

Table 156. Beavercreek Golf Club (Project Number: BA2QALKG)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Split 12.5 Ton Unit	1	1	0

Notes: This project involved the installation of a 12.5-ton split AC unit at a golf club clubhouse. The unit serves a dining room that primarily operates during functions and events. It is controlled by a programmable thermostat, which was set to 67 at the time of the visit. The facilities manager estimated less than 40-48 hours/week of use in the summer months. One power meter was installed to evaluate the AC unit performance during the peak period.

Table 157. Hull Brothers (Project Number: C2H6ZTQB)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	218-watt 6-lamp T8 high bay fixtures	8	8	0

Notes: This is a combine/tractor sales and repair business. The site installed high-efficiency T8 high-bay lighting in all three of their shop areas around the same time. We were unable to identify which eight fixtures were specifically supposed to be evaluated, but the customer received rebates for 58 lamps at or around the same time. All rebated lamps were installed into similar spaces. Cadmus installed one light logger into each of the three spaces. Lights in two of the spaces (tractor shop and combine shop) were on manual switches. Lights in the back warehouse were on occupancy sensors. The company plans to install more occupancy sensors in the future.

Table 158. Wreck-A-Mended (Project Number: C6R0TWZY)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	144W 8-foot 4-lamp T8	29	29	0

Notes: This a LED upgrade for interior lighting at an auto-body shop. Cadmus located all 29 fixtures. The fixtures were controlled by four on/off switches. Four light loggers were installed in various spaces to verify HOU.

Table 159. Carrabba's (Project Number: CSYS8HTV)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Package Unit - 11.5 Ton	1	1	0

Notes: This project involved the installation of an 11.5-ton packaged rooftop unit at a Carrabba's restaurant location. Power metering equipment was installed to verify equipment performance during the peak period. The unit runs seven days a week, from 9 AM to 11 AM, Monday through Friday, and 8 AM to 11 PM on Saturdays and Sundays. The programmable thermostat was set to 70°F during occupied hours.

Table 160. SugarCreek (Project Number: CVL7VBEU)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	No-loss drain	2	2	0

Notes: This project is the installation of two electronic no-loss drains. Several no-loss drains were installed at this facility, and the site contact was not sure exactly which ones were included in this confirmation ID. Cadmus observed a total of four no-loss drains at this site, each with the make and model reported in the project documentation. Drains were installed at filters and surge tanks. The facility contains air compressors in two locations—the first side had one 75-hp and one 100-hp compressor; the second side had two 100-hp compressors.

Table 161. Classic Carriers (Project Number: CWPZNIIM)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Warehouse - Medium/Bulky Material Storage	23,550 Sq Ft 7,020 W	23,550 Sq Ft 7,020 W	0 Sq Ft 0 W

Notes: This project is the installation of new LED lighting with a lower lighting power density than required by code in a repurposed and expanded refrigerated storage facility. Cadmus verified the floor areas and space types, and found them to be consistent with the reported values. Cadmus observed LED high-bay fixtures consistent with the project documentation. Cadmus counted a total of 52 fixtures at the facility. Cadmus observed that all fixtures were controlled by fixture-mounted occupancy sensors. Cadmus installed one light logger at this facility.

Table 162. International Paper (Project Number: DU7SCTTD)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	12-watt 4' linear LED lamps	448	448	0

Notes: This facility makes heavy-duty paper bags and other heavy paper products. The facility operates 24 hours per day, five days per week, year-round. The project involved the installation of 448 12-watt, 4-foot linear LED lamps. The evaluation team verified the installed LED lamp quantity and did not observe any fluorescent lamps. The lamp model number was verified to be Philips 12T8/48-5000 IF 10/1. The majority of lamps were installed in high-bay fixtures, and there was no access to a lift at the time of the visit. The team installed one light logger near a high-bay door, under a high-bay fixture, to record operating hours for two months.

Table 163. Tom Smith Industries (Project Number: DWPWMUAE)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	4’ 2-lamp linear LED fixture, 30 W	88	88	0
P-Lighting-Medium	4’ 2-lamp linear LED fixture, 36 W	1	1	0
P-Lighting-Medium	4’ 3-lamp linear LED fixture, 45 W	11	11	0
P-Lighting-Medium	4’ 4-lamp linear LED fixture, 60 W	80	80	0
P-Lighting-Medium	4’ 4-lamp linear LED fixture, 72 W	9	9	0
P-Lighting-Medium	8’ 4-lamp linear LED fixture, 60 W	39	39	0
P-Lighting-Medium	4’ 6-lamp linear LED fixture, 90 W	294	294	0
P-Lighting-Medium	4’ 6-lamp linear LED fixture, 108 W	10	10	0

Notes: This project involved installing LED fixtures at a plastic injection-molding manufacturing facility. The manufacturing floor operates 24/5, year-round, and the offices operate from 8:00 AM to 5:00 PM, Monday through Friday. The evaluation team inspected the facility and no fluorescent fixtures were found; all fixtures had been changed over to LEDs. The installed LED lamps were a mix of Eiko and Keystone models, with wattages of 15-watts and 18-watts per lamp. All fixtures were controlled by manual on/off switches. The team installed six light loggers to record operating hours for two months: three in the office areas, and three on the manufacturing floor. The loggers on the manufacturing floor were installed in low-bay workstation fixtures and not in any of the high-bay fixtures.

Table 164: Arch Polymers Inc. (Project Number: EL28OSYB)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Pigment Feeder Motor #1 (1hp)	1	1	0
P-Motors	Pigment Feeder Motors #2 (1hp)	1	1	0
P-Motors	Extruder Conveyor Motors #1 (2hp)	1	1	0
P-Motors	Extruder Conveyor Motors #2 (2hp)	1	1	0
P-Motors	Sink Float Tank Motors #1 (3hp)	1	1	0
P-Motors	Sink Float Tank Motors #2 (3hp)	1	1	0
P-Motors	Sink Float Tank Motors #3 (3hp)	1	1	0
P-Motors	Screen Feeder Motor (3hp)	1	1	0
P-Motors	Water Ring Motors #1 (3hp)	1	1	0
P-Motors	Water Ring Motors #2 (3hp)	1	1	0
P-Motors	Conveyor Motor (4hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motors #2 (60hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motor #3 (60hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motors #4 (60hp)	1	1	0
P-Motors	Main Extruder Motor #2 (177 hp)	1	1	0
P-Motors	Pigment Feeder Motor #1 (1hp)	1	1	0
P-Motors	Pigment Feeder Motors #2 (1hp)	1	1	0
P-Motors	Extruder Conveyor Motors #1 (2hp)	1	1	0
P-Motors	Extruder Conveyor Motors #2 (2hp)	1	1	0
P-Motors	Sink Float Tank Motors #1 (3hp)	1	1	0
P-Motors	Sink Float Tank Motors #2 (3hp)	1	1	0
P-Motors	Sink Float Tank Motors #3 (3hp)	1	1	0
P-Motors	Screen Feeder Motor (3hp)	1	1	0
P-Motors	Water Ring Motors #1 (3hp)	1	1	0
P-Motors	Water Ring Motors #2 (3hp)	1	1	0
P-Motors	Conveyor Motor (4hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motors #2 (60hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motor #3 (60hp)	1	1	0
P-Motors	2nd, 3rd Stage Extruder Motors #4 (60hp)	1	1	0
P-Motors	Main Extruder Motor #2 (177 hp)	1	1	0

Notes: This site is a plastics recycling plant. All motors listed were located and found to have VFDs installed. All motor speeds were manually controlled by an operator's dial, and speed varied depending on the material being processed. The site contact confirmed that the extruders, water rings, and pigment feeders all run simultaneously with their matched pair (i.e., if Extruder 1 is running, so is Extruder 2).

Table 165. Venture Manufacturing (Project Number: ERA5HMGM)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Install (1) 30-hp variable speed air compressor	1	1	0

Notes: The manufacturing facility produces actuators for various applications. The facility operates one shift Monday through Friday. The project installed one new 30-hp Gardner Denver LRS15-22A variable speed air compressor for the facility's main compressed air loop. The loop pressure is maintained between 94 psi and 115 psi. The compressor serves presses and pneumatic saws on the production floor and is shut down overnight and on weekends. The evaluation team installed a power meter in the compressor disconnect to record demand and operating hours for approximately two months.

Table 166. TravelCenters of America LLC (Project Number: EZ2OOEDZ)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	4 Package AC units	4	4	0

Notes: This project involved the installation of four packaged AC units, with three different capacities on the roof of a highway rest stop. The four units were 5-, 7.5-, 15-, and 15-tons. Metering equipment was installed on all but one of the 15-ton units. The units were all controlled by programmable thermostats, and likely run for a majority of the summer. The site visit was on a cool day and they ran consistently. The evaluation team observed two thermostats, which were programmable and set to 66°F and 68°F, respectively. The third thermostat was locked and inaccessible.

Table 167. City of Greenville (Project Number: F3L4WIDN)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Variable Frequency Drive for Pump	1	1	0

Notes: This project is the installation of a VFD for a new pump at the Greenville water treatment facility. The VFD was observed at 46.24 Hz on the 40-hp pump that it controlled. Power metering equipment was installed in the locker labeled "Intake Pump #3." This is the primary pump of the facility and runs constantly. There is an older, back-up pump available for use and can meet the flow requirements, but it is leaky and due for replacement. The back-up pump will eventually be replaced with another new pump and VFD, at which time the pumps will split duty.

Table 168. 5 Beach Manufacturing (Project Number: F6NITK4C)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Replacing (1) fixed speed air compressor with (1) 50 hp variable speed air compressor	1	1	0

Notes: This facility is a small automotive parts manufacturer. The facility recently installed one 50-hp VFD rotary-screw air compressor in place of an older fixed-speed air compressor. The older fixed-speed air compressor was found to be still connected to the system. However, it was isolated from the discharge header with hand valves, and was stated to only be for backup purposes. The new 50-hp air

compressor was set to maintain a 120-psig discharge pressure and to unload at 127 psig. The compressor completely shuts off if the pressure reaches 135-psig. A power meter was installed on the new VFD compressor at 5-minute intervals.

Table 169. Erwin Insurance Agency (Project Number: G4HLGWDE)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Install (2) 2.5-ton split system AC units	2	2	0

Notes: This site is a small insurance agency that operates Monday through Friday from 8 AM to 5 PM. The project involved installing two new 2.5-ton split system AC units. The installed outdoor compressor/condenser units were 2.5-ton Goodman GSX14030, controlled by programmable thermostats. The occupied temperature setpoint is 75°F, and the unoccupied temperature setpoint is 85°F. The evaluation team could not install power meters on the 2.5-ton compressor/condenser units due to the small size of the electrical disconnects and AC unit control panels. The team did install mixed and supply air temperature sensors in the indoor air handling unit ducts to estimate load and operating hours.

Table 170. Cloplay (Project Number: GJMTKSEY)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Interior LED fixtures 218 watt Zone 1	60	60	0
C-New Construction	Interior LED fixtures 218 watt Zone 3 North Area	64	67	3
C-New Construction	Interior LED fixtures 218 watt Zone 10	8	8	0
C-New Construction	Interior LED fixtures 325 watt Zone 2 Shipping	108	108	0
C-New Construction	Interior LED fixtures 113 watt Zone 2 Shipping	28	28	0
C-New Construction	Interior LED fixtures 54 watt Zone 2 Hallway	7	7	0
C-New Construction	Interior LED fixtures 54 watt Zone 2 Janitor	1	1	0
C-New Construction	Interior LED fixtures 54 watt Zone 2 Break Room	12	12	0
C-New Construction	Interior LED fixtures 54 watt Women's restroom	3	3	0
C-New Construction	Interior LED fixtures 54 watt Men's restroom	3	3	0
C-New Construction	Interior LED fixtures 54 watt Zone 9 Open office	38	38	0
C-New Construction	Interior LED fixtures 54 watt Zone 9 Conference	3	3	0
C-New Construction	Interior LED fixtures 54 watt Zone 9 Mail Room	2	2	0
C-New Construction	Interior LED fixtures 54 watt Zone 9 Private Offices	13	13	0

Notes: This facility manufactures garage doors. The facility is a multi-building campus, with shipping/receiving, manufacturing, warehouse, and office space. The lighting measures for this project were installed as part of new construction/expansion projects performed at the facility. Nine lighting loggers were installed at the site. All lighting was controlled via manual switches.

Table 171. Greenville Technology (Project Number: GKDS0V66)

Measure Type	Project	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	GKDS0V66	97W high bay LEDs	6	6	0

Notes: Two projects were completed at this site around the same time. Similar lighting projects were implemented at this facility with identical products after this project was implemented. Cadmus was unable to verify for certain whether every fixture looked at was from this particular project, but was able to find more than the quantity reported in locations that made sense for the project. Cadmus installed five light loggers in different areas of the plant. The six 97-W fixtures had occupancy sensors on each individual fixture.

Table 172. Hohman Plating (Project Number: GVW0G078)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Large	130W LEDs	140	140	0
P-Lighting-Large	Occupancy Sensors	152	152	0
P-Lighting-Large	50W LED Fixture	41	41	0
P-Lighting-Large	38W 4’ LED Linear Fixture	27	27	0
P-Lighting-Large	79W 8’ LED Linear Fixture	77	77	0
P-Lighting-Large	Delamping 840 Linear Feet of T8 Bulbs	840 ft	840 ft	0
P-Lighting-Large	Relamping 240 Linear Feet of T8 Bulbs	240 ft	240 ft	0
P-Lighting-Large	4’ T8 Fixtures	48	48	0
P-Lighting-Large	65W LED Fixtures	2	2	0
P-Lighting-Large	32W LED Fixtures	17	17	0
P-Lighting-Large	T8 4’ 3 Lamp Fixtures	10	13	0

Notes: This is a relamping project in a metal plating industrial plant. Cadmus could not access the entire facility. Where the facility was accessible, Cadmus observed that the installed fixtures and lamps matched the rebate documentation.

Table 173. White Alan European Auto (Project Number: I1ZUL8HE)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	320-watt LED parking lot flood lights	46	46	0
C-Medium	110-watt LED wall sconce	5	5	0

Notes: Cadmus verified all parking lot LED fixtures and wall sconces at this auto dealership. No fixtures were found to be on during daylight hours. Controls were not visible, but were reported as photocells. The fixture types were identical to the White Alan Chevrolet site.

Table 174. DM Tool and Plastics (Project Number: IGZR4M5A)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	226W 6 lamp T8 high bay fixtures	14	14	0

Notes: This is a secondary building for DM Tool and Plastics. It serves as a mix of warehouse space and an auto shop. The project involved the installation of 14 226-watt, six-lamp, T8 fluorescent fixtures to replace T12 fixtures. The evaluation team observed all of these fixtures. All fixtures were controlled by manual on/off switches. Cadmus installed two light loggers to record fixture operating hours for two months.

Table 175. Crown Equipment (Project Number: IN0BS87N)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	50 HP variable Speed Air Compressor	1	1	0

Notes: This facility manufactures combustion engines for LP gas-fueled forklifts. A new variable speed air compressor was added to act as the primary source of compressed air. An older compressor operated as a lag compressor. Cadmus verified the compressor and discussed the hours of use and operation with the site contact. The facility operates 12 hours/day, five days/week, with nine holidays. Cadmus installed a power meter to gather data about the compressor's operation.

Table 176. Clopay (Project Number: IYN30C88)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Interior LED fixtures 218 watt Zone 4	74	74	0

Notes: This facility manufactures garage doors. The facility is a multi-building campus with shipping/ receiving, manufacturing, warehouse, and office space. The lighting measure for this project was installed as part of new construction/expansion projects performed at the facility. At the time of the site visit, the space was not being used, and the lights were kept off via their manual wall switches. For this reason, we did not install light loggers.

Table 177. Shelby County YMCA (Project Number: J1S5GZ9T)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	10W LED screw-bulb lamps	48	48	0

Notes: This project involved the installation of screw-bulb lamps in a YMCA gym facility. The facility manager stated that he received 48 bulbs and installed them throughout the building in locations where previous bulbs had burned out frequently or were hard to reach. He did not have any documentation of where bulbs had been installed. Cadmus located 38 bulbs during the site visit; one of those was burnt out and had been discarded. The remaining 10 were unaccounted for, and presumed to be in spaces that were inaccessible. All lights were on manual switches, and the lamps matched the wattages specified. Cadmus installed four light loggers in diverse space types throughout the building. HOU are

expected to vary significantly between the bulbs; some were installed in high-usage areas such as locker rooms, others were installed in infrequently used spaces, such as janitorial closets.

Table 178. Mad River Local Schools (Project Number: JKH8WXB7)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Exterior 39W LED	1	1	0

Notes: This project involved the installation of a 39-watt LED to illuminate a flag pole. The flag illumination spotlight was located outside a middle school. No controls were visible, and the site contact believed it was controlled by a photocell.

Table 179. Barrett Paving Materials (Project Number: KAH97BOS)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	(2) VFDs serving motors that run a single exhaust fan at an aggregate, asphalt, and ready-mix concrete materials manufacturing facility.	2	2	0

Notes: This project involved installing two VFDs, serving 150 HP motors at a facility that produces aggregate, asphalt, and ready-mix concrete materials. Each VFD serves a 150 HP motor. Both motors operate together to operate a single exhaust fan pulley. The exhaust fan serves the asphalt production line. Cadmus observed that the motors were controlled manually, based on the production capacity, and were observed to run at 51.9Hz during the site visit. The facility operates from April through Thanksgiving Day, but it does not operate if it is raining. Cadmus installed a power meter on the common feed to the two VFDs since both always operate together.

Table 180. Landrum Oil Inc. (Project Number L1H79GIQ)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	15 Wallpack LED Lights	15	15	0

Notes: This measure is the installation of wallpack LEDs at an unattended car wash. There was no apparent photocell, indicating they were likely controlled by a schedule. The site contact was unavailable to verify the control methodology or give access to maintenance spaces. The light fixtures matched the rebate documentation.

Table 181. Landes Fresh Meats (Project Number: LUBEC7CF)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Interior LED fixtures 50 watt	17	17	0

Notes: This facility is a retail meat and groceries market. The project installed new LED lighting in the retail area, meat counter, and office area. All lighting was controlled via manual switches. Cadmus verified the light fixture counts, but could not access the make/model information as the store was very busy during the site visit. Cadmus installed two light loggers to gather data about the hours of operation of the fixtures.

Table 182. Sacred Heart Catholic Church (Project Number: LZ2N0H27)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	(32) LED fixtures. Model: Sylvania LED 26 PAR 38 HO	32	32	0

Notes: This project involved the replacement of (32) 250W halogen flood bulbs with (32) 26W PAR38 LED bulbs in the sanctuary of a Catholic church. The evaluation team confirmed makes, models, and quantities of the bulbs were consistent with project documentation. The lights were controlled by a Levitron dimming system. Site contact confirmed that the sanctuary lights were used approximately five hours per day during the week and at least 8-10 hours per day on weekends. No light loggers were installed due much ambient light from large windows, which interfered with logger readings and the dimming system, which made it difficult to calibrate the loggers.

Table 183. Turner Properties (Project Number: M5N2JNQ8)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	Exterior - LED or Induction (8,760 operating hours) replacing 175 W or less	136	136	0

Notes: This project is the installation new LED fixtures in a two-level basement parking garage. Old metal halide fixtures were retrofitted with new sockets and LED lamps. Cadmus observed LED lamps consistent with the project documentation. The site contact confirmed that the lights are on 24/7. Cadmus installed one light logger at this site.

Table 184.: Peace Evangelical Church (Project Number: M9E07CY3)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	10W LED screw bulbs	6	6	0
	10.5W LED downlight	1	1	0
	18W LED tubes	50	50	0

Notes: This project involved an LED upgrade at a church. All lights were on manual switches. The project documentation stated “200 linear feet” for the quantity of the LED tubes. These were four-foot fixtures, so this was the equivalent to 50 lamps. Cadmus located 78 lamps during the site visit. The property manager informed me that they had continued to replace their remaining T8 fluorescent lamps with LEDs, and he was not sure which ones had been installed with the initial rebate application. Cadmus installed three light loggers.

Table 185. Plastipak (Project Number: MAMPN4T5)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Variable frequency drives on product elevator	1	1	0

Notes: This facility manufactures plastic containers for food and other products. This project involved the installation of a VFD serving a 20 HP motor on an elevator lift. The project is a replace on failure

type. Cadmus verified the new VFD installation and nameplate data. The motor was inaccessible, so motor nameplate information was not collected. An interview with the site contact confirmed that this VFD replaced a failed VFD. Cadmus took spot power measurements with the elevator under different load scenarios. The operator indicated there were approximately 50 load lifts per day, with the load varying between 330 and 1,000 lbs. The lift distance is 16 vertical feet.

Table 186: Greenville Technology (Project Number: MGC5VF47)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	(10) 97W LEDs	10	10	0
P-Lighting-Medium	(30) 75W LEDs	30	30	0
P-Lighting-Medium	(10) Occupancy controls on 97W LEDs	10	10	0
P-Lighting-Medium	(7) 39W LEDs	7	7	0

Notes: This project involved an LED upgrade. Cadmus verified the incentivized fixtures matched the rebate documentation. Cadmus installed four light loggers in different areas of the plant anticipated to have different HOU. The (10) 97W LED fixtures had occupancy sensors on each individual fixture. All other fixtures were controlled by manual switches.

Table 187. Prairie Farms Dairy Inc. (Project Number: MP0D285W)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Split AC Unit – 3 Ton Unit	1	1	0

Notes: This project is the replacement of a split AC unit on a dairy processing facility. The rebated equipment was identified and matched the associated documentation. A programmable thermostat was observed to control the AC unit with setpoints of 72F during occupied times and 78F in unoccupied times. The facility is occupied 9 hours/day (8 AM—5 PM), M-F. The unit serves the offices of the facility, and runs all summer.

Table 188. Salem Church of God (Project Number: MZ64SGEN)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	40-watt fixtures	34	34	0

Notes: This is a meeting room within a church. The lights have dimmer switch controls as well as controls using smart Wi-Fi controls by the church electrician's phone. Cadmus observed 34 LED fixtures, each using 40 watts. The site contact reported that HOU were inconsistent and dependent on church activity schedules.

Table 189. R&R Takhar Operation (Project Number: N93TAPC2)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Exterior - LED or Induction (operating hours < 8,760) replacing 251W or greater	1	1	0

Notes: This project installed one LED fixture on the exterior of a food sales building. Cadmus observed one LED fixture consistent with the project documentation.

Table 190. Clopay (Project Number: NJ50KK1O)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Exterior LED fixtures PL1	74	74	0
C-New Construction	Exterior LED fixtures PL2	18	18	0
C-New Construction	Exterior LED fixtures WP1	17	17	0
C-New Construction	Exterior LED fixtures WP2	18	18	0
C-New Construction	Exterior LED fixtures FLOOD	16	16	0
C-New Construction	Exterior LED fixtures R	12	12	0

Notes: This facility manufactures garage doors. The facility is a multi-building campus with shipping/ receiving, manufacturing, warehouse, and office space. The lighting measures for this project were installed as part of new construction/expansion projects performed at the facility. All fixtures were found and matched rebate documentation.

Table 191. Heapy Engineering (Project Number: NKZ313A)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Heat Pump Hot Water Heater	1	1	0

Notes: This facility is an office building that houses an engineering firm. The project installed a heat pump water heater to meet the domestic hot water needs of the building. Cadmus verified the water heater installation and nameplate data. We also gathered information about all the points of hot water use in the building. The facility operates 10 hours/day, five days/week with 10 holidays. Cadmus installed a power meter on the hot water heater circuit to gather data about its operation.

Table 192. Norwood Tool Company (Project Number: NNA0ALJY)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Installing (6) 116W LED exterior wallpack fixtures in place of high wattage HID fixtures.	6	6	0
P-Lighting-Small	Installing (2) 124W LED pole mounted fixtures in place of high wattage HID fixtures.	2	2	0

Notes: This project was an upgrade to exterior lighting at a specialty device manufacturer. Cadmus observed that two pole-mounted LED fixtures were installed in a small facility parking lot, and six wallpack LED fixtures were installed on the front and back of a manufacturing building. Facility staff confirmed that fixtures related to this project were controlled using a photocell. Cadmus could not verify fixture wattages during the site visit because the new fixtures did not display any nameplate information. However, Cadmus verified the fixture wattages from the fixture cutsheets, using the model numbers in the project invoices. Based on this, Cadmus found that reported LED fixture wattages were

incorrect. It appears that reported wattages were actually the lumens per watt (LPW) for the fixtures, and not the actual fixture wattages.

Table 193. Mahle Behr (Project Number: NRN1ED40)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	Interior LED fixtures 197W high bay	35	35	0

Notes: This facility manufactures and assembles specialty parts for automobiles. The project installed new LED lighting fixtures with onboard occupancy sensors in the manufacturing area. Cadmus verified the installation, counts, and nameplate data of the fixtures. We interviewed the site contact about the hours of operation and controls. The facility operates 24 hours/day, five days/week, with occasional partial weekend use. The facility is closed for six holidays/year.

Table 194. City of Greenville Public Works (Project Number: NZ2PJPBJ)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	22W LED flood light	2	2	0
P-Lighting-Small	41W LED flood light	1	1	0

Notes: This project involved installation of LED flood lights. Cadmus confirmed all fixtures were controlled by a photocell. The fixtures were installed at a local park, not at the administrative address provided on the application.

Table 195. Advanced Composites (Project Number: NZMXR18B)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Manufacturing—High-Bay (>=25 ft Floor to Ceiling Height)	38,585 Sq Ft 17,100 W	38,585 Sq Ft 17,280 W	0 Sq Ft 180 W
C-New Construction	Warehouse—Medium/Bulky Material Storage	15,708 Sq Ft 6,840 W	15,708 Sq Ft 6,912 W	0 Sq Ft 72 W
C-New Construction	Electrical/Mechanical	144 Sq Ft 78 W	144 Sq Ft 78 W	0 Sq Ft 0 W

Notes: This project was a new addition to a manufacturing facility with lower lighting power density than required by code. Cadmus verified the installation of LED high-bay fixtures as well as two 4-foot, two-lamp, T8 linear fluorescent fixtures in the fire room, all consistent with the project documentation. The documented lighting power calculations used 190 watts/fixture for the high-bay fixtures, but according to the product literature for the model number Cadmus observed, this fixture was rated at 192 watts. Cadmus observed the main space was used for storage rather than manufacturing activities, and therefore the manufacturing space type did not seem appropriate; "Warehouse—Medium/Bulky Material Storage" would be a better classification. Cadmus measured the lighting plan to verify the space areas, and found them consistent with the reported values. Cadmus installed two light loggers at this site.

Table 196. Reynolds and Reynolds (Project Number: OKXZUUKV)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Large	45W LED fixture	4,000	4,000	0
P-Lighting-Large	Linear feet of LED Lighting	24,504	24,504	0

Notes: The site is a large commercial office building. The office is predominantly large open office spaces. Due to the large amount of lighting, Cadmus sampled the spaces with the greatest concentration of lighting and associated energy savings. All sampled areas matched the rebate documentation. Cadmus installed eight light loggers throughout the facility.

Table 197. Plastipak (Project Number: PG5REW7U)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	PLC controller for plastic extruder line 39	1	1	0

Notes: This facility manufactures plastic containers for food and other products. This project involved the installation of PLC controls to the Line 39 plastic extruder heaters to reduce overheating and overcooling of equipment within the plastic product manufacturing facility. A PLC controller had been installed to better control the cooling process. This included utilizing a warmer cooling water temperature and better logic to control when cooling was activated. Cadmus verified the PLC controller installation and gathered data from the chillers serving this line. The chillers were Trane GCAA 80-120 Ton and, based on the interview with the site contact, operated at 1.3kW/ton. The heater elements at the production line were (12) 2.4kW.

Table 198. Perrigo (Project Number: PM5QJWZZ)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Install (1) 100-hp variable speed air compressor	1	1	0

Notes: This site produces specialty powdered baby formula and operates continuously, year-round. The project installed one new 100-hp variable speed Gardner Denver LRS55-75B for the plant's main compressed air system (referred to as the "East" air compressor). The primary loads on the system were control valves for production equipment. The pressure setpoint was controlled to 108 psi, but the airflow demand varied slightly over the course of the day and week. The evaluation team installed a power meter in the compressor's motor control box to record demand and operating hours for approximately two months.

Table 199. Clopay (Project Number: Q952Y6BU)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	21.5 Ton RTU	1	1	0
P-HVAC	50 Ton RTU	3	3	0

Notes: This facility manufactures garage doors. The facility is a multi-building campus with shipping/receiving, manufacturing, warehouse, and office space. This project installed (3) 50 ton RTUs and (1) 21.5 ton RTU as part of a new construction/expansion project. Cadmus verified the new equipment and installed power meters on the 21.5-ton unit and one of the 50 ton units. A temperature logger was installed on the 21.5-ton unit. Cadmus interviewed the site contact to gather operating hours and thermostat setpoints. The facility operates 8,760 hours per year. The cooling setpoint was 70°F and the heating setpoint was 72°F. Setback/setup was only used if there was a dip in production hours, which was not anticipated.

Table 200. Clinton Hills Equities Group (Project Number: QN4OGZ42)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Large	40W exterior parking lot LEDs	65	65	0
P-Lighting-Large	21W LEDs	103	103	0
P-Lighting-Large	Vending machine controllers	15	15	0
P-Lighting-Large	13W LEDs	252	252	0
P-Lighting-Large	Linear LED relamping (# of linear feet)	36,468	36,468	0
P-Lighting-Large	Linear T12 delamping (# of linear feet)	40	40	0
P-Lighting-Large	Linear T8 delamping (# of linear feet)	184	184	0
P-Lighting-Large	18 W LEDs	2	2	0

Notes: This facility is a large, multi-wing, office complex with several tenants. The measures consisted of LED replacements for linear fluorescents and other lamp types, fluorescent delamping, and motion sensors for vending machine lights. Due to the size and private sections of the facility, the evaluation team could not verify all lamp installations. However, no fluorescents were observed—the entire facility had been converted to LED lighting. Lamp model numbers were confirmed—or at least wattages of the lamps. The building manager estimated that approximately 2% of the installed LED lamps had burned out (these were still included in this audit). Most of the lighting fixtures were on timeclock controls from 6:00 AM to 9:30 PM during weekdays, from 8:00 AM to 5:00 PM on Saturdays, and off on Sundays. Emergency and bathroom fixtures were on 24/7. The evaluation team installed six light loggers randomly throughout the facility to record fixture operating hours for two months.

Table 201. Plastipak (Project Number: QRYHWACG)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	VFDs controlling 2HP motors	18	18	0

Notes: This facility manufactures plastic containers for food and other products. Cadmus was shown several 2 HP motors with VFDs, but the operators could not pinpoint the specific VFDs incentivized by this project. Many motor nameplates were inaccessible. The motors we saw were 2 HP and 92% efficiency. The VFDs were manually adjusted to fixed setpoints based on production needs. Operators said they were planning to implement proximity control when possible. The site contact indicated that about 75% of the VFDs replaced existing failed VFDs. and 25% were applied as new installations.

Table 202. Dayton Office Properties (Project Number: R1W48A7O)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Exterior LED fixtures 105W	6	6	0
P-Lighting-Small	Exterior LED fixtures 81W	2	2	0
P-Lighting-Small	Exterior LED fixtures 150W	2	2	0
P-Lighting-Small	Exterior LED fixtures 107W	4	4	0
P-Lighting-Small	Exterior LED fixtures 109W	4	4	0

Notes: This office building houses a credit union, Montgomery County Services, and Marsh & McLennan Agency. The project installed parking lot LED fixtures and two LED flagpole fixtures. Cadmus verified the counts of all fixtures and nameplates of the ground-mounted fixtures. We could not access the nameplate data of the pole-mounted fixtures.

Table 203: idX Dayton (Project Number: R572MQIP)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Warehouse—Medium/Bulky Material Storage	30,300 Sq Ft 10,373 W	30,300 Sq Ft 10,373 W	0 Sq Ft 0 W

Notes: This project installed new LED lighting with a lower lighting power density than required by code in a repurposed high-bay manufacturing facility. Cadmus verified the floor area and space type, and found them consistent with the reported values. Cadmus observed LED high-bay fixtures consistent with the project documentation. Cadmus counted a total of 41 fixtures at the facility. The site contact reported that hours of operation for the facility are 24 hours/day six days/week, and that light fixtures were manually controlled by a switch at the breaker. Cadmus installed two light loggers at this facility.

Table 204. Clinton County Courthouse (Project Number: R5O232M9)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	12-ton Outdoor VRF Heat Recovery Systems (CARRIER PURY-P120TKMU-A)	2	2	0
P-HVAC	8-ton Outdoor VRF Heat Recovery Systems (CARRIER PURY-P96TKMU-A)	2	2	0
P-HVAC	8-ton Outdoor VRF Heat Recovery Systems (CARRIER PURY-HP96TKMU-A-H)	7	7	0
P-HVAC	6-ton Outdoor VRF Heat Recovery Systems (CARRIER PURY-HP72TKMU-A-H)	1	1	0

Notes: This facility is a courthouse. The project involved the installation of 12 outdoor variable refrigerant flow (VRF) systems to provide cooling, heating, and ventilation air to the facility. The quantities, make, and model numbers of all 12 outdoor units were confirmed. The allowable temperature deadband for each office space served by the VRF systems was 70°F to 76°F. The allowable temperature deadband was controlled by the building manager. About ¾ of the units had an unoccupied cooling temperature setback of 78°F from 6:00 PM to 6:00 AM.

Table 205. Ohio Department of Transportation District 7 (Project Number: RZZD6BOC)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	50 hp Variable Frequency Drive	1	1	0

Notes: This project involved installing a 50 hp-rated VFD to control four 10 hp motors on an air-handling unit for an administration building. Cadmus confirmed the VFD and associated fans. The air-handler operated during the building hours, 9:00 AM-5:00 PM. Cadmus installed power metering equipment on the VFD to monitor operation during the peak summer period.

Table 206. Bon Builders (Project Number: S7O50HMH)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Install (1) 7.5-ton packaged AC unit	1	1	0

Notes: The site is a warehouse that operates three to four hours per week. The project installed a new 7.5-ton Trane TWA090D split system heat pump to provide heating and cooling for the warehouse. The unit was controlled by a programmable thermostat. During the site visit, the evaluation team found that the unit was off (the outside air temperature was ~90°F). The team asked the site contact about how the heat pump was operated, and the contact stated that it was used for heating the garage only. They only used the unit for cooling during one or two days in the past summer. They had not used the unit for cooling at all during that week, during which the outside air temperature and humidity had reached ~95°F and 90%, respectively. The evaluation team did not install power meters on this unit due to the low operating hours and the likelihood of recording no data during the two-month period.

Table 207: Vic Green Realty (Project Number: SCPSOAK9)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Installing 100W exterior LED fixtures	8	8	0

Notes: This project involved the installation of 100-watt exterior LED fixtures in an outdoor parking lot. The site contact was not available at the site. More fixtures were found than applied for in the project, but it is possible they installed additional fixtures after the initial rebate project. The control mechanism was not visible, but was reported to be photocells during a phone call with the facility manager.

Table 208. AGC Automotive (Project Number: SQ01K7WO)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	Install new air compressor sequencer for medium pressure line	1	1	0

Notes: This site is an automotive glass manufacturer. Nine air compressors served the medium-pressure loop. The main end-users for the medium pressure loop were production furnaces. The loop pressure was maintained between 128 psi and 130 psi. The compressor sequencer was verified to be installed and operational. The evaluation team did not install power meters at this site due to the number of meters required to accurately capture savings. The site records pressure and flow trend data.

Table 209. White Alan Chevrolet (Project Number: SYRKSRRF)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	320-watt LED parking lot flood lights	32	28	-4
	110-watt LED wall sconce	5	5	0
	42-watt LED wall sconce	5	5	0

Notes: White Alan received incentives for multiple car dealerships this year. This project involved the installation of exterior LEDs at a Chevrolet dealership with another White Alan dealership property across the street. The same fixture types were installed at both sites. No photocells were visible, but the project files reported photocells were installed. All other fixtures were found to be off during daytime hours.

Table 210: Pro Line Finishing (Project Number: TO2VD8Z7)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Air Compressor – 100 HP Variable Speed	1	1	0

Notes: This project was the installation of a large air compressor in a paint finishing industrial facility. The compressor was 100-HP, variable speed, with a 94.1% efficient motor. Trend data were not being recorded at the compressor beyond what the interface had as storage, but data recorded from the interface indicated the unit generally ran about 40%. Based on interview responses, the compressor daily use was very dependent on how many color changes there were in a day, which could vary significantly. Power metering equipment was installed on the air compressor to monitor performance during the summer peak period.

Table 211. Lefeld Welding & Steel Supplies Inc. (Project Number: U5K8HC95)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	129W LED flood lights	4	4	0

Notes: This site replaced exterior parking lot flood lights with LED floor lights. Two different fixture types were used, but both were 129W fixtures. One light (DSXF3) illuminated the flag, the other three (NFFLD-A40) illuminated the parking lot. The photocell was not visible, but site staff confirmed that they were controlled by a photocell on the roof.

Table 212. Dayton Progress (Project Number: UTOW2NXB)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Large	Install (789) 60-watt Eaton Cooper 24GR-LD4-64 LEDs	789	789	0
	(2,144) linear feet of T8 de-lamping	2,144	2,144	0
	Install (57) 57-watt Eaton Cooper 41LED-LD4-7-W LEDs	57	57	0
	Install (15) 33-watt Eaton Cooper 22GR-LD4-32 LEDs	15	15	0
	Install (1) 23-watt Eaton Cooper 22GR-LD4-24 LEDs	1	1	0

	Install (7) 50-watt Eaton Cooper 8TSNLED-LD4-62SL LEDs	7	7	0
	Install (12) 203-watt Eaton Cooper HBLED-LD4-24 LEDs	12	12	0

Notes: This site produces specialized punches, brushes, pins, and other die components. The site is in production 24/7, year-round. The lighting fixtures are turned off during some holidays, but are typically left on for security. The facility is conditioned with gas-fired heating and DX cooling systems. The project involved retrofitting the existing fluorescent lighting systems serving offices, production, storage, and receiving areas with LEDs. The project also involved delamping 2,144 linear feet of fluorescent T8 fixtures. The site planned to install occupancy sensors in the offices, but has not done so yet. The evaluation team verified the quantity and type of installed LED lighting fixtures. The team was able to confirm the model numbers for three of the fixture types using spare fixtures. The team could not confirm the T8 delamping quantity, but the site contact confirmed that they had fewer fixtures now, but had improved illumination. The team installed six light loggers throughout the offices, production floor, storage, and receiving areas to record lighting fixture operating hours for two months.

Table 213. Montgomery County Facilities (Project Number: V0PLOO81)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Installing (2) VFDs on (2) 40-hp AHU fans	2	2	0

Notes: The facility is a high-rise office building. Cadmus observed new VFDs installed on a 40-hp hot deck supply fan and a 40-hp return fan, each in a single AHU. Cadmus verified that the fan speeds modulated and were controlled by the building's EMS, based on conditioning loads of the served space(s). Cadmus verified the size and efficiency of each motor. Two power meters were installed to verify performance during the summer months.

Table 214. Honda East Liberty (Project Number: V0PYX1R3)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Medium	(125) 240W LEDS. Model: CREE CXBAJPH40K8	125	125	0

Notes: Cadmus was not allowed to take photos while on factory floor for proprietary reasons. All 125 fixtures were identified and were confirmed to be controlled by a timeclock. All fixtures were on the same circuit. Four light loggers were installed on site to verify lighting hours of use during the summer peak period.

Table 215. Plastipak (Project Number: VEFQ20K0)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	VFDs controlling 3HP motors	29	29	0

Notes: This facility manufactures plastic containers for food and other products. Cadmus was shown several different 3 HP motors with VFDs, but the operators could not pinpoint the specific VFDs incentivized with this project. Many motor nameplates were inaccessible. The motors we saw were 3 HP

and 92% efficiency. The VFDs were manually adjusted to fixed setpoints, based on production needs. Operators said they were planning to implement proximity controls when possible. The site contact indicated that about 75% of VFDs replaced existing failed VFDs, and 25% were applied as new installations.

Table 216. City of Troy Ohio Water Plant (Project Number: VIB2R5S1)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	100 HP VFD	1	1	0

Notes: This facility treats and provides domestic water to the local community. The project installed a 100-hp VFD on the low service #2 pump. This pump provides water to the lower elevation customer service area. Cadmus verified the VFD installation and nameplate data of the VFD and associated motor. Cadmus interviewed the system operators and acquired trend data about the pump operating hours, flow, and pressure. Trend data indicated that the accumulated run hours year-to-date were 909. The flow rate was between 3-3.7 MGD at pressures between 58-69 PSI. Cadmus installed a power meter on the feed to the VFD to gather data about its energy use.

Table 217. Berkway Properties LLC (Project Number: VTYGE4DU)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	(1)79 watt LED exterior wall pack	1	1	0

Notes: This project involved a 79-watt LED fixture installed on the exterior of an office space for a light manufacturing facility. Cadmus observed one wall pack fixture. The fixture operated from an onboard photocell.

Table 218. Cedarville University (Project Number: VUPCL2HX)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	Variable Frequency Drive – Air Handling Units	2	2	0

Notes: This measure involved the installation of two VFDs on air handling units in a university. The temperature setting was controlled by the BAS, but had not yet been fully implemented. The temperature setting was constant at 72°F for 24 hours a day, seven days a week for cooling and 70°F for heating. The motors for both AHUs were 20 HP. They do not currently make adjustments to setpoints when school is out. Metering equipment was installed in the enclosures labeled “AHU1” and “AHU2.”

Table 219. Hobart Institute of Welding (Project Number: WTP06EU3)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Air Compressor – 10 HP Variable Speed	1	1	0

Notes: This project involved the replacement of an older air compressor with a variable speed air compressor at a welding school. This air compressor served an auxiliary machining area, which operates

10 hours per day, four days per week and just eight hours per day, one day a week. No energy monitoring equipment was installed, due to spatial limitations. Storage pressure targeted 120 psig, and the VFD was observed at 23.5 Hz with relative consistency. The compressor served an area with four machines used by one technician.

Table 220. Miamisburg Moose Club (Project Number: X5EWQQC3)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Install (3) 10-ton packaged AC units	3	3	0
P-HVAC	Install (1) 12.5-ton packaged AC unit	1	1	0

Notes: This site is a fraternal organization club house with a gaming area, kitchen, dining area, bar, and office space. The site is open Tuesday through Sunday from 9:00 AM to 12:00 AM. The project involved the installation of three 10-ton Carrier 48TCED12A rooftop units for the kitchen, offices, and social area, and one 12.5-ton Carrier 48TCED14A rooftop unit for the gaming area. The units were controlled by manual (non-programmable) thermostats, set to 72°F during the site visit. The evaluation team did not install power meters on the rooftop units due to size constraints of the electrical disconnects and a lack of voltage connection in the control panels. The team did install outside air, mixed air, and supply air temperature sensors in the 12.5-ton unit to estimate load and operating hours.

Table 221. Twist (Project Number: XE5MB587)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	(15) 97W LED high bay fixtures. Model: Lithonia IBG15000 LMSEFAFLGNDMVOLTOZ10	15	15	0

Notes: This site is a manufacturer of precision metal products. They normally operate two shifts from 4:00 AM to 6:00 PM, with fluctuations based on work demand. They replaced all lighting fixtures on their production floor, and this custom project involved the installation of (15) 97W LED high-bay fixtures as night lights. The LEDs replaced (30) 500W high-bay fixtures. The lights were controlled manually by one switch, and were turned on when the last shift left, and turned off when the first shift arrived. The evaluation team installed two light loggers to confirm the hours of operation.

Table 222. Plastipak (Project Number: XSMQZRY2)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	225 HP variable Speed Air Compressor	1	1	0

Notes: This facility manufactures plastic containers for food and other products. The project installed a new 225-HP variable speed air compressor to serve plastic injection machines that produce food-grade containers. Cadmus verified the installed compressor and collected nameplate data. The facility operates 8,760 hours/yr. The compressor was operating at 93 PSI at the time of our visit and had accumulated 3,000 run hours from January 2017 through June 5, 2017. The compressor was not connected to a SCADA or other control/data storage system.

Table 223. Christ United Methodist Church (Project Number: XUVRK6NT)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	213W LED parking lot fixture	7	7	0
	264W LED parking lot fixture	1	1	0

Notes: This project involved a LED lighting upgrade to the parking areas serving a church. All lights were found to match the rebate documentation and were observed to operate on photocells.

Table 224. Stolle Machinery (Project Number: XWBWXVYH)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Medium	Replacing (1) 150 hp fixed speed air compressor with (1) 177 hp variable speed air compressor	1	1	0

Notes: This facility is a specialty machinery manufacturer. The facility recently installed one 177-hp VFD rotary screw air compressor in place of an older fixed-speed air compressor. The older fixed-speed air compressor was found to be still connected to the system. However, it was isolated from the discharge header with hand valves, and was stated to only be for backup purposes. The 177-hp air compressors were set to maintain a 105-psig discharge pressure and to shut off completely if the pressure reached 115-psig. The air receiver was approximately 12’ tall with a diameter of 4’. Cadmus installed a power meter on the new VFD compressor.

Table 225. Wayne Hospital (Project Number: Y1SF1HXI)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Restrooms	662 Sq Ft 703 W	662 Sq Ft 703 W	0 Sq Ft 0 W
C-New Construction	Conference/Meeting/Multipurpose	323 Sq Ft 450 W	323 Sq Ft 360 W	0 Sq Ft -90 W
C-New Construction	Corridor/Transition	2449 Sq Ft 1097 W	2449 Sq Ft 1097 W	0 Sq Ft 0 W
C-New Construction	Electrical/Mechanical	50 Sq Ft 40 W	50 Sq Ft 40 W	0 Sq Ft 0 W
C-New Construction	Hospital – Exam/Treatment	132 Sq Ft 180 W	132 Sq Ft 180 W	0 Sq Ft 0 W
C-New Construction	Food Preparation	111 Sq Ft 180 W	111 Sq Ft 180 W	0 Sq Ft 0 W
C-New Construction	Hospital – Laundry/Washing	48 Sq Ft 40 W	48 Sq Ft 40 W	0 Sq Ft 0 W
C-New Construction	Lounge/Recreation – for Hospital	944 Sq Ft 900 W	944 Sq Ft 900 W	0 Sq Ft 0 W
C-New Construction	Hospital – Medical Supply	231 Sq Ft 360 W	231 Sq Ft 360 W	0 Sq Ft 0 W
C-New Construction	Hospital – Nurses Station	252 Sq Ft 412 W	252 Sq Ft 412 W	0 Sq Ft 0 W
C-New Construction	Office - Enclosed	451 Sq Ft 720 W	451 Sq Ft 720 W	0 Sq Ft 0 W

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-New Construction	Hospital – Patient Room	1727 Sq Ft 1322 W	1727 Sq Ft 1322 W	0 Sq Ft 0 W
C-New Construction	Active Storage for Hospital	250 Sq Ft 400 W	250 Sq Ft 400 W	0 Sq Ft 0 W
C-New Construction	Hospital – Physical Therapy	206 Sq Ft 360 W	206 Sq Ft 360 W	0 Sq Ft 0 W

Notes: This project was the renovation of an existing med/surgery floor into a 12-bed behavioral health unit with new LED lighting and a lower lighting power density than required by code. Cadmus observed all fixture types were consistent with those described in the project documentation. Cadmus counted fixtures and measured floor areas in a sample of the building spaces, and all findings were consistent with the project documentation, except for one fewer fixture found in the break room. Documentation indicated that the lights operate 8,760 hours per year. However, the site contact reported that was probably only true in the nurse's station, while the lighting in the rest of the spaces was typically only on from 8:00 AM – 8:00 PM Monday through Friday, and was manually controlled. Cadmus observed occupancy sensors in most spaces other than the nurse's station, corridors, and patient rooms. No light loggers were installed at this site due to restrictions of it being a behavioral health unit.

Table 226. Plastipak (Project Number: Y237IBKM)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Motors	VFDs controlling 1HP motors	6	6	0

Notes: This facility manufactures plastic containers for food and other products. Cadmus verified the VFDs added under this Confirmation ID. All motor nameplates were inaccessible. The VFDs were manually adjusted to a fixed setpoint, based on production needs. Operators said they were planning to implement proximity control when possible. The site contact indicated that about 75% of the VFDs replaced existing failed VFDs. and 25% were applied as new installations.

Table 227. Mike-Sells Potato Chips (Project Number: Y3HR7X6M)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-HVAC	Install (1) 3.5-ton split system AC unit	1	1	0

Notes: This site produces small-batch potato chips and operates Monday through Friday from 8:00 AM to 5:00 PM. The project involved the installation of a new 3.5-ton Lennox TSA042S4N split system AC unit for the site's offices and break room. The unit was controlled by a programmable thermostat, but the thermostat was currently programmed to a constant setpoint of 72°F due to high outdoor air temperatures. The site contact stated that the unit would not be able to meet the occupied setpoint during the day if it was set back overnight. The contact was planning to bring in an HVAC contractor to review the unit for possible undersizing. The evaluation team installed a power meter in the panel serving the outdoor compressor/condenser unit and indoor air handling unit to record total unit demand and operating hours for approximately two months. The team also installed supply and mixed air temperature sensors in the indoor air handling unit ducts to estimate load.

Table 228. Dollar General (Project Number: Y9HDA6XG)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	Exterior - LED replacing 251W or greater	11	10	-1
P-Lighting-Small	Exterior - LED replacing 251W or greater	4	4	0

Notes: This project was the installation of exterior LED fixtures at a retail facility. Cadmus observed four LED flood lights as indicated in the project documentation. Cadmus also observed 10 LED wall packs, while the project documentation indicated 11 fixtures. Cadmus noted one existing wall pack on the south side of the building that contained an HID lamp; so it is possible that this fixture was intended to be replaced by the 11th LED fixture. No model numbers were visible on any of the fixtures. The store manager reported that the exterior lights were controlled automatically, but was unsure if they used a timer or photocell.

Table 229. New Paris Car Wash (Project Number: YDML5LRS)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
C-Small	48 W linear LED fixtures	10	8	-2

Notes: This facility is an unmanned car wash. The project involved the installation of 10 48-watt linear LED fixtures. The evaluation team observed all LED fixtures, two in each wash stall. The control method for the installed LEDs could not be observed.

Table 230. PVS Plastics Tech Corps (Project Number: YJ42S07D)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	127W LED 2x2 panels	21	21	0

Notes: This is a plastics injection molding company. There was a mixture of old 2x4 T8 fixtures and new 2x2 LED panels in the high-bay shop area. All lights were on a manual switch. Cadmus installed one light logger on a wall in the corner of the shop area to determine lighting performance during the summer peak period.

Table 231. Castilian and Company (Project Number: ZD99Y3K0)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Lighting-Small	18W 4' LED tubes (T12 replacement)	70	70	0
	9W LED screw bulbs	25	25	0

Notes: This site is a salon/barber shop. The LED tubes were installed in 2x4' two-lamp ceiling troffers. Cadmus confirmed the quantity of lamps installed matched the rebate documentation. All lights were operated by manual switches. Cadmus installed three light loggers.

Table 232. Norwood Tool Company (Project Number: ZEBA0EVB)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference

P-HVAC	Installing (2) 25-ton packaged A/C units	2	2*	0

*At the time of the site visit, only one unit was connected and operating. The other unit was in the process of being reinstalled.

Notes: This facility is a specialty device manufacturer. As a part of this application, the facility installed two high-efficiency, 25-ton, rooftop packaged AC units to serve a particular manufacturing space in a particular building in a multi-building campus. During the site visit, Cadmus observed that the units had been moved from their original location and installed on a different building on the campus, as the facility's space need had changed since the time of the original installation. Cadmus found that both units were moved to the roof of the new building; with one unit being fully installed and operating, and the other nearly fully installed, but not yet serving the space. Facility staff stated that the non-operational unit should have started operation within the week of the site visit. Cadmus also observed that both units were controlled using programable thermostats. However, both thermostats were unprogrammed and set to maintain a constant setpoint temperature of 72 F. Facility staff stated that the typical working hours of the facility were 7:00 am to 4:00 pm, Monday through Friday; with frequent overtime shifts from 7:00 am to noon on Saturdays. Cadmus installed two power meters on both units.

Table 233. Mancor (Project Number: ZQYRWNG5)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	No-loss drain	2	2	0

Notes: This project was the installation of two pneumatic, no-loss drains on air dryers. Cadmus verified the presence of two no-loss drains with make/model numbers as reported in the rebate documentation.

Table 234. ISS America (Project Number: ZSIF2JY9)

Measure Type	Reported Measure	Reported Quantity	Verified Quantity	Difference
P-Compressed Air	Install (1) 30-hp variable speed air compressor	1	1	0

Notes: This site produces machining parts, press parts, and dowel pins. The site consistently operates one full shift Monday through Friday, but tends to operate additional hours based on product orders. This project involved the installation of a new 30-hp Gardner Denver L23 variable speed air compressor to serve the machining line (grinding and chamfer machines) and QA machines. The compressor was verified to be installed and operational. The pressure setpoint varied between 110 psi and 115 psi; and the compressed air demand varied throughout the day, depending on the product being made. The site did not record trend data on its compressed air system. The evaluation team installed a power meter in the compressor's main disconnect to record demand and operating hours for approximately two months.

Appendix I. *Ex Ante* Measure Level Savings Documentation

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
Residential					
Lighting	LED	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	In addition to using the inputs and algorithms in the 2010 draft Ohio TRM, baselines are based on EISA standards dependent on lumen output. The LED ISR of 0.96 is based on benchmarking LED ISR values from five studies.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	In addition to using the inputs and algorithms in the 2010 draft Ohio TRM, baseline wattages are based on CLEAResult's in-store shelf stocking study. These baseline wattages account for the availability of inefficient incandescent bulbs that are phased out by the EISA law. The LED ISR of 0.96 is based on benchmarking LED ISR values from five studies.
Appliance Recycling	Refrigerator Replacement	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Deemed Per Unit Savings	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Summer Peak Demand Savings
	Freezer Replacement	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Deemed Per Unit Savings	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Summer Peak Demand Savings
	Room Air Conditioner Recycling	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Deemed Per Unit Savings	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 23-25	2010 Ohio draft TRM Summer Peak Demand Savings
	Dehumidifier Recycling	Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030	Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030	Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030	Technical Support Document: Energy Efficiency Program for Consumer Product and Commercial and Industrial Equipment: Residential Dehumidifiers. U.S. Department of Energy. May 2015. Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0027-0030

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	13W CFLs	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. Installation rate and baseline wattage determined using ARP participant survey.	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. Installation rate and baseline wattage determined using ARP participant survey.
	9W LED	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. Baseline wattage determined using ARP participant survey. Installation rate based on energy savings kits participant survey.	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. Installation rate and baseline wattage determined using ARP participant survey.
	Bathroom Faucet Aerators	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. Installation rate determined from ARP participant survey.	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. Installation rate determined from ARP participant survey.
	Kitchen Faucet Aerators	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. Installation rate determined from ARP participant survey.	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. Installation rate determined from ARP participant survey.
	Efficient Showerheads	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 93-96; Potential Study; Cadmus and Opinion Dynamics Showerhead and Faucet	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM.	ARP Participant Survey. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 93-96; Potential Study; Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. Installation rate

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		Aerator Meter Study Memorandum Pages 1-16.	Installation rate determined from ARP participant survey.		determined from ARP participant survey.
Income Eligible Efficiency (OPAE)	Air Sealing	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.
	Attic Insulation				
	Central AC				
	CFLs				
	Faucet Aerator				
	Foundation Wall Insulation				
	Freezer Replacement				
	Heat Pump				
	LEDs				
	Pipe Insulation				
	Refrigerator Replacement				
	Showerhead				
	Smart Strip				
	WH Tank Setback				
	WH Wrap				
	Air Sealing				
	Attic Insulation				
	Central AC				
	CFLs				
	Faucet Aerator				
	Foundation Wall Insulation				
	Freezer Replacement				
	Heat Pump				
	LEDs				
	Pipe Insulation				
	Refrigerator Replacement				
	Showerhead				
	Smart Strip				
	WH Tank Setback				
	WH Wrap				

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
Income Eligible Efficiency (PWC)	Air Sealing	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.	Ex Ante kWh Savings are the same as the verified and adjusted gross savings.
	Attic Insulation				
	Bathroom Faucet Aerator				
	Central AC				
	Floor Insulation				
	Freezer Replacement				
	Heat Pump				
	Kitchen Faucet Aerator				
	Lighting				
	Pipe Insulation				
	Refrigerator Replacement				
	Showerhead				
	Wall Insulation				
	WH Wrap				
HVAC Rebates	ER AC 14/15 SEER	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 78 - 81.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ER AC 16+ SEER	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 78 - 81.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC AC 14/15 SEER	2010 draft Ohio TRM filed August 6, 2010 under Case	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation	2010 draft Ohio TRM filed August 6, 2010 under Case No.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		No. 09-0512-GE-UNC. Pages 30 - 32.	methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	09-0512-GE-UNC. Pages 30 - 32.	methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC AC 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 30 - 32.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 30 - 32.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP AC 14/15 SEER	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 30 - 32.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP AC 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 30 - 32.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 30 - 32.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ER GSHP 16/18 EER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 82 - 85.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ER GSHP 19+ EER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation	2010 draft Ohio TRM filed August 6, 2010 under Case No.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
			methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	09-0512-GE-UNC. Pages 82 - 85.	methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC GSHP 16/18 EER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 82 - 85.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC GSHP 19+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 82 - 85.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP GSHP 16/18 EER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 82 - 85.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP GSHP 19+ EER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 82 - 85.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ER HP 14/15 SEER	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation	2010 draft Ohio TRM filed August 6, 2010 under Case No.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
			methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	09-0512-GE-UNC. Pages 33 - 35.	methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ER HP 16+ SEER	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC HP 14/15 SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC HP 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP HP 14/15 SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 33 - 35.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP HP 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation	2010 draft Ohio TRM filed August 6, 2010 under Case No.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		No. 09-0512-GE-UNC. Pages 33 - 35.	methodology provided on pages 56 - 59 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	09-0512-GE-UNC. Pages 33 - 35.	methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC MS AC 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 67 -69 and engineering calculations based on secondary data.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 59 - 62 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	RP MS HP 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 67 -69 and engineering calculations based on secondary data.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 59 - 62 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC MS HP 14/15 SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 67 -69 and engineering calculations based on secondary data.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 59 - 62 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	NC MS HP 16+ SEER	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 67 -69 and engineering calculations based on secondary data.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 59 - 62 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	HVAC - Programmable	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	Thermostat with AC				
	HVAC - Programmable Thermostat with HP	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
	HVAC – Programmable Thermostat with GSHP	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
	HVAC - Smart Thermostat with AC	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.
	HVAC - Smart Thermostat with HP or GSHP	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.
	ECM with New AC	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ECM	Cadmus post-fixed effects model.	Estimates calculated by Cadmus using a post-fixed effects model. Calculation methodology provided on pages 53 - 56 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.
	ECM with New HP	Engineering calculations based on secondary data.	Estimates calculated by Cadmus using draft Ohio TRM and primary data. Calculation methodology provided on pages 59 - 62 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.	Engineering calculations and secondary data.	Estimates calculated by Cadmus using engineering algorithms and secondary data. Calculation methodology provided on pages 62 - 65 of Cadmus Annual EM&V Report filed May 15, 2013 under Case No. 13-1140-EL-POR.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
Be E3 Smart	Heat Pump Water Heater - Gas Home	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 86-88.	Deemed savings taken from value for homes with fossil fuel heating systems.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 86-88.	Deemed savings taken from value for homes with fossil fuel heating systems.
	Heat Pump Water Heater - Electric Home	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 86-88.	Deemed savings taken from value for homes with electric heat pump heating. Measure data did not indicate whether the home was heated with electric resistance or heat pump systems.	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 86-88.	Deemed savings taken from value for homes with electric heat pump heating. Measure data did not indicate whether the home was heated with electric resistance or heat pump systems.
	Air Sealing	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.
	Wall Insulation	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.
	Attic Insulation	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.	Deemed savings based on a custom engineering study.	Deemed savings provided by implementer.
	9W LED	Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16. DOE Uniform Methods Project, Ch. 21: Residential Lighting Evaluation Protocol. Pages 8-10.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. ISR determined using participant survey with 2016-17 Energy Savings Kit program participants. ISR determined using UMP protocol.	Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 11 - 16. DOE Uniform Methods Project, Ch. 21: Residential Lighting Evaluation Protocol. Pages 8-10.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM. ISR determined using participant survey with 2016-17 Energy Savings Kit program participants. ISR determined using UMP protocol.
	LED Night Light	Parent follow-up survey with 2016-17 school year participants. 2015 Indiana TRM Version 2.2. Pages 135-136.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM and 2015 Indiana TRM Version 2.2. ISR determined using 2016-17 family participant survey and parent follow-up survey.	Parent follow-up survey with 2016-17 school year participants. 2015 Indiana TRM Version 2.2. Pages 135-136.	Calculated using the inputs and algorithms in the 2010 draft Ohio TRM and 2015 Indiana TRM Version 2.2. ISR determined using 2016-17 family participant survey and parent follow-up survey.
	Bathroom Faucet Aerators (2 in each kit)	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stem from Cadmus and Opinion Dynamics metering study and the draft 2010 Ohio	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stem from Cadmus and Opinion Dynamics metering study and the draft 2010 Ohio TRM. ISR

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	TRM. ISR determined using the parent follow-up survey with 2016-17 school year participants.	under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	determined using the parent follow-up survey with 2016-17 school year participants.
	Kitchen Faucet Aerator	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. ISR determined using the parent follow-up survey with 2016-17 school year participants.	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. ISR determined using the parent follow-up survey with 2016-17 school year participants.
	Efficient Showerhead	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. ISR determined using the parent follow-up survey with 2016-17 school year participants.	Family home installation survey distributed during the 2016-17 school year. Parent follow-up survey with 2016-17 school year participants. 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC Pages 89-92; Potential Study; 2013 Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum Pages 1-16.	Calculated using the algorithm listed in the 2010 draft Ohio TRM. Algorithm inputs stems from potential study, Cadmus and Opinion Dynamics metering study, and the draft 2010 Ohio TRM. ISR determined using the parent follow-up survey with 2016-17 school year participants.
Smart Thermostats	Pilot - Smart Thermostat with AC	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.
	Pilot - Smart Thermostat	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.	Engineering calculations based on secondary data.	Estimates calculated by program implementer using engineering formulas.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	with HP or GSHP				
	Nest Online	Based on HVAC savings, weighted by HVAC system type from 2016 pilot	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
	Rebates for Retail	Based on HVAC savings, weighted by HVAC system type from 2016 pilot	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
	IGS Energy	Based on HVAC savings, weighted by HVAC system type from 2016 pilot	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
	DP&L Online Store	Based on HVAC savings, weighted by HVAC system type from 2016 pilot	Estimates calculated by program implementer using engineering formulas.	No kW savings are claimed for thermostats.	No kW savings are claimed for thermostats.
Nonresidential Prescriptive					
Nonresidential Prescriptive: HVAC	Air cooled chiller - any size	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 146 - 148.	Estimates calculated by DP&L using draft Ohio TRM and primary data. Estimated equivalent full load hours from the TRM are averaged across all system types with and without economizers (1,645 EFLH).	2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 146 - 148.	Estimates calculated by DP&L using draft Ohio TRM. Summer Peak Coincidence Factor (CF) from the TRM is used for this measure.
	Air source heat pump < 65,000 BTUH (split or single package)	2010 draft Ohio TRM pages 197 - 200.	Baseline efficiencies from TRM. Efficient SEER of 14.0 and efficient HSPF of 8.2 used in calculation. Full load cooling hours are 942 and full load heating hours are 810.	2010 draft Ohio TRM pages 197 - 200.	Baseline efficiencies from TRM. Efficient SEER of 14.0 and efficient HSPF of 8.2 used in calculation.
	Air source heat pump 65,000 - 135,000 BTUH	2010 draft Ohio TRM pages 197 - 200.	Baseline efficiencies from TRM. Efficient EER of 11.0 and efficient COP of 2.2 used in calculation. Full load cooling hours are 942 and full load heating hours are 810.	2010 draft Ohio TRM pages 197 - 200.	Baseline efficiencies from TRM. Efficient EER of 11.0 and efficient COP of 2.2 used in calculation.
	Energy recovery ventilation > 450 CFM	October 2009 draft Ohio TRM page 137.	No changes from TRM.	October 2009 draft Ohio TRM page 137. Measure was not included in 2010 draft Ohio TRM	No changes from TRM.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	HVAC occupancy sensor	October 2009 draft Ohio TRM page 141.	Efficiency of 14 SEER used in calculation. Full load cooling hours are 942.	October 2009 draft Ohio TRM page 141.	Efficiency of 14 SEER used in calculation.
	Outside air economizer with two enthalpy sensors	Cadmus engineering analysis, assuming 12% energy savings.	The savings from economizers will vary by building application, loads and climate. Typically a 12 percent savings can be achieved. Assumed 10 ton unit, 11 EER, and 1,000 cooling load hours. Energy savings of 1,309 kWh per year.	Cadmus engineering analysis, assuming 12% energy savings.	The savings from economizers will vary by building application, loads and climate. Typically a 12 percent savings can be achieved. Assumed 10 ton unit and 11 EER. Demand savings of .36kW.
	Packaged terminal air conditioning and heat pumps	Technical Reference Manual 2010 for Pennsylvania Act 129 Energy Efficiency and Conservation Program pages 55 - 59	Baseline values from ASHRAE 90.1-2007. Energy savings of 247 kWh per ton.	Technical Reference Manual 2010 for Pennsylvania Act 129 Energy Efficiency and Conservation Program pages 55 - 59	Baseline values from ASHRAE 90.1-2007. Demand savings of 0.25 per ton.
	Unitary and split system A/C 65,000 - 135,000 BTUH (5.4-11.25 tons)	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 11.0 used in calculation. Full load cooling hours are 942.	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 11.0 used in calculation.
	Unitary and split system A/C < 65,000 BTUH (<5.4 tons)	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient SEER of 14.0 used in calculation. Full load cooling hours are 942.	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient SEER of 14.0 used in calculation.
	Unitary and split system A/C > 760,000 BTUH (>63.33 tons)	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 9.7 used in calculation. Full load cooling hours are 942.	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 9.7 used in calculation.
	Unitary and split system A/C 136,000 - 240,000 BTUH (11.33-20 tons)	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 10.8 used in calculation. Full load cooling hours are 942.	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known. Efficient EER of 10.8 used in calculation.
	Unitary and split system A/C	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known.	2010 draft Ohio TRM, pages 194 - 196.	Baseline efficiencies from TRM unless otherwise known.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	241,000 - 760,000 BTUH (20-63.33 tons)		Efficient EER of 10.0 used in calculation. Full load cooling hours are 942.		Efficient EER of 10.0 used in calculation.
	Variable frequency drive up to 250 HP	Engineering calculations based on primary and secondary data, including the 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 207- 209.	Estimates calculated by Cadmus using primary data, secondary data, and the draft Ohio TRM. Application information of the existing motor efficiency, brake horsepower and application type are not collected. Estimated efficiency of the motor that is driven by the VFD is assumed to 91%. An overall percent savings of 30% is used as an average where the TRM percent savings range from 9.2% to 53.5% depending on baseline conditions. Instead of brake horsepower, nominal motor horsepower and 85% load factor is assumed.	Engineering calculations based on primary and secondary data, including the 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 207- 209.	Estimates calculated by Cadmus using primary data, secondary data, and the draft Ohio TRM. Application information of the existing motor efficiency, brake horsepower and application type are not collected. Estimated efficiency of the motor that is driven by the VFD is assumed to 91%. An overall percent savings of 30% is used as an average where the TRM percent savings range from 3% to 34.8% depending on baseline conditions. Instead of brake horsepower, nominal motor horsepower and 85% load factor is assumed.
	Variable Refrigerant Flow System < 65,000 BTUH	Calculation savings methodology reflect similar methodology used for heat pump systems: 2010 draft Ohio TRM, pages 197-200.	Base efficiency, new efficiency, and HOU are application specific.	Calculation savings methodology reflect similar methodology used for heat pump systems: 2010 draft Ohio TRM, pages 197-200.	Base efficiency, new efficiency, and HOU are application specific.
	Variable Refrigerant Flow System 136,000 - 240,000 BTUH	Calculation savings methodology reflect similar methodology used for heat pump systems: 2010 draft Ohio TRM, pages 197-200.	Base efficiency, new efficiency, and HOU are application specific.	Calculation savings methodology reflect similar methodology used for heat pump systems: 2010 draft Ohio TRM, pages 197-200.	Base efficiency, new efficiency, and HOU are application specific.
	Water cooled chiller > 300 tons	2010 draft Ohio TRM, pages 147 - 148.	EFLH is an average of the 3 system types for Dayton, resulting in 1,645 EFLH.	2010 draft Ohio TRM, pages 147 - 148.	No changes from TRM.
	Window film	2010 draft Ohio TRM, pages 214 - 217.	ΔkWh is average of "light industrial, small office and small retail" resulting in 266.	2010 draft Ohio TRM, pages 214 - 217.	ΔkW is average of "light industrial, small office and small retail" resulting in .14.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
Nonresidential Prescriptive: Lighting	Central lighting control	2010 draft Ohio TRM with specific project HOU assumptions. Pages 149-152	2010 draft Ohio TRM with specific project HOU assumptions. Pages 149-152	2010 draft Ohio TRM. Pages 149-152	No demand savings are collected.
	CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	2010 draft Ohio TRM, pages 153 - 156.	Assume 68 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 68 watts of savings. Coincidence factor is the average of the first 13 building type measures .732.
	CFL screw-in bulb or pin-based fixture 21W to 32W replacing incandescent	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. Coincidence factor is the average of the first 13 building type measures .732.
	CFL screw-in bulb or pin-based fixture up to 20W replacing incandescent	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. Coincidence factor is the average of the first 13 building type measures .732.
	Delamping HID	2010 draft Ohio TRM, pages 169 - 172.	Actual lamp wattage removed including ballast is used. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Actual lamp wattage removed including ballast is used. Coincidence factor is the average of the first 13 building type measures .732.
	Delamping T12 (# linear feet)	2010 draft Ohio TRM, pages 169 - 172.	72 watts per 4-foot lamp is used to calculated savings. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	72 watts per 4-foot lamp is used to calculated savings. Coincidence factor is the average of the first 13 building type measures .732.
	Delamping T8 (# linear feet)	2010 draft Ohio TRM, pages 169 - 172.	23 watts per 4-foot lamp is used to calculated savings. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	23 watts per 4-foot lamp is used to calculated savings. Coincidence factor is the average of the first 13 building type measures .732.
	Energy Star CFL screw-in bulb or pin-based fixture > 32W replacing incandescent	2010 draft Ohio TRM, pages 153 - 156.	Assume 55 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 55 watts of savings. Coincidence factor is the average of the first 13 building type measures .732.
	Energy Star CFL screw-in bulb or	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. Coincidence factor is the average

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	pin-based fixture 21W to 32W replacing incandescent				of the first 13 building type measures .732.
	Energy Star CFL screw-in bulb or pin-based fixture up to 20W replacing incandescent	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. HOU is application specific.	2010 draft Ohio TRM, pages 153 - 156.	Assume 20 watts of savings. Coincidence factor is the average of the first 13 building type measures .732.
	Energy Star LED luminaires or screw-in base lamps (replacing incandescent)	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	Energy Star LED screw-in base lamps (replacing CFL)	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	Exterior - LED or Induction (8,760 operating hours) replacing 175 W or less	Simple savings formula using 8760 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	Exterior - LED or Induction (8,760 operating hours) replacing 176W to 250W	Simple savings formula using 8760 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	Exterior - LED or Induction (8,760 operating hours) replacing 251W or greater	Simple savings formula using 8760 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	Exterior - LED or Induction (operating hours < 8,760) replacing 175W or less	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	Exterior - LED or Induction (operating hours < 8,760) replacing 176W to 250W	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	Exterior - LED or Induction (operating hours < 8,760) replacing 251W or greater	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing incandescent, ENERGY STAR certified)	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	No demand savings are collected.
	Exterior LED recessed downlight luminaires or screw-in base lamps (replacing incandescent, ENERGY STAR certified)1	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	No demand savings are collected.
	Fixture-mounted occupancy sensor	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 204 watts. Assumed 200 sqft controlled to roughly have 1.0 watts/square foot lighting load.	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 204 watts. Assumed 200 sqft controlled to roughly have 1.0 watts/square foot lighting load.
	LED 4-ft 1-lamp tube	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	LED 4-ft 2-lamp tubes	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED 4-ft 3-lamp tubes	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED 4-ft 3-lamp tubes 1	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED 4-ft 4-lamp tubes	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED case lighting sensor controls	2010 draft Ohio TRM, pages 180 - 182.	Fixture savings is averaged between 5 and 6 foot lamps resulting in 52 watts of savings per door. Waste heat factor savings is averaged and results in .465. These savings are multiplied by a factor of 0.43.	2010 draft Ohio TRM, pages 180 - 182.	No demand savings are collected.
	LED High Bay Replacing 150 W or less HID, T8 or T5	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED High Bay Replacing 151 W to 200 W HID, T8 or T5	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	LED High Bay Replacing 201 W to 350 W HID, T8 or T5	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED High Bay Replacing 351 W to 500 W HID, T8 or T5	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED High Bay Replacing 501 W or greater HID, T8 or T5	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency, new efficiency, and HOU are application specific.	2010 draft Ohio TRM, pages 161 - 162.	Base efficiency and new efficiency are application specific. Coincidence factor is the average of the first 13 building type measures .732.
	LED lighting in reach-in freezer/cooler case	2010 draft Ohio TRM, pages 180 - 182.	Fixture savings is averaged between 5 and 6 foot lamps resulting in 52 watts of savings per door. Waste heat factor savings is averaged and results in .465.	2010 draft Ohio TRM, pages 180 - 182.	Fixture savings is averaged between 5 and 6 foot lamps resulting in 52 watts of savings per door. Waste heat factor savings is averaged and results in .465.
	LED lighting in reach-in freezer/cooler case (per tube)	2010 draft Ohio TRM, pages 180 - 182.	Fixture savings is averaged between 5 and 6 foot lamps resulting in 52 watts of savings per door. Waste heat factor savings is averaged and results in .465.	2010 draft Ohio TRM, pages 180 - 182.	Fixture savings is averaged between 5 and 6 foot lamps resulting in 52 watts of savings per door. Waste heat factor savings is averaged and results in .465.
	LED luminaires up to 18 watts (replacing incandescent)	Simple savings formula using specific project HOU assumptions.	Assume baseline of 75 watts and efficient wattage of 18 watts, or actual wattages if known.	Simple savings formula.	Assume baseline of 75 watts and efficient wattage of 18 watts, or actual wattages if known.
	LED or Electroluminescent exit sign	2010 draft Ohio TRM, pages 183 - 184.	No changes from TRM.	2010 draft Ohio TRM, pages 183 - 184.	No changes from TRM.
	LED or Induction (8,760 operating hours) replacing 175 W or less	Simple savings formula using 8760 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	LED or Induction (8,760 operating hours) replacing 251W or greater	Simple savings formula using 8760 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	LED or Induction (operating hours < 8,760) replacing 175W or less	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	LED or Induction (operating hours < 8,760) replacing 176W to 250W	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	LED or Induction (operating hours < 8,760) replacing 251W or greater	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	LED or Induction (operating hours < 8,760) replacing 251W to 400W	Simple savings formula using 4380 hours.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage	Simple savings formula.	Efficient fixture wattage is subtracted from baseline fixture including ballast wattage
	LED pedestrian walk/don't walk sign	2010 draft Ohio TRM, pages 185 - 188.	Baseline and efficient wattages are averaged between the two sizes resulting in 109.5 baseline watts and 10.5 efficient watts.	2010 draft Ohio TRM, pages 185 - 188.	Baseline and efficient wattages are averaged between the two sizes resulting in 109.5 baseline watts and 10.5 efficient watts.
	LED Replacing 50 W or less HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED Replacing 51 W to 100 W HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED Replacing 101 W to 150 W HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED Replacing 151 W to 200 W HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	LED Replacing 201 W to 350 W HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED Replacing 351 W to 500 W HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED Replacing 501 W or greater HID or Fluorescent	Simple savings formula using specific project HOU assumptions.	Baseline efficiency, new efficiency, and HOU is application specific.	Simple savings formula.	Baseline efficiency and new efficiency is application specific
	LED traffic signal - green	2010 draft Ohio TRM, pages 185 - 188.	No changes from TRM.	2010 draft Ohio TRM, pages 185 - 188.	CF is averaged between "Man" and "Hand" signals resulting in .48.
	LED traffic signal - red	2010 draft Ohio TRM, pages 185 - 188.	Baseline and efficient wattages are averaged between the two sizes resulting in 109.5 baseline watts and 6.5 efficient watts.	2010 draft Ohio TRM, pages 185 - 188.	Baseline and efficient wattages are averaged between the two sizes resulting in 109.5 baseline watts and 6.5 efficient watts.
	LED Traffic Signal (Arrow)	2010 draft Ohio TRM, pages 185 - 188.	Baseline wattage of 116; new wattage of 40.	2010 draft Ohio TRM, pages 185 - 188.	Baseline wattage of 116; new wattage of 40.
	Low-watt T8 4-foot 1 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 43W and new efficiency 22W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 43W and new efficiency 22W. Coincidence factor is the average of the first 13 building type measures .732.
	Low-watt T8 4-foot 2 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 72W and new efficiency 42W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 72W and new efficiency 42W. Coincidence factor is the average of the first 13 building type measures .732.
	Low-watt T8 4-foot 2 lamp fixture replacing T8	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 59W and new efficiency 42W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 59W and new efficiency 42W. Coincidence factor is the average of the first 13 building type measures .732.
	Low-watt T8 4-foot 3 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 115W and new efficiency 64W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 115W and new efficiency 64W. Coincidence factor is the average of the first 13 building type measures .732.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	Low-watt T8 4-foot 3 lamp fixture replacing T8	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 64W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 64W. Coincidence factor is the average of the first 13 building type measures .732.
	Low-watt T8 4-foot 4 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 144W and new efficiency 85W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 144W and new efficiency 85W. Coincidence factor is the average of the first 13 building type measures .732.
	Low-watt T8 4-foot 4 lamp fixture replacing T8	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 112W and new efficiency 85W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 112W and new efficiency 85W. Coincidence factor is the average of the first 13 building type measures .732.
	Occupancy sensor controlling 100 watts or more	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 332 watts.	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 332 watts.
	Occupancy sensor controlling less than 100 watts	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 50 watts.	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions. Pages 149 - 152 2010 draft Ohio TRM.	Assumed controlled wattage is 50 watts.
	Re-lamping 25 watt or less	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 31W and new efficiency 24W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 31W and new efficiency 24W. Coincidence factor is the average of the first 13 building type measures .732.
	Re-lamping 28 watt	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 31W and new efficiency 27W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 31W and new efficiency 27W. Coincidence factor is the average of the first 13 building type measures .732.
	T5 high-output high-bay 10 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 1,080W and new efficiency 585W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 1,080W and new efficiency 585W. Coincidence factor is the average of the first 13 building type measures .732.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	T5 high-output high-bay 2 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 190W and new efficiency 117W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 190W and new efficiency 117W. Coincidence factor is the average of the first 13 building type measures .732.
	T5 high-output high-bay 4 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 234W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 234W. Coincidence factor is the average of the first 13 building type measures .732.
	T5 high-output high-bay 6 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 351W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 351W. Coincidence factor is the average of the first 13 building type measures .732.
	T5 high-output high-bay 8 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 1,080W and new efficiency 468W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 1,080W and new efficiency 468W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 1 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 43W and new efficiency 25W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 43W and new efficiency 25W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 2 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 72W and new efficiency 48W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 72W and new efficiency 48W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 2 lamp fixture replacing T8	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 59W and new efficiency 48W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 59W and new efficiency 48W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 3 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 115W and new efficiency 73W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 115W and new efficiency 73W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 3 lamp	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 73W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 73W. Coincidence

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
	fixture replacing T8				factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T12	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 144W and new efficiency 96W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 144W and new efficiency 96W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 (BF < 0.78) 4-foot 4 lamp fixture replacing T8	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 64W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 89W and new efficiency 64W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 high-bay 4-foot 3 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 190W and new efficiency 112W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 190W and new efficiency 112W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 high-bay 4-foot 4 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 295W and new efficiency 151W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 295W and new efficiency 151W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 high-bay 4-foot 6 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 226W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 226W. Coincidence factor is the average of the first 13 building type measures .732.
	T8 high-bay 4-foot 8 lamp fixture replacing HID	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 288W. HOU is application specific.	2010 draft Ohio TRM, pages 169 - 172.	Baseline efficiency 458W and new efficiency 288W. Coincidence factor is the average of the first 13 building type measures .732.
	Vending equipment controller	2010 draft Ohio TRM, pages 274 - 275.	Assumed all equipment was for refrigerated vending machines at 400 watts baseline and an ESF of 46%.	2010 draft Ohio TRM, pages 274 - 275.	No demand savings are collected.
	Wall or Ceiling-mounted occupancy sensor	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions.	Assumed controlled wattage is 658 watts.	2010 draft Ohio TRM method with adjusted controlled wattage on Cadmus engineering assumptions.	Assumed controlled wattage is 658 watts.

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		Pages 149 - 152 2010 draft Ohio TRM.		Pages 149 - 152 2010 draft Ohio TRM.	
Nonresidential Prescriptive: Compressed Air	Air compressor 1 - 100 HP Load/No Load	2010 draft Ohio TRM with specific project HOU assumptions. Pages 272 - 273.	Use nominal hp; assumed 90% motor efficiency and ESF of 10%.	2010 draft Ohio TRM, pages 272 - 273.	Use nominal hp; assumed 90% motor efficiency and ESF of 10%.
	Air compressor 1 - 100 HP Variable Speed	2010 draft Ohio TRM with specific project HOU assumptions. Pages 272 - 273.	Use nominal hp; assumed 90% motor efficiency and ESF of 26%.	2010 draft Ohio TRM, pages 272 - 273.	Use nominal hp; assumed 90% motor efficiency and ESF of 26%.
	No-loss drain	Engineering calculations based on Best Practices for Compressed Air Systems.	Operation pressure, quantity of drains and HOU are application specific.	Engineering calculations based on Best Practices for Compressed Air Systems.	Operation pressure and quantity of drains are application specific.
Nonresidential Prescriptive: Motors & Drives	Barrel wraps	Deemed savings based on a custom engineering study.	Controlled tons multiplied by .0075 and HOU.	Deemed savings based on a Custom Rebate engineering study.	Controlled tons multiplied by .0075.
	CEE premium efficiency motor 20HP	2010 draft Ohio TRM with specific project HOU assumptions. Pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.	2010 draft Ohio TRM, pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.
	CEE premium efficiency motor 30HP	2010 draft Ohio TRM with specific project HOU assumptions. Pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.	2010 draft Ohio TRM, pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.
	Premium Efficiency Motor 125HP	2010 draft Ohio TRM with specific project HOU assumptions. Pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.	2010 draft Ohio TRM, pages 265 - 268.	Assumed baseline efficiency based on 1800 RPM ODP; actual efficiency based on NEMA required standard.
	Variable frequency drive up to 250 HP	Engineering calculations based on primary and secondary data, including the 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 207- 209.	Estimates calculated by Cadmus using primary data, secondary data, and the draft Ohio TRM. Application information of the existing motor efficiency, brake horsepower and application type are not collected. Estimated efficiency of the motor that is driven by the VFD is assumed to 91%. An overall percent savings of 30% is used as an average where the TRM percent	Engineering calculations based on primary and secondary data, including the 2010 draft Ohio TRM filed August 6, 2010 under Case No. 09-0512-GE-UNC. Pages 207- 209.	Estimates calculated by Cadmus using primary data, secondary data, and the draft Ohio TRM. Application information of the existing motor efficiency, brake horsepower and application type are not collected. Estimated efficiency of the motor that is driven by the VFD is assumed to 91%. An overall percent savings of 30% is used as an average where the TRM percent savings range from 3% to 34.8% depending on baseline

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
			savings range from 9.2% to 53.5% depending on baseline conditions. Instead of brake horsepower, nominal motor horsepower and 85% load factor is assumed.		conditions. Instead of brake horsepower, nominal motor horsepower and 85% load factor is assumed.
Nonresidential Prescriptive: Midstream Incentives	LED Screw-in	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Simple savings formula is used.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	LED 4 Pin CFL Replacement	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used, and the baseline is assumed to be 32W. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Simple savings formula is used.	Actual lamp wattage is used, and the baseline is assumed to be 32W. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	Re-lamp 25 watt	Calculations are based on the Ohio 2010 TRM. HOU is measure specific and is derived from previous evaluation data.	A deemed baseline of 32 watts is assumed. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Calculations are based on the Ohio 2010 TRM.	A deemed baseline of 32 watts is assumed. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	Re-lamp 28 watt	Calculations are based on the Ohio 2010 TRM. HOU is measure specific and is derived from previous evaluation data.	A deemed baseline of 32 watts is assumed. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Calculations are based on the Ohio 2010 TRM.	A deemed baseline of 32 watts is assumed. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	LED T8	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Calculations are based on the Ohio 2010 TRM and include the impact of the Energy Independence and Security Act.	A deemed baseline of 32 watts is assumed. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	T5	Calculations are based on the Ohio 2010 TRM. HOU is measure specific and is	A deemed baseline of 54 watts is assumed. HOU is measure specific. WHF is from 2010 draft Ohio TRM, page	Calculations are based on the Ohio 2010 TRM and include the impact of the Energy Independence and Security Act.	A deemed baseline of 54 watts is assumed. CF is from 2010 draft Ohio TRM. WHF is from 2010

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
		derived from previous evaluation data.	171. ISR is assumed to be 100%.		draft Ohio TRM, page 171. ISR is assumed to be 100%.
	LED Fixtures	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Baseline wattage assumed based on product type and manufacturer information (Eaton). HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Simple savings formula is used.	Baseline wattage assumed based on product type and manufacturer information. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	Eatons Cooper LED Fixtures with Integrated Sensors	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Baseline wattage assumed based on product type and manufacturer information (Eaton). HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Simple savings formula is used.	Baseline wattage assumed based on product type and manufacturer information. CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	High Bay / Low Bay LED	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence using a table from the PA Interim-Measures Protocol (IMP). HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Calculations are based on the Ohio 2010 TRM. Baselines are sourced from a Pennsylvania interim-measure protocol.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence using a table from the PA Interim-Measures Protocol (IMP). CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	LED Exterior Flood	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence using a table from the PA Interim-Measures Protocol (IMP). HOU is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.	Calculations are based on the Ohio 2010 TRM. Baselines are sourced from a Pennsylvania interim-measure protocol.	Actual lamp wattage is used, and the baseline is determined through lumen equivalence using a table from the PA Interim-Measures Protocol (IMP). CF is from 2010 draft Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	LED Exterior Wall Pack	Simple savings formula is used. HOU is measure specific and is derived from previous evaluation data.	Actual lamp wattage is used, and the baseline is determined through a lookup table from the MN TRM. HOU	Simple savings formula is used.	Actual lamp wattage is used, and the baseline is determined through a lookup table from the MN TRM. CF is from 2010 draft

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
			is measure specific. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.		Ohio TRM. WHF is from 2010 draft Ohio TRM, page 171. ISR is assumed to be 100%.
	Midstream VFDs	Calculations are based on the Ohio 2010 TRM.	Inputs were provided by the implementation team.	Calculations are based on the Ohio 2010 TRM.	Inputs were provided by the implementation team.
Nonresidential Custom	Custom NC	Custom engineering calculation	A full impact analysis report is completed. Specific to each project, as-built building simulations are developed and used to determine electric kWh savings.	Custom engineering calculation	A full impact analysis report is completed. Specific to each project, as-built building simulations are developed and used to determine electric kW savings.
	Custom NC-LPD	Custom engineering calculation	A full impact analysis report is completed. Specific to each project, lighting power density calculations are used to determine electric kWh savings.	Custom engineering calculation	A full impact analysis report is completed. Specific to each project, lighting power density calculations are used to determine electric kW savings.
	Custom-HVAC	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post- metering, billing analysis, and custom engineering calculations.	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post- metering, billing analysis, and custom engineering calculations.
	Custom-Lighting	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post- metering, billing analysis, and custom engineering calculations.	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post- metering, billing analysis, and custom engineering calculations.
	Custom-Other	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post- metering,	Custom engineering calculation	Depending on project size and scope, a full impact analysis report is completed. Specific to each project, the impact analysis may include pre- and post-

Program	Measure	*Ex Ante* kWh Savings Documentation	*Ex Ante* kWh Savings Documentation Detail	*Ex Ante* kW Savings Documentation	*Ex Ante* kW Savings Documentation Detail
			billing analysis, and custom engineering calculations.		metering, billing analysis, and custom engineering calculations.

Appendix J. Billing Analysis

Detailed Methodology

For both the Income Eligible Efficiency Program, implemented by the OPAE, and Residential HVAC Equipment Program, DP&L provided billing data and tracking data for 2016–2017 participants. This allowed estimation of overall program savings and measure savings through a billing analysis. Cadmus used the billing analysis results to establish the program's adjusted gross savings.

DP&L provided pre- and post-period billing data in various extracts. Tracking data included details about measures installed, installation dates, other program participation, installed and existing equipment details, and various other useful participant details. For the OPAE Income Eligible Efficiency Program, Cadmus populated the *ex ante* savings estimates based on engineering estimates for all measures installed through the program from previous program periods.[41] For the Residential HVAC Program, Cadmus used *ex ante* savings estimates calculated as a part of last year's evaluation.

Finally, Cadmus obtained the earliest and latest participation dates for all measures installed, and combined this customer-level, measure category information with the billing data.

In conducting the billing analysis, Cadmus completed the following steps:

- Matched measure data from the tracking database with electric billing data.
- Used zip code mapping to determine the nearest weather station for each zip code.
- Obtained daily average temperature weather data (July 2013 through January 2018) for six NOAA weather stations, representing all zip codes associated with participants.
- Used daily average temperatures to determine base 45–85 HDDs and CDDs for each station.
- Obtained typical meteorological year 3 (TMY3; 1991–2005) annual normal heating and CDDs to weather normalize the billing data.
- Matched billing data periods with CDDs and HDDs from associated stations.
- For each account, Cadmus defined the pre-period as 12 months prior to installation of the first measure, and defined the post-period as 12 months after installation of the last measure. Cadmus received two years of post-period usage data, from February 2016 to February 2018. Consequently, accounts with final measure installation dates prior to February 2016 did not have usage data immediately following their final measure installations. Thus, Cadmus assigned these accounts a post-period of February 2016 to February 2017.

Data Screening

Cadmus removed the following elements from the analysis:

- Electric billing data monthly readings where usage fell below 1 kWh per day.

[41] For the past several years, Cadmus has calculated *ex ante* savings on DP&L's behalf.

- Participant and nonparticipant customers with fewer than 11 pre- and 11 post-installation months.
- Participant and nonparticipant customers with fewer than 300 pre- and 300 post-installation months.
- Participants and nonparticipants with post-usage 70% higher or lower than pre-usage.
- Accounts with outliers, apparent vacancies, seasonal usage, and/or non-programmatic equipment or occupancy changes in the pre- and/or post-installation periods. To determine this, Cadmus examined monthly billing data by plotting each participant's monthly usage.
- Accounts with atypical consumption patterns determined via a visual inspection of the data to check for anomalies and removed.
- Accounts receiving additional measures through other programs during the analysis period, based on tracking data (e.g., participation in Ohio's HWAP).

Comparison Group

As an important aspect of a billing analysis' quasi-experimental design, a billing analysis—when possible—should use a comparison group of "nonparticipants" to account for exogenous factors that may have occurred simultaneously with program activity. These factors can include macroeconomic effects, increases or decreases in energy rates, or other interactions that could affect energy consumption outside of the program's influence. Cadmus established a comparison group for the OPAE Income Eligible Efficiency Program, in which comparison group customers could be identified using samples of future program participants (i.e., participating after the analysis period).

Using future participants this way offered several advantages over selecting randomly from the customer population:

- Future participants proved more representative of the participant treatment group than a random sample of residential customers (i.e., more likely to closely resemble participants from previous years in terms of energy awareness and pre-program building characteristics).
- As this population received program measures, Cadmus could control and isolate the comparison group's installation periods to ensure program impacts did not influence the analysis period.

As the comparison group's pre-period usage might not be identical to participant pre-usage, a "percent of pre" approach provided the adjusted gross participant savings. The following formula shows the specific calculation used for adjusted gross participant savings:

$$Adj.Gross\ Savings = (Pre\ Part\ Usage)\left(\frac{Part\ Change\ In\ Usage}{Pre\ Part\ Usage} - \frac{NonPart\ Change\ In\ Usage}{Pre\ NonPart\ Usage}\right)$$

Through this process (rather than taking the difference between the participant savings delta and the nonparticipant savings delta [i.e., a difference-of-differences approach]), the percentage reduction of participant and nonparticipant groups could be obtained. The percentage reduction, representative of adjusted gross savings, provided the participant percentage-change reduction minus the nonparticipant

percentage reduction. This adjusted gross percentage reduction could then be multiplied by participant pre-period usage to obtain the adjusted gross participant savings, effectively accounting for differences in pre-period usage between participants and nonparticipants.

Cadmus defined the "future" nonparticipant group as participants installing measures from August 2017 through December 2017. Though these customers did not have sufficient post-period billing data, the group produced sufficient pre-participation billing data.

The study used the following definitions:

- The participant pre-installation period as one year before the first measure installation
- The post-installation period as one year after the last measure installation
- The nonparticipant pre-period as the period from August 2015 to July 2016
- The post-period as August 2016 to July 2017

Cadmus primarily relied on the PRInceton Scorekeeping Method (PRISM) to develop the savings estimates. The evaluators also used a Conditional Savings Analysis (CSA) fixed-effects modeling approach to corroborate PRISM findings at the overall program level. Cadmus selected the PRISM modeling approach as the models would be easier to summarize across various groups, and would yield nearly identical precisions to the more complex CSA method.

PRISM Modeling Approach

Cadmus estimated PRISM models for pre- and post-installation billing data. These models provided weather-normalized, pre- and post-installation, annual usage for each account, and an alternate check to savings obtained from the fixed-effects model.

For each participant and nonparticipant home, Cadmus estimated a heating and cooling PRISM model for both the pre- and post-installation periods to weather-normalize raw billing data. Each model allowed the heating reference temperature to range from 45°F to 85°F and the cooling reference temperature to range from the heating reference temperature to 85°F.

The PRISM electric model used the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer i and month t:

ADC_{it}	= Average daily kWh consumption in the pre-/post-installation period
α_i	= Participant intercept; represents the average daily kWh base load
β_1	= Model space heating parameter value
β_2	= Model cooling parameter value
$AVGHDD_{it}$	= Base 45-85 average daily HDDs for the specific location
$AVGCDD_{it}$	= Base 45-85 average daily CDDs for the specific location
ε_{it}	= Error term

Using this model, Cadmus computed weather-normalized annual consumption (NAC) for each heating and cooling reference temperature, as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \beta_2 LRCDD_i + \varepsilon_i$$

Where for each customer 'i':

NAC_i	= Normalized annual kWh consumption
α_i	= Intercept is the average daily or base load for each participant; it represents the average daily base load from the model
$\alpha_i * 365$	= Annual base load kWh usage (non-weather sensitive)
β_1	= Heating parameter value; in effect, this is usage per heating degree day from the model above
$LRHDD_i$	= Annual, long-run HDDs of a TMY3 in the 1991–2005 series from NOAA, based on the home location
$\beta_1 * LRHDD_i$	= Weather-normalized annual weather sensitive heating usage, also known as HEATNAC
β_2	= Cooling parameter value; in effect, this is usage per CDD from the model above
$LRCDD_i$	= Annual, long-run CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location
$\beta_2 * LRCDD_i$	= Weather-normalized annual weather-sensitive cooling usage, also known as COOLNAC
ε_i	= Error term

Further, if the heating and cooling models above yielded negative intercepts, negative heating parameters, or negative cooling parameters, Cadmus estimated additional models that included only the cooling usage (i.e., cooling-only models) or the heating usage (i.e., heating-only models). From these models, with correct signs on all parameters, the best model chosen for each participant for the pre- and post-installation periods was the one with the highest R-square.

Table 235 summarizes the participant (January 2016–July 2017) account attrition from the various screens. The tracking data indicated 634 participant accounts receiving measures. Approximately 31% of the attrition resulted from insufficient months of billing data, or the inability to match billing data and participant account numbers. The process removed another 14% from PRISM screening, large percentage changes, and individual billing review problems; and 9% due to participation in other programs.[42]

[42] Program tracking data included flags for other program participation, including HWAP, Electric Partnership Program, Warm Choice, and other miscellaneous programs.

Table 235. OPAE Program Participant Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Accounts	**634**	**100%**	**0**	**0%**
Less than 10 Months of Pre- or Post-Period Billing Data	436	69%	198	31%
Usage/Percent Change Screens + PRISM Screening	428	68%	8	32%
Individual Customer Bill Review: Outliers, Vacancies, Seasonal Usage, and Equipment Changes	342	54%	86	46%
Participated in Other Programs	285	45%	57	55%
Final Analysis Group	**285**	**45%**	**349**	**55%**

Table 236 summarizes nonparticipant (August 2017–December 2017) account attrition from the various screens. Of 345 nonparticipant accounts, approximately 79% of attrition resulted from an inability to match billing data and insufficient months of billing data. Less than 4% of removal resulted from PRISM screening, large percent changes, and individual billing review problems.

Table 236. OPAE Program Nonparticipant Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Accounts	**345**	**100%**	**0**	**0%**
Less than 10 Months of Pre- or Post-Period Billing Data*	133	39%	212	79%
Usage/Percent Change Screens + PRISM Screening	132	38%	1	79%
Individual Customer Bill Review: Outliers, Vacancies, Seasonal Usage, and Equipment Changes	116	34%	16	82%
Participated in Other Programs	113	33%	3	82%
Final Analysis Group	**113**	**33%**	**232**	**82%**

*Availability of billing data from January 2015–January 2017 resulted in this high attrition: Cadmus required billing data back to July 2015. This left but a few nonparticipants passing these criteria.

Following these screens, the model analysis group included 285 participants (45%) and 113 nonparticipants (33%). From the above PRISM models, the average Difference in Normalized Annual Consumption (DNAC = PRENAC – POSTNAC) yielded the average program savings. The PRISM method also provides weather-normalized, pre-installation period usage (PRENAC), which was used to determine the percent savings.

Fixed Effect Modeling Approach

To estimate the savings resulting from the program, Cadmus conducted a pre- and post-installation combined CSA to compare weather-normalized energy consumption prior to and after participation in the program. Cadmus also applied a PRISM model, as detailed above, to verify CSA results.

Cadmus used the following model specification to determine the overall program impacts:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST_i + \beta_4 POST_i * AVGCDD_{it} + \beta_5 POST_i * AVGHDD_{it} + \varepsilon_{it}$$

Where (for participant 'i' and monthly billing period 't'):

ADC_{it}	=	Average daily kWh consumption during the pre- or post-installation program period
α_i	=	Average daily kWh baseload intercept for each participant (part of the fixed-effects specification)
β_1	=	Average baseline heating kWh usage per HDD
$AVGHDD_{it}$	=	Average HDDs[43], based on home and home location
β_2	=	Average baseline cooling kWh usage per CDD
$AVGCDD_{it}$	=	Average CDDs[44], based on home and home location
β_3	=	Average daily baseload (non-weather sensitive) kWh
$POST_i$	=	Indicator variable of 1 in the post-installation period and 0 in the pre-installation period
β_4	=	Cooling kWh savings per CDD
β_5	=	Heating kWh per HDD
ε_{it}	=	Error term

Similar screens were applied to Residential HVAC Program participants as OPAE participants. Notable differences included exclusion of participants that installed multiple, major HVAC measures (e.g., two heat pumps); and exclusion of participants that changed equipment types. Table 237 presents attrition for participant accounts.

[43] The base reference temperature to calculate HDDs was selected as the average heating reference temperature selected from the PRISM models across all participants.

[44] The base reference temperature to calculate CDDs was selected as the average cooling reference temperature selected from the PRISM models across all participants.

Table 237. Residential HVAC Program Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Accounts	**3,964**	**100%**	**0**	**0%**
Dropped Due to Installing Multiple Major HVAC Measures	3,889	98%	75	2%
Matched to Billing Data Provided*	3,516	89%	373	10%
Less than 11 Months of Pre- or Post-Period Billing Data	3,112	79%	404	11%
Usage/Percent Change Screens + PRISM Screening	3,091	78%	21	1%
Individual Customer Bill Review: Outliers, Vacancies, Seasonal Usage	2,755	70%	336	11%
Dropped for Switching HVAC Systems	2,645	67%	110	4%
Final Analysis Group	**2,645**	**67%**	**1,319**	**33%**

Detailed Results

Residential Income Eligible Efficiency Program (OPAE) Results

This section includes billing analysis results at various detailed levels (e.g., fixed effects results, at the quartile level, and for other subgroup savings results). Table 238 presents the fixed effect model savings. Fixed-effects model results were comparable to the PRISM model.

Table 238. OPAE Fixed Effect Energy Savings from Billing Analysis

Group	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Adjusted Gross % Savings	*Ex Ante* % Savings
Participant	285	1,370	2,139	64%	15%	12,419	11%	17%
Non-participant	113	-201	-	%	112%	9,181	-2%	-
Participant Adjusted Gross	**285**	**1,642**	**2,139**	**77%**	**22%**	**12,419**	**13%**	**17%**

Cadmus also separated PRENAC usage into four usage quartiles.

Table 239 presents the evaluated gross quartile savings, and Table 240 presents adjusted gross quartile savings. The program achieved a percent of adjusted gross savings between 11% and 17% for the various quartile levels. As expected, the greater the usage, the higher the savings (i.e., ranging from 553 kWh in Q1 to 3,501 kWh in Q4). Larger homes in Q3 and Q4 achieved targeted savings or achieved higher savings than expected (i.e., realization rates of 106%, 128%). This was expected as *ex ante* estimates sometimes take on only one value, regardless of pre-period usage. An improvement on the savings estimate calculation might account for pre-period usage or square footage of a home.

Conversely, smaller homes in Q1 and Q2 overstated *ex ante* estimates with realization rates of 31% and 60%, respectively.

Table 239. OPAE Evaluated Gross Quartile Level Energy Savings from Billing Analysis

Group	n	Model Savings (kWh)	*Ex Ante* Savings (kWh)	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC (kWh)	Percent Savings	*Ex Ante* Percent Savings
Overall	**285**	**1,455**	**2,139**	**68%**	**15%**	**12,419**	**11.7%**	**17.2%**
Q1: <6,491 kWh pre period consumption	71	375	1,709	22%	41%	4,673	8.0%	36.6%
Q2: 6,491 – 10,761 kWh pre period consumption	72	906	1,989	46%	26%	8,735	10.4%	22.8%
Q3: 10,762 – 17,013 kWh pre period consumption	71	1,826	2,136	85%	20%	13,175	13.9%	16.2%
Q4: >17,013 kWh pre period consumption	71	2,720	2,726	100%	24%	23,142	11.8%	11.8%

Table 240. OPAE Adjusted Gross Quartile Level Energy Savings from Billing Analysis

Group	n	Model Savings (kWh)	*Ex Ante* Savings (kWh)	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC (kWh)	Percent Savings	*Ex Ante* Percent Savings
Overall	**285**	**1,874**	**2,139**	**88%**	**21%**	**12,419**	**15.1%**	**17.2%**
Q1: <6,491 kWh pre period consumption	71	533	1,709	31%	37%	4,673	11.4%	36.6%
Q2: 6,491 – 10,761 kWh pre period consumption	72	1,201	1,989	60%	28%	8,735	13.7%	22.8%
Q3: 10,762 – 17,013 kWh pre period consumption	71	2,271	2,136	106%	22%	13,175	17.2%	16.2%
Q4: >17,013 kWh pre period consumption	71	3,501	2,726	128%	26%	23,142	15.1%	11.8%

Table 241 presents measure group results not adjusted with nonparticipant's results. As with adjusted gross savings by measure groups, these results should not be summed or viewed as saving estimates for each measure.

Table 241. OPAE Evaluated Gross Quartile Level Energy Savings from Billing Analysis

Measure Group	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Modeled Percent Savings	*Ex Ante* Percent Savings	SE
Overall	**285**	**1,455**	**2,139**	**68%**	**15%**	**12,419**	**11.7%**	**17.2%**	**132**
Refrigerators/Freezers	226	1,439	2,263	64%	17%	12,032	12.0%	18.8%	147
Refrigerators/Freezers Only	6	480	1,685	28%	215%	8,841	5.4%	19.1%	628
HVAC	2	-1,144	3,156	-36%	-43%	15,567	-7.4%	20.3%	302
Air Sealing	10	4,050	8,094	50%	38%	30,595	13.2%	26.5%	942
Insulation	10	4,050	8,094	50%	38%	30,595	13.2%	26.5%	942
Lighting	272	1,422	2,093	68%	15%	12,281	11.6%	17.0%	131
Lighting Only	31	1,187	539	220%	48%	9,447	12.6%	5.7%	348
Water Heating	43	1,664	2,395	69%	34%	17,465	9.5%	13.7%	348
Other	2	144	947	15%	1289%	25,401	0.6%	3.7%	1,129

Table 242 summarizes savings for various other categories, used as indications of accurate *ex ante* estimates, or those underperforming or over performing. Some results with small sample sizes were not statistically significant. Though this report presents these results for informational purposes, they should not necessarily be used to make program decisions.

Table 242. Additional OPAE Adjusted Gross Energy Savings from Billing Analysis

Variable	Category	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Percent Savings	*Ex Ante* Percent Savings
Overall	**Overall**	285	1,874	2,139	88%	21%	12,419	15.1%	17.2%
Job Type	Baseload Job	31	1,811	2,068	88%	44%	16,837	10.8%	12.3%
Job Type	Heating Customer/Water Heating	43	2,200	3,019	73%	36%	19,767	11.1%	15.3%
Job Type	Heating Job	1	-330	3,200	-10%	-122%	15,171	-2.2%	21.1%
Job Type	Water Heating Job	32	2,537	1,716	148%	31%	14,150	17.9%	12.1%
Agency	COMMUNITY ACTION AGENCY OF DELAWARE, MADISON, AND UNION COUNTIES	52	1,491	906	165%	30%	9,737	15.3%	9.3%
Agency	COMMUNITY ACTION COMMISION OF FAYETTE COUNTY	6	1,140	1,865	61%	92%	19,287	5.9%	9.7%
Agency	COMMUNITY ACTION PARTNERSHIP OF THE GREATER DAYTON AREA	196	2,008	2,486	81%	21%	12,221	16.4%	20.3%
Agency	HIGHLAND COUNTY COMMUNITY ACTION ORGANIZATION	31	1,811	2,068	88%	44%	16,837	10.8%	12.3%
Income Level	0-100% of Federal Poverty Level	134	2,056	2,031	101%	24%	13,882	14.8%	14.6%
Income Level	101-150% of Federal Poverty Level	115	1,730	2,272	76%	26%	10,946	15.8%	20.8%
Income Level	151-200% of Federal Poverty Level	36	1,659	2,118	78%	32%	11,674	14.2%	18.1%
Income Source	Disability	61	1,926	2,232	86%	29%	13,024	14.8%	17.1%

Variable	Category	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Percent Savings	*Ex Ante* Percent Savings
Income Source	Employment	75	1,731	2,148	81%	29%	12,975	13.3%	16.6%
Income Source	Other - must provide notes	70	2,004	2,392	84%	32%	11,767	17.0%	20.3%
Income Source	Pension/Retirement	62	1,723	1,606	107%	29%	10,066	17.1%	16.0%
Income Source	Public Assistance	12	2,983	2,010	148%	41%	16,406	18.2%	12.3%
Income Source	Unemployment	5	774	4,284	18%	88%	25,416	3.0%	16.9%
Own/Rent	Own	217	1,924	2,348	82%	22%	12,212	15.8%	19.2%
Own/Rent	Rent	68	1,715	1,472	116%	28%	13,077	13.1%	11.3%
House Type	Multi-Fam. i.e. condo or apt. up to 4 units	26	1,004	762	132%	40%	8,448	11.9%	9.0%
House Type	Other	6	1,930	2,102	92%	29%	9,521	20.3%	22.1%
House Type	Single Fam. 1-1/2, 2 or more story	153	1,975	2,330	85%	24%	13,083	15.1%	17.8%
House Type	Single Fam. Bi-level or Split-level	3	2,543	2,442	104%	25%	17,972	14.2%	13.6%
House Type	Single Fam. Duplex(Semi-Det.)2-unit side-by-side	8	3,090	2,413	128%	62%	11,347	27.2%	21.3%
House Type	Single Fam. Mobile Home	22	2,224	1,737	128%	43%	12,500	17.8%	13.9%
House Type	Single Fam. Ranch, single level	67	1,685	2,329	72%	28%	12,554	13.4%	18.5%
County	ADAMS	2	223	1,283	17%	332%	9,710	2.3%	13.2%

Variable	Category	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Percent Savings	*Ex Ante* Percent Savings
County	CHAMPAIGN	1	5,102	388	1317%	9%	16,690	30.6%	2.3%
County	DARKE	8	1,890	4,390	43%	59%	12,673	14.9%	34.6%
County	FAYETTE	6	1,140	1,865	61%	92%	19,287	5.9%	9.7%
County	GREENE	30	989	2,132	46%	53%	10,214	9.7%	20.9%
County	HIGHLAND	30	1,844	2,077	89%	45%	16,912	10.9%	12.3%
County	LOGAN	13	1,379	1,225	113%	40%	10,705	12.9%	11.4%
County	MERCER	1	143	1,988	7%	75%	4,028	3.5%	49.3%
County	MIAMI	4	1,030	2,252	46%	113%	12,084	8.5%	18.6%
County	MONROE	1	-432	2,294	-19%	-92%	14,853	-2.9%	15.4%
County	MONTGOMERY	143	2,181	2,444	89%	22%	12,450	17.5%	19.6%
County	PREBLE	6	4,476	3,075	146%	43%	15,518	28.8%	19.8%
County	SHELBY	7	4,134	844	490%	41%	16,055	25.8%	5.3%
County	UNION	31	825	803	103%	35%	7,680	10.7%	10.5%
County	WARREN	2	3,324	3,131	106%	61%	21,008	15.8%	14.9%
Heating Type	Electric Baseboard	33	1,385	2,116	65%	40%	15,908	8.7%	13.3%
Heating Type	Electric Boiler	1	143	1,988	7%	75%	4,028	3.5%	49.3%
Heating Type	Electric Furnace	13	2,974	3,907	76%	65%	24,724	12.0%	15.8%
Heating Type	Electric Heat Pump	5	4,721	5,084	93%	51%	33,182	14.2%	15.3%
Heating Type	Electric Radiant	1	1,864	1,669	112%	31%	21,672	8.6%	7.7%
Heating Type	Gas Boiler	2	365	2,738	13%	81%	5,485	6.6%	49.9%

Variable	Category	n	Model Savings	*Ex Ante* Savings	Adjusted Gross Savings Realization Rate	Relative Precision 90% Confidence Level	Pre Period NAC	Percent Savings	*Ex Ante* Percent Savings
Heating Type	Gas Furnace	218	1,791	1,986	90%	21%	10,593	16.9%	18.8%
Heating Type	Oil Boiler	1	-689	3,606	-19%	-25%	6,354	-10.8%	56.8%
Heating Type	Oil Furnace	8	2,865	1,775	161%	55%	16,943	16.9%	10.5%
Heating Type	Other - must provide notes	3	3,588	1,240	289%	93%	13,023	27.6%	9.5%
Water Heat Type	Bottle gas/propane	3	140	1,373	10%	584%	8,642	1.6%	15.9%
Water Heat Type	Electric	94	2,258	2,423	93%	26%	16,831	13.4%	14.4%
Water Heat Type	Fuel Oil	2	2,277	1,847	123%	17%	14,268	16.0%	12.9%
Water Heat Type	Utility gas	186	1,703	2,012	85%	22%	10,229	16.7%	19.7%

Residential HVAC Rebates Program Detailed Findings

Table 243 provides detailed fixed effects model results. This table includes relative precision and the lower and upper bound for the confidence interval, indicating that Cadmus can be 90% confident that the true estimate lies within that interval. The table also includes weather normalized pre-period usage (i.e. Pre Period NAC), and percent savings relative to weather normalized pre-period usage.

Table 243. Detailed Residential HVAC Program Fixed Effects Results

Measure	n	*Ex Ante* Savings	Model Savings	Relative Precision 90% Confidence Level	Lower Confidence Bound	Upper Confidence Bound	Adjusted Gross Savings Realization Rate	Pre Period NAC (kWh)	Percent Savings
ER AC 14/15 SEER	722	1,089	1,130	10%	1,018	1,242	104%	11,629	10%
ER AC 16+ SEER	977	1,246	1,440	8%	1,329	1,551	116%	11,766	12%
RP AC 14/15 SEER	53	196	362	40%	218	506	185%	11,293	3%
RP AC 16+ SEER	44	516	722	31%	496	948	140%	15,496	5%
ER HP 14/15 SEER	179	3,093	3,415	12%	2,988	3,841	110%	21,778	16%
ER HP 16+ SEER	315	3,301	2,934	11%	2,616	3,251	89%	22,062	13%
RP HP 14/15 SEER	24	964	682	28%	493	872	71%	23,096	3%
RP HP 16+ SEER	27	1,454	1,466	27%	1,064	1,867	101%	23,670	6%
ECM	266	758	714	23%	550	878	94%	11,169	10%
HPWH	38	1,297	2,138	39%	1,309	2,968	165%	22,438	6%

Table 244 presents the results of the PRISM models for HVAC, which followed the same methodology as the OPAE program. The results between the PRISM models and fixed effects models were similar in both size and precision, and this lends confidence that are estimates are precise.

Table 244. Residential HVAC Program PRISM Results

Measure	n	*Ex Ante* Savings	PRISM Savings	Relative Precision 90% Confidence Level	Lower Confidence Bound	Upper Confidence Bound	Adjusted Gross Savings Realization Rate	Pre Period NAC (kWh)	Percent Savings
ER AC 14/15 SEER	722	1,089	1,179	9%	1,071	1,286	108%	11,629	10%
ER AC 16+ SEER	977	1,246	1,532	7%	1,419	1,646	123%	11,766	13%
RP AC 14/15 SEER	53	196	390	36%	249	531	199%	11,293	3%
RP AC 16+ SEER	44	516	811	28%	581	1,042	157%	15,496	5%
ER HP 14/15 SEER	179	3,093	3,643	13%	3,181	4,105	118%	21,778	17%
ER HP 16+ SEER	315	3,301	3,140	11%	2,810	3,469	95%	22,062	14%
RP HP 14/15 SEER	24	964	694	30%	493	872	72%	23,096	3%
RP HP 16+ SEER	27	1,454	1,473	28%	1,068	1,879	101%	23,670	6%
ECM	266	758	756	22%	590	922	100%	11,169	9%
HPWH	38	1,297	2,021	44%	1,140	2,902	156%	22,438	7%

Table 245 presents the breakdown of savings between customers who received an incentive for an early replacement air conditioner and customers who received an incentive for both an AC and an ECM. All customers were modeled together with a dummy flag, indicating if whether a customer received an incentive for an ECM alongside an AC.

Table 245. ECM with AC Detailed Savings

Measure	n	*Ex Ante* Savings	Model Savings	Relative Precision 90% Confidence Level	Lower Confidence Bound	Upper Confidence Bound	Adjusted Gross Savings Realization Rate	Pre Period NAC (kWh)	Percent Savings
ACER-14/15	722	1,089	948	15%	809	1,086	87.02%	11,629	8%
ACER-16+	977	1,246	1,071	18%	880	1,261	85.95%	11,766	9%
ECMA	1,243	417	406	45%	224	587	97.32%	11,906	3%

This model indicated that ECMs installed with an AC saved approximately 406 kWh in energy savings. However, savings estimates for both the ACER 14/15 and ACER-16+ were estimated to be approximately 15% lower than the current *ex ante* estimate. Applying these savings estimates resulted in an 89% realization rate for this sub-group of measures.

The current methodology, described in Residential Heating and Cooling Rebate Program, results in an 88% realization rate for the measures. Alongside the 2016 evaluation, this provides evidence that, as a group, these measures currently saved less than claimed. The *ex ante* savings estimates, however, either fall within the confidence interval of the savings estimates or are very close.

BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of The Dayton Power and Light Company's Portfolio Status Report.	)))	Case No. 18-0742-EL-POR

Affidavit of Craig Jackson

State of Ohio)
) SS:
County of Montgomery)

I, Craig Jackson, being first duly cautioned and sworn, do hereby swear and affirm the following to the best of my knowledge and belief:

1. I have attained the age of eighteen and have personal knowledge of the matters set forth herein.

2. I am the President and Chief Executive Officer of The Dayton Power and Light Company ("DP&L"). As part of my overall responsibilities, I am responsible for ensuring DP&L's compliance with statutorily imposed energy efficiency and peak demand reduction requirements.

3. DP&L has met its statutory benchmarks for energy efficiency and peak demand reduction as set forth in the Portfolio Status Report being filed contemporaneously with this Affidavit.

FURTHER AFFIANT SAYETH NAUGHT.

Craig Jackson

Sworn to and subscribed in my presence on this 26th day of April, 2018.

Joya L Murr, Notary Public
In and for the State of Ohio
My Commission Expires May 31, 2019

Notary Public

This foregoing document was electronically filed with the Public Utilities

Commission of Ohio Docketing Information System on

5/15/2018 2:12:22 PM

in

Case No(s). 18-0742-EL-POR

Summary: Notice of the Dayton Power and Light Company's Combined Notice of Filing Portfolio Status Report and Application to Adjust Baselines electronically filed by Mr. Alan M. O'Meara on behalf of The Dayton Power and Light Company