BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Application of The Dayton Power and Light Company for Approval of Its Energy Efficiency and Peak Demand Reduction Program Portfolio Plan for 2018 through 2020	: : : : :	Case No. 17-1398-EL-POR Case No. 17-1399-EL-WVR

APPLICATION OF THE DAYTON POWER AND LIGHT COMPANY FOR APPROVAL OF ITS ENERGY EFFICIENCY AND PEAK REDUCTION PROGRAM PORTFOLIO PLAN

The Dayton Power and Light Company ("DP&L" or "the Company") hereby submits this Application seeking authority to implement the attached 2018 – 2020 energy efficiency and peak demand reduction program portfolio plan ("Program Portfolio"), pursuant to Ohio Administrative Code ("O.A.C") §4901:1-39-04.

I. OVERVIEW OF APPLICATION

1. DP&L is a public utility and electric light company as defined by Ohio Revised Code ("R.C.") §4905.02 and §4905.03(C), respectively, and an electric distribution utility ("EDU") as defined by R.C. §4928.01(A)(6).

2. R.C. §4928.66(A)(1)(a) required an EDU, starting in 2009, to "implement energy efficiency programs that achieve energy savings equivalent to at least three-tenths of one percent 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." For the plan period, the savings requirement increases "for years 2017, 2018, 2019, and 2020, one per cent of the baseline." In addition, R.C. §4928.66(A)(1)(b) requires an EDU, to "implement peak demand reduction programs designed to achieve a one per cent reduction in peak demand in 2009" and

"(i)n 2017 and each year thereafter through 2020, the utility shall achieve an additional seventy-five hundredths of one per cent reduction in peak demand."

II. BACKGROUND AND HISTORY

3. O.A.C. §4901:1-39-04 required an electric utility to propose its first energy efficiency and peak demand reduction program portfolio plan by January 1, 2010. DP&L's first Program Portfolio for 2010 through 2012, as approved by the Commission by Opinion and Order dated June 24, 2009 in Case No. 08-1094-EL-SSO, was filed pursuant to O.A.C §4901:1-39-04 in Case No. 09-1986-EL-POR on December 23, 2009, and was supplemented by its Notice of Filing Supplement to Application filed and docketed on July 15, 2010 and July 16, 2010. DP&L's first Program Portfolio was ultimately approved by the Commission by Opinion and Order dated April 27, 2011.

4. On April 15, 2013, DP&L filed its second Program Portfolio for 2013 through 2015 in Case No. 13-833-EL-POR, *et al*. The Commission approved the Stipulation and Recommendation filed by DP&L on December 4, 2013.[1] The approved Program Portfolio was to last through plan year 2015; however, with the signing of Senate Bill (S.B.) 310 on June 13, 2014, DP&L was presented with the option to either continue its current Program Portfolio through 2016 with no amendments or file a new Program Portfolio.[2] DP&L chose to continue its Program Portfolio as approved by the Commission on December 4, 2013. On June 15, 2016, DP&L filed its third Program Portfolio for program years 2017 through 2019. On December 13,

[1] Commission Opinion and Order dated December 4, 2013, in Case No. 13-833-EL-POR, *et al.*
[2] See S.B. 310, Section 6 (D).

2016, DP&L filed a Stipulation and Recommendation.[3] Consistent with that Stipulation, DP&L files this three-year plan for program years 2018 through 2020.[4]

5. DP&L is requesting that the Commission approve a total Program Portfolio budget up to the amount included in this filing, with no minimum requirement.

6. DP&L has calculated its energy efficiency savings and peak demand reduction benchmarks in accordance with the requirements of R.C. §4928.66.[5] The proposed programs within DP&L's 2018-2020 Program Portfolio provide significant opportunities for energy and cost savings for all classes of DP&L's customers, while creating lasting economic and societal benefits to both DP&L's customers and the State of Ohio.

III. OVERVIEW OF POTENTIAL PROGRAM PORTFOLIO PLAN

7. DP&L's Program Portfolio, attached as Exhibit 1, which satisfies the requirements of O.A.C. §4901:1-39-04(A), provides detail as to the proposed energy efficiency and peak demand reduction programs for which DP&L seeks Commission authorization to implement. This updated Program Portfolio seeks to build on the success of the current programs while exploring new ways to help customers save through a continuation of the previous plan's approved Pilot Program, and through the offering of additional programs as mentioned below. Like DP&L's existing plan, this plan passes the Total Resource Cost test on a portfolio basis.

8. Also attached, as Exhibit 2, is a Market Potential Study, as required by O.A.C. §4901:1-39-03(A), developed by The Cadmus Group, Inc.

[3] Stipulation and Recommendation dated December 13, 2016, in Case No. 16-649-EL-POR, *et al*.
[4] The Stipulation in Case No. 16-649-EL-POR is pending before the Commission.
[5] See *In the Matter of the Dayton Power and Light Company's Portfolio Status Report*, Case Nos. 10-0303-EL-POR, 11-1276-EL-POR, 12-1420-EL-POR, 13-140-EL-POR, 14-738-EL-POR, 15-777-EL-POR, 16-851-EL-POR, and 17-1092-EL-POR.

9. DP&L requests that the Commission authorize implementation of the following residential programs, at DP&L's discretion, some of which represent a continuation of programs currently being implemented, with the bottom five (5) representing programs that are not part of the existing Program Portfolio:

a. Efficient Products (previously Residential Lighting);

b. HVAC Equipment (previously Residential HVAC Rebates);

c. Appliance Recycling;

d. Income Eligible Efficiency (previously Low Income Affordability);

e. School Education;

f. Home Audit;

g. Behavior Change;

h. Smart Thermostats;

i. Energy Savings Kits; and

j. Multi-Family Direct Install.

10. DP&L requests that the Commission authorize implementation of the following non-residential programs, at DP&L's discretion, some of which represent a continuation of programs currently being implemented, with the fourth (d.) representing the only program that is not part of the existing Program Portfolio:

a. Rapid Rebates (Prescriptive Rebates);

b. Custom Rebates;

c. Mercantile Self-Direct Rebates; and

d. Small Business Direct Install.

11. DP&L also requests that the Commission authorize implementation of the following Cross Sector Programs, at DP&L's discretion, the first three of which are continuation of current programs:

a. Customer Education;

b. Pilot Program;

c. Transmission & Distribution Infrastructure Improvements;

d. Smart Grid;

e. Stakeholder Initiatives; and

f. Non-Programmatic Savings.

The Non-Programmatic Savings and Stakeholder Initiatives programs are not currently part of the existing Program Portfolio. Further, if during the time period of the proposed Program Portfolio, DP&L institutes Transmission and Distribution Infrastructure Improvements and Smart Grid programs, DP&L is requesting authority to count the savings generated by these initiatives pursuant to R.C. §4928.66(A)(2)(d)(i)(IV) and (II), respectively. The aforementioned Revised Code provisions permit utilities to count energy efficiency savings generated by transmission and distribution infrastructure improvements that reduce line losses and Smart Grid investment programs, provided that such programs are demonstrated to be cost-beneficial toward compliance benchmarks.

IV. SHARED SAVINGS

12. DP&L is also requesting approval of a shared savings mechanism, consistent with previous incentives and those approved for other Ohio electric utilities, that provides an after-tax net benefit of 87% to DP&L's customers and 13% to DP&L, based on the Utility Cost Test (UCT), when DP&L exceeds its energy efficiency requirements (kWh) by 15%.

13. DP&L will be eligible for shared savings if it exceeds the incremental benchmarks of R.C. §4928.66 (A)(1)(a) and (A)(1)(b) for the current year, in accordance with the following chart:

Incremental Energy Savings Achievement	Shared Savings Incentive %
≤100%	0.0%
>100%-105%	5.0%
>105%-110%	7.5%
>110%-115%	10.0%
>115%	13.0%

14. Total gross, annualized savings will be used in the shared savings calculation. The following programs will not be included in the calculation of the shared savings incentive: Mercantile Self-Direct, Residential Low Income Affordability, Pilot Program, Transmission and Distribution Infrastructure Improvements, Stakeholder Initiatives, and Smart Thermostats.

15. DP&L understands that it may only count savings for shared savings one-time (meaning there is no double counting of shared savings), and only in the year in which the savings were generated. In a year in which previous years' over-compliance is used to comply with the benchmarks, shared savings shall be based only on impacts generated in the current year.

16. DP&L may only count savings for compliance one time (meaning there is no double counting for compliance) during the plan timeframe of 2018-2020, but reserves the option of either counting any portion of over-compliance in the year of compliance, or banking any portion of over-compliance for use in connection with a subsequent

year. To reduce the cost of compliance for a future Program Portfolio, any over-compliance achieved may be carried over to the next plan.

VI. COST RECOVERY

17. Pursuant to R.C. §4928.66 and O.A.C. §4901:1-39-07, DP&L is authorized to recover the costs of its Program Portfolio to the extent it is implemented. The structure and function of the DP&L's existing cost recovery mechanism, the EER, has been approved by the Commission in DP&L's first ESP Case No. 08-1094-EL-SSO. Consistent and in accordance with R.C. §4928.66, DP&L will recover all prudently incurred costs identified in the Program Portfolio, including approved shared savings, to the extent the plan is implemented. To the extent DP&L institutes transmission and distribution infrastructure improvements or Smart Grid, the costs associated with those projects will not be included for recovery through the EER.

18. DP&L will file its EER application annually pursuant to O.A.C. §4901:1-39-07(A). DP&L will file its EER schedules, tariffs and application at the Commission within 90 days of the effective date of the tariffs. Tariffs will then be automatically effective on the filed effective date subject to a future Commission prudence audit and final reconciliation notwithstanding automatic true-up approval.

V. WAIVER REQUESTS

19. O.A.C. §4901:1-39-05(C) requires EDUs to file an annual portfolio status report addressing the performance of all of its approved energy efficiency and peak-demand reduction programs by no later than March 15th of each year. As a provision of

DP&L's last approved Program Portfolio Stipulation[6] and its pending Stipulation and Recommendation,[7] the parties agreed to DP&L's request that the filing date to comply with the above code be May 15th of each year. Moreover, the Commission granted all electric distribution utilities a waiver of O.A.C. § 4901:1-39-05(C) through 2018.[8] The extended deadline provides for additional improvement of the accuracy of the data and the evaluation of program impacts as filed in the annual report, which will also further enable the progress toward statewide efficiency goals. Therefore, DP&L respectfully requests the requirements of O.A.C.§4901:1-39-05(C) be waived each year for the duration of the Program Portfolio, and that to the extent the plan is implemented, DP&L's annual portfolio status report filing deadline be extended by two (2) months, until May 15th.

VI. CONCLUSION

20. Based upon this Application and the attached supporting materials, DP&L respectfully asks that the Commission issue an Opinion and Order that: (i) authorizes implementation of DP&L's Program Portfolio, at DP&L's discretion, finding it to be just, reasonable, and consistent with statutory requirements and Commission directives; (ii) approves the requested waiver of O.A.C.§4901:1-39-05(C), so that the annual portfolio status report is due on May 15th of each year for the duration of the Program Portfolio; and (iii) authorizes DP&L to recover all prudently incurred costs identified in the Program Portfolio, including approved shared savings, to the extent

[6] Commission Opinion and Order dated December 4, 2013 in Case No. 13-833-EL-POR, *et al.*
[7] Stipulation and Recommendation dated December 13, 2016, in Case No. 16-649-EL-POR, *et al*.
[8] *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

the plan is implemented, through DP&L's EER, finding such costs to be just and reasonable.

21. Finally, DP&L is also seeking the authority to file a new or amended Program Portfolio if there are changes in legislation during the 2018-2020 Program Portfolio period.

Respectfully submitted,

/s/ Michael J. Schuler
Michael J. Schuler (0082390)
The Dayton Power and Light Company
1065 Woodman Drive
Dayton, OH 45432
Telephone: (937) 259-7358
Facsimile: (937) 259-7178
Email: michael.schuler@aes.com
Counsel for The Dayton Power & Light Company

Dayton Power and Light

June 15

2017

2018-2020 Portfolio Plan

Table of Contents

Table of Tables

Executive Summary

In keeping with the energy efficiency goals of Ohio Senate Bill 221, DP&L launched a series of energy-efficiency programs in 2009 designed to help customers save energy and money.

DP&L believes these efforts to-date have been a success. From 2009 through 2016, DP&L's residential and business programs helped customers save 1,408,603 megawatt hours of energy,[1] or enough energy to power more than 100,000 homes for a year.

This updated portfolio plan seeks to build on the success of the current programs, help customers save, and enable DP&L to continue on a trajectory to achieve the statutory benchmarks through 2027. Included in this plan is a review of the savings potential within the DP&L service area, cost-benefit analyses, implementation plans for a balanced portfolio of energy saving programs, and an overview of DP&L's evaluation, measurement and verification approach.

In developing this updated portfolio of energy efficiency programs, DP&L had the following goals:

- Comply with Ohio's energy efficiency benchmark targets as outlined in O.R.C §4928.66(A)(1)(a) and O.R.C. §4928.66(A)(1)(b).
- Develop cost-effective programs that provide value to customers.
- Leverage current program successes and lessons learned since 2009.
- Equitably provide savings opportunities for all customer classes.
- Provide a variety of programs in which customers can participate.
- Deliver quality customer programs that promote customer satisfaction with energy efficiency.
- Promote general market transformation and education to promote energy efficiency.
- Capture savings opportunities that have been identified in the market potential study.
- Implement best practices of other successful energy efficiency programs.

[1] Actual benchmarks and results are filed in the 2016 Energy Efficiency and Demand Reduction/Response Portfolio Status Report, Case No. 17-1092-EL-POR.

- Partner with collaborative members and other utilities when possible to capture program efficiencies and reach various customer groups.

Historical Savings

Since 2013, DP&L has been implementing its programs as filed in Case No. 13-0833-EL-POR and Case No. 16-649-EL-POR. Current programs to-date are as follows:

Residential:

- Lighting
- HVAC Rebates
- Income Eligible Efficiency
- Appliance Recycling
- School Education

Business & Government:

- Prescriptive Rebates
- Mercantile
- Custom Rebates[2]

Cross Sector:

- Education and Marketing[3]
- Pilot
- Transmission and Distribution Infrastructure Improvements

[2] DP&L's Custom Rebate program includes a business audit program; partnerships with Montgomery County on its DRG program; and combined heat and power incentives.
[3] Education and Marketing includes public education and marketing campaign activities.

Portfolio Planning Process

In developing this portfolio, DP&L undertook a comprehensive approach that considered its own experience delivering energy efficiency programs, an analysis of the potential savings within DP&L's service area, programs currently being implemented by other utilities and cost effectiveness results. The final step of the process was to develop implementation plans for each program that includes a budget, projected savings and a timeline.

During the planning process, DP&L also took into account the program design criteria consistent with O.R.C. §4901: 1-39-03, which include the following:

- Benefits to customer classes and potential for broad participation
- Non-energy benefits
- Relative advantages and disadvantages of programs
- Bundling measures for cost effectiveness
- Addressing market barriers and market transformation
- Magnitude of energy and demand savings
- Equity among customer classes
- Integration with other utility programs
- Engaging supply chain and leveraging partners

DP&L has engaged its stakeholder groups since it launched programs in 2009. Two of DP&L's program implementers are collaborative members: Ohio Partners for Affordable Energy and People Working Cooperatively. DP&L has also worked directly with collaborative members, such as the Ohio Hospital Association and the Ohio Manufacturers' Association, to market energy efficiency and DP&L's programs to their members. In addition, DP&L worked with the Ohio Environmental Council to organize a combined heat and power workshop for customers and offer the first CHP incentive program in the state.

With regard to the portfolio plan, the energy efficiency collaborative stakeholder group is very familiar with DP&L's current and continuing suite of programs. Since the programs began in 2009, the collaborative has met quarterly and is provided with a program update at each meeting. Additional meeting topics include bidding energy efficiency into PJM, other utility programs and their potential value, the benefits of combined heat and power, and pilot programming.

Summary of 2018 to 2020 Plan

Presented below in Table 1 is a summary of the program energy and demand savings for the 2018-2020 portfolio plan. It should be noted that savings values have not been calculated for the pilot program, T&D infrastructure programs, or savings associated with potential Smart Grid initiatives. Savings for these programs will be calculated

through evaluation, measurement and verification activities and submitted with the annual portfolio status reports.

Programs	Energy (MWH) Savings				Demand (MW) Savings			
Residential Programs	**2018**	**2019**	**2020**	**3-Year Total**	**2018**	**2019**	**2020**	**3-Year Total**
Efficient Products	47,467	47,467	47,467	142,401	7.9	7.9	7.9	23.7
HVAC Equipment	7,755	7,755	7,755	23,265	1.4	1.4	1.4	4.2
Appliance Recycling	3,410	3,410	3,410	10,230	0.8	0.8	0.8	2.4
Income Eligible Efficiency	1,217	1,217	1,217	3,651	0.2	0.2	0.2	0.5
School Education	3,846	3,846	3,846	11,538	0.3	0.3	0.3	0.9
Home Audit	1,408	1,690	2,028	5,126	0.3	0.3	0.4	1.0
Behavior Change	6,700	15,400	18,700	40,800	1.9	2.7	3.2	7.8
Energy Savings Kits	3,881	3,881	3,881	11,643	0.4	0.4	0.4	1.2
Multi-Family Direct Install	3,383	3,424	3,451	10,258	0.7	0.7	0.7	2.1
Smart Thermostats	2,075	2,075	2,075	6,225	0.3	0.3	0.3	0.9
Residential Total	81,142	90,164	93,830	265,136	14.1	14.9	15.4	44.4
Business Programs	**2018**	**2019**	**2020**	**3-Year Total**	**2018**	**2019**	**2020**	**3-Year Total**
Rapid Rebates (Prescriptive)	74,777	77,320	79,991	232,088	11.9	12.0	12.1	36.0
Custom	23,190	29,216	35,492	87,898	4.4	5.7	7.2	17.3
Small Business Direct Install	5,000	5,000	5,000	15,000	1.3	1.3	1.3	3.9
Mercantile Self-Direct	5,937	4,750	4,750	15,437	1.4	1.1	1.1	3.6
Business Total	108,904	116,286	125,232	350,422	19.0	20.1	21.7	60.8
Cross-Sector Programs	**2018**	**2019**	**2020**	**3-Year Total**	**2018**	**2019**	**2020**	**3-Year Total**
Customer Education and Marketing	-	-	-	-	-	-	-	-
Pilot Program	-	-	-	-	-	-	-	-
Stakeholder Initiatives	-	-	-	-	-	-	-	-
T&D Infrastructure Improvement	-	-	-	-	-	-	-	-
Smart Grid	-	-	-	-	-	-	-	-
Non-Programmatic Savings	71,971	57,577	46,061	175,609	16.2	12.9	10.3	39.4
Cross-Sector Total	71,971	57,577	46,061	175,609	16.2	12.9	10.3	39.4
Other	**2018**	**2019**	**2020**	**3-Year Total**	**2018**	**2019**	**2020**	**3-Year Total**
Evaluations, Measurement & Verification	-	-	-	-	-	-	-	-
Other Total	-	-	-	-	-	-	-	-
PLAN TOTAL	**262,017**	**264,027**	**265,123**	**791,167**	**49.3**	**47.9**	**47.4**	**144.6**

Table 1 Energy (MWh) and Demand (MW) Savings for 2018-2020 Plan

Presented below in Table 2 is a summary of the program costs for the 2018-2020 portfolio plan. Costs include incentives, implementation vendor charges and DP&L administrative costs. Implementation vendors either have been or will be selected through a request for proposal (RFP) process.

Programs	Program Costs			
Residential Programs	**2018**	**2019**	**2020**	**3-Year Total**
Efficient Products	$ 3,223,155	$ 3,217,175	$ 3,216,769	$ 9,657,099
HVAC Equipment	$ 1,303,023	$ 1,316,731	$ 1,330,862	$ 3,950,616
Appliance Recycling	$ 627,675	$ 628,870	$ 630,112	$ 1,886,657
Income Eligible Efficiency	$ 1,292,086	$ 1,293,580	$ 1,295,134	$ 3,880,800
School Education	$ 385,988	$ 394,042	$ 402,490	$ 1,182,520
Home Audit	$ 1,214,101	$ 1,327,722	$ 1,509,718	$ 4,051,541
Behavior Change	$ 576,471	$ 577,851	$ 579,285	$ 1,733,607
Energy Savings Kits	$ 399,662	$ 400,558	$ 401,481	$ 1,201,701
Multi-Family Direct Install	$ 648,358	$ 656,622	$ 662,372	$ 1,967,352
Smart Thermostats	$ 600,000	$ 600,900	$ 601,827	$ 1,802,727
Residential Total	$ 10,270,519	$ 10,414,051	$ 10,630,050	$ 31,314,620
Business Programs	**2018**	**2019**	**2020**	**3-Year Total**
Rapid Rebates (Prescriptive)	$ 7,575,108	$ 7,775,457	$ 8,062,584	$ 23,413,149
Custom	$ 3,910,255	$ 4,396,854	$ 4,907,728	$ 13,214,837
Small Business Direct Install	$ 987,693	$ 1,027,201	$ 1,027,729	$ 3,042,623
Mercantile Self-Direct	$ 197,547	$ 181,442	$ 184,256	$ 563,245
Business Total	$ 12,670,603	$ 13,380,954	$ 14,182,297	$ 40,233,854
Cross-Sector Programs	**2018**	**2019**	**2020**	**3-Year Total**
Customer Education and Marketing	$ 1,628,418	$ 1,628,419	$ 1,628,420	$ 4,885,257
Pilot Program	$ 573,528	$ 594,876	$ 620,309	$ 1,788,713
Stakeholder Initiatives	$ 645,000	$ 645,000	$ 645,000	$ 1,935,000
T&D Infrastructure Improvement	$ -	$ -	$ -	$ -
Smart Grid	$ -	$ -	$ -	$ -
Non-Programmatic Savings	$ 310,257	$ 248,205	$ 198,564	$ 757,026
Cross-Sector Total	$ 3,157,203	$ 3,116,500	$ 3,092,293	$ 9,365,996
Other Costs	**2018**	**2019**	**2020**	**3-Year Total**
Evaluations, Measurement & Verification	$ 1,031,523	$ 1,066,532	$ 1,108,243	$ 3,206,298
Other Costs Total	$ 1,031,523	$ 1,066,532	$ 1,108,243	$ 3,206,298
PORTFOLIO TOTAL	**$ 27,129,848**	**$ 27,978,037**	**$ 29,012,883**	**$ 84,120,768**

Table 2 Summary of Program Costs for 2018-2020 Plan

Evaluations, Measurement & Verification

Effective evaluation, measurement and verification (EM&V) play an important role in a quality energy efficiency portfolio. EM&V activities ensure that reported savings are verified, energy and demand calculations are valid, program delivery is effective, customers are satisfied and the overall portfolio is cost-effective.

To date, DP&L's evaluation efforts, in conjunction with its independent evaluator, The Cadmus Group, have been received positively by the state's independent evaluator. In its review of the 2011 program year evaluations, the state's independent evaluator, Evergreen Economics, stated "we found that the Cadmus evaluation report adheres to industry best practices for evaluating DP&L's program offerings. The report is of high quality and provides the details necessary to substantiate the savings estimates provided. We have a high level of confidence in the evaluation research." [4] DP&L received similar comments in Evergreen's 2012 and 2013 program year evaluation

[4] PUCO Case No. 13-1027-EL-UNC, Evergreen Economics "Report of the Ohio Independent Evaluator," page 30.

reports. DP&L is pleased with this positive feedback and believes it is establishing a solid record of program implementation accompanied by an appropriate level of EM&V. Going forward, DP&L plans to follow the same EM&V process that resulted in the positive review by the independent statewide evaluator.

Evaluation activities performed by DP&L's independent evaluator include impact evaluations, process evaluations, tracking system review, savings verifications and cost effectiveness calculations. In addition, if a state independent evaluator is appointed to evaluate the 2018-2020 program years, DP&L will coordinate EM&V activities with that party. This will include providing the state's evaluator with an annual evaluations plan for review, survey instruments, and notification of pending site visits. DP&L believes this cooperative approach improves the overall quality and effectiveness of evaluations and plans to continue to work with the statewide evaluator in the future.

Cost Effectiveness

In keeping with PUCO rules, DP&L used the Total Resource Cost Test (TRC) as the overall test of the portfolio's cost effectiveness and as a guide to determine the inclusion of programs in the portfolio. Overall, the portfolio is cost-effective as measured by the TRC. In addition, cost effectiveness calculations were performed for the Utility Cost Test (UCT), the Ratepayer Impact Measure (RIM), and the Participant Cost Test (PCT).

For all tests, a program is cost effective when the present value of the benefits is greater than the present value of the costs. What varies among the different cost effectiveness tests is which benefits and costs are included. Using the benefit/cost ratio, an offering is cost effective when the ratio is greater than one.

$$\frac{B}{C} ratio = \frac{Present\ Value\ of\ Benefits}{Present\ Value\ of\ Costs} \geq 1$$

Total Resource Cost Test (TRC): The TRC measures the benefits of avoided supply costs over the lifecycle incremental costs of the energy efficiency measures and program administrative costs. Unlike the UCT, the TRC considers the cost of the measure, not just the utility incentive cost.

Utility Cost Test (UCT): The UCT is a valuation of the costs and benefits from the perspective of the utility. It is measured by comparing the value of the supply-side benefits to the incentive and administrative costs associated with the energy efficiency programs. Unlike the TRC, the UCT considers incentive costs as opposed to incremental measure costs.

Ratepayer Impact Measure (RIM): The RIM is a valuation of the net benefits of the energy efficiency programs from the perspective of the nonparticipants. It is measured by comparing supply-side benefits to the costs of the programs, in terms of utility incentive costs, utility administrative costs and electric monetary savings.

Participant Cost Test (PCT): The PCT values the benefits of the programs from the perspective of program participants. It measures the electric monetary savings of the participants as compared to the measures costs net of utility incentives.

Table 3 is a summary of cost effectiveness test benefit/cost ratios for all proposed programs and for the overall portfolio.

Residential Programs	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Efficient Products	6.38	9.48	12.05	0.54
HVAC Equipment	0.83	4.47	1.52	0.50
Appliance Recycling	2.04	2.01	-	0.37
Income Eligible Efficiency	0.43	0.40	-	0.22
School Education	2.76	2.63	-	0.35
Home Audit	0.60	0.54	-	0.26
Behavior Change	3.35	3.35	-	0.35
Energy Savings Kits	4.48	4.04	-	0.43
Multi-Family Direct Install	2.20	2.02	-	0.41
Smart Thermostats	0.55	1.52	1.53	0.35
Residential Total	**2.57**	**4.39**	**6.65**	**0.48**
Business Programs	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Rapid Rebates (Prescriptive)	2.22	5.21	3.36	0.64
Custom	1.54	3.96	2.36	0.66
Small Business Direct Install	2.43	3.51	3.49	0.68
Mercantile Self-Direct	1.56	13.26	2.21	0.69
Business Total	**1.97**	**4.79**	**2.99**	**0.65**
Cross Sector	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Non-Programmatic Savings	2.64	146.12	4.02	0.60
	Total Resource Cost Test (TRC)	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
PLAN TOTAL*	**2.16**	**5.25**	**4.06**	**0.57**

*Costs in plan total include Customer Education & Marketing, Pilot, Stakeholder Initiatives and EM&V.

Table 3 Summary of Cost Effectiveness Scores

Introduction

In keeping with the energy efficiency goals of Ohio Senate Bill 221, DP&L launched a series of energy efficiency programs in 2009 designed to help customers save energy and money. Program offerings are designed to serve all customer classes, including residential, business and cross sector.

In accordance with O.R.C. §4901: 1-39-04, DP&L is submitting this three-year energy efficiency portfolio plan. This plan seeks to build on the success of the current programs executed under the portfolio plan filed in Case No. 13-833-EL-POR and continued in Case No. 16-0649-EL-POR, while exploring new ways to help customers save. Included in this plan is a review of the savings potential within the DP&L service area, cost-benefit analyses, implementation plans for a balanced portfolio of energy saving programs, and an overview of DP&L's evaluation, measurement and verification approach.

Plan Goals

In developing this updated portfolio of energy efficiency programs, DP&L had the following goals:

- Comply with Ohio's energy efficiency benchmark targets as outlined in O.R.C §4928.66(A)(1)(a) and O.R.C. §4928.66(A)(1)(b).
- Develop cost-effective programs that provide value to customers.
- Leverage current program successes and program learning since 2009.
- Equitably provide savings opportunities for all customer classes.
- Provide a variety of programs in which customers can participate.
- Deliver quality customer programs that promote customer satisfaction with energy efficiency.
- Promote general market transformation and education to promote energy efficiency.
- Capture savings opportunities that have been identified in the market potential study.
- Implement best practices of other successful energy efficiency programs.
- Partner with collaborative members and other utilities when possible to capture program efficiencies and reach various customer groups.

Portfolio Plan Development

This section outlines various steps that were taken and elements that were considered during the development of the portfolio plan including the market potential update, various program design criteria, stakeholder participation and alignment with other utility programs.

Market Potential Study

In accordance with O.R.C. §4901: 1-39-03, DP&L commissioned The Cadmus Group to conduct a market potential study. The study analyzed the levels of technical, economic, and achievable potential in DP&L's service territory for the time period starting in 2018 through 2027. Study results inform energy-efficiency program planning and program design by showing the quantity of available potential and how it is distributed by sector, market segment, and end use. The complete study is included as Appendix A.

Program Design Criteria

In designing the energy efficiency programs and portfolio as a whole, DP&L took into account the criteria consistent with O.R.C. §4901: 1-39-03, which include the following:

Relative Cost Effectiveness

The primary test used to determine the overall cost effectiveness of the portfolio was the total resource cost test (TRC). Although individual programs are not required to be cost effective, DP&L used the TRC to determine program cost effectiveness as well. The relative cost effectiveness of programs was one of the criteria used in determining the programs to include in the portfolio, although not the only criteria. Other program design criteria include the additional criteria listed in this section.

In addition to the TRC, DP&L also calculated the utility cost test (UCT), the ratepayer impact test (RIM) and the participant cost test (PCT) at the program and portfolio level.

A further explanation of the cost effectiveness tests and test data are included in the cost effectiveness section of this plan.

Benefit to All Members of a Customer Class & Potential for Broad Participation

DP&L considered the breadth of potential participation within a customer class. A broader level of potential participation within a customer class provides equity and promotes higher levels of savings.

Magnitude of Energy and Demand Savings

The magnitude of energy and demand savings was taken into account in developing a portfolio that would enable DP&L to continue on a trajectory to achieve the statutory benchmarks through 2027. The magnitude of energy and demand savings was also taken into account to calculate the cost effectiveness tests, since the greater the

savings the greater the benefits. Estimated energy and demand savings are included in each program plan.

Non-Energy Benefits

As stated in O.R.C. §4901: 1-39-04, DP&L's portfolio must be cost effective but individual programs need not be. In accordance with this rule, DP&L considered non-energy benefits beyond cost effectiveness when designing its portfolio. Non-energy benefits include assisting income eligible groups reduce utility arrears, creating a balanced portfolio that can benefit all customer classes as well as the additional design criteria items listed in this section.

Equity Among Customer Classes

DP&L's portfolio plan seeks to provide equity among customer classes by including programs that can benefit all customer classes, including income eligible, residential non-heating, residential heating, commercial, industrial and governmental.

Relative Advantages/Disadvantages of Programs

In evaluating programs for inclusion in the portfolio plan, DP&L considered the relative advantages and disadvantage of programs. Advantages and disadvantages considered included potential savings, cost effectiveness, past program successes, and the additional criteria listed in this section.

Integration with Other Utilities' Programs

DP&L currently implements its school education program in conjunction with Vectren, the local gas distribution utility. DP&L has and will continue to integrate programs with other utilities as opportunities arise.

Bundling Measures for Cost Effectiveness

DP&L considered cost effectiveness and developed a TRC score for each program. Programs bundle multiple measures together to create cost effective programs, even though the cost effectiveness of measures within a program varies. Likewise, at the portfolio level, programs are bundled together to provide an overall cost effective portfolio, even though a specific program may not be cost effective.

Engaging Supply Chain, Leveraging Partners

DP&L programs currently engage the supply chain and leverage partners in program delivery. This includes working with lighting manufacturers, area retailers, HVAC contractors and distributors, community action agencies, and commercial and industrial distributors and contractors. These partners are a critical component of the success of the programs. This portfolio plan seeks to continue and build on this success.

Addressing Market Barriers or Failures, Market Transformation

In developing program implementation plans, DP&L considered the program's potential for addressing market barriers or failures in order to deliver energy efficiency to customers. DP&L programs work to overcome these barriers, and transform markets, through economic incentives as well as promotion and education.

Stakeholder Participation

DP&L engaged its stakeholder group with the adoption of its first energy efficiency portfolio plan and has held quarterly meetings of the stakeholder group since it launched its programs in 2009. Meeting topics include updates on program performance, expenditures, evaluation results, program modifications and other topics as requested by collaborative members. In addition, two of DP&L's program implementers are collaborative members: Ohio Partners for Affordable Energy and People Working Cooperatively.

DP&L also works with its collaborative members outside of the formal meeting process as requested. For instance, in 2015 DP&L coordinated a combined heat and power customer workshop with the Ohio Environmental Council.

Members of the stakeholder group, also known as the energy efficiency collaborative, include representatives of:

Environmental Law and Policy Center
Industrial Energy Users – Ohio
Ohio Environmental Council
Ohio Manufacturers' Association
Public Utilities Commission of Ohio
Ohio Energy Group
Ohio Consumers' Counsel
Ohio Advanced Energy Economy
Ohio Hospital Association
Ohio Partners for Affordable Energy
People Working Cooperatively
Interstate Gas Supply
The Kroger Company

With regard to the portfolio plan, the energy efficiency collaborative is very familiar with DP&L's current and continuing suite of programs. The Collaborative is provided with a program update at each meeting. These include pilot programs, combined heat and power, bidding into PJM and shared savings. In addition, informal discussions have occurred about other utility programs and their potential value, such as behavior modification.

Alignment of Programs with Other Utilities

DP&L worked with other utilities in implementing its previous portfolio plans and will continue to do so as opportunities present themselves to create program efficiencies and enhance customer service.

At the suggestion of the energy efficiency collaborative, DP&L and Vectren have worked together to deliver a school education program that addresses both electric and gas savings. DP&L and Vectren share a number of common customers in the Dayton area, and this combined program creates efficiencies in program delivery and increases the quality of the program for teachers and students alike.

In the past, DP&L and Vectren have worked jointly with the University of Dayton to deliver commercial building assessments at no cost to the customer.

In addition to these programs, DP&L communicates with the other utilities in the state to learn about best practices, other utility programs and common challenges. Beyond Ohio, DP&L is a member of the Midwest Energy Efficiency Alliance (MEEA) and participates in the organization's information-sharing efforts. DP&L is also a member of the Association of Energy Service Professionals (AESP) and the DesignLights Consortium™, and has been an ENERGY STAR Partner since 2009.

Residential Programs

Programs Overview

The following pages contain plans for programs offered to residential customers. These plans are intended to be general implementation guidelines as opposed to specific and detailed operating plans. DP&L has learned through its previous experience that a level of implementation flexibility needs to be maintained to allow for necessary program adjustments.

Expected budgets, participation, and savings have been developed based on past experience, best practices, and implementation vendor projections to demonstrate the expected size and scope of each program. Actual results may vary depending on factors such as customer acceptance, product and technological innovations, changing standards and codes, and evaluation practices.

Likewise, the evaluation plans are intended to provide an overview of the evaluation, measurement, and verification activities that will most likely occur over the three-year portfolio plan period. Detailed evaluation plans will be developed each year to ensure evaluations are following most current evaluation protocols and incorporate any new objectives to help administer the programs more effectively.

Additional information regarding the past implementation and evaluation of existing programs may be found in DP&L's annual energy efficiency and demand reduction/response portfolio status reports.[5]

The following are the proposed residential customer programs:

- Efficient Products – Expanded Program
- HVAC Equipment – Existing Program
- Appliance Recycling – Existing Program
- Income Eligible Efficiency – Existing Program
- School Education – Existing Program
- Home Audit– New Program
- Behavior Change – New Program
- Energy Savings Kits – New Program
- Multi-Family Direct Install – New Program
- Smart Thermostats – New Program

[5]The most recent portfolio status report is PUCO Case No. 17-1092-EL-POR.

Residential Efficient Products

Program Description

The Residential Efficient Products program offers incentives for the purchase of energy efficient residential measures, like lighting and appliances. The program will be offered in two ways: 1) as an upstream, manufacturer buy-down of efficient products, like LED light bulbs, sold at the retail level and 2) as an online/mail-in rebate program for qualifying products purchased by the customer. The program, an expansion of the existing Residential Lighting program, will increase the number and variety of energy-efficient products sold by providing incentives to decrease consumer costs. The program increases consumer awareness and acceptance of energy-efficient products and their benefits. Throughout the duration of the portfolio, DP&L will continue to evaluate the addition of efficient products as well as program delivery mechanisms.

Program Objectives

The goal of this program is to sell 3.5 million energy-efficient light bulbs and 30,000 energy-efficient appliances and save approximately 142,401 MWH of energy and 23.7 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

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

Program Duration

The Efficient Products program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Efficient Light Bulbs	1,165,000	1,165,000	1,165,000	3,495,000
Efficient Appliances	9,973	9,973	9,973	29,919
Total Efficient Products	**1,174,973**	**1,174,973**	**1,174,973**	**3,524,919**

Program Participation Requirements

Intended program participants are residential customers of DP&L that purchase a qualified efficient product from a retail channel.

Incentives

Incentives may be offered in the form of a discount at the register at the time of purchase or in the form of a rebate check or prepaid credit card mailed to the participating customer's home. The decreased cost along with the ease of participation will contribute to influencing customer choice of efficient products purchased.

Marketing Approach

Marketing efforts will include a combination of in-store signage and mass media communications. Marketing materials will promote not only the incentive available to customers but the overall savings in energy costs from switching to efficient products. In-store, point-of-purchase materials will educate the customer at the time of the purchasing decision. To create general program awareness, mass communications may include radio, print, and web ads, which have been utilized successfully in previous program years.

This program also lends itself well to events at participating retail outlets. These events generate awareness, allow program staff to educate customers one-on-one, and increase purchases of efficient products.

Other marketing tactics may include bill stuffers, web pages, and presence at community events.

Implementation Approach

DP&L and implementation partners will negotiate discounts with light bulb manufacturers, establish partnerships with retailers, oversee the implementation of cooperative advertising and in-store signage, audit retail outlets to confirm appropriate program policies are being implemented, and track the number of efficient products purchased. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	47,467	47,467	47,467	142,401
Summer Peak Demand (MW)	7.9	7.9	7.9	23.7

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$2,280,770	$2,251,970	$2,251,970	$6,784,710
Vendor & Administrative	$942,385	$965,205	$964,799	$2,872,389
Total	**$3,223,155**	**$3,217,175**	**$3,216,769**	**$9,657,099**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	$5,703,780	$4,200,464	$2,995,621	$12,899,865

Market Transformation Activities

The Residential Efficient Products program addresses two primary market barriers that deter customers from switching to efficient products: lack of awareness and knowledge of efficient products, and upfront cost. Through this program, DP&L will communicate the energy and cost-saving benefits of energy-efficient residential products as well as the variety of efficient product options available. In addition, program staff will educate customers about how to select efficient light bulbs, in particular, considering lumens and degrees Kelvin as opposed to simply wattage. This is of particular importance as lighting standards continue to evolve and the wattage of common and familiar light bulbs is reduced.

The incentive provided will help reduce the upfront cost for customers and facilitate purchases of efficient products. The ultimate goal for this program is to create customer demand for efficient products and move the market.

EM&V Plan

The evaluation approach for Residential Efficient Products may include: review of the participant database, a review of secondary sources and TRM savings calculations, surveys, on-site product inventory, and a cost-effectiveness analysis. The participant database is maintained by the implementation vendor and includes information such as bulb types, package size, wattage, number of packages shipped, appliance type, and appliance model number. The information will be reviewed for accuracy and reasonableness. The Ohio TRM has been the primary source for calculating savings. However, secondary sources have been referenced and utilized as needed. For example, past evaluation activities have included surveys, on-site product inventory and hours of use metering with a randomly selected sample of DP&L's residential population. These data sources provided information such as customer awareness of

efficient products, customer satisfaction and barriers to adoption, penetration and saturation of efficient products. Similar surveys will be utilized in future program years if needed.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	6.38
Utility Cost Test (UCT)	9.48
Participant Cost Test (PCT)	12.05
Rate Impact Measure (RIM)	0.54

Residential HVAC Equipment

Program Description

The Residential HVAC Equipment program offers rebates for the installation of new or replacement, high efficiency heating and cooling equipment. The objectives are to increase consumer awareness of energy-efficient products and their benefits as well as motivate customers to purchase efficient HVAC equipment that goes above and beyond the current minimum standard for efficiency.

Program Objectives

The goal of this program is to provide rebates for 21,615 new efficient HVAC products and save approximately 23,265 MWH of energy and 4.2 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

Intended program participants are homeowners or landlords purchasing new or replacement HVAC equipment 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.

Program Duration

The Residential HVAC Equipment program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participation (Units)				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Central Air Conditioners	2,042	2,042	2,042	6,126
Air Source Heat Pumps	871	871	871	2,613
Ground Source Heat Pumps	171	171	171	513
Ductless Mini-Splits	116	116	116	348
Electronically Commutated Motors	1,335	1,335	1,335	4,005
Thermostats	2,655	2,655	2,655	7,965
Heat Pump Water Heaters	15	15	15	45
Total HVAC Rebates	**7,205**	**7,205**	**7,205**	**21,615**

Program Participation Requirements

Customers must purchase qualifying units through participating HVAC contractors. The customer will receive a rebate from DP&L. Throughout the duration of the portfolio, DP&L will continue to evaluate the addition of efficient HVAC measures as well as program delivery mechanisms.

Incentives

HVAC incentives will be offered in the form of a rebate from DP&L. The decreased cost along with the ease of participation will contribute to influencing customer decisions to move forward with the efficient system installation.

Marketing Approach

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

Contractor efforts will be supplemented with direct consumer marketing. Materials will communicate the available discount as well as the benefits of energy efficient HVAC systems. Marketing tactics may include bill stuffers, web pages, mass media advertising, and presence at community events.

Implementation Approach

DP&L and its implementation partner(s) will establish and maintain a participating retailer and contractor network, oversee the implementation of cooperative advertising, audit contractor paperwork, and track the number of rebates issued. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	7,755	7,755	7,755	23,265
Summer Peak Demand (MW)	1.4	1.4	1.4	4.2

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	$856,595	$856,595	$856,595	$2,569,785
Vendor & Administrative	$446,428	$460,136	$474,267	$1,380,831
Total	**$1,303,023**	**$1,316,731**	**$1,330,862**	**$3,950,616**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	$6,601,108	$6,601,108	$6,601,108	$19,803,324

Market Transformation Activities

The upfront cost required to purchase a new HVAC system is a barrier for customers. The incremental cost required to purchase a system with an efficiency rating beyond the minimum code is an additional barrier for customers. This program helps ease the cost burden by providing a financial incentive. Since the incentive is only provided for high-efficiency systems, the program is more effective when paired with messaging regarding the energy and cost savings benefits of an efficient HVAC system. Because HVAC contractors work directly with DP&L customers, a goal of the program is to work closely with contractors on how to clearly communicate and properly sell high efficiency systems.

EM&V Plan

The impact evaluation approach for the Residential HVAC Rebate program will include participant billing analysis, engineering calculations and secondary sources, program database review and cost-effectiveness analysis. Savings will be calculated using a combination of billing analyses, engineering calculations, secondary sources and the Ohio TRM. The program database will be reviewed for input accuracy and completeness of data.

The general process evaluation approach will consist of: staff interviews, participant surveys, and/or trade ally surveys (as needed). Staff interviews will focus on program processes and procedures, changes to program design if applicable, training opportunities with customers and contractors, program successes to date and future program challenges.

In the past, surveys targeting stratified samples of program participants were conducted to assess how customers learned about the program, satisfaction with program processes and incentive levels, general information regarding the functionality of replaced equipment, and motivations for replacing existing equipment. Similarly, surveys with participating contractors have been used to understand how well the program is working for their company, their insights into why customers are purchasing high-efficiency equipment, information regarding equipment replaced, and typical business practices. Moving forward participant and trade ally surveys may be used to

capture similar information or incorporate new research objectives to help inform program planning as needed.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	0.83
Utility Cost Test (UCT)	4.47
Participant Cost Test (PCT)	1.52
Rate Impact Measure (RIM)	0.50

Residential Appliance Recycling

Program Description

The Residential Appliance Recycling program is designed to promote the retirement and recycling of inefficient appliances from households by offering an incentive for turning in working equipment. Appliances are picked up directly from customers' homes and are transported to a facility for recycling. The targeted appliances are refrigerators, freezers, room air conditioners and dehumidifiers, but DP&L may include or exclude appliances as appropriate. Participating customers may also be offered a free energy savings kit when their appliance is picked up.

Program Objectives

The goal of this program is to retire 11,052 working appliances and save approximately 10,230 MWH of energy and 2.4 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

The Residential Appliance Recycling program is targeted for all DP&L residential customers with working inefficient appliances. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier. Business customers with qualifying units are eligible to participate in this program. All costs for business customer pick-ups will be appropriately charged to the non-residential energy efficiency rider.

Program Duration

The Residential Appliance Recycling program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Inefficient Refrigerators and Freezers	3,101	3,101	3,101	9,303
Other Appliances	583	583	583	1,749

Program Participation Requirements

Intended program participants are residential and business customers of DP&L who own appliances. Appliances must be standard-sized residential units. Refrigerators

and freezers will be picked up from any location in the home, including the basement, but there must be a clear path of access. To prove there is energy to be saved, appliances must be plugged in and in working condition at the time of the pick-up.

Incentives

Incentives will be distributed to the participating customer. A variety of incentive distribution methods may be utilized including check, prepaid credit card, or digital credit card.

Marketing Approach

Marketing materials will communicate the incentive available to customers, the convenience of the free pickup, and the long-term energy savings potential from discontinuing the use of an old, inefficient refrigerator or freezer. Promotions will also communicate the environmental benefit of recycling appliance materials and properly disposing of ozone-destroying toxins. Marketing tactics may include bill stuffers, web pages, mass media advertising, and presence at community events, all with the goal of increasing program awareness and customer participation.

Implementation Approach

DP&L will work with an implementation partner that will complete all details of the process including scheduling appointments, picking up qualifying units, and processing payments to participating customers. The implementation vendor will also be responsible for properly deconstructing appliances as well as recycling and disposal of appliance components. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	3,410	3,410	3,410	10,230
Summer Peak Demand (MW)	0.8	0.8	0.8	2.4

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$222,490	$222,490	$222,490	$667,470
Vendor & Administrative	$405,185	$406,380	$407,622	$1,219,187
Total	**$627,675**	**$628,870**	**$630,112**	**$1,886,657**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

Getting rid of an old refrigerator or freezer can be challenging. Knowing where to take the appliance for recycling is the first hurdle. Then, there are often costs and transportation required. Due to the challenges, many old inefficient appliances simply move to the basement or garage and become second refrigerators or freezers in the home. The appliance recycling program addresses these barriers, providing an easy, no-cost way for customers to dispose of their old appliance. It also provides an incentive payment to customers to encourage them to take action and schedule a pick-up.

EM&V Plan

Evaluations for Appliance Recycling programs differ from most demand side management programs in that savings are incentivized by removing an operable but inefficient measure, rather than rebating a more efficient one. The impact evaluation approach will include a program database review, use of a previously developed regression model to estimate use of removed units, a participant survey, and a cost-effectiveness analysis. Data tracking will be assessed for quality. Participant surveys will be conducted primarily to develop a part-use factor which will then be applied to the estimated use through the regression model. The participant survey will also determine satisfaction, general energy efficiency awareness and performance of implementation vendor.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.04
Utility Cost Test (UCT)	2.01
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.37

Residential Income Eligible Efficiency

Program Description

The Residential Income Eligible Efficiency program is designed to identify and implement energy efficiency measures for qualifying homes, thereby reducing the homeowners' electric bill. Home energy audits and inspections will be conducted and cost-effective efficiency measures will be installed. A limited number of health and safety measures may also be addressed through the program.

Program Objectives

The goal of this program is to impact approximately 1,893 homes and save approximately 3,650 MWH of energy and 0.48 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

This program is available to income eligible customers. All qualifying customers taking delivery service from DP&L are eligible for this program, regardless of their choice of generation supplier.

Program Duration

The Residential Income Eligible Efficiency program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Homes Impacted	631	631	631	1,893

Program Participations Requirements

The program is available to income eligible participants and/or who are qualified 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.

Incentives

Energy-efficient measures will be installed in customers' homes, at no charge. Property landlords may be required to pay for a portion of the measures installed.

Marketing Approach

Participant acquisition program marketing is primarily performed by implementation partners and agencies. As a result, this program requires less direct customer marketing. However, DP&L may offer promotional information to implementation partners and agencies for distribution to participants. Messages will focus on increasing consumer awareness of the services available to them as well as the long-term benefits of energy efficiency.

Implementation Approach

DP&L will work with an implementation partner that will perform home energy audits and the installation of qualified, energy-efficient measures. The implementation partner will ensure that all services, materials, and supplies are of good quality and installed in a professional, workmanlike way, and that all auditors and contractors are trained and certified to complete energy efficiency work. The implementation partner will track the quantity and type of measures installed. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	1,217	1,217	1,217	3,651
Summer Peak Demand (MW)	0.16	0.16	0.16	0.48

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$997,891	$997,891	$997,891	$2,993,673
Vendor & Administrative	$294,195	$295,689	$297,243	$887,127
Total	**$1,292,086**	**$1,293,580**	**$1,295,134**	**$3,880,800**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

Income eligible customers often live in inefficient homes in need of upgrades. As a result, energy bills are high and homes are uncomfortable. However, due to financial constraints, customers are often unable to pay their bills or pay for the upgrades needed to reduce energy consumption. By providing no-cost services to eligible customers, this program reduces the homeowners' electric bills and saves them money. The program has the secondary benefit of reducing customer arrearages, which can help save money for all customers.

EM&V Plan

The impact evaluation approach for the Residential Income Eligible Efficiency program will include the following components as needed: engineering analysis, program database review, participant surveys, on-site measure and quality verification and cost-effectiveness analysis. Savings will be calculated based on engineering analyses, data from other sources as well as information from the Ohio TRM. The program database will be reviewed for irregularities in data collection and to ensure that all data needed for evaluation is being collected.

The process evaluation will include participant surveys to collect data regarding participant satisfaction, and document measure installation as well as some potential non-energy benefits. In the past, the income eligible evaluation included in-depth surveys with agencies and program staff. Moving forward similar in-depth interviews will be conducted with some or all interested program stakeholders.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	0.43
Utility Cost Test (UCT)	0.40
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.22

Residential School Education

Program Description

The Residential 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 and training for teachers. Additional educational events and opportunities, like the Energy Fair, are offered to schools and students throughout the year. This program may be delivered jointly with the local gas company in order to educate students about using both gas and electricity efficiently. Kit contents may include:

- LEDs
- Furnace filter whistle
- LED night light
- Foam weather-strip
- Energy efficient showerhead
- Bathroom sink aerator
- Kitchen sink aerator
- Hot water temperature card
- Energy use gauge thermometer
- Door sweep
- Energy savers booklets
- Flow meter bag
- Refrigerator thermometer card

Program Objectives

The goal of this program is to distribute 27,000 take-home energy savings kits and save approximately 11,538 MWH of energy and 0.9 MW of demand during program years 2018 to 2020. Program years run July through June to align with the school calendar. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

This program is available to school districts in the DP&L service territory.

Program Duration

The Residential School Education program is designed to run through May of 2021.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Energy Savings Kits	9,000	9,000	9,000	27,000

Program Participation Requirements

This program is available to school districts in the DP&L service territory. Energy-savings kits and curriculum are most appropriate for students in grades 5-12. Program participants are asked to complete a survey reporting whether they installed measures in the take home energy savings kits.

Incentives

Take-home kits, curriculum, and classroom materials will be provided to participating schools and teachers at no charge.

Marketing Approach

The program will be promoted to school districts in DP&L's service territory, emphasizing the educational value of the program as well as the availability of the energy savings materials. Marketing tactics may include emails, letters, and personal meetings with curriculum coordinators, principals, or superintendents.

Implementation Approach

DP&L will work with an implementation partner that will develop and maintain relationships with school administrators and teachers. The implementation partner will train teachers, coordinate the distribution of take home energy savings kits, and collect data regarding installation of energy savings measures. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	3,846	3,846	3,846	11,538
Summer Peak Demand (MW)	0.3	0.3	0.3	0.9

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	$221,030	$221,030	$221,030	$663,090
Vendor & Administrative	$164,958	$173,012	$181,460	$519,430
Total	**$385,988**	**$394,042**	**$402,490**	**$1,182,520**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

This program produces measureable energy savings through the installation of measures like LEDs and low flow showerheads. However, it is difficult to measure on an absolute basis the long-term impact of this program since the core and primary motivation is education. The hands-on educational lessons provide an opportunity for students and their families to engage with principles of energy and energy efficiency that will ideally generate awareness and energy-efficient habits throughout their lives.

EM&V Plan

The School Education program impact evaluation will utilize student surveys, which are administered by the program, to verify measure installation, assess baseline usage and summarize behavioral changes. This approach is consistent with previous program evaluations. Participant data will be used to conduct follow-up parent surveys. The follow-up parent survey will determine the installation rate of kit measures after the student survey was completed as well as possible participation in other energy efficiency programs and customer satisfaction. The Ohio TRM and secondary sources will be used to determine deemed savings. A cost-effectiveness analysis will be conducted.

The process evaluation will consist of interviews with program staff. Program staff surveys will address program processes and procedures, progress on teacher training and the program's effectiveness. These interviews may also address perceived barriers and approaches to overcome as well program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.76
Utility Cost Test (UCT)	2.63
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.35

Residential Audit Program

Program Description

The Residential Audit program will provide energy audit services and low-cost direct install measures to residential customers living in single family homes and multifamily buildings of four units or less. The single family market has significant barriers to energy efficiency. The primary barrier is a lack of knowledge as to the ways homeowners can improve home efficiency and change behaviors to save energy. Another barrier is the lack of funds to make needed improvements to their homes that would save energy and money. By providing audits and direct installed measures, the homeowner can improve their efficiency and reduce energy costs.

Program Objectives

The goal of this program is to make 10,920 home visits and save approximately 5,126 MWH of energy and 1.0 MW of demand during program years 2018 to 2020. The objective of the Residential Audit program is to provide in-home energy information and easy to install measures to help customers take immediate action to reduce energy use. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

All residential buildings of four units or less are eligible for the Residential Audit program. Other types of residential dwellings, such as connected houses, condominiums and townhouses, may be eligible for the program. The program will also attempt to work collaboratively with the local gas utility for dual fuel homes.

Program Duration

The Residential Audit program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Customer Homes	3,000	3,600	4,320	10,920

Program Participation Requirements

Intended program participants are residential customers of DP&L that enroll to receive a home visit. Throughout the duration of the portfolio, DP&L will continue to evaluate the addition of efficient measures as well as program delivery mechanisms.

Incentives

Audits will be performed and energy-efficient measures will be installed in customers' homes, at no charge.

Marketing Approach

Education and promotional materials will be developed for residential customers. The marketing and communications strategy will be designed to inform customers of the availability and benefits of the program and how they can participate. Presentations may be made to key trade ally groups to actively solicit their participation in the program. Marketing activities may include:

- Direct mail to potential participant customers based on zip codes that indicate an age of homes that would likely benefit from the audit program;
- Public relations materials and general media;
- Brochures that describe the benefits and features of the program, including program contact information;
- Bill inserts, bill messages and email messages to targeted customers;
- Informational content on the DP&L website;
- Customer representatives trained to promote the program to customers

Implementation Approach

DP&L will utilize an implementation contractor to provide turn-key implementation services including training and education, application and incentive processing, tracking and reporting, verification, technical support, customer support, and marketing. Audits and low-cost direct install measures, such as LED bulbs, faucet aerators, night lights and smart strips, will be installed at no cost to the customer. The implementation of this program may be coordinated with the local gas utility, when feasible, where its territory overlaps with DP&L's. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	1,408	1,690	2,028	5,126
Summer Peak Demand (MW)	0.3	0.3	0.4	1.0

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$238,164	$285,797	$342,956	$866,917
Vendor & Administrative	$975,937	$1,041,925	$1,166,762	$3,184,624
Total	**$1,214,101**	**$1,327,722**	**$1,509,718**	**$4,051,541**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

The single family market has significant barriers to energy efficiency. The primary barrier is a lack of knowledge as to the ways homeowners can improve home efficiency and change behaviors to save energy. Another barrier is the lack of funds to make needed improvements to homes that would save energy and money. By providing audits and direct installed measures, homeowners can improve their efficiency and reduce energy costs. This program is designed to help overcome these barriers and improve energy efficiency for this customer group who has significant energy needs and a large potential for savings.

EM&V Plan

The impact evaluation approach for the Residential Audit program may include participant billing analysis, engineering calculations and secondary sources, program database review and cost-effectiveness analysis. Savings will be calculated using a combination of billing analyses, engineering calculations, secondary sources and the Ohio TRM.

The general process evaluation approach may consist of: staff interviews, participant surveys, and/or trade ally surveys (as needed). Staff interviews will focus on program processes and procedures, changes to program design if applicable, training opportunities with customers and contractors, program successes to date and future program challenges.

In past residential programs, surveys targeting stratified samples of program participants were conducted to assess how customers learned about the program, satisfaction with program processes and incentive levels, general information regarding

the functionality of installed measures, and motivations for replacing existing equipment. Moving forward, participant surveys may be used to capture similar information or incorporate new research objectives to help inform program planning as needed.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	0.60
Utility Cost Test (UCT)	0.54
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.26

Residential Behavior Change

Program Description

The goal of the Residential Behavior Change program is to motivate customers to better manage their energy use through education, benchmarking, and customer-specific information about how to reduce their usage. Customers will receive home energy reports mailed to their homes, access to online tools, and periodic communications from the utility including high usage alerts. The goal is that by informing customers, they will become more engaged and begin to make behavioral changes that will have both an immediate and lasting impact of reducing their energy consumption.

Program Objectives

The goal of this program is to send 300,000 home energy reports and save approximately 40,800 MWH of energy and 7.8 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

The Residential Behavior Change program is designed for all DP&L residential customers. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

Program Duration

The Residential Behavior Change program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Home Energy Reports	100,000	100,000	100,000	300,000

Program Participation Requirements

There is no cost to participate, and customers can choose their level of involvement.

Incentives

The program is designed to provide low or no cost suggestions for behavior changes that, if adopted, will ideally produce energy and cost savings for the customer. This program will also direct customers to other DP&L energy efficiency programs which provide a financial incentive.

Marketing Approach

In contrast to other programs in this portfolio, DP&L does not need to solicit customer participation. Customers are selected to receive home energy reports based on sharing similar characteristics with other customers and exhibiting the potential to reduce energy usage. All customers can opt out of receiving reports at any time. The marketing challenge is to capture customers' attention, keep them engaged, and encourage them to make behavioral changes throughout the duration of the program. This effort will rely on consistent and repeated messaging across a variety of communication channels which may include but are not limited to mail, web, and email. Messaging must be simple, easy to understand, and compelling in order to stimulate behavior change.

Implementation Approach

DP&L will work with an implementation partner to manage this program. Implementation strategy will include a consistent flow of communication in order to keep customers engaged. DP&L will work with an implementation partner to craft messages that are informative, easy to understand, and motivate customers to act. The implementation partner will oversee the production of all communications pieces and the collection and tracking of data for savings reports. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	6,700	15,400	18,700	40,800
Summer Peak Demand (MW)	1.9	2.7	3.2	7.8

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	N/A	N/A	N/A	N/A
Vendor & Administrative	$576,471	$577,851	$579,285	$1,733,607
Total	**$576,471**	**$577,851**	**$579,285**	**$1,733,607**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

A potential barrier to customers pursuing energy efficiency is an understanding of how energy is used in their home and the potential savings that can be realized from taking certain actions. By providing specific information about their own energy usage, customers will begin to learn how to gauge the volume of their energy consumption compared to similar homes and what behavior changes they can take to decrease it. To be effective, this program will need to provide regular communications with customers in order to capture their attention and keep them engaged in their behavior change process.

EM&V Plan

The Residential Behavior Change program impact evaluation may include billing and cost-effectiveness analyses. The billing analysis will include a minimum of one-year customer consumption data for the census of participating and control groups. Consumption data will be weather normalized and savings already attributed to other programs will be removed from analysis.

The process evaluation will consist of surveys for both the participant and non-participant groups. Surveys will focus on any differences between the groups and impacts the program is having on participants.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	3.35
Utility Cost Test (UCT)	3.35
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.35

Residential Energy Savings Kits

Program Description

The Residential Energy Savings Kits program is designed to promote the adoption of energy-efficient measures in households by offering a free energy savings kit mailed to a participating customer's home. Customers must enroll in the program and request a kit. The kits may include LED light bulbs, energy-efficient showerheads, and kitchen and bathroom faucet aerators. DP&L will continue to evaluate the inclusion or exclusion of measures as appropriate.

Program Objectives

The goal of this program is to mail 45,000 energy savings kits and save approximately 11,643 MWH of energy and 1.2 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

The Residential Energy Savings Kits program is targeted for all DP&L residential customers. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier. Landlords may qualify to participate in this program.

Program Duration

The Residential Energy Savings Kits program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Energy Savings Kits	15,000	15,000	15,000	45,000

Program Participation Requirements

Intended program participants are residential customers of DP&L.

Incentives

The program is designed to provide energy efficient measures at no cost to the customer that, if installed, will produce energy and cost savings for the customer. This

program will also direct customers to other DP&L energy efficiency programs which provide a financial incentive.

Marketing Approach

Marketing materials will communicate the energy savings kit availability to customers in addition to the long-term energy savings potential from installing the measures. Marketing tactics may include bill stuffers, web pages, mass media advertising, and presence at community events, all with the goal of increasing program awareness and customer participation.

Implementation Approach

DP&L will work with an implementation partner that will complete all details of the process including building energy savings kits, collecting customer orders, and fulfilling customer orders. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	3,881	3,881	3,881	11,643
Summer Peak Demand (MW)	0.4	0.4	0.4	1.2

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$322,200	$322,200	$322,200	$966,600
Vendor & Administrative	$77,462	$78,358	$79,281	$235,101
Total	**$399,662**	**$400,558**	**$401,481**	**$1,201,701**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

A potential barrier to customers pursuing energy efficiency is an understanding of where to start. By offering easy enrollment and mailing an energy savings kit directly to a customer's home along with installation instructions, the customer can begin with the energy-efficient measures provided. After trying these measures and saving energy, participating customers may decide to adopt additional energy-efficient measures in their homes.

EM&V Plan

The Energy Savings Kits program impact evaluation will include a program database review and engineering calculations to determine program savings. The evaluation will also include a participant survey to verify measure installation and assess baseline usage and customer satisfaction. The Ohio TRM and secondary sources will be used to determine deemed savings. A cost-effectiveness analysis will be conducted.

The process evaluation will consist of interviews with program staff. Program staff surveys will address program processes and procedures, and the program's effectiveness. These interviews may also address perceived barriers and approaches to overcome as well program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	4.48
Utility Cost Test (UCT)	4.04
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.43

Residential Multi-Family

Program Description

The Residential Multi-Family program provides targeted, cost-effective measures to multifamily households. The program targets multifamily complexes with units that are both individually metered and master metered. The program is designed to go beyond providing financial incentives to multi-family households and aims to make them well-educated energy consumers. The program will help residents gain a better understanding of their home energy use and achieve savings while also improving the comfort of their homes. In addition to educating and empowering multi-family customers to make energy-efficient home improvements, the program contains a set of direct install measures.

The Residential Multi-Family program has several components:

- Walk-Through Audits – On-site inspections and tests used to identify energy efficiency opportunities; audit reports contain specific recommendations, including expected costs, energy savings, and resource referrals.
- Direct Installation of Low-Cost Measures – Installation of a package of low-cost energy-saving measures, at no additional charge to the customer, to immediately improve the energy performance of the residential unit.
- Assistance with Additional Measure Adoption – Assistance on how to access rebates under other programs.

Program Objectives

The purpose of the Residential Multi-Family program is to bring customers to a more holistic view of home energy performance. The program is part of a long-term goal to raise awareness of home energy savings opportunities among residential customers and to help them take action using incentives offered by DP&L's energy efficiency programs.

The program will achieve several objectives:

- Improve customer understanding of how their homes use energy and how they can use it more effectively
- Procure immediate energy savings through installation of low-cost energy-saving measures
- Encourage installation of additional energy-saving measures with additional incentives

Targeted Customer Sector

The program targets electric only multifamily complexes with units that are both individually metered and master metered. Recruitment efforts target:

- Property management companies
- Multifamily property owners
- Condominium board members

The goal is to have a single point of contact to schedule multiple properties to be retrofitted whenever possible. Customers living in rental properties are typically underserved by energy efficiency programs, due to property owners' and management companies' reluctance to invest in energy efficiency measures. This program addresses this barrier by providing measures that benefit both the resident and the property owner or management company through lower electric bills.

Program Duration

The Residential Multi Family program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Customer Homes	4,940	5,000	5,040	14,980

Program Participation Requirements

This program targets all multifamily housing building owners of four or more tenant-occupied residential apartments or condominiums. Townhomes and buildings with three or fewer residential living units are directed to DP&L's Residential Audit Program.

Incentives

The measures and services within this program may include, but are not limited to:

- LED Bulbs
- Kitchen Aerators
- Bathroom Aerators
- Low Flow Showerheads
- Smart Strips
- LED Nightlights

Marketing Approach

The program is marketed to apartment associations using face to face meetings with property management firms and owners. As needed, apartment associations are identified and targeted for presentations. Participants are accepted on a first come, first served basis to prevent oversubscription. Should the need arise to target additional property types, the program implementer will work directly with property owners, associations, and management firms to identify qualified, interested customers. DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Implementation Approach

DP&L will administer the Residential Multi-Family program through an implementation contractor.

DP&L's role will be to ensure:

- The implementation contractor performs all the activities associated with delivery of all components of the program, and
- Educational and program messages are delivered accurately and clearly to ensure the effectiveness of program delivery and maximize customer satisfaction with the program.

The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2019-2020**
Energy (MWh)	3,383	3,424	3,451	10,258
Summer Peak Demand (MW)	0.7	0.7	0.7	2.1

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$502,917	$509,025	$513,097	$1,525,039
Vendor & Administrative	$145,441	$147,597	$149,275	$442,313
Total	**$648,358**	**$656,622**	**$662,372**	**$1,967,352**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

The multi-family market has significant barriers to energy efficiency. The primary barrier is the general lack of incentive for renters and landlords to invest in energy efficiency. Other barriers include a lack of awareness and knowledge as to ways to improve the residential units and change behaviors, as well as lack of funds to make needed improvements to save energy and money. This program is designed to help overcome these barriers and improve energy efficiency for this customer group who has a high potential for savings.

EM&V Plan

The impact evaluation approach for the Residential Multi-Family program may include participant billing analysis, engineering calculations and secondary sources, program database review and cost-effectiveness analysis. Savings will be calculated using a combination of billing analyses, engineering calculations, secondary sources and the Ohio TRM.

The general process evaluation approach may consist of: staff interviews, participant surveys, and/or trade ally surveys (as needed). Staff interviews will focus on program processes and procedures, changes to program design if applicable, training opportunities with customers and contractors, program successes to date and future program challenges.

In past residential programs, surveys targeting stratified samples of program participants were conducted to assess how customers learned about the program, satisfaction with program processes and incentive levels, general information regarding the functionality of installed measures, and motivations for replacing existing equipment. Similarly, surveys with participating contractors have been used to understand how well the program is working for their company and their insights into why customers are participating. Moving forward, participant and trade ally surveys may be used to capture similar information or incorporate new research objectives to help inform program planning as needed.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.20
Utility Cost Test (UCT)	2.02
Participant Cost Test (PCT)	-
Rate Impact Measure (RIM)	0.41

Residential Smart Thermostats

Program Description

The Residential Smart Thermostats program offers rebates to apply toward the purchase of a new smart thermostat. Customers will be able to purchase a smart thermostat through a variety of distribution channels and receive a rebate. For example, customers may be able to purchase a thermostat through a retail outlet or through a participating HVAC contractor when purchasing a new HVAC system. The program increases consumer awareness and acceptance of smart thermostats and their benefits. DP&L will continue to evaluate the inclusion or exclusion of distribution channels as appropriate.

Program Objectives

The goal of this program is to rebate 18,000 smart thermostats and save approximately 6,225 MWH of energy and 0.9 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

The Residential Smart Thermostats program is targeted for all DP&L residential customers. All customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier. Landlords may qualify to participate in this program.

Program Duration

This program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
Smart Thermostats	6,000	6,000	6,000	18,000

Program Participation Requirements

Intended program participants are residential customers of DP&L. Non-residential customers, while not a targeted group, may participate in the Smart Thermostat program by applying for a smart thermostat rebate through the Non-residential Prescriptive program. Any Non-residential incentives and the proportionate administrative expenses will be allocated to the non-residential programs.

Incentives

Incentives may be offered in the form of an instant discount at the time of purchase or in the form of a rebate check or prepaid credit card mailed to the participating customer's home. The decreased cost along with the ease of participation will contribute to influencing customer adoption of smart thermostats.

Marketing Approach

Marketing materials will communicate the availability of rebates for customers as well as the benefits of smart thermostats. Marketing tactics may include 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.

Implementation Approach

DP&L will work with implementation partner(s) that will oversee all details of the process including placement of in-store signage, auditing retail outlets to confirm appropriate program policies are being implemented, tracking the number of efficient products purchased, and processing incentives. The third party implementation vendor will serve as an extension of the utility to help implement this program.

Savings Targets

Incremental Annual Savings				
	2018	2019	2020	Total 2018-2020
Energy (MWh)	2,075	2,075	2,075	6,225
Summer Peak Demand (MW)	0.3	0.3	0.3	0.9

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	$450,000	$450,000	$450,000	$1,350,000
Vendor & Administrative	$150,000	$150,900	$151,827	$452,727
Total	**$600,000**	**$600,900**	**$601,827**	**$1,802,727**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	$1,500,000	$1,500,000	$1,500,000	$4,500,000

Market Transformation Activities

The Residential Smart Thermostats program addresses two primary market barriers: lack of awareness and knowledge of the benefits and upfront cost of smart thermostats. Through this program, DP&L will communicate the energy and cost-saving benefits of smart thermostats as well as the variety of efficient smart thermostat models available. The incentive provided will help reduce the upfront cost for customers and facilitate purchases of smart thermostats.

EM&V Plan

The Residential Smart Thermostats program impact evaluation may include a program database review and engineering calculations to determine program savings. The evaluation will also include a participant survey to verify measure installation and assess baseline usage and customer satisfaction. The Ohio TRM, secondary sources, and a billing analysis will be used to determine deemed savings. A cost-effectiveness analysis will be conducted.

The process evaluation may consist of interviews with program staff. Program staff surveys will address program processes and procedures, and the program's effectiveness. These interviews may also address perceived barriers and approaches to overcome as well program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	0.55
Utility Cost Test (UCT)	1.52
Participant Cost Test (PCT)	1.53
Rate Impact Measure (RIM)	0.35

Commercial, Industrial, and Government Programs

Programs Overview

The following pages contain plans for programs offered to commercial, industrial and government customers. These plans are intended to be general implementation guidelines as opposed to specific and detailed operating plans. DP&L has learned through its previous experience that a level of implementation flexibility needs to be maintained to allow for necessary program adjustments.

Expected budgets, participation, and savings have been developed based on past experience and best practices to demonstrate the expected size and scope of each program. Actual results may vary depending on factors such as customer acceptance, product and technological innovations, changing standards and codes, and evaluation practices.

Likewise, the evaluation plans are intended to provide an overview of the evaluation, measurement, and verification activities that will most likely occur over the three-year portfolio plan period. Detailed evaluation plans will be developed each year to ensure evaluations are following most current evaluation protocols and incorporate any new objectives to help administer the programs more effectively.

Additional information regarding the past implementation and evaluation of existing programs may be found in DP&L's annual energy efficiency and demand reduction/response portfolio status reports.[6]

The following are the commercial, industrial, and government customer programs:

- Rapid Rebates – Existing Program
- Custom Rebates – Existing Program
- Small Business Direct Install – New Program
- Mercantile Self-Direct – Existing Program

[6]The most recent portfolio status report is PUCO Case No. 17-1092-EL-POR.

Rapid Rebates

Program Description

The Non-Residential Prescriptive Rebate program (Rapid Rebates®) provides non-residential customers with incentives for new equipment purchases that reduce energy consumption and demand. Technologies that are covered in the program include energy efficient lighting, HVAC, motors, drives and compressed air. Approximately 70 unique measures are offered through the Rapid Rebates® program.

Program Objectives

The objective of the program is to help business and government customers overcome the upfront cost hurdle associated with energy efficient technologies. The program is designed to provide simple solutions for business customers who want to operate more efficiently. The goal of the program is to save 232,088 MWh and 36.0 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

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. Customers can either file an on-line application through the Rapid Rebates® program or utilize a midstream channel to receive an instant discount at the point of sale from a participating distributor. All business and government customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

Program Duration

The Rapid Rebates® program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

The following participation levels are based on past participation Qualifying measures and participation levels may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Participants				
Measure Category	**2018**	**2019**	**2020**	**Total 2018-2020**
Lighting	1,258	1,321	1,387	3,966
HVAC	141	148	156	445
Motors & Drives	20	21	22	63
Compressed Air	37	39	41	117
Midstream	3,149	3,149	3,149	9,447
Total Measures Installed	**7,629**	**8,410**	**9,333**	**25,372**

Program Participation Requirements

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 Rapid Rebates® measure lists or is on a qualified products list of a participating distributor. Additionally, equipment must use electricity as the fuel source and be replacing existing equipment or be installed as part of a retrofit or new construction project.

Incentives

Incentives are intended to cover the incremental cost associated with moving to equipment with a higher efficiency rating than the available standard efficiency. Incentives may be adjusted at any time, in response to various factors such as customer demand, changing technology, and market price.

Marketing Approach

Marketing methods include publication of program information on the company website, mass media, print literature, bill inserts, inserts in local business journals, presentations at community- and vendor-sponsored events, one-on-one marketing by DP&L major account managers, and the 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.

Implementation Approach

DP&L plans to continue to implement and manage the Rapid Rebates® program primarily with internal staff. Implementing the program in-house strengthens DP&L employee knowledge of energy efficiency programs and technologies. It also provides DP&L with the opportunity to build relationships with contractor networks and customers, leading to quality customer service. From time to time, DP&L may evaluate

this internal implementation approach based on program volume and required technical knowledge and expertise. DP&L may also work with third-party vendors on various aspects of the program, which will serve as an extension of the utility.

For the midstream channel, DP&L and implementation partners will establish partnerships with distributors, oversee the implementation of cooperative advertising and in-store signage, audit distributor outlets to confirm appropriate program policies are being implemented, and track the number of efficient products purchased.

Savings Targets

The following savings estimates have been used for planning purposes. Qualifying measures and associated savings may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Savings				
	2018	2019	2020	Total 2018-2020
Energy (MWh)	74,777	77,320	79,991	232,088
Summer Peak Demand (MW)	11.9	12.0	12.1	36.0

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, EM&V requirements and emerging technologies.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	$6,191,356	$6,342,950	$6,587,955	$19,122,261
Vendor & Administrative	$1,383,752	$1,432,507	$1,474,629	$4,290,888
Total	**$7,575,108**	**$7,775,457**	**$8,062,584**	**$23,413,149**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	$16,680,700	$17,406,286	$18,168,151	$52,255,137

Market Transformation Activities

Through the Rapid Rebates® program, DP&L will communicate the energy and cost-saving benefits of energy-efficient upgrades to business customers. The program will also inform manufacturers, engineers, distributors and retailers about customer demand

and preferences for energy-efficient technologies. These efforts, combined with the financial incentives provided by the rebates, will help to increase demand for energy efficient products.

EM&V Plan

The impact evaluation approach for the Rapid Rebates® program may include a database review, site visits/engineering analysis, stakeholder interviews and a cost-effectiveness analysis. The project database will be reviewed to assure appropriate data are being collected. Site visits will be utilized to verify measures are installed and operating. Engineering analysis will be used to calculate energy savings. The Ohio TRM and secondary source savings calculations and assumptions will be used as a reference to calculate deemed savings.

The process evaluation may include the following as needed: stakeholder interviews, participant and trade ally surveys. These interviews and surveys will address program processes and procedures, progress on customer and contractor education, and the incentive mechanism effectiveness. These interviews may also address perceived barriers to overcome as well as program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.22
Utility Cost Test (UCT)	5.21
Participant Cost Test (PCT)	3.36
Rate Impact Measure (RIM)	0.64

Custom Rebates

Program Description

The Non-Residential Custom Rebate program provides non-residential customers with incentives for equipment purchases and industrial process improvements that reduce energy consumption and demand. Custom Rebates are for equipment not covered by DP&L's Rapid Rebates® program and is generally best suited for customized industry-specific or facility-specific applications. Energy efficient new construction projects, retro-commissioning projects, strategic energy management initiatives, combined heat and power (CHP) projects and subsidized facility audits are included in the Custom Rebate Program.

Program Objectives

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 goal of the program is to save 87,898 MWh and 17.3 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, through data-logging of equipment and processes, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

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. DP&L will explore targeting various customer segments to determine potential savings and develop appropriate targeted marketing efforts.

Program Duration

The Custom Rebate program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

The following participation levels have been used for planning purposes. Qualifying measures and participation levels may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Participants (Projects Rebated)				
Project Category	**2018**	**2019**	**2020**	**Total 2018-2020**
Equipment/Process Rebates	102	105	95	302
New Construction	23	25	28	76
Retro-Commissioning	8	10	12	30
Combined Heat and Power	0	2	3	5
Facility Audits	41	47	50	138

Program Participation Requirements

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 or new construction project. 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.

Incentives

Incentives are intended to cover the incremental cost associated with moving to equipment with a higher efficiency rating than the available standard efficiency. Incentives will be capped at various levels depending on the type of project and rebate. Incentives may be adjusted at any time, in response to factors such as customer demand, portfolio budget constraints, changing technology, and market price.

Marketing Approach

Marketing methods include publication of program information on the company website, mass media, print literature, bill inserts, inserts in local business journals, presentations at community- and vendor-sponsored events, one-on-one marketing by DP&L major account managers, and the 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.

Implementation Approach

DP&L plans to continue to implement and manage the Custom Rebate program primarily with internal staff. Implementing the program in-house strengthens DP&L employee knowledge of energy efficiency programs and technologies. It also provides

DP&L with the opportunity to build relationships with contractor networks and customers, leading to quality customer service. From time to time, DP&L may evaluate this internal implementation approach based on program volume and required technical knowledge and expertise. DP&L may also work with a third-party vendor, which will serve as an extension of the utility, to help implement this program or certain components of the program.

Savings Targets

The following savings estimates have been used for planning purposes. Qualifying measures and associated savings may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	23,190	29,216	35,492	87,898
Summer Peak Demand (MW)	4.4	5.7	7.2	17.3

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, EM&V requirements and emerging technologies.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$2,602,735	$3,044,668	$3,509,089	$9,156,492
Vendor & Administrative	$1,307,520	$1,352,186	$1,398,639	$4,058,345
Total	**$3,910,255**	**$4,396,854**	**$4,907,728**	**$13,214,837**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	$7,780,170	$9,694,232	$11,721,592	$29,195,994

Market Transformation Activities

Through the Custom Rebate program, DP&L will communicate the energy and cost-saving benefits of energy-efficient upgrades to business customers. The program will also inform manufacturers, engineers, distributors and retailers about customer demand and preferences for energy-efficient technologies. Combined with financial incentives in the form of rebates, these activities will help to increase the demand for energy efficient

products. Additionally, the DP&L Energy Audit provides incentives to subsidize the cost of a targeted ASHRAE Level I facility audit or a CHP Feasibility Study.

EM&V Plan

The Custom Rebate program offers incentives for projects not eligible under the Rapid Rebates® program. Therefore, evaluations under this program will require a broad range of activities which may include, but not limited to, the following: program database review, stakeholder interviews, participant surveys, site visits/engineering analysis, and cost effectiveness analysis.

The database will be reviewed to assure appropriate data are being collected. Site visits will be utilized to verify measures are installed and operating. Engineering analysis will be used to calculate energy savings. Secondary sources and assumptions will be used as a reference to calculate deemed savings.

The process evaluation will include the following as needed: stakeholder interviews, participant and trade ally surveys. These interviews and surveys will address program processes and procedures, progress on customer and contractor education, and the incentive mechanism effectiveness. These interviews may also address perceived barriers to overcome as well program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	1.54
Utility Cost Test (UCT)	3.96
Participant Cost Test (PCT)	2.36
Rate Impact Measure (RIM)	0.66

Small Business Direct Install Program

Program Description

The Small Business Direct Install program (SBDI) provides small non-residential customers with a one-stop option for professionally installed new equipment that reduces energy consumption and demand. Technologies covered in the program include, but are not limited to, energy efficient lighting, variable frequency drives, refrigeration equipment, and other efficiency products and services.

Program Objectives

The objective of the program is to help small business customers overcome the upfront cost hurdle associated with energy efficient technologies. The program is designed to provide simple solutions for business customers who want to operate more efficiently. The goal of the program is to upgrade 714 small businesses and save 15,000 MWh and 3.9 MW of demand during program years 2018 to 2020. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sector

The SBDI program is designed for all DP&L business customers with monthly electrical demand under 200 kW. This program allows small customers to have energy-saving equipment installed at a reduced cost.

Program Duration

The SBDI program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

The following participation levels have been used for planning purposes. Qualifying measures and participation levels may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Participants				
Measure Category	**2018**	**2019**	**2020**	**Total 2018-2020**
Participants	238	238	238	714

Program Participation Requirements

Intended program participants are business customers of DP&L with monthly electrical demand of less than 200 kW. This threshold number may change with participation levels.

Incentives

Incentives for energy efficiency retrofit projects in SBDI are generally higher than the Rapid Rebates® program. Small business customers usually don't have the time, understanding, or capital necessary to invest in energy efficiency projects. Therefore, the utility covers a significant portion of the equipment and labor costs to upgrade small businesses effectively. Incentives may be adjusted at any time, in response to various factors such as customer demand, changing technology, and market price.

Marketing Approach

Marketing methods include direct phone calls, door-to-door sales, publication of program information on the company website, mass media, print literature, bill inserts, inserts in local business journals and presentations at community- and vendor-sponsored events.

Implementation Approach

DP&L and implementation partners will establish partnerships with distributors and installers, oversee the implementation of cooperative advertising, and track the number of efficient equipment installations. DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Savings Targets

The following savings estimates have been used for planning purposes. Qualifying measures and associated savings may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Savings				
	2018	2019	2020	Total 2018-2020
Energy (MWh)	5,000	5,000	5,000	15,000
Summer Peak Demand (MW)	1.3	1.3	1.3	3.9

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, EM&V requirements and emerging technologies.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$875,000	$910,000	$910,000	$2,695,000
Vendor & Administrative	$112,693	$117,201	$117,729	$347,623
Total	**$987,693**	**$1,027,201**	**$1,027,729**	**$3,042,623**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	$1,312,500	$1,365,000	$1,365,000	$4,042,500

Market Transformation Activities

Through the SBDI program, DP&L will assist a traditionally underserved business market by communicating the energy and cost-saving benefits of energy-efficient upgrades to small business customers. The program will also inform manufacturers, engineers, distributors and retailers about customer demand and preferences for energy-efficient technologies. These efforts, combined with the financial incentives provided by the rebates, will help to increase demand for energy efficient products.

EM&V Plan

The impact evaluation approach for the SBDI program may include site visits/engineering analysis, stakeholder interviews and a cost-effectiveness analysis. Site visits will be utilized to verify measures are installed and operating. Engineering analysis will be used to calculate energy savings. The Ohio TRM and secondary source savings calculations and assumptions will be used as a reference to calculate deemed savings.

The process evaluation may include the following as needed: stakeholder interviews, participant and trade ally surveys. These interviews and surveys will address program processes and procedures, progress on customer and contractor education, and the incentive mechanism effectiveness. These interviews may also address perceived barriers to overcome as well as program successes and future challenges.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.43
Utility Cost Test (UCT)	3.51
Participant Cost Test (PCT)	3.49
Rate Impact Measure (RIM)	0.68

Mercantile Self Direct Rebates

Program Description

The Non-Residential Mercantile Self-Direct program allows mercantile customers who have successfully identified and documented savings from energy efficiency projects on a rolling 3-year historical basis to apply for a one-time incentive payment or an exemption from the Energy Efficiency Rider (EER). DP&L will implement this program in accordance with Ohio law and PUCO rules.

Program Objectives

The objective of the program is to allow mercantile customers the ability to commit energy efficiency projects for integration toward DP&L's energy efficiency compliance benchmarks.

Targeted Customer Sector

The Mercantile 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. All mercantile customers taking delivery service from DP&L are eligible for this program regardless of their choice of generation supplier.

Program Duration

This program is a continuing program and is designed to run through the duration of the PUCO mercantile self-direct program. DP&L will implement this program as Ohio law and PUCO rules permit.

Estimated Program Participation Levels

The following participation levels have been used for planning purposes. Qualifying measures and participation levels may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Participants (Applications filed with PUCO)				
Measure Category	**2018**	**2019**	**2020**	**Total 2018-2020**
Participants	15	12	12	39

Program Participation Requirements

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 receiving incentives are required to conform to the measure eligibility requirements of the Rapid Rebates® and/or Custom Rebate programs.

Incentives

Per Case No. 10-834-EL-EEC, the one-time incentive payments will not exceed 50% of the total project cost. 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. 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 self-direct applications must be approved by the PUCO prior to taking effect.

Marketing Approach

Marketing methods include presentations at community- and vendor-sponsored events, one-on-one marketing by DP&L major account managers, and the 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.

Implementation Approach

DP&L plans to continue to implement and manage the Mercantile Self-Direct program primarily with internal staff. Implementing the program in-house strengthens DP&L employee knowledge of energy efficiency programs and technologies. It also provides DP&L with the opportunity to build relationships with contractor networks and customers, leading to quality customer service. From time to time, DP&L may evaluate this internal implementation approach based on program volume and required technical knowledge and expertise. DP&L may also work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Savings Targets

The following savings estimates have been used for planning purposes. Qualifying measures and associated savings may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Savings				
	2018	2019	2020	Total 2018-2020
Energy (MWh)	5,937	4,750	4,750	15,437
Summer Peak Demand (MW)	1.4	1.1	1.1	3.6

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, EM&V requirements and emerging technologies. Given the limited budget, customers will be directed to take the EER exemption as opposed to an incentive payment.

Incremental Annual Budget				
	2018	2019	2020	Total 2018-2020
Incentive	$50,000	$50,000	$50,000	$150,000
Vendor & Administrative	$147,547	$131,442	$134,256	$413,245
Total	**$197,547**	**$181,442**	**$184,256**	**$563,245**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	$1,674,920	$1,339,937	$1,339,937	$4,354,793

Market Transformation Activities

Through the Mercantile Self-Direct program, DP&L will communicate the energy and cost-saving benefits of energy-efficient upgrades to business customers. The program will also inform manufacturers, engineers, distributors and retailers about customer demand and preferences for energy-efficient technologies. Combined with financial incentives, these activities will help to strengthen demand for energy efficient products.

EM&V Plan

DP&L administers the Mercantile Self Direct program in-house. A third-party auditor may be utilized to verify measures are installed and operating. Engineering analysis will be used to calculate energy savings. The Ohio TRM and secondary source savings calculations and assumptions will be used as a reference to calculate deemed savings.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	1.56
Utility Cost Test (UCT)	13.26
Participant Cost Test (PCT)	2.21
Rate Impact Measure (RIM)	0.69

Cross Sector Programs

PROGRAMS OVERVIEW

The following pages contain plans for programs that impact all customer classes. These plans are intended to be general implementation guidelines as opposed to specific and detailed operating plans. DP&L has learned through its previous experience that a level of implementation flexibility needs to be maintained to allow for necessary program adjustments.

Given the unique nature of the cross-sector programs, elements such as expected participation and savings are not included for some programs. Further, the transmission and distribution infrastructure and smart grid sections are included as recognition that Ohio law allows infrastructure projects to be counted toward compliance benchmarks.

Additional information regarding the past implementation of existing programs may be found in DP&L's annual energy efficiency and demand reduction/response portfolio status reports.[7]

The following are the cross-sector programs:

- Customer Education and Marketing
- Pilot Program
- Stakeholder Initiatives
- Transmission & Distribution Infrastructure Improvements
- Smart Grid
- Non-Programmatic Savings

[7]The most recent portfolio status report is PUCO Case No. 17-1092-EL-POR.

Education and Marketing

Program Description

Education and Marketing will include efforts to increase knowledge of energy efficiency and encourage adoption of energy efficient measures. Education and Marketing may include a broad based mass communications effort to promote the value of energy efficiency, and, at the same time, to provide marketing support for DP&L's programs. DP&L may use a variety of mass communication channels to reach customers including television, print, the web, and promotional events. This effort may also include technical training for customers and DP&L employees

Program Objectives

The objective of the Education and Marketing program is to increase knowledge and communicate the value of energy efficiency as well as to increase the awareness of available energy efficiency programs. The program will also provide marketing support, helping to promote the continued expansion of customer participation in energy efficiency programs.

Targeted Customer Sector

This program is designed to reach all customers taking delivery service from DP&L, regardless of their choice of generation supplier.

Program Duration

The Education and Marketing program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
N/A	N/A	N/A	N/A	N/A

Program Participation Requirements

N/A

Incentives

N/A

Marketing Approach

DP&L will utilize a variety of marketing and communication channels that may include mass media, the web, news releases, bill inserts, DP&L's web site, and promotional events.

Implementation Approach

The Education and Marketing activities will be coordinated by DP&L's Energy Programs staff while leveraging additional company resources such as Corporate Communications. DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Savings Targets

Due to the supportive nature of this program, there are no savings goals.

Program Budgets

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions and general program participation levels.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	N/A	N/A	N/A	N/A
Vendor & Administrative	$1,628,418	$1,628,419	$1,628,420	$4,885,257
Total	**$1,628,418**	**$1,628,419**	**$1,628,420**	**$4,885,257**

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

This program helps to transform the market by educating customers about the value of energy efficiency and the opportunity to make lasting changes to decrease their energy usage. This, in turn, will help drive customer actions toward energy efficiency and increase the demand for energy efficient products.

EM&V Plan

Due to the supportive nature of this program and the fact that no savings are claimed, there is no evaluations, measurement and verification plan.

Cost Effectiveness Results

Due to the supportive nature of this program and the fact that no savings are claimed, cost effectiveness tests are not performed at the program level. However, the costs associated with Customer Education and Marketing are included in the cost effectiveness tests performed for the portfolio as a whole.

Pilot Program

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. Pilot programs executed under the 2013-2016 portfolio plan approved in Case No. 13-833-EL-POR included:

- Appliance Rebates (Residential)
- Energy Savings Kits (Residential)
- Small Business Direct Install (Non-Residential)
- Notched V-Belts (Non-Residential)

Program Objectives

The objective of the Pilot program is to develop and deploy new opportunities as they arise. Results of pilot programs may also inform mid-stream adjustments to the current plan programs as needed. Implementation plans and pilot program results will be shared with the DP&L Energy Efficiency Collaborative. Savings estimates will be calculated in partnership with program implementers and evaluators, and may be influenced by codes and standards, calculations from the Ohio Technical Reference Manual, and ongoing evaluations research.

Targeted Customer Sectors

The Pilot program is intended to cover all DP&L customer segments, both residential and business. All customers taking delivery service from DP&L will be eligible for participation in pilot programs regardless of their choice of generation supplier.

Program Duration

DP&L's ability to deploy pilot programs will begin upon portfolio approval and run through the duration of this portfolio plan.

Estimated Program Participation Levels

Estimated participation levels will be dependent on the specific pilot programs being implemented.

Program Participation Requirements

Program participation requirements will be dependent on the specific pilot programs being implemented.

Incentives

Incentives will vary based on the programs being implemented.

Marketing Approach

The marketing approach will be dependent on the pilot programs being implemented.

Implementation Approach

Pilot programs will be screened for implementation based on a variety of factors including:

- Customer demand/participation levels
- Savings potential
- Estimated cost
- Channel Partner engagement
- Collaborative input
- Non-energy benefits

DP&L may work with one or more third-party vendors, which will serve as an extension of the utility, to help implement this program.

Savings Targets

Specific programs are not yet planned and as a result, it is not possible to project energy and demand savings.

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	N/A	N/A	N/A	N/A
Summer Peak Demand (MW)	N/A	N/A	N/A	N/A

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, participation levels, and EM&V requirements.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Incentive	$401,470	$416,413	$434,216	$1,252,099
Vendor & Administrative	$172,058	$178,463	$186,093	$536,614
Total	**$573,528**	**$594,876**	**$620,309**	**$1,788,713**

Participant Costs

Participant costs will be dependent on the programs being implemented.

Market Transformation Activities

Market transformation activities will be dependent on the programs being implemented.

EM&V Plans

EM&V plans will be dependent on the programs being implemented.

Cost Effectiveness Results

Cost effectiveness results will be dependent on the programs being implemented. In the early years of a pilot program, it is possible that a pilot program will not be cost effective due to start-up costs.

Stakeholder Initiatives

Program Description

DP&L has engaged its stakeholder groups since it launched its programs in 2009. To comply with Ohio's energy efficiency benchmark targets, DP&L partners with collaborative members when possible to reach various customer groups. This program is intended to identify those stakeholders with whom a commitment has been established in pending cases before the PUCO.

Program Objectives

The Stakeholder Initiative program allocates resources to stakeholder partners described in and consistent with DP&L's Amended Stipulation filed in Case No. 16-395-EL-SSO, contingent upon Commission approval. These resources will be used to communicate the value of energy efficiency as well as to increase the awareness of available energy efficiency programs to their constituents. The program will also allow DP&L to provide program management and to coordinate marketing efforts and information-based initiatives to promote the continued expansion of customer participation in energy efficiency programs.

Targeted Customer Sector

This program is designed to reach all customers taking delivery service from DP&L, regardless of their choice of generation supplier, with an emphasis on the constituents of the identified stakeholders.

Program Duration

The Stakeholder Initiatives program is designed to run through the duration of this portfolio plan.

Estimated Program Participation Levels

Incremental Annual Participants				
Measure	**2018**	**2019**	**2020**	**Total 2018-2020**
N/A	N/A	N/A	N/A	N/A

Program Participation Requirements

N/A

Incentives

N/A

Marketing Approach

DP&L will work with stakeholders to utilize a variety of marketing and communication channels that may include the web, news releases, bill inserts, DP&L's web site, and promotional events.

Implementation Approach

DP&L's Energy Programs staff will coordinate Stakeholder Initiatives while leveraging additional company resources such as Corporate Communications, legal and regulatory. DP&L may work with third-party vendors, which will serve as an extension of the utility, to help implement this program.

Savings Targets

Due to the supportive nature of this program, there are no savings goals.

Program Budgets

The following budget estimates have been used for planning purposes. Budgets are based on commitments established in DP&L's most recent Electric Security Plan, Case No. 16-0395-EL-SSO and are contingent upon Commission approval.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Electric Security Plan (16-0395-EL-SSO)				
• City of Dayton	$200,000	$200,000	$200,000	$600,000
• Honda	$45,000	$45,000	$45,000	$135,000
• Ohio Hospital Association	$200,000	$200,000	$200,000	$600,000
• People Working Cooperatively	$200,000	$200,000	$200,000	$600,000
Total	$645,000	$645,000	$645,000	$1,935,000

Participant Costs

Incremental Annual Participant Costs				
	2018	**2019**	**2020**	**Total 2018-2020**
Participant Costs	N/A	N/A	N/A	N/A

Market Transformation Activities

This program helps to transform the market by engaging a diverse group of customer advocate stakeholders to educate customers about the value of energy efficiency and the availability of DP&L's programs. This will help drive customer actions toward energy efficiency and increase the demand for energy efficient products.

EM&V Plan

Due to the educational nature of this program and the fact that no savings are claimed, there is no evaluations, measurement and verification plan.

Cost Effectiveness Results

Due to the supportive nature of this program and the fact that no savings are claimed, cost effectiveness tests are not performed at the program level.

Transmission & Distribution Infrastructure Improvements

Program Description

In the discussion of Ohio's energy efficiency and demand benchmarks, Ohio Revised Code Section 4928.66(A)(2)(d)(i)(IV) provides, in part, "Programs implemented by a utility may include transmission and distribution infrastructure improvements that reduce line losses."

Consistent with this provision, DP&L may undertake various infrastructure improvements that reduce line losses and count the savings toward its statutory benchmarks as a part of its overall compliance efforts. Savings will be reported in its annual energy efficiency and demand reduction/response portfolio status report. However, DP&L is not seeking to recover transmission and distribution program costs through the Energy Efficiency Rider. DP&L is including the infrastructure program in this portfolio plan to note that it may be reporting savings annually and counting the savings toward its benchmarks.

In addition to energy savings, these projects can produce a number of ancillary benefits such as:

- Strengthening reliability for customers as older equipment is replaced.
- Increasing the available capacity on the existing transmission and distribution system to serve customers.
- Realizing energy savings without various external costs, such as program marketing, required of traditional energy efficient programs.

DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

EM&V Plan

The evaluation, measurement and verification of the savings related to each project will be conducted by DP&L's independent evaluations consultant. Given the unique nature of the projects, DP&L will work with the independent evaluator to develop an appropriate evaluations plan. Depending on the project, the plan could include independent verification of completed work, engineering models to verify savings and supplemental metering. The results will be included in the independent evaluator's report which is submitted with DP&L's annual portfolio status report.

Smart Grid

Program Description

In the discussion of Ohio's energy efficiency and demand benchmarks, Ohio Revised Code Section 4928.66(A)(2)(d)(i)(II) provides, in part, "Programs implemented by a utility may include smart grid investment programs, provided that such programs are demonstrated to be cost beneficial."

Consistent with this provision, DP&L reserves the ability to count savings from smart grid-enabled initiatives if DP&L were to file and gain approval from the PUCO to pursue a plan to invest in smart grid technologies. Savings from smart grid-enabled initiatives would be reported in its annual energy efficiency and demand reduction/response portfolio status report.

Savings can be generated as a result of a number of different types of smart grid-enabled initiatives which could include:

- An Energy Web Portal
- Enhanced Home Energy Reports
- Time-of-Use Rates
- Conservation Voltage Reduction
- Volt-Var Optimization

Specific smart grid-enabled initiatives would be pursued only if DP&L were to file and gain approval of a smart grid plan. Therefore, DP&L is not addressing specific programs, budgets or savings estimates in this energy efficiency portfolio plan.

DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

EM&V Plan

The evaluation, measurement and verification of the savings related to each project will be conducted by DP&L's independent evaluations consultant. Given the unique nature of the projects, DP&L will work with the independent evaluator to develop an appropriate evaluations plan. Depending on the project, the plan could include independent verification of completed work, engineering models to verify savings and supplemental metering. The results will be included in the independent evaluator's report which is submitted with DP&L's annual portfolio status report.

Non-Programmatic Savings

Program Description

Ohio Revised Code Section 4928.66(A) and (B) provide, in part, the PUCO "shall count and recognize compliance" for both

- "Energy efficiency savings and peak demand reduction achieved by actions taken by customers or through electric distribution utility programs;" and
- "Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method."

Consistent with this provision, DP&L may implement a Non-Programmatic Savings program to account for customer efficiency efforts undertaken outside of the utility-administered programs. This will include employing a variety of methodologies to collect customer and market information, including but not limited to: surveying customers, retailers and trade allies; market research; billing analyses; site verifications and other evaluation, measurement and verification activities

Program Objectives

The objective of the program is to quantify energy efficiency improvements occurring in the DP&L territory, beyond those savings recorded by other DP&L programs, and integrating the resulting savings toward compliance with energy efficiency benchmarks as permitted by Ohio law.

Targeted Customer Sector

This program will consider potential savings from all customers taking delivery service from DP&L, regardless of their choice of generation supplier.

Program Duration

The Non-Programmatic Savings program is designed to run through the duration of the portfolio plan.

Estimated Program Participation Levels

N/A

Program Participation Requirements

As defined by Ohio law, this program is designed to capture savings associated with non-participants.

Incentives

N/A

Marketing Approach

N/A

Implementation Approach

DP&L plans to will use an independent firm to quantify the savings through a variety of market research methodologies. DP&L may work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Savings Targets

The following savings estimates have been used for planning purposes. Qualifying measures and associated savings may change as a result of technology, changing codes and standards, EM&V results, and customer and supplier feedback.

Incremental Annual Savings				
	2018	**2019**	**2020**	**Total 2018-2020**
Energy (MWh)	71,971	57,577	46,061	175,609
Summer Peak Demand (MW)	16.2	12.9	10.3	39.4

Program Budget

The following budget estimates have been used for planning purposes. DP&L may adjust program budgets as a result of market conditions, EM&V requirements and emerging technologies.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Vendor & Administrative	$310,257	$248,205	$198,564	$757,026
Total	**$310,257**	**$248,205**	**$198,564**	**$757,026**

Participant Costs

Incremental Annual Participant Costs				
	2018	2019	2020	Total 2018-2020
Participant Costs	$16,862,388	$13,489,910	$10,791,928	$41,144,226

Market Transformation Activities

N/A

EM&V Plan

The evaluation, measurement and verification of the savings related to this program will be conducted by DP&L's independent evaluations consultant. Given the nature of the initiative, DP&L will work with the independent evaluator to develop an appropriate evaluations plan. The results will be included in the independent evaluator's report which is submitted with DP&L's annual portfolio status report.

Cost Effectiveness Results

Benefit-Cost Test	2018-2020 Ratio
Total Resource Cost (TRC)	2.64
Utility Cost Test (UCT)	146.12
Participant Cost Test (PCT)	4.02
Rate Impact Measure (RIM)	0.60

Evaluation Measurement & Verification

EM&V History and Overview

Effective evaluation, measurement and verification (EM&V) play an important role in a quality energy efficiency portfolio. EM&V activities ensure that reported savings are verified, energy and demand calculations are valid, program delivery is effective, customers are satisfied and the overall portfolio is cost-effective. DP&L will work with a third-party vendor, which will serve as an extension of the utility, to help implement this program.

Through a request-for-proposal (RFP) process, DP&L selected Cadmus to conduct independent EM&V for its current portfolio of programs. To date, Cadmus has conducted EM&V and produced a report for each of the years 2009 through 2016. DP&L has submitted the Cadmus reports as a part of its annual energy efficiency and demand-reduction portfolio status reports.

Evergreen Economics (the independent statewide evaluator for program years 2009-2013) has reviewed the 2009 through 2013 Cadmus reports. In its review of the 2011 Cadmus report, Evergreen states:

> "In general, we found that the Cadmus evaluation report adheres to industry best practices for evaluating DP&L's program offerings. The report is of high quality and provides details necessary to substantiate the savings estimates provided. We have a high level of confidence in this evaluation research and do not have any specific recommendations for changes to the DP&L's PY2011 reported savings."[8]

Likewise, in its review of the 2012 and 2013 Cadmus reports, Evergreen states:

> "In general, we found that the Cadmus evaluation report adheres to industry best practices for evaluating DP&L's program offerings. The report is comprehensive and provides the details necessary to rely on the savings estimates provided. We have a high level of confidence in this evaluation research and do not have any specific recommendations for changes to the DP&L's 2012/2013 reported savings." [9]

DP&L is pleased with this positive feedback and believes it is establishing a solid record of program implementation accompanied by an appropriate level of EM&V. Going forward, DP&L plans to follow the same EM&V process that resulted in the positive review by the Independent Statewide Evaluator.

[8]PUCO Case No. 13-1027-EL-UNC, Evergreen Economics "Report of the Ohio Independent Evaluator," page 30.
[9]PUCO Independent Evaluator Reports 2012PY and 2013PY. Submitted to the PUCO but not filed.

DP&L's EM&V APPROACH

DP&L's past and current approach to EM&V stands on four pillars:

1. Evaluation is integral to the overall portfolio and is best organized as an adaptive process;
2. Evaluation at the program and measure level are prioritized based on several factors such as uncertainty and available budget;
3. Evaluations are based on industry-standard methods and well-established protocols; and
4. Evaluation plans are flexible to accommodate portfolio changes.

Pillar One: Evaluation is Integrated

DP&L believes that it is important to work with an independent evaluator throughout the entire life cycle of an energy efficiency program and the portfolio as a whole. This approach calls for the independent evaluator to be involved at various stages in a program or portfolio's life cycle, including planning, implementation and post-implementation assessment. As shown in the figure below, this adaptive approach allows DP&L to benefit from its evaluator's experience, receive timely feedback and make adjustments throughout the life of the program.

Ongoing Evaluations Input Helps Ensure Programs Are Implemented Effectively

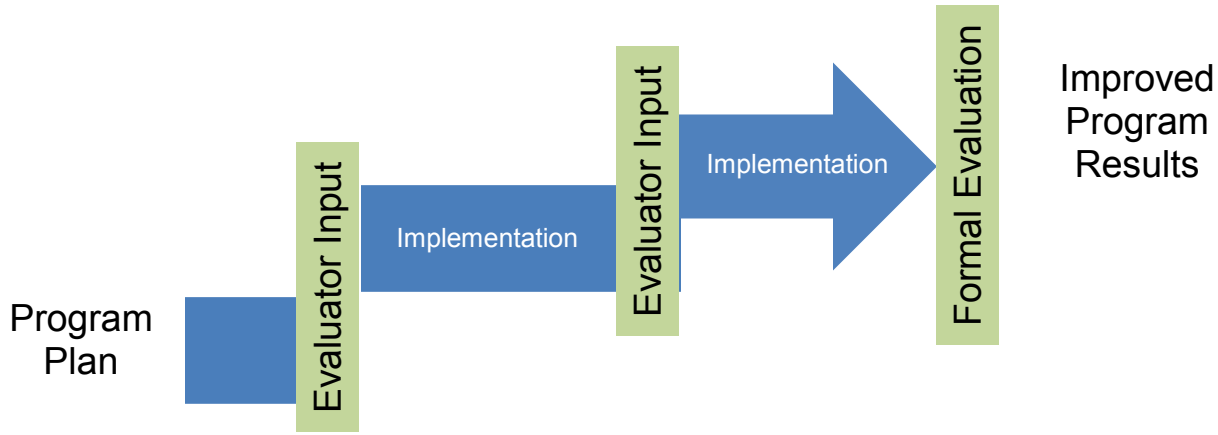


Figure 8 Ongoing Evaluations Process

This approach is in direct contrast to the approach commonly taken in a previous era of energy efficiency where the EM&V firm only provided feedback after a program had been implemented. By that time, the program may have ended or it may have been difficult and costly to make program adjustments. By pro-actively including the independent evaluator throughout the program lifecycle, DP&L believes its programs are stronger and its savings results are more consistent with general industry practices.

Pillar Two: Evaluation Tasks are Prioritized

Evaluation plans and objectives at the program and measure level are prioritized to allocate evaluation resources based on the following:

- A program's estimated contribution (MWh and MW) to the whole portfolio savings.
- The stage in a program's life cycle.
- A program's budget share of the whole portfolio.
- The expected degree of uncertainty in a program's savings.
- The input values currently listed in the Technical Reference Manual (TRM).
- The life expectancy of a program.
- The importance of a program to market transformation and awareness.
- Specific research issues relevant to particular programs.
- Whether any special features of a program require exceptional evaluation effort.

Evaluation plans designed around the above issues will help ensure DP&L uses evaluation resources appropriately and where they are most needed.

Pillar Three: Evaluations Adhere to Accepted and Proven Protocols

DP&L expects and requires all plans and work are prepared in a manner meeting industry standards and established protocols. These include: (1) International Program Measurement and Verification Protocols: Concepts and Options for Determining Energy and Water Savings Volume 1, June 2014; (2) Model Energy Efficiency Program Impact Evaluation Guide: A Resource of the National Action Plan for Energy Efficiency, December 2012; (3) Electric Power Research Institute: Guidebook for Energy Efficiency Program Evaluation, Measurement, and Verification, 2008; and (4) Uniform Method Project for Determining Energy Efficiency Program Savings, 2014.

Pillar Four: Evaluations Must be Flexible and Adaptive

Finally, DP&L believes that successful and useful evaluations begin from well-conceived and comprehensive evaluation plans. At the same time, various influences such as changes in program design, regulatory environment, and market trends require that evaluation plans (and those implementing the plans) be adaptable to mid-course adjustments. DP&L views evaluation plans as a living document, which may change during the program cycle.

EM&V PLANNING

Before evaluation work begins for each calendar year, DP&L's independent evaluator develops a comprehensive evaluations plan for each program.

In developing the plan, the independent evaluator takes into account the availability of data from previous EM&V results, the relative size of the program within the overall portfolio, implementation staff feedback, and any changes to program design that may require additional evaluations. Depending on the program, impact evaluations may include engineering analysis, billing analysis, site visits and a review of calculations. Process evaluations may include surveys and interviews with various market participants.

The impact evaluation objectives are as follows:

- Determine program and portfolio cost-effectiveness;
- Assess the appropriateness of the program's gross *ex ante* claimed savings; and
- Calculate gross *ex post* savings estimates.

Primary process evaluation objectives are:

- Assess overall satisfaction with the program;
- Identify any changes to program design and delivery that would improve performance;
- Assess the effectiveness of program marketing and outreach; and
- Identify barriers and how effectively the programs are overcoming them.

PROGRAM PROCESS REVIEW

The process evaluation focuses on qualitative assessments of the program's design, operation, and implementation. DP&L's independent evaluator will assess how well the program is functioning by using multiple industry standard approaches, such as a survey with customers, contractors, or other stakeholders. Depending on the type of program and overall objectives, in-depth interviews or focus groups may be used to gather deeper qualitative data from these stakeholders.

Process objectives will be identified in the evaluation planning stage each year and include DP&L, evaluator and any third-party program implementers. Ensuring all parties are involved in the process planning will confirm process objectives not only produce results needed from the independent evaluator perspective, but also from the program implementers so they receive feedback to make necessary course corrections.

ESTIMATION OF GROSS SAVINGS

DP&L primarily uses the Ohio Technical Reference Manual (TRM) as well as other appropriate data specific to each measure to report *ex ante* or "pre-evaluation savings"

estimates. This *ex ante* value is reported to the independent evaluator along with appropriate back-up data. The evaluator then reviews the savings estimates for each program and assesses the reasonableness of the values. This assessment includes:

- Review of deemed savings, such as those found in the Ohio TRM;
- On-site visits to collect information regarding installation rates;
- Simple engineering calculations; and
- Statistical analysis.

As stated previously, DP&L works with its independent evaluator throughout the program lifecycle, which includes establishing reasonable *ex ante* values. This, combined with using the Ohio TRM, minimizes issues at the end of the evaluation and affords implementers the opportunity to adjust program design in order to meet the savings goals. Further, this approach helps minimize differences between program and portfolio realization rates.

CALCULATING COST EFFECTIVENESS

DP&L's independent evaluator calculates cost effectiveness for individual programs and the portfolio as a whole. Cost effectiveness is calculated based on costs incurred by DP&L and participants, energy savings and avoided capacity and energy wholesale prices. Four cost effectiveness tests are calculated for each program and the portfolio as a whole: Total Resource Cost Test (TRC), Utility Cost Test (UCT), Ratepayer Impact Measure Test (RIM), and Participant Cost Test (PCT).

REPORTING

DP&L submits the independent evaluator report as an appendix to its annual energy efficiency and demand reduction/response portfolio status report. The EM&V report includes an executive summary, a comprehensive review of program-by-program evaluations, recommendations and cost effectiveness results.

STATEWIDE EVALUATOR

Once the PUCO appoints an independent statewide evaluator to review and monitor the Ohio utilities energy efficiency program evaluations, DP&L will fully cooperate with the process. DP&L will provide the statewide evaluator with a copy of each year's evaluation plan for their review as well as survey instruments used throughout the year. DP&L will also provide the notice of pending site visits which will provide the statewide evaluator with the opportunity to participate.

Program Budget

The following budget estimates have been used for planning purposes.

Incremental Annual Budget				
	2018	**2019**	**2020**	**Total 2018-2020**
Vendor & Administrative	$1,031,523	$1,066,532	$1,108,243	$3,206,298
Total	**$1,031,523**	**$1,066,532**	**$1,108,243**	**$3,206,298**

Cost Effectiveness

OVERVIEW

In compliance with PUCO rules, DP&L used the Total Resource Cost Test (TRC) as the overall test of the portfolio's cost effectiveness and as a guide to determine the inclusion of programs in the portfolio. Overall, DP&L's portfolio is cost-effective as measured by the TRC. In addition, cost effectiveness calculations were performed using the Utility Cost Test (UCT), the Ratepayer Impact Measure (RIM), and the Participant Cost Test (PCT).

For all tests, a program is cost effective when the present value of the benefits is greater than the present value of the costs. What varies among the different cost effectiveness tests is which benefits and costs are included. Using the benefit/cost ratio, an offering is cost effective when the ratio is greater than one.

$$\frac{B}{C} ratio = \frac{Present\ Value\ of\ Benefits}{Present\ Value\ of\ Costs} \geq 1$$

Total Resource Cost Test (TRC): The TRC measures the benefits of avoided supply costs over the lifecycle incremental costs of the energy efficiency measures and program administrative costs. Unlike the UCT, the TRC considers the cost of the measure, not just the utility incentive cost.

$$\text{Total Resource Benefits} = PV\left(\sum_{Year=1}^{Measure\ Life}\left(\sum_{i}^{i=8760}(\text{impact}_i \textbf{ X } \text{avoided cost}_i)\right)\right)$$

Total Resource Costs = PV (incremental measure costs + utility administrative costs)

Utility Cost Test (UCT): The UCT is a valuation of the costs and benefits from the perspective of the utility. It is measured by comparing the value of the supply-side benefits to the incentive and administrative costs associated with the energy efficiency programs. Unlike the TRC, the UCT considers incentive costs as opposed to incremental measure costs.

$$\text{Utility Benefits} = PV\left(\sum_{Year=1}^{Measure\ Life}\left(\sum_{i}^{i=8760}(\text{impact}_i \textbf{ X } \text{avoided cost}_i)\right)\right)$$

Utility Costs = PV (utility incentive costs + utility administrative costs)

Ratepayer Impact Measure (RIM): The RIM is a valuation of the net benefits of the energy efficiency programs from the perspective of the nonparticipants. It is measured by comparing the supply-side benefits to the costs of the programs, in terms of utility incentive costs, utility administrative costs and electric monetary savings.

$$\text{Ratepayer Benefits} = PV\left(\sum_{Year=1}^{Measure\ Life}\left(\sum_{i}^{i=8760}(\text{impact}_i \textbf{ X } \text{avoided cost}_i)\right)\right)$$

Ratepayer Costs = PV (utility incentive costs + utility admin costs + electric monetary savings)

Participant Cost Test (PCT): The PCT values the benefits of the programs from the perspective of program participants. It measures the electric monetary savings of the participants as compared to the measures costs net of utility incentives.

$$\text{Participant Benefits} = PV\left(\sum_{Year=1}^{Measure\ Life}\left(\sum_{i}^{i=8760}(\text{impact}_i \textbf{ X } \text{rate}_i)\right)\right)$$

Participant Costs = PV (net participant measure costs)

Presented below in Table 4 are the discount rates applied to each cost-effectiveness test.

Benefit – Cost Test	Discount Rate
TRC	7.86%
UCT	7.86%
RIM	7.86%
PCT	10.00%

Table 4 Discount Rates

Presented below in Table is the cost effectiveness for each program and for the portfolio as a whole by the various tests.

Residential Programs	Total Resource Cost Test (TRC)	Utility Cost Test (UCT)	Participant Cost Test (PCT)	Ratepayer Impact Measure Test (RIM)
Efficient Products	6.38	9.48	12.05	0.54
HVAC Equipment	0.83	4.47	1.52	0.50
Appliance Recycling	2.04	2.01	-	0.37
Income Eligible Efficiency	0.43	0.40	-	0.22
School Education	2.76	2.63	-	0.35
Home Audit	0.60	0.54	-	0.26
Behavior Change	3.35	3.35	-	0.35
Energy Savings Kits	4.48	4.04	-	0.43
Multi-Family Direct Install	2.20	2.02	-	0.41
Smart Thermostats	0.55	1.52	1.53	0.35
Residential Total	**2.57**	**4.39**	**6.65**	**0.48**
Business Programs	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Rapid Rebates (Prescriptive)	2.22	5.21	3.36	0.64
Custom	1.54	3.96	2.36	0.66
Small Business Direct Install	2.43	3.51	3.49	0.68
Mercantile Self-Direct	1.56	13.26	2.21	0.69
Business Total	**1.97**	**4.79**	**2.99**	**0.65**
Cross Sector	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Non-Programmatic Savings	2.64	146.12	4.02	0.60
	Total Resource Cost Test (TRC)	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
PLAN TOTAL*	**2.16**	**5.25**	**4.06**	**0.57**

*Costs in plan total include Customer Education & Marketing, Pilot, Stakeholder Initiatives and EM&V.

Table 5 Cost Effectiveness by Program and Total Portfolio

PROGRAM BENEFIT COMPONENTS

Benefits counted in the TRC, Utility, RIM, and PCT include the full value of time and seasonally differentiated energy and capacity costs. They also take into account avoided line losses. Line loss assumptions are specified in Table 6. For each energy-efficiency measure included in a program, hourly (8,760) system-avoided costs were applied to estimate hourly impacts derived using hourly load shapes of the affected end use. Non-energy benefits such as water savings were not factored into the calculation.

Sector	Energy Line Losses	Demand Line Losses
Residential	7.05%	8.14%
Commercial & Industrial	3.90%	5.01%

Table 6 Line Loss Assumptions Used in Cost Effectiveness Calculations

PROGRAM COST COMPONENTS

The following are the cost components included in the cost-effectiveness analysis.

Incremental measure costs: The incremental purchase cost of the energy efficiency measure to the participant.

Utility administrative costs: The administrative costs incurred by the utility to run the program, including program development, implementation vendor administrative costs, marketing, operation, and evaluations, measurement and verification.

Utility incentive costs: Direct incentives paid to customers by either the utility or the utility's implementation vendor.

Electric Monetary Savings: It is the energy impact multiplied by the retail rate. It is also a benefit in the PCT.

Net participant measure costs: The incremental purchase cost of the energy efficiency measure to the participant net of utility incentives paid to the participant.

Cost categories and whether they are applied at the program or portfolio level are summarized in Table .

Cost Category	Level Cost Applied	Description
Implementation Vendor	Program	Costs paid to program implementation vendors.
Incentives	Program	Incentives paid to customers for each program.
DP&L Administrative	Program & Portfolio	DP&L costs assigned to a specific program are applied at the program level.
Education and Marketing	Portfolio	Costs associated with education and marketing activities.
Evaluations, Measurement & Verification	Portfolio	Costs associated with performing EM&V activities.

Table 7 Cost Categories and Descriptions

PROJECTED NET BENEFITS

Presented below in Table 8 are the projected net benefits for each program and for the portfolio as a whole by the various tests.

Residential Programs	Total Resource Cost Test (TRC)	Utility Cost Test (UCT)	Participant Cost Test (PCT)	Ratepayer Impact Measure Test (RIM)
Efficient Products	$ 79,821,626	$ 76,107,667	$ 132,568,866	$ (73,821,054)
HVAC Equipment	$ (3,286,437)	$ 12,721,761	$ 9,390,026	$ (16,305,687)
Appliance Recycling	$ 1,820,910	$ 1,778,187	$ 7,125,049	$ (5,908,644)
Income Eligible Efficiency	$ (2,059,371)	$ (2,152,328)	$ 2,700,088	$ (5,094,387)
School Education	$ 1,936,269	$ 1,788,211	$ 6,737,893	$ (5,364,913)
Home Audit	$ (1,498,622)	$ (1,721,129)	$ 3,729,808	$ (5,614,831)
Behavior Change	$ 3,781,709	$ 3,781,709	$ 13,015,517	$ (9,806,201)
Energy Savings Kits	$ 3,881,615	$ 3,388,086	$ 8,796,693	$ (5,988,080)
Multi-Family Direct Install	$ 2,185,813	$ 1,871,356	$ 6,876,542	$ (5,335,357)
Smart Thermostats	$ (2,054,948)	$ 871,080	$ 2,177,680	$ (4,672,481)
Residential Total	**$ 84,528,564**	**$ 98,434,600**	**$ 193,118,162**	**$ (137,911,635)**
Business Programs	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Rapid Rebates (Prescriptive)	$ 64,102,129	$ 91,469,403	$ 112,007,671	$ (63,496,072)
Custom	$ 16,903,553	$ 36,147,312	$ 35,756,366	$ (25,453,299)
Small Business Direct Install	$ 5,822,493	$ 7,072,939	$ 9,165,923	$ (4,710,360)
Mercantile Self-Direct	$ 2,496,461	$ 6,426,102	$ 4,841,193	$ (3,114,833)
Business Total	**$ 89,324,636**	**$ 141,115,756**	**$ 161,771,153**	**$ (96,774,564)**
Cross Sector	**Total Resource Cost Test (TRC)**	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
Non-Programmatic Savings	$ 64,539,874	$ 103,185,505	$ 114,791,026	$ (68,375,097)
	Total Resource Cost Test (TRC)	**Utility Cost Test (UCT)**	**Participant Cost Test (PCT)**	**Ratepayer Impact Measure Test (RIM)**
PLAN TOTAL*	**$227,386,989**	**$331,729,777**	**$469,680,342**	**$314,067,382**

*Costs in plan total include Customer Education & Marketing, Pilot, Stakeholder Initiatives and EM&V.

Table 8 Projected Net Benefits

Appendix A

Market Potential Update

Energy Efficiency Potential Assessment

June 15, 2017

Dayton Power and Light
1900 Dryden Rd,
Dayton, Ohio 45439

This page left blank.

CADMUS

Prepared by:
Aquila Velonis
Travis Walker
Anna Kelly
Torsten Lund Snee
Sara Gordon
Steve Cofer

Cadmus

This page left blank

List of Acronyms

AAPOR: American Association for Public Opinion Research

ACEEE: American Council for an Energy-Efficient Economy

Btu: British thermal unit

CBECS: Commercial Building Energy Consumption Survey (Energy Information Agency)

CFL: Compact fluorescent light

CHP: Combine heat and power

DEER: Database for Energy Efficient Resources

DOE: United States Department of Energy

ECM: Energy conservation measure

EERE: Office of Energy Efficiency and Renewable Energy

EIA: Energy Information Agency

EISA: Energy Independence and Security Act (of 2007)

EPA: Environmental Protection Agency

EUC: End-use consumption

EUL: Effective useful life

EUI: End-use Intensities

GE: Greater than or equal to, in context of "Water heat GE 55 gallons"

GWh: Gigawatt hours

HVAC: Heating, ventilation, and air conditioning

IAC: Industrial Assessment Center

ISPP: Industrial savings potential project

ITC: Federal investment tax credit

kW: Kilowatt

kWh: Kilowatt hour

LCOE: Levelized cost of energy

LE: Less than, in context of "Water heat LE 55 gallons"

LED: Light emitting diode

LMOP: Landfill methane outreach program

MECS: Manufacturing Energy Consumption Survey (Energy Information Agency)

MW: Megawatt

MWh: Megawatt hour

NPV: Net present value

NYMEX: New York Mercantile Exchange

O&M: Operation and maintenance

RAC: Window/room air conditioner

RECS: Residential Energy Consumption Survey (Energy Information Agency)

SPM: California Standard Practice Manual

TLED: Tube light emitting diode

TRC: Total resource cost

TRM: Technical reference manual

VFD: Variable frequency drive

VSD: Variable speed drive

WHP: Waste heat-to-power

WWTFs: Wastewater treatment facilities

CADMUS

Table of Contents

List of Tables

List of Figures

Executive Summary

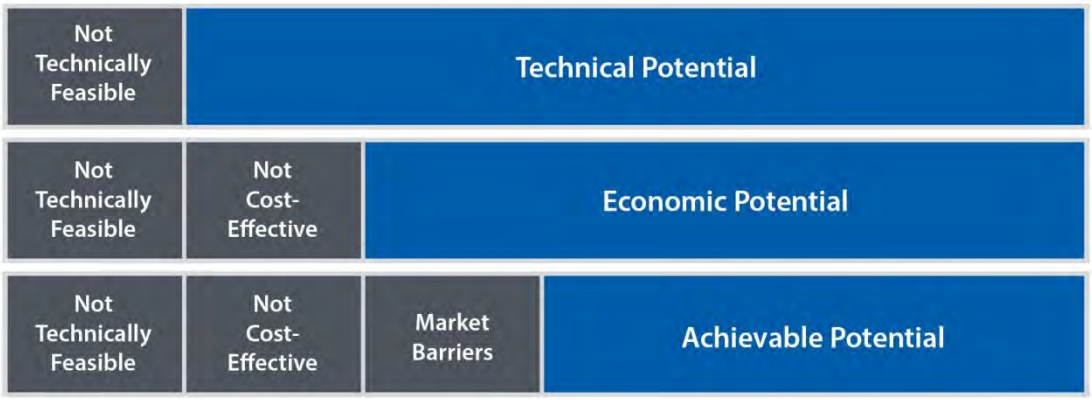
This report summarizes results from an independent study of the technical, economic, and achievable energy efficiency and combined heat and power (CHP) potential for Dayton Power and Light (DP&L) over the next 10 years, beginning in 2018. The results of this study will inform DP&L's future program plans, including the 2018 to 2020 planning period.

The study relies on both primary and secondary data specific to DP&L's service territory. Cadmus completed nearly 600 phone surveys with residential and commercial customers to estimate end-use saturations in Dayton-area buildings and homes and to assess customers' willingness to adopt efficiency measures. Secondary data included the utility's load forecasts, long-term avoided costs (including annual energy and capacity values), line losses, and discount rates. Cadmus reviewed the Ohio Technical Reference Manual (Ohio TRM), DP&L's program offerings and current evaluation data, and Cadmus' internal energy efficiency measures database to develop a comprehensive list of commercially available measures for assessment in the study. Cadmus supplemented primary and secondary data with information from secondary sources (e.g. U.S. Census and Energy Information Administration).

Together, these provided the foundation for estimating technical, economic, and achievable potential, defined as follows:

- *Technical potential* assumes all technically feasible, energy efficiency measures which may be implemented, regardless of their costs or market barriers.
- *Economic potential* represents a subset of technical potential, consisting only of measures meeting cost-effectiveness criteria based on the utility's avoided supply costs for delivering electricity and avoided line losses. Cadmus determined the economic potential using a total resource cost (TRC) test, which compares the net benefits of energy efficiency measures with their costs.
- *Achievable potential* is the portion of economic potential assumed to be reasonably achievable in the course of the planning horizon, given market barriers that may impede customers' participation in utility programs. In this study, Cadmus examined survey results to assess customers' willingness to adopt energy efficiency measures at the following four levels, depending on the fraction of the measure's incremental cost covered by DP&L's incentives: (1) none, (2) 50%, (3) 75%, and (4) 100%.

Figure 1. Definitions of Energy Efficiency Potential

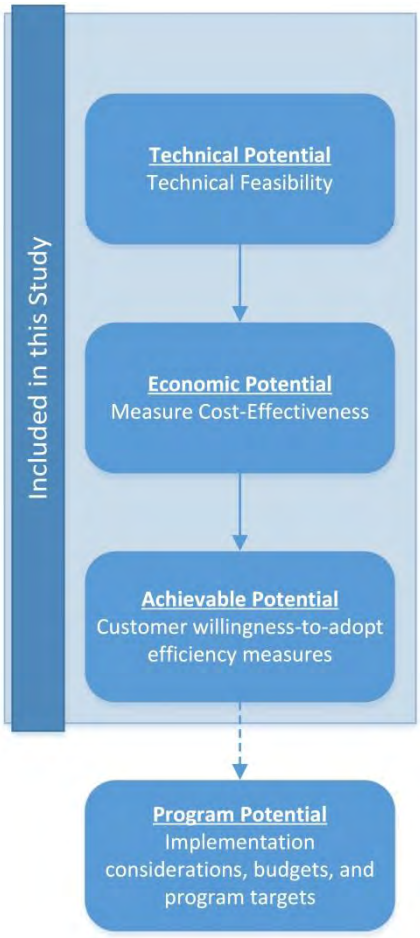


EPA – National Guide for Resource Planning

To estimate technical potential, as referenced in Figure 1 above, Cadmus used the industry-standard, bottom-up approach. This approach is consistent with energy efficiency studies by Cadmus and other consultants in various jurisdictions in the United States. We began with a comprehensive review of electric energy efficiency measures applicable to each utility's sector and market segments. Using technical measure data and market characteristics, we determined likely long-term saturations of each measure in specific sectors and market segments. This assessment resulted in a technical potential supply curve at the measure level, which we then screened for cost-effectiveness to determine the economic potential. The study determined achievable levels of energy efficiency potential by assessing customers' willingness to pay for energy efficiency measures based on survey results.

This study does not consider a fourth type energy-efficiency potential—program potential. Program potential is the short-run (typically three to five years) energy efficiency potential that can be realistically achieved through utility energy efficiency programs after accounting for implementation barriers and program budgets. Estimates of achievable potential can inform program potential by informing upper and lower bounds of program targets and identifying which measures a utility can offer to cost-effectively meet those targets. Figure 2 shows the types of energy efficiency considered in this study and how they relate to one another.

Figure 2. Types of Potential Considered



Study Objectives

The purpose of this study is to conduct an assessment of remaining energy efficiency potential of DP&L's service territory to inform their 2018 to 2020 program planning cycle. Specific objectives to fulfill this purpose include the following:

- Collect and analyze primary data on the saturation of specific end uses and equipment in Dayton-area homes and commercial facilities;
- Assess customers' willingness to participate in energy efficiency programs for specific measures at different incentive levels;
- Develop baseline end-use load forecasts for the residential, commercial, and industrial sectors for the utility that capture the unique mixture of end-use consumption in each sector, account for the impact of energy building codes and federal equipment standards, and reflect the natural adoption of efficient technology;
- Characterize a comprehensive list of commercially available energy efficiency measures, which includes estimates of measure costs, savings, and applicability;

- Quantify technical, economic, and achievable potential over the study horizon (2018 to 2027) for the residential, commercial, and industrial sectors;
- Identify the relative savings potential for a list of energy efficiency measures. Compare measures with high savings potential to those offered through DP&L's existing programs;
- Identify market segments with high energy efficiency savings potential; and
- Quantify technical and market potential for CHP technologies for nonresidential sectors.

Although this study is meant to inform program design, it does not set program targets. Specifically, this study does not include estimates of the fourth type of energy efficiency potential—program potential. Program potential reflects energy savings that a utility expects to achieve given certain spending levels and program design objectives. It requires a more detailed look at rebate levels, expenditures on marketing and administration, and the possible mixture of measures utilities can offer in a portfolio. Although study results are an excellent reference point for program development, they are based on broad assumptions that may not apply to DP&L's specific programs. Differences between program planning and estimates of energy efficiency potential include the following:

- First, estimates of achievable potential include all cost-effective energy efficiency measures and no measures that fail the TRC benefit-cost test. Ohio rules allow for utilities to include measures that are not cost-effective in a portfolio as long as the portfolio-level TRC benefit ratio exceeds 1.0. For some measures, estimates of energy efficiency potential are lower than planned savings because of the cost-effectiveness requirement in the potential study.
- Second, estimates of achievable energy efficiency potential reflect broad assumptions on expenditures on incentives and marketing and the adoption of energy efficiency measures. These broad assumptions allow Cadmus to produce a realistic range of achievable potential; however, they do not produce estimates for specific DP&L programs. Furthermore, estimates of achievable potential do not account for program factors such as budgets and implementation infrastructure (e.g., trade ally networks and certified contractors).
- Third, estimates of economic and achievable potential assume energy efficiency measure costs stay constant over the study horizon. Cadmus has reviewed historic measure costs for most measures considered in this study and have found no discernible trend—some measures' costs have increased, some have decreased, and some have both increased and decreased. Because of the uncertainty produced by forecasting energy efficiency measure costs, Cadmus adopts the conservative assumption that costs stay nominally constant. However, although DP&L completes potential studies only every three years, program implementation is much more nimble; DP&L continuously evaluates the cost-effectiveness of measures as new technologies emerge and as costs increase and decrease. For this reason, DP&L could offer measures in future program years that were not cost-effective in the potential study and if these measures come down in price.
- Fourth, the achievable energy efficiency potential in this study provide estimates for the annual savings as a percent of DP&L sales. The methodology to determine these estimates use the

cumulative 2027 potential over the forecasted DP&L sales in 2027, then divided by ten years result in an average annual savings percent of sales. Program planning may look at a shorter planning period, such as three years in the case for DP&L, where the annual savings percent of sales will be specific to each year within their planning period.

- Finally, potential studies characterize the average customer within a given sector, market segment, and building vintage. When a measure fails the benefit-cost screen in a potential study, it means the measure is not cost-effective when assuming average building characteristics and operation. However, although some measures may not be cost-effective for an average customer, they may be economic for a specific customers. For instance, while residential heat pump water heaters did not pass the benefit-cost screen in this study, DP&L may find projects where heat pump water heater is cost-effective given an individual building's characteristics (such as hot water usage,). For this reason, program potential may exceed achievable potential.

The potential study identifies new cost-effective measures (as well as updating savings estimates for existing measures), estimating the impact of building energy codes and standards on future savings, and shows relative savings in different sector and market segments. It also provides a framework to help DP&L understand how potential savings may change given changes in load forecasts, incentive levels, or regulatory/policy factors. The potential study, however, does not incorporate nuanced programmatic assumption for each energy efficiency measure. DP&L's program planning process incorporates details related to program and measure-specific implementation barriers. For these reasons, DP&L's planned savings may differ from estimates of achievable potential.

Summary of Results

This study quantifies the amount of energy and demand that can be saved as well as CHP potential within DP&L's service territory from 2018 to 2027, including 2018 to 2020, which is DP&L's next program planning period. DP&L can achieve potential savings through proven, commercially available energy-efficient technologies while accounting for the following:

- Changes in codes and standards (taking effect from 2018 to 2027),
- Technical feasibility and limitations (technical potential),
- Cost-effectiveness (economic potential) using the TRC, and
- Consumers' willingness to adopt energy efficiency measures (achievable potential).

This study compares estimates of technical, economic, and achievable potential to forecasts of DP&L's sales. Cadmus developed forecasts based on DP&L's forecast; however, Cadmus' end-use forecast may differ from DP&L's forecast because Cadmus accounted for future equipment standards that were not explicitly accounted for in DP&L's load forecast.

It is worth noting that the customer forecast used in this study include opt-out customers. Beginning in January of 2015, Ohio Senate Bill 310 allows for certain large commercial and industrial customers to

opt out of DP&L's energy efficiency and demand reduction programs. DP&L's likely opt-out customers can account for approximately 21% of their commercial and 55% of their industrial sales. Although excluding opt-out customers would impact the results of this study, opt-out customers can still pursue cost effectiveness energy efficiency improvements on their own without the help of utility incentives. In addition, including these customers enables us to compare results to DP&L's previous potential studies as well as to other utilities' potential studies.

Energy Efficiency Results

DP&L results indicate 3,820 cumulative gigawatt hours (GWh) of technically feasible, electric energy efficiency potential by 2027, with approximately 2,250 GWh (59%) of savings coming from cost-effective measures. Economic potential represents 16% of DP&L's forecasted 2027 sales. Table 1 summarizes technical and economic potential by sector.

Table 1. Technical and Economic Energy Efficiency Potential by Sector – Energy (GWh)

Sector	Baseline Sales	Cumulative 2018-2027				
		Technical Potential		Economic Potential		
		GWh	% of Baseline	GWh	% of Baseline	% of Technical
Residential	6,006	2,275	38%	1,307	22%	57%
Commercial	4,157	1,016	24%	626	15%	62%
Industrial	4,266	529	12%	317	7%	60%
Total	14,429	3,820	26%	2,250	16%	59%

Peak demand savings from all technically feasible energy efficiency measures is equivalent to 573 megawatts (MW), and 364 MW for measures that are both technically feasible and cost-effective. Table 2 shows technical and economic peak demand savings potential by sector.

Table 2. Technical and Economic Energy Efficiency Potential by Sector – Demand (MW)

Sector	Cumulative 2018-2027		
	Technical Potential (MW)	Economic Potential (MW)	Economic % of Technical
Residential	328	222	68%
Commercial	166	95	57%
Industrial	80	48	60%
Total	573	364	64%

Estimates of technical and economic potential require the broad assumptions that customers install either all technically feasible measures or all measures that are both technically feasible and cost-effective. These estimates likely exceed the amount of savings DP&L can realistically achieve. Estimates of achievable potential not only account for technical constraints and measure cost-effectiveness, but they also incorporate barriers to market adoption. Achievable potential is best presented as a range of

estimates instead of a single-point estimate—the range of estimates account for various levels of expenditures on energy efficiency and the uncertainty around customer adoption.

Cadmus gathered primary data through a survey and asked customers about their willingness to invest in energy efficiency if DP&L subsidized the investment by paying 0%, 50%, 75%, or 100% of the energy efficiency measure's incremental cost. The incentive level—0%, 50%, 75%, or 100%—was not related to DP&L's avoided cost of energy or capacity. Cadmus designed this effort to gather information on which incentive levels would motivate customers to install energy efficiency measures. Table 3 and Table 4 shows the low, medium, high, and max levels of cumulative, electric energy efficiency potential DP&L can expect to be achievable over the course of this study's 10-year horizon. Table 3 and Table 4 present achievable energy and demand savings by sector in 2027.

Table 3. Achievable Energy Efficiency Potential by Sector – Energy (GWh)

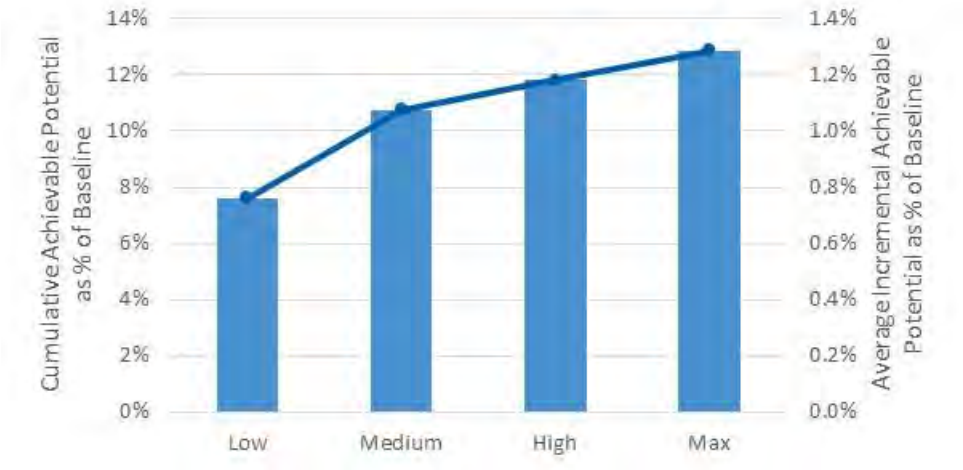
Sector	Baseline Sales	Cumulative GWh 2018 - 2027				% of Baseline			
		Low	Medium	High	Max	Low	Medium	High	Max
Residential	6,006	718	949	1,031	1,100	12%	16%	17%	18%
Commercial	4,157	252	399	447	503	6%	10%	11%	12%
Industrial	4,266	128	202	226	254	3%	5%	5%	6%
Total	14,429	1,098	1,550	1,704	1,857	8%	11%	12%	13%

Table 4. Achievable Energy Efficiency Potential by Sector – Demand (MW)

Sector	Cumulative MW 2018 - 2027			
	Low	Medium	High	Max
Residential	122	161	175	187
Commercial	38	60	68	76
Industrial	19	30	34	38
Total	179	252	276	301

Over the 10-year study horizon, cumulative achievable potential for DP&L can account for between approximately 8% and 13% of baseline sales. This translates to average annual savings ranging from 0.8% to 1.3% of baseline sales (Figure 3).

Figure 3. Ten-Year Cumulative and Average Annual Incremental Savings as Percent of Baseline



Combined Heat and Power Results

Cadmus assessed the applicable technical and market CHP potential for commercial and industrial sectors as well as for landfills, farms, and wastewater treatment facilities within DP&L service territory. CHP systems generate electricity and use waste heat for thermal loads, such as space or water heating. CHP can be used in buildings with a coincident thermal and electric load or in buildings producing combustible biomass or biogas, such as pulp and paper manufacturing facilities or landfills.

Traditionally, CHP systems have been installed in hospitals, schools, and manufacturing facilities, but can be used across nearly all commercial and industrial market segments with average monthly energy loads greater than about 30 kW. CHP is generally divided into two subcategories based on fuels used: nonrenewable CHP, which typically runs on natural gas, and renewable CHP, which runs on biologically derived fuel (biomass or biogas).

Cadmus analyzed the following natural gas-consuming CHP systems:

- Reciprocating engines,
- Microturbines,
- Gas turbines, and
- Fuel cells.

Reciprocating engines cover a wide size range, whereas gas turbines typically are large systems. Fuel cells and microturbines represent newer technologies with higher capital costs, although fuel cells have the highest electrical conversion efficiency.

The renewable CHPs Cadmus analyzed were industrial biomass systems and anaerobic digester biogas systems, described as follows:

- Industrial biomass systems are used in industries such as pulp and paper manufacturing in which site-generated waste products can be combusted in place of natural gas or other fuels. This

analysis assumed that the combustion process includes a CHP system (typically, steam turbines) to generate electricity on-site. Industrial biomass systems generally operate on large scales, with a capacity greater than 1 MW.

- Anaerobic digesters create methane gas (biogas fuel) by breaking down liquid or solid biological waste. Anaerobic digesters can be coupled with a variety of generators, including REs and MTs, and typically are installed at landfills, wastewater treatment facilities, and livestock farms.

The resulting total 10-year (2018-2027), system-wide technical potential was estimated to be 1,060 MW, as measured at generator. Table 5, below, details technical potential by fuel (MW).

Table 5. CHP Technical Potential by Fuel (Cumulative MW in 2027)

DP&L	Technical Potential
Commercial	
Natural gas MW	545
Number of sites	1,223
Industrial	
Natural gas MW	492
Number of sites	374
Biomass and biogas MW	23
Number of sites	27
Industrial total MW	515
Industrial total number of sites	402
Total	
Total MW	1,060
Total number of sites	1,624

Cadmus applied a market penetration rate on the technical potential data to determine market potential or likely installations in future years. The study based the assumed annual market penetration rate on secondary research of market acceptance curves from payback models and from best available data. Cadmus assumed the base-case scenario assumption of 0.66% (annual percentage of technical to market penetration) because it best represented the current regulatory and federal incentive conditions. Cadmus also compared the estimated market penetration rate with two other CHP potential study reports conducted by Cadmus and found the market penetration rate used for DP&L fell within these two studies (0.39% to 0.82%). The market penetration rate was applied to the technical potential for each year to calculate market potential over the next 10 years, as shown in Table 6. The study estimated a cumulative 10-year market potential of 69.7 MW at the generator. The DP&L line loss assumption used for this study was 5.21%.

Table 6. Cumulative 2018-2027 Market Potential

Technology	2018-2027 MW at Site	2018-2027 MW at Generator	Number of Sites
Nonrenewable - Natural Gas (Total)	**64.6**	**68.1**	**99.5**
30–99 kW	0.67	0.70	10
100–199 kW	5.10	5.38	34
200–499 kW	10.88	11.48	31
500–999 kW	10.88	11.48	15
1–4.9 MW	23.28	24.56	8
5 MW+	13.76	14.52	2
Renewable - Biomass (Total)	**1.1**	**1.1**	**1**
< 500 kW	0.06	0.06	1
500–999 kW	0.09	0.09	0
1–4.9 MW	0.60	0.63	0
5 MW+	0.32	0.34	0
Renewable - Biogas (Total)	**0.4**	**0.4**	**1**
Landfill	0.17	0.18	0
Farm	0.17	0.18	1
Wastewater	0.04	0.04	0
Total	66.0	69.7	101.2

The CHP market potential did not assume ramping. That is, each year's incremental potential is roughly one-tenth of the total 10-year potential. Because DP&L's load growth forecast was incorporated into the analysis, the incremental potential was slightly less in the earlier years, as shown in Table 7.

Table 7. Incremental Market Potential by Year by Technology at Generation (MW)

Technology	2018	2019	2020	2021	2022	2023	2024	2025	2027	2027
Nonrenewable (Total)	**6.60**	**6.67**	**6.71**	**6.74**	**6.80**	**6.89**	**6.99**	**7.07**	**7.14**	**7.21**
Fuel cell	0.29	0.29	0.29	0.30	0.30	0.30	0.31	0.31	0.31	0.32
Gas turbine	1.93	1.95	1.97	1.97	1.99	2.02	2.04	2.07	2.09	2.11
Microturbine	0.49	0.50	0.50	0.50	0.51	0.51	0.52	0.53	0.53	0.54
Reciprocating Engine	3.89	3.93	3.95	3.97	4.01	4.06	4.11	4.16	4.20	4.25
Renewable (Total)	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**	**0.16**
Biomass	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12
Biogas	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total CHP	6.75	6.82	6.86	6.89	6.95	7.04	7.14	7.23	7.30	7.37

Study Findings

Achievable energy efficiency could produce average annual savings of between 0.8% and 1.3% of DP&L's baseline sales. However, these estimates do not account for program design constraints, such as budgets, measure bundling, and requirements to serve specific market segments, such as low-income customers. As noted previously, this study is meant to inform program design and is a reference point or guide for program development, but it does not set program targets. As with any potential study, this assessment requires broad assumptions about program expenditures and cost-effectiveness (as discussed above); DP&L refines these assumptions as it plans specific programs. Because of these differences, achievable potential may not equal DP&L's planned savings.

Overall, Cadmus identified several measures with significant cost-effective savings potential including following:

- LED lighting, low flow showerheads, ENERGY STAR multifunction devices, and refrigerator recycling offer high cost-effective savings potential in the residential sector. However, LED lighting potential does diminish after 2020 due to federal lighting standards enacted in the Energy Independence and Security Act (EISA).
- LED linear lighting (TLEDs), lighting controls, screw base LED lighting, and efficient ventilation and circulation systems offer high savings potential for the commercial sector. Various lighting control measures, including occupancy sensors, daylighting controls, and continuous dimming fixtures collectively account for 26% of economic potential in the commercial sector.
- High-saving industrial measures depend on the mixture of industries for each respective utility. DP&L customers are largely manufacturing customers, which have high lighting and process potential.
- The CHP potential estimated a cumulative 10-year market potential of 69.7 MW at generator. The technologies with the lowest levelized cost tend to be renewable applications because fuel costs are typically a process byproduct and are considered zero cost. Larger systems, such as reciprocating engines and gas turbines, also have low LCOE. The market potential for these larger systems is much higher than for the renewable applications. Smaller systems such as fuel cells and microturbines have the highest material cost per kW, resulting in high levelized costs.

Top Energy Efficiency Measures

From the study results, the highest technical and economic measures can be summarized of the residential, commercial, and industrial sectors. These top saving measures can provide insight on available cost-effective measures for programs and identify non-cost effective measures with high potential to watch for in the future if their costs decline. Cadmus summarized the top 15 measures for each sector, sorted by technical potential.

Of the residential sector's top 15 measures with the highest technical potential, eight also have economic potential. In terms of individual measures, the measure with the most technical and economic potential is the ENERGY STAR LED lighting general service lamp. This is followed by the ENERGY STAR

LED Lighting specialty lamp, ENERGY STAR multifunction devices, and refrigerator recycling without replacement. Table 8 shows the technical and economic potential in GWh for the top 15 residential measures, and the percentage of total technical and economic potential held by that measure.

Table 8. Top Residential Measures

Measure Name	GWh - 2027		% of Total	
	Technical Potential	Economic Potential	Technical Potential	Economic Potential
Lighting General Service Lamp - LED - ENERGY STAR	282	284	12%	22%
Lighting Specialty Lamp - LED - ENERGY STAR	254	266	11%	20%
CO2 Heat Pump Water Heater	185	0	8%	0%
Ceiling / Attic Insulation	131	5	6%	0%
Dryer - Heat Pump Dryer	97	0	4%	0%
Heat Pump Water Heater - Advanced Efficiency	89	0	4%	0%
Central Air Conditioner - ENERGY STAR Most Efficient	84	0	4%	0%
Multifunction Device - ENERGY STAR	82	82	4%	6%
Refrigerator Recycling without Replacement	69	77	3%	6%
Air Sealing	62	0	3%	0%
Duct Sealing	56	61	2%	5%
TV LCD - ENERGY STAR Most Efficient	54	0	2%	0%
Computer - ENERGY STAR	53	53	2%	4%
Central Air Conditioner - Quality Install	50	0	2%	0%
Showerhead Low Flow	49	91	2%	7%

Of the 15 commercial measures with the highest technical potential, 11 also have economic potential. In terms of individual measures, the measure with the most technical and economic potential is "occupancy sensor control," which makes up 11% of commercial technical potential and 15% of commercial economic potential. Measures such as continuous commissioning and CO2 heat pump water heaters have significant technical potential, however, these measures would likely need to come down in cost to eventually become cost-effective. Table 9 shows the technical and economic potential in GWh for the top 15 commercial measures and the percentage of total technical and economic potential held by that measure.

Table 9. Top Commercial Measures

Measure Name	GWh - 2027		% of Total	
	Technical Potential	Economic Potential	Technical Potential	Economic Potential
Occupancy Sensor Control	111	92	11%	15%
Continuous Commissioning	96	0	9%	0%
Dimming-Continuous Fixtures	71	70	7%	11%
Lighting Interior - TLED - Above Standard	47	45	5%	7%
CO2 Heat Pump Water Heater	41	6	4%	1%
Daylighting Controls, Outdoors (Photocell)	38	38	4%	6%
Motor - Pump & Fan System - Variable Speed Control	36	36	4%	6%
Lighting Interior - Screw Base LED - Above Standard	28	28	3%	4%
Advanced Power Strip - Occupancy Sensor	27	0	3%	0%
Automated Ventilation VFD Control (Occupancy Sensors / CO2 Sensors)	23	8	2%	1%
Lighting Package - Advanced Efficiency	22	22	2%	3%
Convert Constant Volume Air System to VAV	21	0	2%	0%
Exit Sign - Electroluminescent	20	20	2%	3%
Solar Hot Water (SHW)	18	0	2%	0%
Outside Air Economizer with Dual-Enthalpy Sensors	16	14	2%	2%

Of the industrial sector's top 15 measures with the highest technical potential, 11 also have economic potential. Aside from Integrated Plant Energy Management, which was the highest share of the "other" end use in the previous figures, the three top measures for technical potential are all lighting measures. The top measures in the industrial sector are notable because all the technical potential is also economic potential. In terms of individual measures, the measure with the most technical and economic potential is "lighting"—specifically, "High Bay LED packages," which makes up 19% of industrial technical potential band and 31% of industrial economic potential.

Table 10 shows the technical and economic potential in MWh for the top 15 industrial measures and the percentage of total technical and economic potential held by those measures.

Table 10. Top Industrial Measures

Measure Name	GWh - 2027		% of Total	
	Technical	Economic	Technical	Economic
Lighting - High Bay LED Packages	98	98	19%	31%
Integrated Plant Energy Management	89	0	17%	0%
Lighting - LED Linear Packages	38	0	7%	0%
Lighting - LED Lamp Packages	29	29	6%	9%
Air Compressor Optimization	23	23	4%	7%
VFD Controlled Compressor	23	6	4%	2%
Material Handling	23	0	4%	0%
Chiller - Water Piping Loop with VSD Control	17	17	3%	5%
Variable Speed Drive Control	14	14	3%	5%
Motor Management Plan	14	14	3%	4%
Variable Speed Compressor Systems	14	14	3%	4%
Floating Head Pressure Controller	13	13	2%	4%
VFD on Cooling Tower Fans	11	11	2%	3%
Lighting - High Bay High Output Packages	11	0	2%	0%
Chiller Water-Cooled	10	10	2%	3%

Introduction

Dayton Power and Light (DP&L) contracted Cadmus to assess remaining energy efficiency potential to inform their 2018 to 2020 program planning cycle. Such a study gives DP&L insight into how much savings is realistically achievable, the costs of acquiring the savings, and the mixture of high-saving measures that can be incorporated into DP&L's programs. This study assesses the technical, economic, and achievable potential over the study horizon (2018 to 2027) for the residential, commercial, and industrial sectors. In addition, this study estimates the technical and market potential for combined heat and power (CHP) technologies for nonresidential sectors.

This assessment includes primary data collection through phone surveys of DP&L residential and commercial customers to augment the existing data. The surveys were designed to fill in gaps in the existing secondary data by collecting equipment saturations, fuel type, and other needed building characteristics. The surveys also assessed customers' willingness to participate in energy efficiency programs for specific measures at different incentive levels, which is used to determine the achievable potential. Primary data collection comprised the following:

- 210 residential phone surveys sampling segments within single-family, multifamily, and manufactured homes and
- 350 nonresidential phone surveys sampling five major building types—office, retail, health care, grocery, and education.

This assessment represents an update to the 2015 potential study which was filed in 2016, and is based on DP&L's current program and planning assumptions, the 2010 Ohio Technical Reference Manual (Ohio TRM), and recent evaluation results to inform DP&L's upcoming 2018 to 2020 planning cycle. This study accounts for DP&L's latest measures such as commercial linear LEDs and WiFi thermostats as well as selecting emerging technologies such as behavioral measures, CO_2 heat pump water heaters, and commercial active chilled beam cooling systems. This study incorporates primary data collected for the residential and commercial sectors. In addition, it accounts for all measures impacted by today's codes and standards.

Cadmus also developed the market potential for CHP within DP&L territory. CHP has been a topic of interest for DP&L as well as their stakeholders and this potential study will help inform future program plans.

CHP generates electricity and uses waste heat for space or water heating requirements. It can be used in nearly any building that has a coincident thermal and electric load or that produces combustible biomass or biogas. CHP units have traditionally been installed in hospitals, schools, and manufacturing facilities; however, they can be used across nearly all segments that have an average annual energy load greater than about 30 kW. CHP is broadly divided into subcategories based on fuel use. Nonrenewable CHP runs on natural gas, whereas renewable CHP runs on a biologically derived fuel (biomass or biogas).

Organization of this Report

This report presents the study's methodologies and findings. The appendices include supplemental materials such as a summary of survey results and survey instruments.

This report is organized in the following sections, described below:

- Methodology provides an overview of the methodology Cadmus used to estimate technical, economic, and achievable potential.
- Technical and Economic Potential presents the technical and economic potential available from energy efficiency resources. This section provides detailed summaries by sector, segment, and end use, and identifies measures with high savings potential.
- Achievable Potential describes the basis for, and results of, estimating realistically achievable energy efficiency potential.
- Combined Heat and Power Potential describes results and assumptions for the assessment of CHP technologies such as gas turbines, reciprocating engines, and fuel cells that run on natural gas, as well as renewable CHP applications such as biomass or biogas.
- Conclusion reiterates key study findings.
- Appendix A: Primary Data Collection Results (Residential and Commercial)

Methodology

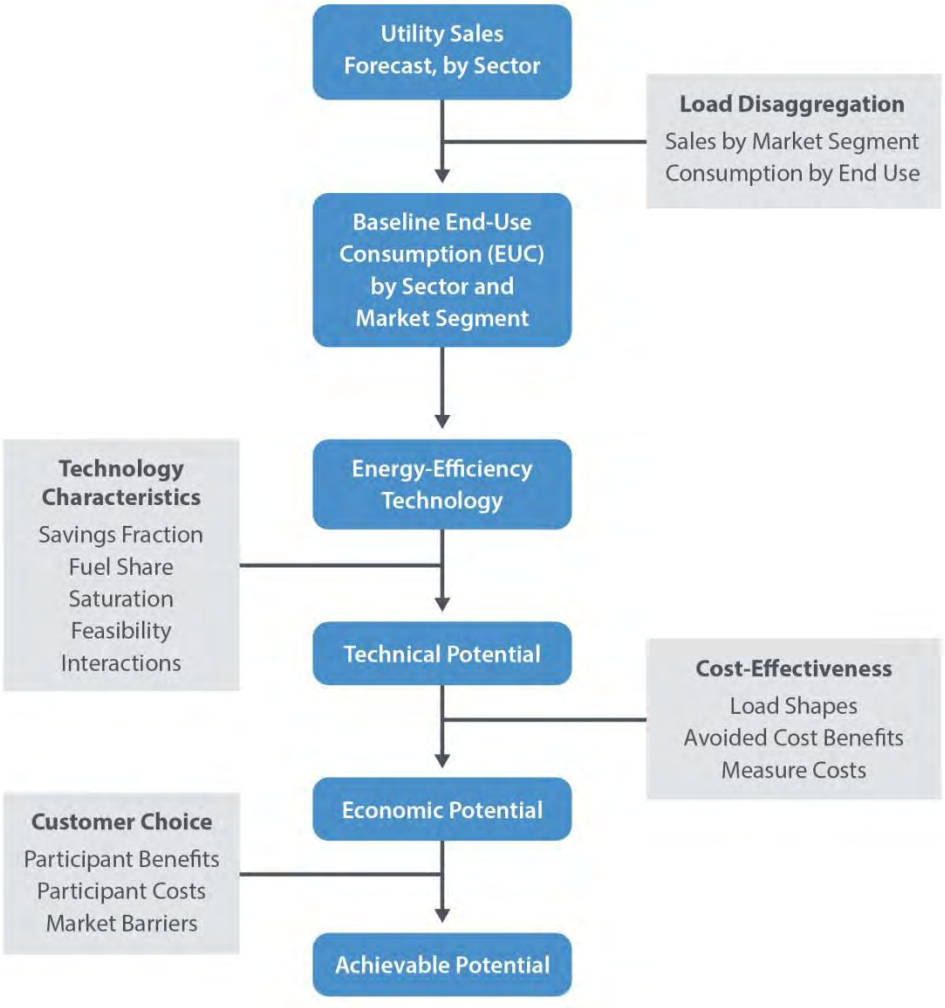
Assessing Energy Efficiency Potential

This assessment relies on industry best practices, analytic rigor, and flexible and transparent tools to accurately estimate the potential for energy and capacity savings in DP&L's service territory from 2018 to 2027. This section describes each step in the assessment process.

General Approach

The methodology used for estimating the technical, economic, and achievable energy efficiency potential drew upon standard industry practices. Figure 4 depicts the general methodology and illustrates how Cadmus combined baseline and efficiency data to estimate savings for each type of potential.

Figure 4. Methodology for Estimating Energy Efficiency Potential



The study assessed the following three types of potential:

- Technical potential, which assumes that all technically feasible demand side management measures will be implemented, regardless of their costs or market barriers. For energy efficiency resources, technical potential can be divided into three distinct classes: (1) retrofit opportunities in existing buildings, (2) equipment replacements in existing buildings, (3) and new construction. Customers can implement the first class, existing in current building stock, at any point in the planning horizon, while end-use equipment turnover rates and new construction rates dictate the timing of the other two classes.
- Economic potential, which represents a subset of technical potential, consisting only of measures meeting the cost-effectiveness criteria based on the organization's avoided energy and capacity costs. For each energy efficiency measure, the study structures the benefit-cost test as the ratio of the net present values of the measure's benefits and costs; only measures with a benefit-to-cost ratio of 1.0 or greater will be deemed cost-effective.
- Achievable potential, which derives from the portion of economic potential that might be assumed reasonably achievable during the planning horizon given market barriers that might impede customer participation in utility programs. Achievable potential can vary greatly based on program incentive structures, marketing efforts, energy costs, customer socioeconomic characteristics, and other factors. In this study, Cadmus examined survey results to assess customers' willingness to adopt energy efficiency measures at four levels depending on the fraction of the measure's incremental cost covered by DP&L's incentives: (1) none, (2) 50%, (3) 75%, and (4) 100%.

Although this study is meant to inform program design, it does not set program targets. Specifically, this study does not include estimates of the fourth type of energy efficiency potential—program potential. Program potential reflects energy savings that a utility expects to achieve given certain spending levels and program design objectives. It requires a more detailed look at rebate levels, expenditures on marketing and administration, and the possible mixture of measures utilities can offer in a portfolio. Although study results are an excellent reference point for program development, they are based on some broad assumptions that may not apply to DP&L's specific programs.

For example, estimates of achievable potential include all cost-effective energy efficiency measures and no measures that fail the total resource costs (TRC) benefit-cost test. Ohio rules allow for utilities to include measures that are not cost-effective in a portfolio as along as the portfolio-level TRC benefit ratio exceeds 1.0. Because of this, the results from this study can be viewed as a directional indicator of energy efficiency potential available for DP&L. The results of this study will identify areas and provide indicators of what energy efficiency measures have the most remaining energy efficiency potential savings as well as areas that have limited remaining potential based on today's commercial available energy efficiency technologies.

It is worth noting that the customer forecast used in this study include opt-out customers. Beginning in January of 2015, Ohio Senate Bill 310[1] allows for certain large commercial and industrial customers to opt out of DP&L's energy efficiency and demand reduction programs. DP&L's likely opt-out customers can account for approximately 21% of their commercial and 55% of their industrial sales. Although excluding opt-out customers would impact the results of this study, opt-out customers can still pursue cost effectiveness energy efficiency improvements on their own without the help of utility incentives. In addition, including these customers enables us to compare results to DP&L's previous potential studies as well as to other utilities' potential studies.

Overview

Estimating energy efficiency potential is based on a sequential analysis of various energy efficiency measures in terms of technical feasibility (technical potential), cost-effectiveness (economic potential), and expected market acceptance considering normal barriers possibly impeding measure implementation (achievable technical potential). The assessment followed four steps:

1. Developing baseline forecast—Cadmus determined 10-year future energy consumption by sector, market segment, and end use. The study calibrated the base year, 2015, to DP&L's forecasted sector loads. Baseline forecasts shown in this report include estimates of naturally occurring potential, such as savings attributable to building energy codes and federal equipment standards.
2. Estimating technical potential—We estimated technical potential using alternative forecasts that reflect technical impacts of specific energy efficiency measures.
3. Estimating economic potential—Cadmus estimated economic potential using forecasts that reflect economic impacts of cost-effective energy efficiency measures.
4. Estimating achievable potential—We calculated achievable potential by applying ramp rates and an achievability percentage to cost-effective measures (detailed later in this section).

Baseline Forecasts

Creating a baseline forecast requires multiple data inputs to accurately characterize energy consumption in DP&L's service area. These key inputs include the following:

- Sales and customer forecasts;
- Major customer segments (e.g., residential dwelling types or commercial business types);

[1] Senate Bill 310, Section 8, states the following: "Beginning January 1, 2015, a customer of an electric distribution utility may opt out of the opportunity and ability to obtain direct benefits from the utility's portfolio plan that is amended under division (B) of Section 6 of this act. The opt out shall apply only to the amended plan. The opt out shall extend to all of the customer's accounts, irrespective of the size or service voltage level that are associated with the activities performed by the customer and that are located on or adjacent to the customer's premises."

- End-use saturations;
- Equipment saturations;
- Fuel shares;
- Efficiency shares (the percentage of equipment below, at, and above code); and
- Annual end-use consumption estimates by efficiency level.

Data specific to DP&L's service territory not only provided the basis for baseline calibration, but supported the estimation of technical potential. The assessment included a primary data collection effort to ensure use of the best available data. DP&L also provided data on actual and forecasted sales by sector. Table 11 identifies key data sources.

Table 11. Key Data Sources

Data	Residential	Commercial	Industrial
Baseline Sales and Customers	DP&L actual	DP&L actual	DP&L actual
Forecasted Sales	DP&L forecasts	DP&L forecasts	DP&L forecasts
% Sales by Building Type	Census data	DP&L customer database	DP&L customer database
End-Use Energy Consumption	DP&L Load Forecast, EIA RECS, ENERGY STAR, 2014 DP&L Evaluation, Ohio TRM, etc.	DP&L Load Forecast, EIA CBECS, ENERGY STAR, 2014 DP&L Evaluation, Ohio TRM, etc.	DP&L Load Forecast, EIA MECS, ACEEE Reports
Saturations and Fuel Shares	Cadmus phone survey, EIA RECS	Cadmus phone survey, EIA CBECS	N/A
Efficiency Shares	Cadmus phone Survey, EIA RECS, ENERGY STAR Reports	Cadmus phone survey, EIA CBECS, ENERGY STAR Reports	N/A
Energy Efficiency Measures	Cadmus measure list, ENERGY STAR, 2014 DP&L Evaluation, Ohio TRM, RSMeans, etc.	Cadmus measure list, ENERGY STAR, 2014 DP&L Evaluation, Ohio TRM, RSMeans, etc.	Cadmus measure list

Measure Characterization

Cadmus developed a comprehensive database of technical and market data of energy conservation measures (ECMs) that apply to all end uses in various market segments. We included the following measures from our database:

- All measures identified in the 2010 Ohio TRM,
- All measures currently included in DP&L's prescriptive programs,
- Efficiency tiers from Consortium for Energy Efficiency and ENERGY STAR®,

- Measures from Cadmus' extensive database that includes measures in regional or national databases (e.g., DEER) and technical reference manuals, and
- Selected emerging technologies and particular technologies identified by DP&L as relevant to the study.

The emerging technologies in this study included behavioral measures, CO_2 heat pump water heaters, and commercial active chilled beam cooling systems. We focused on emerging technologies approaching commercialization or those that may become cost-effective within the next five years.

After creating a list of electric energy efficiency measures applicable to DP&L service territory, Cadmus classified energy efficiency measures into the following two categories:

1. High-efficiency equipment measures—These measures directly affect end-use equipment (e.g., high-efficiency central air conditioners), which follow normal replacement patterns based on expected lifetimes.
2. Non-equipment measures—These measures affect end-use consumption without replacing end-use equipment (e.g., insulation). Such measures do not include timing constraints from equipment turnover (except for new construction) and should be considered as discretionary as savings can be acquired at any point over the planning horizon.

This study assumes all high-efficiency equipment measures are installed at the end of the existing equipment's remaining useful life. Cadmus did not assess energy efficiency potential for early replacement. First, because most measures will naturally turn over within the study horizon, long-run technical potential from early replacement measures will equal savings from replace-on-burnout measures. However, costs for early replacement measures are much higher than replace-on-burnout measures because they reflect the full measure cost, not incremental costs. The economic potential, therefore, depends on the allocation of early replacement and replace-on-burnout measures. Inclusion of these early replacement measures would contribute to estimates of technical and economic potential that are inconsistent with their definitions.[2]

Early replacement, however, can be considered in estimates of program potential. Short-run savings from early replacement measures may exceed savings from replace-on-burnout iterations because early replacement savings are calculated using a below-standard baseline. Because this study did not include program potential, Cadmus excluded early replacement measures from the analysis.

[2] Cadmus did consider refrigerator, freezer, and room air-conditioner recycling to estimate savings associated with the removal of below-standard secondary units. These measures, however, are not considered "early replacement" because they do not assume that the secondary unit is replaced with an efficient unit.

The following are relevant inputs for equipment and non-equipment measures:

- Energy savings—average annual savings attributable to installing the measure, in absolute and/or percentage terms;
- Equipment cost—full or incremental, depending on the nature of the measure and the application;
- Labor cost—the expense of installing the measure; and
- Measure life—the expected life of measure equipment.

The following are relevant inputs for non-equipment measures only:

- Technical feasibility—the percentage of buildings where customers can install this measure, accounting for physical constraints;
- Percentage incomplete—the percentage of buildings where customers have not installed the measure, but where it is technically feasible to install it;
- Measure competition—for mutually exclusive measures, accounting for the percentage of each measure likely installed (to avoid double-counting savings); and
- Measure interaction—accounting for end-use interactions (e.g., a decrease in lighting power density causing heating loads to increase).

Cadmus derived these inputs from various sources, primarily from the Ohio TRM.

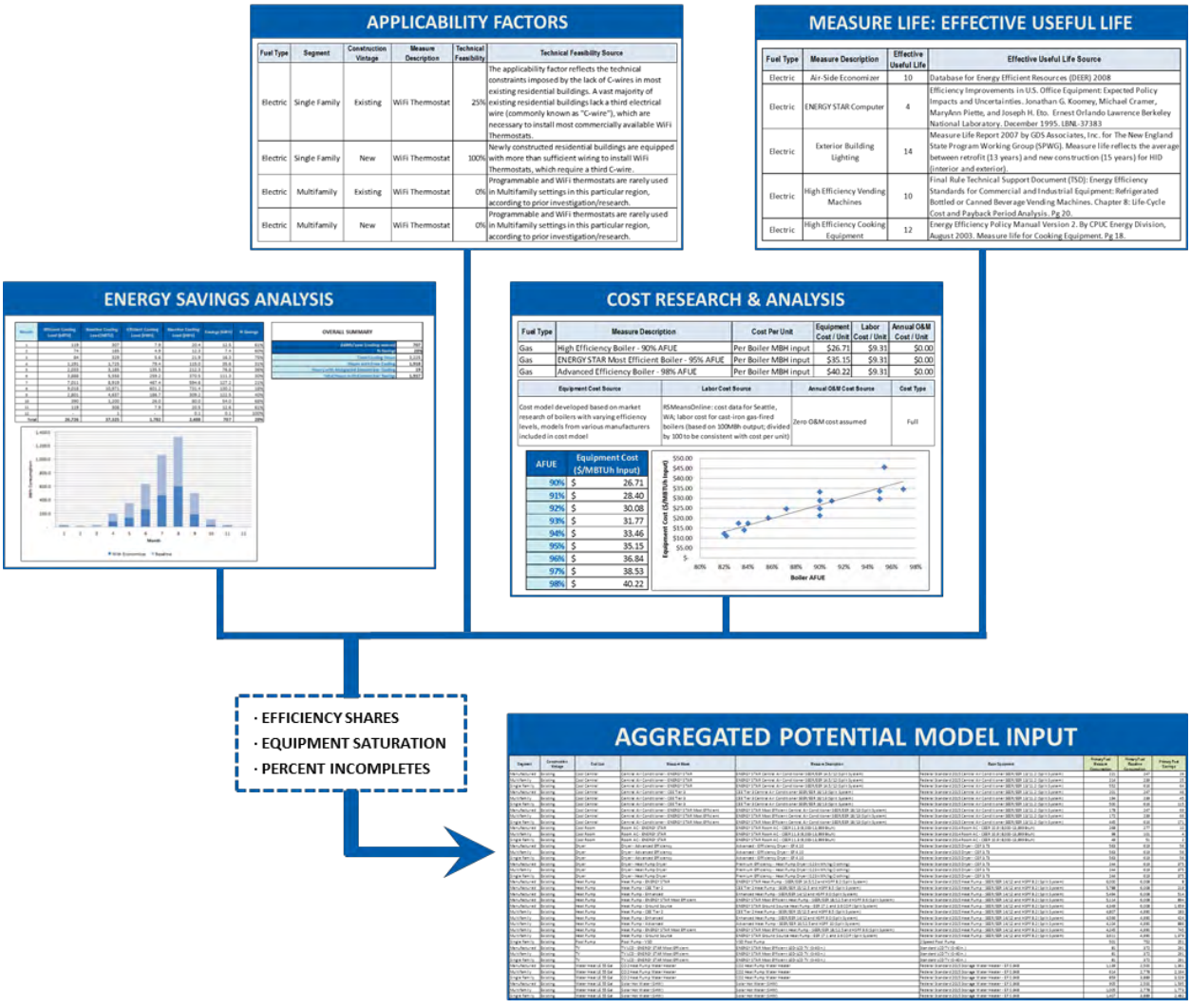
Table 12 lists the primary sources referenced in this study by data input.

Table 12. Key Measure Data Sources

Data	Residential	Commercial	Industrial
Energy Savings	Ohio TRM, DP&L 2014 Program Evaluation, ENERGY STAR, other state-wide TRMs, DOE/EERE, Regional Technical Forum, Cadmus research	Ohio TRM, DP&L 2014 Program Evaluation, CBECS 2003 Microdata, ENERGY STAR, DEER, other state-wide TRMs, DOE/EERE, Regional Technical Forum, Cadmus research	DOE's Industrial Assessment Center Database (IAC), Industrial Savings Potential Project (ISPP), Industrial Council Data, Cadmus research
Equipment and labor costs	National Residential Efficiency Measures Database, RSMeans, ENERGY STAR, DOE/EERE, DEER, Ohio TRM, Incremental Cost Studies, online retailers, Cadmus research	RSMeans, ENERGY STAR, DOE/EERE, DEER, Regional Technical Forum, Ohio TRM, Incremental Cost Studies, online retailers, Cadmus research	DOE's Industrial Assessment Center Database (IAC), Industrial Savings Potential Project (ISPP), Industrial Council Data, Cadmus research
Measure life	Ohio TRM, ENERGY STAR, DEER, Cadmus research	Ohio TRM, ENERGY STAR, DEER, Cadmus research	DEER, DOE's ITP (Industrial Technologies Program), Industrial Council Data, Cadmus research
Technical feasibility	Cadmus research	Cadmus research	Cadmus research, Industrial Council Data
Percentage incomplete	Primary Data Collection Phone Survey, DP&L Program Accomplishments, RECS, Cadmus research	Primary Data Collection Phone Survey, DP&L Program Accomplishments, Cadmus research	DP&L Program Accomplishments, Cadmus research
Measure interaction	Ohio TRM	Ohio TRM	Cadmus research

Underlining measure assumptions and analysis are characterized in Excel workbooks (by measure), as shown in Figure 5. Measure workbooks will contain detailed saving calculations, cost research, effective useful life data, applicability factor values, and measure assumptions as well as well-documented source descriptions. All measure data will be aggregated into a final master input file for the potential model.

Figure 5. Example of Measure Technical Workbooks



Incorporating Codes and Standards

Cadmus' assessment accounts for changes in codes and standards over the planning horizon. These changes affect customers' energy consumption patterns and behaviors, but they determine which energy efficiency measures continue to produce savings over minimum requirements. Cadmus captured current efficiency requirements, including those enacted but not yet in effect.

Cadmus did not attempt to predict how energy codes and standards might change in the future; rather, we only factored in enacted legislation—notably, the 2007 Energy Independence and Security Act (EISA) provisions slated to take effect over the course of the analysis.

Cadmus accounted for Ohio's energy code, the 2009 International Energy Conservation Code, and current and pending federal codes and standards. For the residential sector, these included appliances,

HVAC, and water heating standards. For the commercial sector, these included appliances, motors, water heating, HVAC, and lighting standards.

Table 13 provides a comprehensive list of codes and standards considered in this study.[3]

Table 13. Enacted or Pending Standards Accounted for in Commercial and Residential Sectors: Electric End Uses

Equipment Type	Existing (Baseline) Standard	New Standard	Date Effective*
Appliances			
Clothes washer (top loading)	Federal standard 2007	Federal standard 2015	March 7, 2015
Clothes washer (front loading)	Federal standard 2007	Federal standard 2018	January 1, 2018
Commercial refrigeration equipment (semi-vertical and vertical cases)	Federal standard 2012	Federal standard 2018	March 27, 2018
Dishwasher	Federal standard 2010	Federal standard 2013	May 30, 2013
Dryer	Federal standard 2011	Federal standard 2015	January 1, 2015
Freezer	Federal standard 2001	Federal standard 2014	September 15, 2014
Refrigerator	Federal standard 2001	Federal standard 2014	September 15, 2014
HVAC			
Central air conditioner	Federal standard 2006	Federal standard 2015 (no change for northern region)	January 1, 2015**
Heat pump (air source)	Federal standard 2006	Federal standard 2015	January 1, 2015
Residential furnace fans	Existing conditions (no federal standard)	Federal standard 2019	July 3, 2019
Room air conditioners	Federal standard 2000	Federal standard 2014	June 1, 2014

[3] All applicable standards enacted before 2015 have been accounted for such as 2013 commercial clothes washer standard, 2012 lighting general service fluorescent lamp standard, 2012 lighting incandescent reflector lamp standard, 2012 dehumidifier standard, 2012 vending machine standard, 2012 cooking oven and range standard, 2010 commercial package air conditioner and heat pump standard, 2010 packaged terminal air-conditioner and heat pump standard, 2010 ice maker standard, and 2010 electric motor standard.

Equipment Type	Existing (Baseline) Standard	New Standard	Date Effective*
Lighting			
Lighting general service lamp (EISA)	Existing conditions (no federal standard before EISA 2007)	Federal standard 2014 (phased in over three years)	January 1, 2014
Lighting general service lamp (EISA backstop provision)	Existing conditions (no federal standard before EISA 2007)	Federal standard 2020	January 1, 2020
Fluorescent linear lamps	Federal standard 2012	Federal standard 2018	January 26, 2018
Metal halide lamp fixtures	Federal standard 2009	Federal standard 2018	February 10, 2018
Motors			
Small electric motors	Federal standard 1987	Federal standard 2015	March 9, 2015
Water Heaters			
Water heater > 55 gallons	Federal standard 2004	Federal standard 2015	April 16, 2015
Water heater ≤ 55 gallons	Federal Standard 2004	Federal Standard 2015	April 16, 2015

*The potential will assume standards taking effect midyear will begin on January 1 of the following year.

**Because of uncertainty created by the litigation, the U.S. Department of Energy will not enforce the residential air-conditioning standard until July 1, 2016.

To ensure accurate assessment of the remaining potential, Cadmus accounted for the effects of future standards. Cadmus assumed that customers would replace affected equipment with more efficient alternatives meeting minimum federal standards; in other words, Cadmus assumed complete compliance.

Technical Potential

Once we fully populated the measure database, Cadmus used measure-level inputs to estimate technical potential over the planning horizon. To begin this process, we estimated savings from all measures included in the analysis and then aggregated the results to the end use, market segment, and sector levels.

We characterized individual measure savings, first in terms of the percentage of end-use consumption. For each non-equipment measure, the study estimated absolute savings using the following equation:

$$SAVE_{ijm} = EUI_{ije} * PCTSAV_{ijem} * APP_{ijem}$$

Where

$SAVE_{ijm}$ = annual energy savings for measure (*m*) for end-use (*j*) in customer segment (*i*);

EUI_{ije} = calibrated annual end-use energy consumption for equipment (*e*) for end-use (*j*) and customer segment (*i*);

$PCTSAV_{ijem}$ = the percentage savings of measure (*m*) relative to the base use for the equipment configuration (*ije*) accounting for interactions among measures, such as lighting and HVAC, calibrated to annual end-use energy consumption; and

APP_{ijem} = measure applicability—a fraction representing a combination of the technical feasibility, existing measure saturation, end-use interaction, and any adjustments to account for competing measures.

For example, for wall insulation saving 10% of space heating consumption, the final percentage of the end use saved would be 5%, assuming an overall applicability of 50%. This value represented the percentage of baseline consumption the measure saved in an average home.

However, capturing all applicable measures required examining many instances in which multiple measures affected a single end use. To avoid overestimating total savings, we assessed cumulative impacts that accounted for interactions among the various measures—a treatment called "measure stacking." The primary method to account for stacking effects establishes a rolling, reduced baseline that is applied sequentially upon assessment of measures in the stack. The following equations illustrate this technique, applying measures one ($SAVE_1$), two ($SAVE_2$), and three ($SAVE_3$) to the same end use:

$$SAVE_{ij1} = EUI_{ije} * PCTSAV_{ije1} * APP_{ije1}$$

$$SAVE_{ij2} = (EUI_{ije} - SAVE_{ij1}) * PCTSAV_{ije2} * APP_{ije2}$$

$$SAVE_{ij3} = (EUI_{ije} - SAVE_{ij1} - SAVE_{ij2}) * PCTSAV_{ije3} * APP_{ije3}$$

After iterating all measures in a bundle, the final percentage of the reduced end-use consumption provided the sum of the individual measures' stacked savings, which we then divided by the original baseline consumption.

Economic Potential

Cadmus estimated economic potential using methods described in the California Standard Practice Manual (SPM),[4] which establishes the procedures for economic evaluation from the perspectives of participants, utility (or program administrator), total resource cost, societal and all ratepayers. Consistent with standard practice in the industry and Ohio program rules, the analysis of economic

[4] *California Standard Practice Manual for Economic Analysis of Demand-Side Programs and Projects*, California Public Utilities Commission, October 2001.

potential in this study relied on the TRC test as the criterion for screening energy efficiency measures for cost-effectiveness.

For each measure, application of TRC began with the valuation of the measure's benefits, as measured by the avoided long-run energy, capacity costs, and avoided line losses, and then comparing the result to the measure's costs. For equipment measures, we calculated costs based on the measure's incremental costs, compared with the cost of baseline technology. For retrofit measures, measure costs included the total installed cost of the measure. The study considered a measure to be cost-effective if the net present value of its benefits exceeded the net present value (NPV) of its costs, as measured according to the TRC test, as follows:

$$\frac{\text{TRC Benefits}}{\text{TRC Costs}} \geq 1$$

Where

$$\text{TRC Benefits} = NPV\left(\sum_{year=1}^{measurelife}\left(\sum_{i}^{i=8760}(impact_i \times avoided\cos t_i)\right)\right)$$

And

$$\text{TRC Costs} = \text{NPV (incremental -or total - installed measure cost).}$$

Economic potential represented the savings from the subset of measures that passed the cost-effectiveness criterion according to the TRC test.

Calculating a measure's total resource benefits used the following data:

- **End-use load shapes**—End-use load shapes represented end-use consumption patterns by costing period, which we applied to measures to capture the time-differentiated value of energy savings and determine the amount of savings during peak periods.
- **Line losses**—Line losses represented energy lost between the generator and the customer meter. Thus, we would "gross up" the energy and capacity savings at the customer meter to capture the true value of savings.
- **Discount rate**
- **Avoided energy costs**—Avoided energy costs represented projections of time and seasonally differentiated electric energy costs.
- **Avoided capacity costs**—Avoided capacity costs represented projections of the cost of supplying power during peak periods.

Economic potential can exceed technical potential when a second measure that interacts with a given measure fails a benefit-cost screen. For instance, suppose a homeowner installs an efficient air conditioner that reduces our baseline cooling consumption from 1,000 kWh to 900 kWh. Then suppose

the homeowner installs a weatherization measure that saves 10% off of the baseline cooling consumption. The technical potential for this weatherization measure would equal 90 kWh (900*10%). Now suppose the efficient air conditioner measure is not cost-effective—the homeowner's baseline consumption will remain at 1,000 kWh. If the weatherization measure is cost-effective, the 10% savings will yield economic potential equal to 100 kWh (1,000*10%). In this case, economic potential for the weatherization measure will exceed the technical potential.

Primary Data Collection

Residential Surveys

Cadmus completed a phone survey of 210 residential customers (116 single-family homes, 70 multifamily homes, and 24 manufactured homes). Cadmus collaborated with a survey firm, VuPoint Research, to inform the following topics of energy efficiency potential study and program planning:[5]

- Assess saturation of various technologies related to energy efficiency,
- Assess efficiency program awareness and perceptions,
- Assess key factors affecting program participation, and
- Characterize customers' willingness to adopt and pay for energy efficiency measures.

Cadmus identified the distribution of residential configuration, saturation of measures, fuel shares for equipment and appliances, and the age of equipment. We also summarized the findings of customers' program awareness and overall perception of DP&L. Table 14 lists the population of customers by housing segment, the size of survey sample targets, and the achieved samples.

[5] Sample sizes for individual survey questions vary because of non-response and/or non-relevance.

Table 14. Residential Population and Sample Size by Segment

Segment Type	Population*	Target	Achieved Sample
Single family	414,088	70	116
Manufactured	19,349	70	24
Multifamily	135,925	70	70
Total	**569,362**	**210**	**210**

*The population distribution based on the American Community Survey

It was difficult to identify manufactured homes within DP&L's sample data extract of 25,000 customers. We used data from the Ohio Manufactured Home Commission and geocoding to identify 232 customers that are likely to live in manufactured homes. We identified these "likely" manufactured/mobile homes using the following criteria:

- A (n = 131)—20% or more of households in this block group are manufactured/mobile homes, and customer is less than 250 meters from the nearest geocoded mobile home park,
- B (n = 60)—50% or more of households in this block group are manufactured/mobile homes,
- C (n = 4)—20% or more of households in this block group are manufactured/mobile homes and the street address contains "lot", and
- D (n = 37)—manually identified as a manufactured/mobile home on Google Maps.

Even with this approach, we did not identify enough customers to achieve our desired sample through the phone survey. Because the manufactured/mobile homes make up a small percentage of the overall population, we decided to increase the sample size for single-family homes to 116 improve the confidence level of the collected data. Single-family homes comprise over 72% of the population and represent a higher portion of the potential.

Commercial Surveys

Cadmus and VuPoint Research conducted 200 commercial phone surveys to inform DP&L program planning and Cadmus' assessment of those programs' energy efficiency potential.[6] The commercial survey questions covered the following topics:

- Saturation of energy-consuming equipment and energy-efficient technologies,
- Energy efficiency program awareness and perceptions,
- Factors affecting program participation, and
- Customers' willingness to adopt energy efficiency measures.

To create a list of survey customers, Cadmus developed a stratified sample spanning DP&L's five highest consuming commercial segments—office, health care, education, retail, and grocery (see Table 15).

[6] The sample size(s) for individual survey questions vary due to non-response and/or non-relevance.

Table 15. Commercial Consumption and Sample Size by Segment

Segment	Consumption		Sample Size	
	kWh	Percentage	Target*	Achieved Sample
Office	753,659,242	21.9%	71	71
Health care	368,947,237	10.7%	64	15
Education	360,420,466	10.5%	78	21
Retail	336,810,948	9.8%	78	78
Grocery	138,494,512	4.0%	59	15
Total (five highest segments)	**1,958,332,405**	**56.90%**	**350**	**200**
Overall total (all segments)	**3,437,927,811**	**100.0%**		

*The targets are based on large and small building type distributions.

The targets were attempted with significant effort. However, the sample sizes for health, education, and grocery segments were too small to achieve the target. Office and retail segments had large enough sample sizes to achieve the desired targets.

Baseline Forecasts

Scope of the Analysis

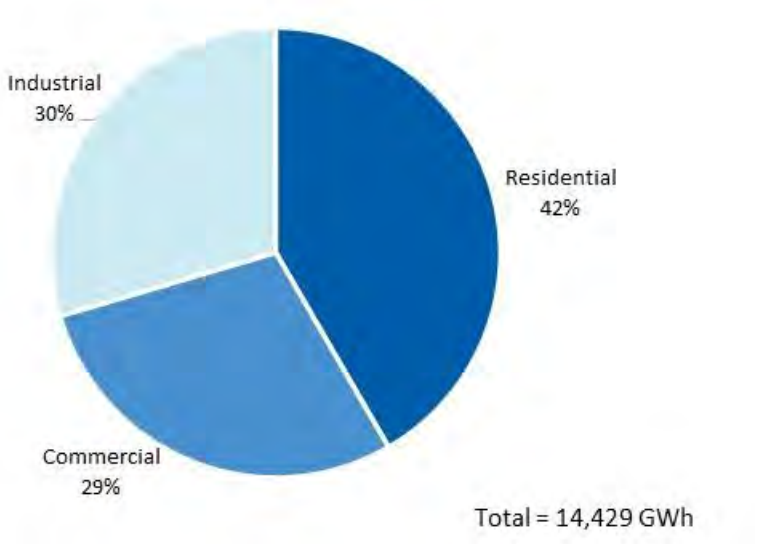
Assessing conservation potential starts with the development of baseline end-use load forecasts over a 10-year (2018 to 2027) planning horizon. These forecasts are calibrated to DP&L's econometric load forecasts; although they are not adjusted for future programmatic conservation, they do account for enacted equipment standards and building energy codes. The study separately considers the residential, commercial, and industrial sectors.

Within each sector-level assessment, the study further distinguished customer segments or facility types and their respective applicable end uses. The analysis addressed the following:

- Ten residential segments (existing and new construction for single-family, low-income single-family, multifamily, low-income multifamily, and manufactured homes);
- Twenty-two commercial segments including new and existing construction for 11 standard commercial segments; and
- 13 industrial segments.

Figure 6 shows the distribution of projected sales in 2027 by sector. The residential sector will account for approximately 42% of projected sales, whereas the industrial and commercial sectors will account for 30% and 29%, respectively.

Figure 6. 2027 Baseline Sales by Sector



Residential

Cadmus considered five residential segments and 31 end uses. Table 16 lists each residential segment and end use considered as well as the broad end-use groups used in this report. Overall, the residential sector accounts for approximately 42% of total baseline sales.

Table 16. Residential Segments and End Uses

Segments	End Uses	
	End-Use Group	End Use
Low-income multifamily	Plug load	Air purifier
Low-income single family	Plug load	Computer
Manufactured home	Cooking	Cooking oven
Multifamily	Cooling	Cool central
Single family	Cooling	Cool room
	Plug load	Copier
	Plug load	DVD - Blu-ray
	Appliances	Dryer
	Plug load	Fax
	Plug load	Freezer
	Heating	Heat central
	Heat pump	Heat pump
	Heating	Heat room
	Plug load	Home audio system
	Lighting	Lighting exterior
	Lighting	Lighting interior specialty
	Lighting	Lighting interior standard
	Plug load	Microwave
	Plug load	Monitor
	Plug load	Multifunction device
	Plug load	Plug load other
	Plug load	Printer
	Appliances	Refrigerator
	Plug load	Set top box
	Plug load	TV
	Plug load	TV big screen
	Ventilation and circulation	Ventilation and circulation
	Water heating	Water heat GT 55 gal
	Water heating	Water heat LE 55 gal
	Pool pump	Pool pump
	Cooking	Cooking range

We relied on three-year American Community Survey estimates of the number of households for each residential segment in DP&L's service territory to disaggregate the residential building stock. Cadmus combined residential household forecasts, estimates of end-use saturations, fuel shares, efficiency shares, and end-use consumption to produce a sales forecast through 2027.

Figure 7 and Figure 8 show the distribution of residential sales in 2027 by segment and end use, respectively. Cadmus considered both low-income and standard-income single-family and multifamily homes. Overall, single-family homes (both low and standard income) account for approximately 73% of total residential consumption. Of this portion, standard-income single-family homes represent 62% of total residential consumption and low-income single-family homes represent 11% of total residential consumption. Multifamily homes account for 23% of total residential consumption (4% low income and 19% standard income). Manufactured homes represent a small portion of residential sales (3%).

Figure 7. 2027 Baseline Residential Sales by Segment

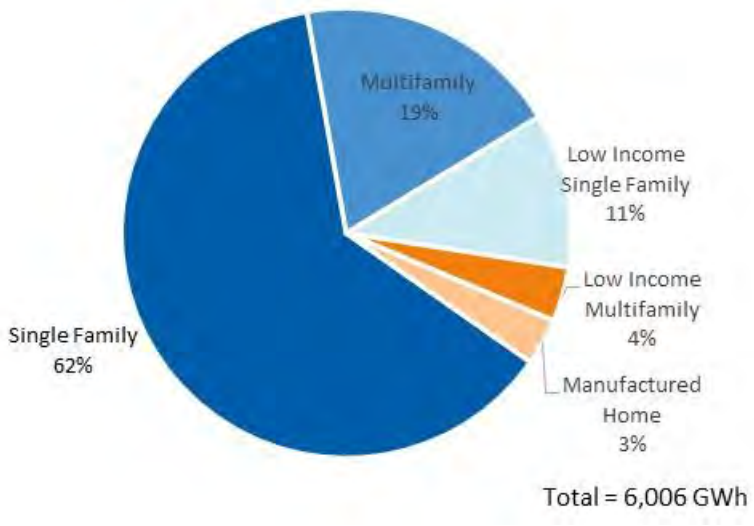
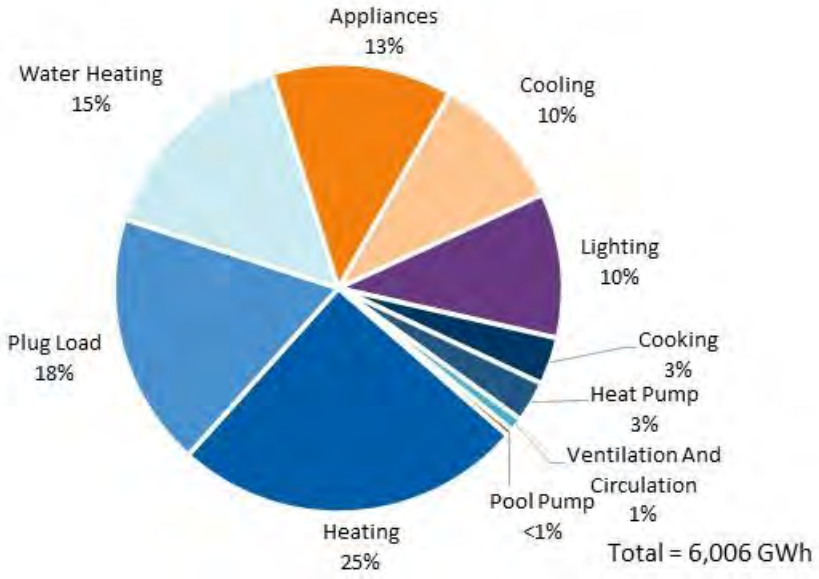


Figure 8 shows "heating" and "plug load" as the two top-consuming end-use groups that account for nearly one-half (45%) of residential consumption. The next three highest forecasted end uses are "water heating" (16%), "appliances" (13%), and "cooling" (10%).

Figure 8. 2027 Baseline Residential Sales by End-Use Group



The plug load end-use group represents a substanital portion of forecasted residential energy consumption in 2027. Figure 9 breaks down the plug load group by end use. Together, the "plug load other" (27%) and "multifunction devices" (18%) categories represent approximately 45% of 2027 baseline sales. The next largest categories are "TV" (12%), "home audio system" (10%), and "computer" (12%).

Figure 9. 2027 Baseline Residential Sales for Plug Load End-Use Group

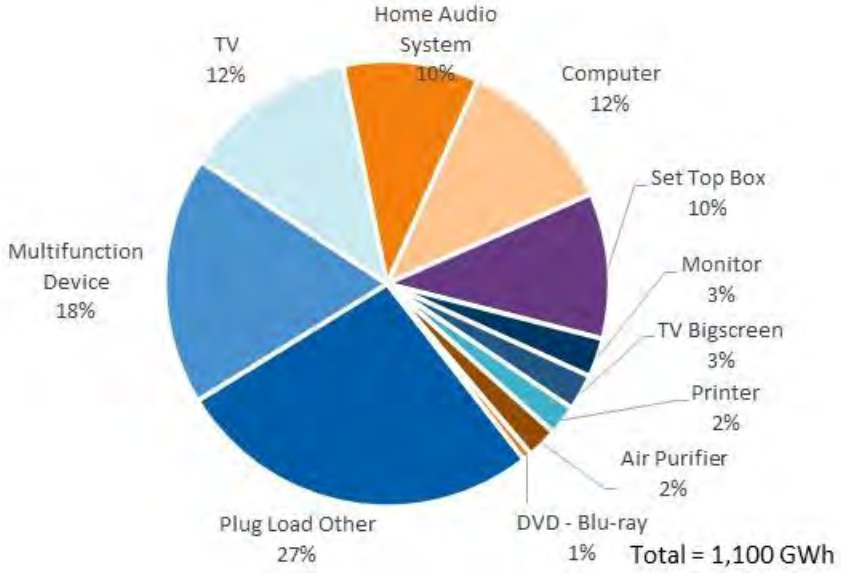


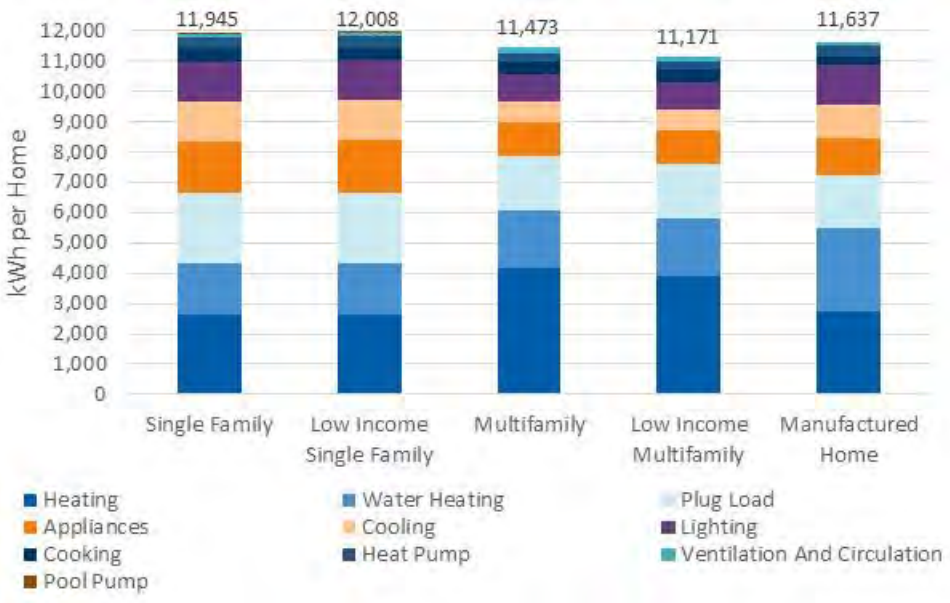
Table 17 and Figure 10 below show baseline sales per household by residential segment. Single-family homes, on average, consume an estimated 11,356 kWh per home, with heating, plug load, water

heating, appliances, and cooling accounting for most consumption. Compared to single-family homes, heating accounts for a higher proportion of average consumption in multifamily homes.

Table 17. Average Baseline Sales per Household in 2027 (kWh/Home)

End Use	Single Family	Low Income Single	Multifamily	Low-Income Multifamily	Manufactured Home
Heating	2,630	2,630	4,162	3,878	2,715
Water heating	1,716	1,716	1,914	1,914	2,788
Plug load	2,298	2,298	1,815	1,815	1,742
Appliances	1,709	1,744	1,065	1,084	1,217
Cooling	1,327	1,327	695	695	1,117
Lighting	1,328	1,328	925	925	1,297
Cooking	408	385	424	406	281
Heat pump	380	380	250	250	364
Ventilation and circulation	71	122	224	203	116
Pool pump	78	78	0	0	0
Total	**11,945**	**12,008**	**11,473**	**11,171**	**11,637**

Figure 10. Average Baseline Sales per Household in 2027



As shown in Table 17 above, average baseline sales per household in 2027 are nearly as high in multifamily structures as in single-family homes. This result is likely attributable to the distribution of saturations of electric central heat and single-room electric space heat in single-family and multifamily homes (see Table 18 below for details).

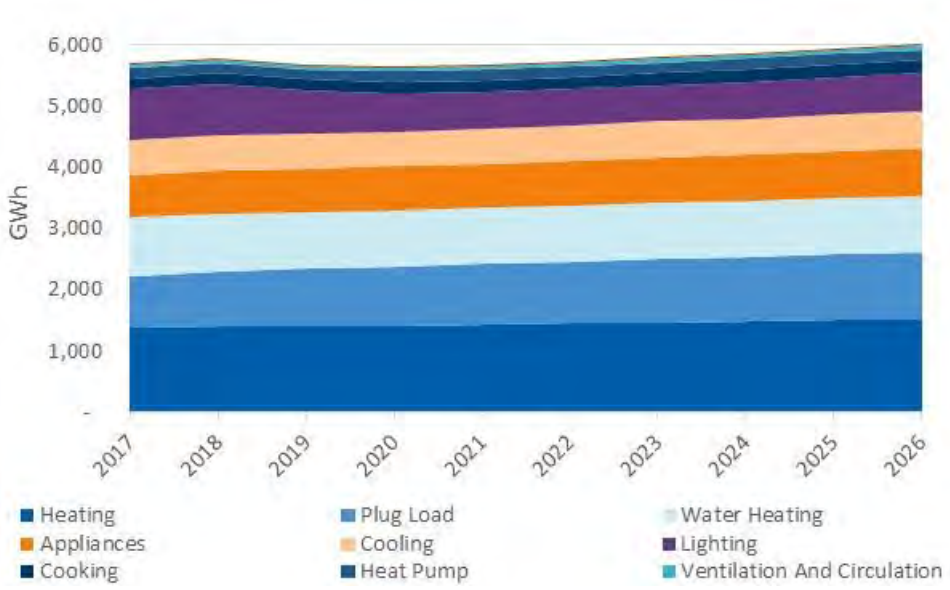
Table 18. Distribution of Electric Central Heat and Electric Room Heat by Residential Segment

End Use	Single Family	Multifamily
Heat central	91.5%	77.7%
Heat room	8.6%	23.9%

Electric central heat accounts for approximately 92% of all electric heating in single-family homes and 78% in multifamily residences. This helps explain why multifamily homes use more energy on heating, on average, than single-family homes.

Figure 11 shows the residential baseline forecast by end use. Overall, DP&L's residential forecast increases by approximately 7% over the 10-year horizon. This is a result of increases in the customer account forecast and use per customer during this time period.

Figure 11. Residential Baseline Forecast by End Use



Commercial

Cadmus considered 11 commercial segments and 26 end uses within these segments. Table 19 shows each commercial segment and end use as well as the general end-use groups used in this report. Overall, the commercial sector accounts for approximately 29% of projected baseline sales in 2027.

Table 19. Commercial Segments and End-Use Groups

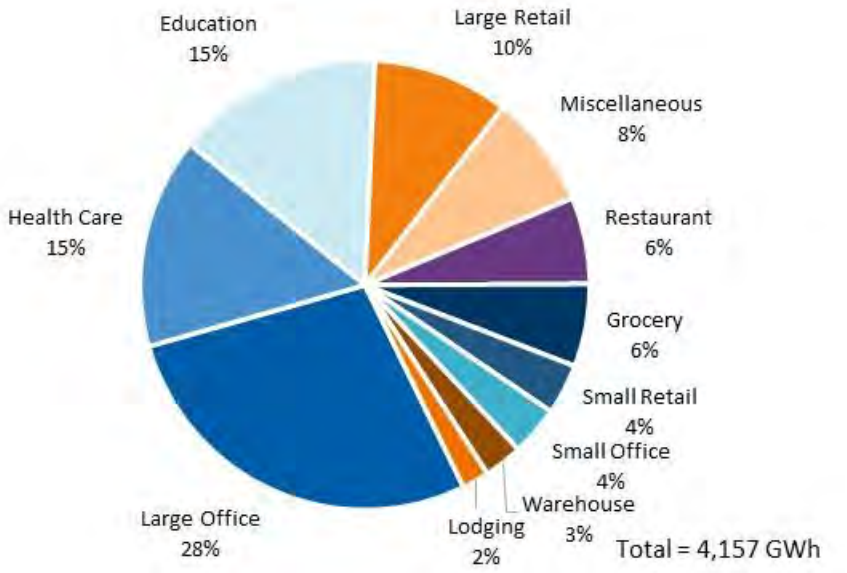
Segments	End Uses	
	End-Use Group	End Use

Education	Office equipment	Computers
Grocery	Cooking	Cooking
Health care	Cooling	Cooling chillers
Large office	Cooling	Cooling DX
Large retail	Office equipment	Fax
Lodging	Office equipment	Flat screen monitors
Miscellaneous	Appliances	Freezer
Restaurant	Heat pump	Heat pump
Small office	Lighting	Lighting exterior
Small retail	Lighting	Lighting interior fluorescent
Warehouse	Lighting	Lighting interior HID
	Lighting	Lighting interior other
	Lighting	Lighting Interior screw base
	Miscellaneous	Other plug load
	Office equipment	Photo copiers
	Office equipment	Printers
	Refrigeration	Refrigeration
	Appliances	Refrigerator
	Office equipment	Servers
	Heating	Space heat
	Miscellaneous	Vending machines
	Ventilation and circulation	Ventilation and circulation
	Water heating	Water heat GT 55 gal
	Water heating	Water heat LE 55 gal
	Miscellaneous	Compressed air
	Heat pump	PTAC

Cadmus used DP&L's nonresidential database to identify the sales and number of customers for each commercial market segment. We used the U.S. Energy Information Administration's Commercial Buildings Energy Consumption Survey (EIA CBECS) as well as other secondary sources to identify the customer segment, floor space, and consumption for nonresidential customers. In addition, Cadmus classified customers as either commercial or industrial based on the rate class identified in DP&L's customer database.

Figure 12 shows the distribution of baseline commercial consumption by segment in 2027.

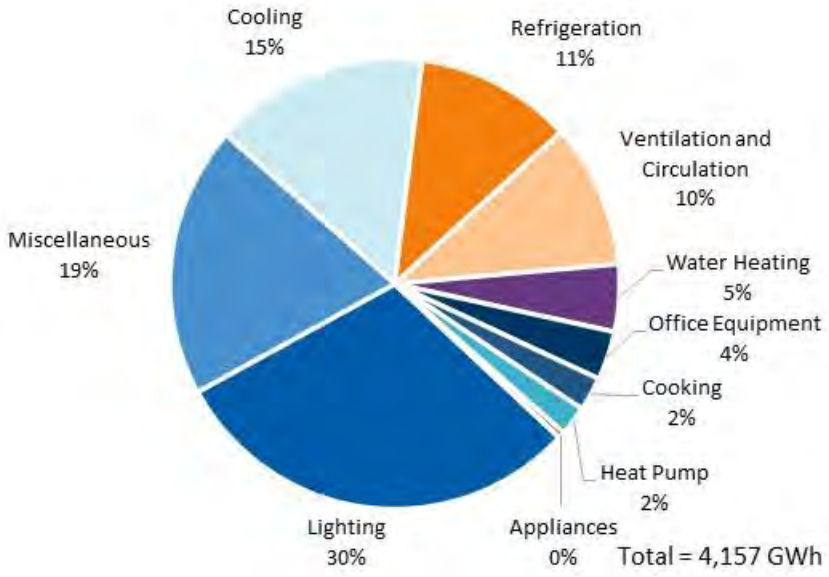
Figure 12. 2027 Commercial Baseline Sales by Segment



Large offices account for over one-quarter (28%) of projected commercial baseline sales in 2027. Health care, education, and large retail account for 15%, 15%, and 10% of baseline sales, respectively. Together, these segments represent over one-third (68%) of all sales in the commercial sector.

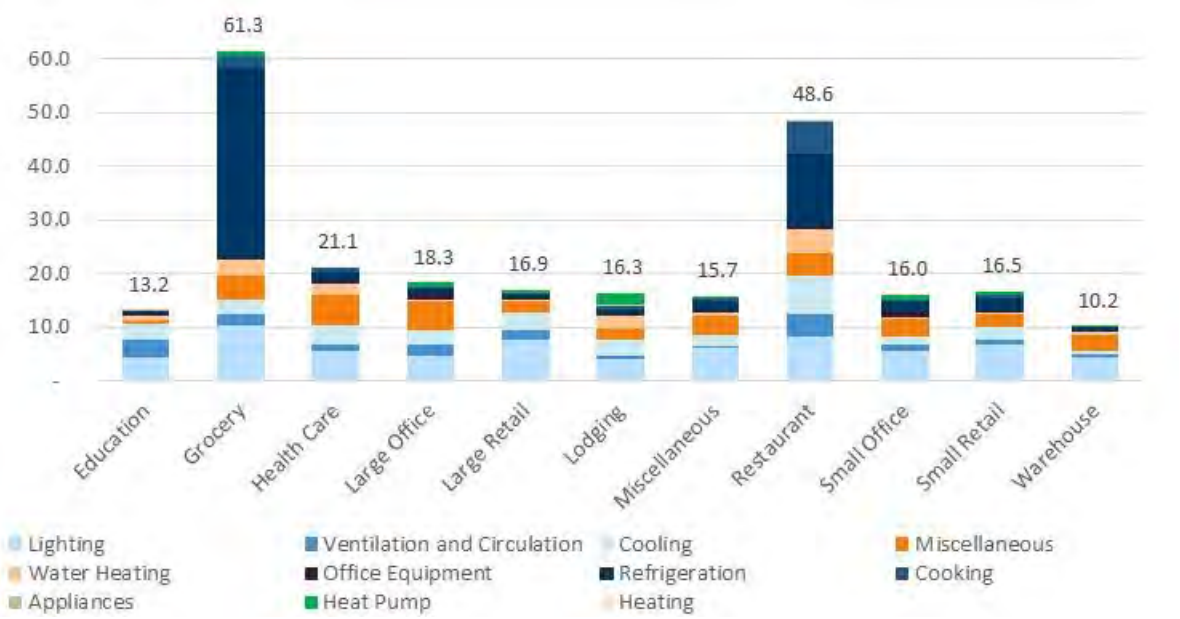
Figure 13 shows the overall distribution of commercial baseline sales by end use. The highest-consuming end use is lighting, which accounts for 28% of projected commercial energy use in 2027. Miscellaneous end uses, cooling, and refrigeration account for roughly half of total energy use, representing 25%, 14%, and 11% of projected sales, respectively.

Figure 13. 2027 Commercial Baseline Sales by End-Use Group



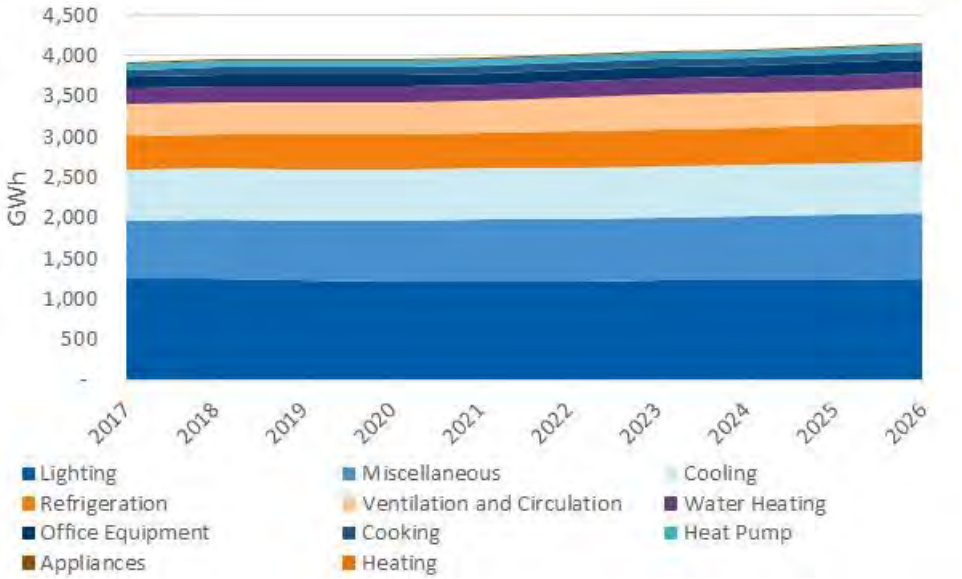
Cadmus developed whole-building energy intensities using consumption and floor space estimates from DP&L's nonresidential customer database. We further disaggregated these energy intensities into end-use intensities; end-use intensities were based on end-use saturations and fuel shares derived from a survey of commercial customers in DP&L's service area and EIA CBECS data. Figure 14 shows energy intensities for each building type and end-use group.

Figure 14. Commercial End-Use Intensities by Building Type



Cadmus' commercial baseline forecast includes roughly 8% growth in energy consumption over the 10-year horizon. Figure 15 shows the commercial baseline forecast by end use.

Figure 15. Commercial Baseline Forecast by End Use



Industrial

Cadmus analyzed the 13 industrial segments and nine end uses shown in Table 20. Overall, the industrial sector accounts for approximately 30% of projected baseline sales in 2027.

Table 20. Industrial Segments and End Uses

Segments	End-Use Group
Chemical manufacturing	Motors
Electrical equipment manufacturing	HVAC
Fabricated metal products	Lighting
Food manufacturing	Motors
Industrial machinery	Other
Miscellaneous manufacturing	Process air compressor
Nonmetallic mineral products	Process refrigeration and cooling
Paper manufacturing	Pumps
Plastics rubber products	Process other
Printing-related support	
Transportation equipment mfg.	
Wastewater	
Water	

Figure 16 shows the projected distribution of industrial sales by segment in 2027. Miscellaneous manufacturing accounts for roughly 20% of total industrial energy consumption, followed by transportation equipment manufacturing (18%), chemical manufacturing (15%), and food manufacturing (13%). Together, these four segments make up roughly two-thirds (66%) of 2027 projected baseline sales.

Figure 16. 2027 Industrial Baseline Sales by Segment

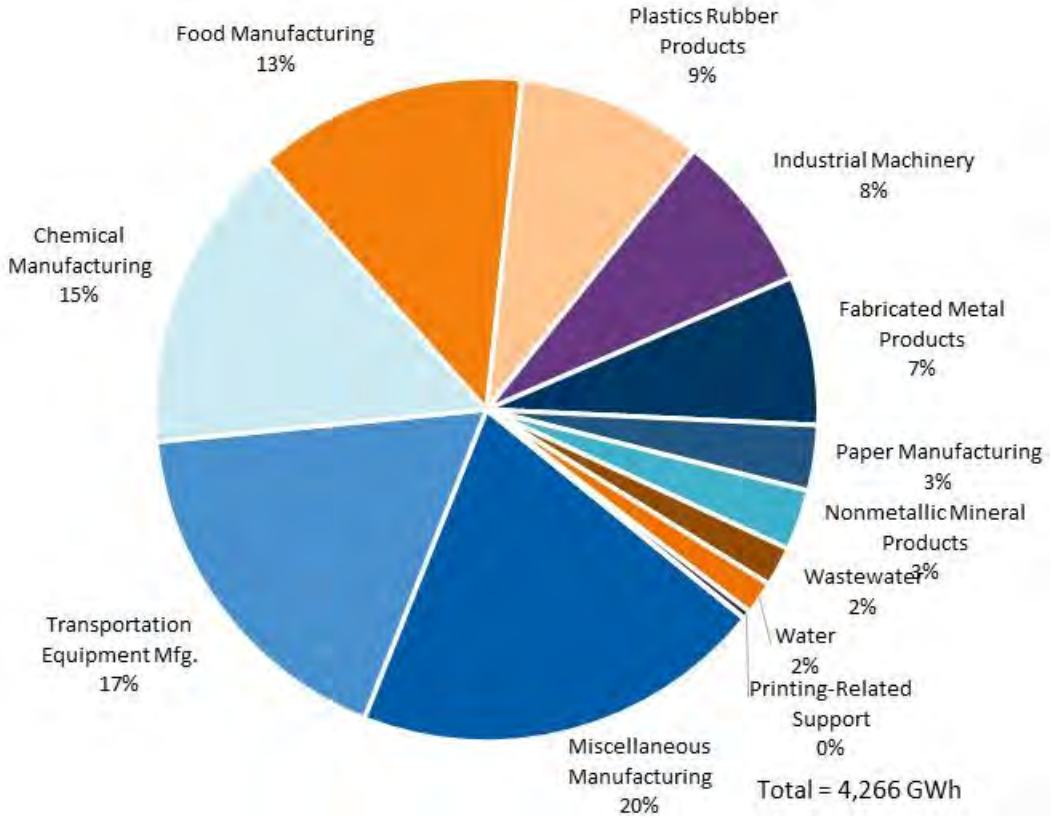
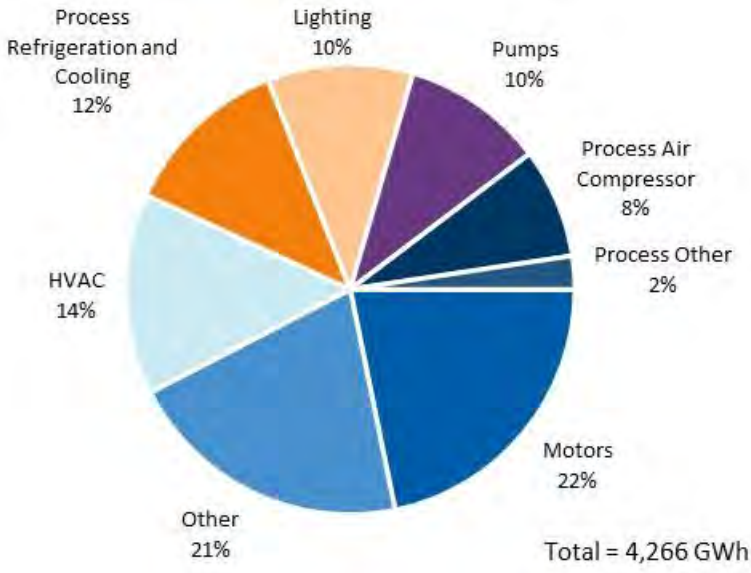


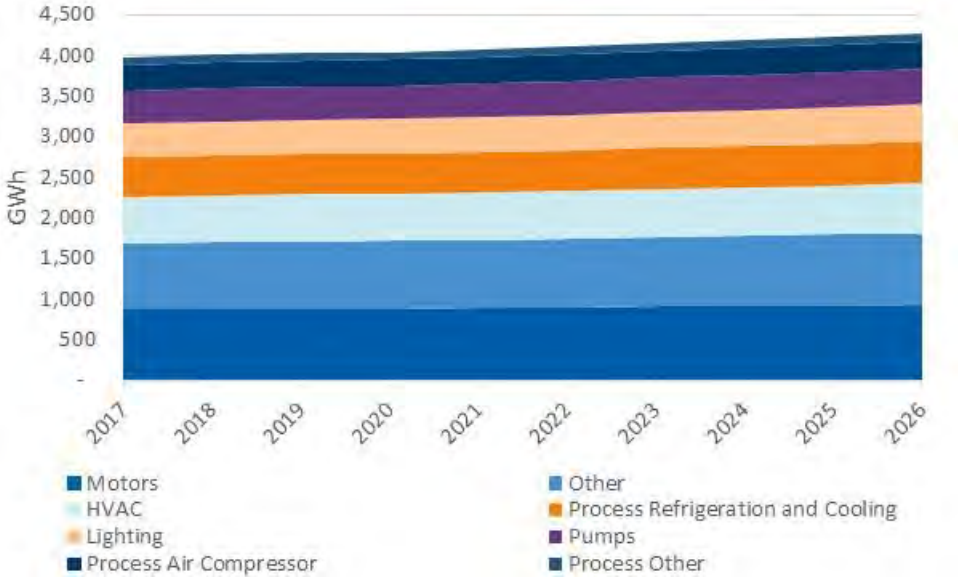
Figure 17 shows the overall distribution of projected industrial baseline sales in 2027 by end-use group. "Motors" (22%), "other" (21%), "HVAC" (15%), and "process refrigeration and cooling" (12%) together account for over two-thirds of projected energy consumption (69%; total differs because of rounding).

Figure 17. 2027 Industrial Baseline Sales by End-Use Group



Industrial energy consumption is predicted to grow approximately 9% over the 10-year study horizon. Figure 18 shows the industrial forecast by end use.

Figure 18. Industrial Baseline Forecast by End-Use Group



Technical and Economic Potential

Scope of Analysis

Cadmus assessed the technical and economic potential in the residential, commercial, and industrial sectors. Within each sector-level assessment, we further distinguished among market segments, business types, and vintage, and applicable end uses. To begin the analysis, Cadmus assessed the technical potential for 289 unique energy efficiency measures (Table 21), which represent a comprehensive set of electric energy efficiency measures applicable to the climate and customer characteristics of DP&L's service territory.

Table 21. Energy Efficiency Measure Counts and Permutations

Sector	Unique Measures	Permutations
Residential	88	1,683
Commercial	147	3,680
Industrial	54	598
Total	**289**	**5,961**

After considering all permutations of these measures across applicable customer sectors, market segments, fuels, and end uses, Cadmus compiled and analyzed the data for over 5,961 measure permutations.

The remainder of this section provides detailed results by sector.

Overview of Results

Technical and economic potential could account for 26% and 16%, respectively, of projected baseline sales in 2027. Overall, economic potential represents 59% of technical potential. Table 22 shows cumulative technical and economic energy-savings potential at the end of the 10-year study horizon. Table 23 shows peak demand savings potential.

Table 22. Technical and Economic Potential by Sector - Energy

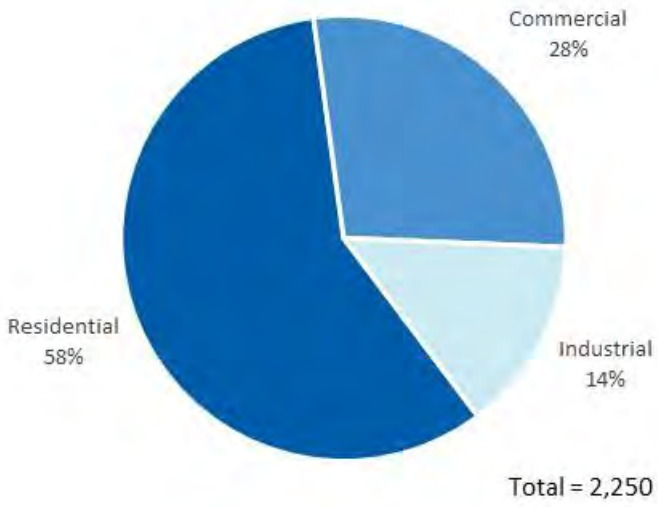
Sector	Baseline Sales - 2027 GWh	Technical Potential - Cumulative 2018-2027		Economic Potential - Cumulative 2018-2027		
		GWh	% of Baseline	GWh	% of Baseline	% of Technical
Residential	6,006	2,275	38%	1,307	22%	57%
Commercial	4,157	1,016	24%	626	15%	62%
Industrial	4,266	529	12%	317	7%	60%
Total	14,429	3,820	26%	2,250	16%	59%

Table 23. Technical and Economic Potential by Sector - Energy

Sector	Cumulative 2018-2027		
	Technical Potential (MW)	Economic Potential (MW)	Economic % of Technical
Residential	328	222	68%
Commercial	166	95	57%
Industrial	80	48	60%
Total	573	364	64%

The residential sector accounts for the largest share of economic potential (58%). The commercial and industrial sectors account for 28% and 14% of total economic potential, respectively (Figure 19).

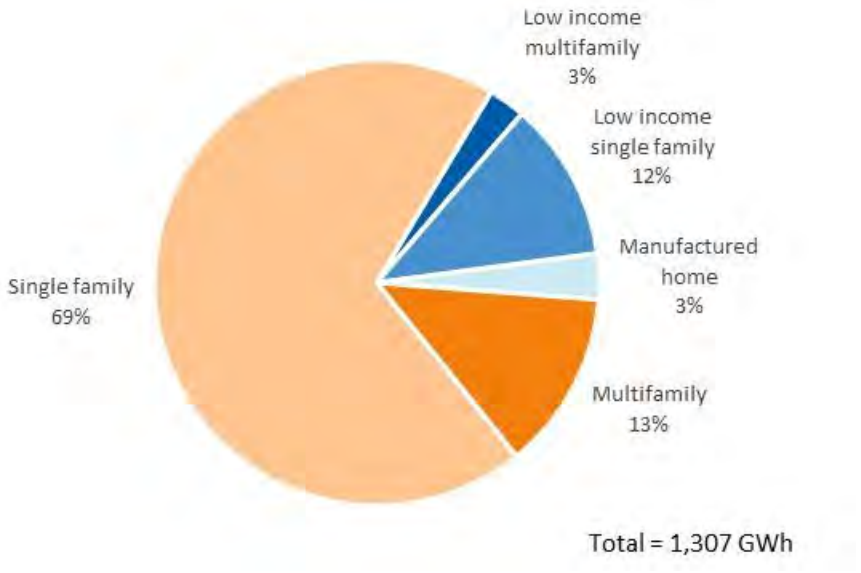
Figure 19. Economic Potential by Sector – Cumulative 2027



Residential

Cadmus broke out the residential sector into five distinct market segments—single family, low-income single family, multifamily, low-income multifamily, and manufactured housing. The standard income single family segment accounts for 69% of total economic potential. Figure 20 shows the distribution of residential economic potential by segment.

Figure 20. Residential Economic Potential by Segment – Cumulative 2027



A larger proportion of projected baseline sales can be met with energy efficiency in single family segments, compared to multifamily segments. While technical potential accounts for 41% of baseline usage in single family homes, it only accounts for 28% of baseline usage in multifamily homes. The different mixture of end use consumption in the two segments drive this difference. Lighting and plug loads, two high-saving end uses, account for a larger share of usage in single family homes. In contrast, electric space heat accounts for a larger share of usage in multifamily homes—an end use which has relatively low savings potential. Table 24 shows cumulative technical and economic potential for each segment.

Table 24. Residential Technical and Economic Potential by Segment

Segment	Baseline-2027 GWh	GWh – Cumulative 2018-2027		% of Baseline	
		Technical Potential	Economic Potential	Technical Potential	Economic Potential
Low-income multifamily	236	70	35	30%	15%
Low-income single family	667	266	152	40%	23%
Manufactured home	201	80	43	40%	22%
Multifamily	1,150	326	170	28%	15%
Single family	3,753	1,533	907	41%	24%

Overall, lighting accounts for the largest share of economic potential (43%), followed by plug loads (19%), appliances (14%), and water heating (12%). Figure 21 shows the distribution of residential economic potential by end use.

Figure 21. Residential Economic Potential by End-Use

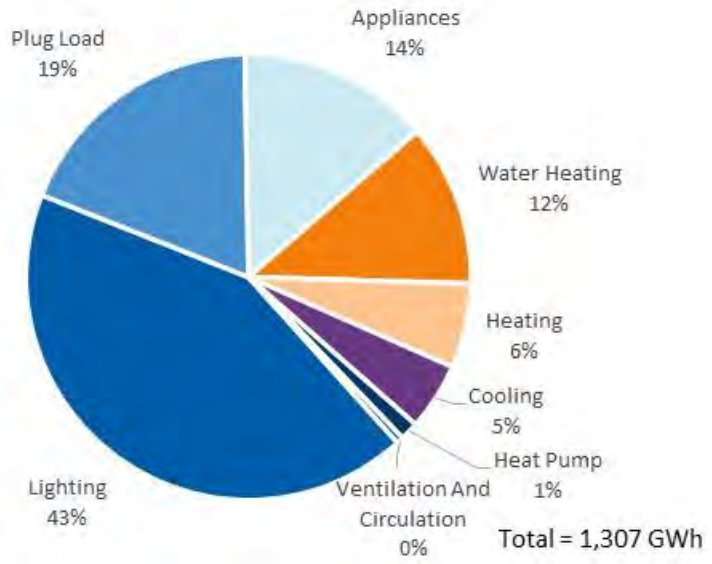


Table 25 show the fifteen highest-saving measures in the residential sector. General service and specialty LED lamps, CO2 heat pump water heaters, ENERGY STAR multifunction devices, heat pump dryers, and heat pump water heaters have high technical potential, compared to other measures. However, of these measures, only lighting and multifunction devices are cost-effective. Costs for advanced technologies, such as heat pump dryers and heat pump water heaters, must come down before they become a viable cost-effective measure.

Table 25. Top Residential Measures

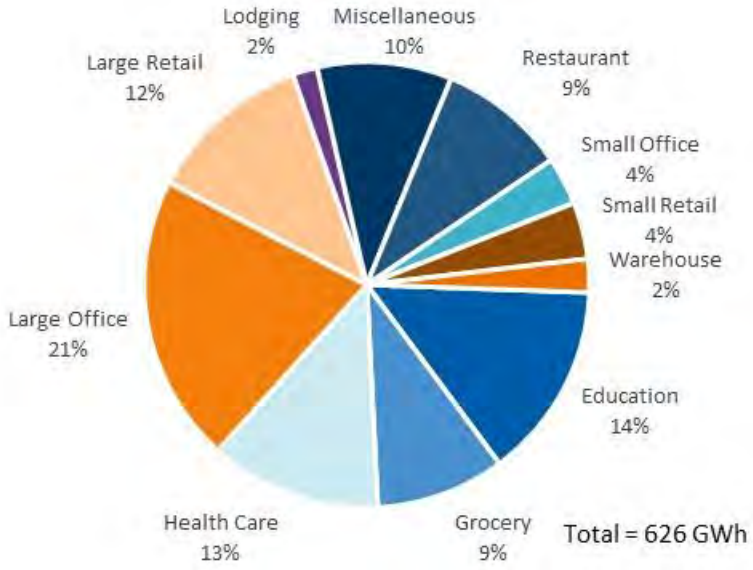
Measure Name	GWh – Cumulative 2018-2027		% of Total	
	Technical Potential	Economic Potential	Technical Potential	Economic Potential
Lighting General Service Lamp - LED - ENERGY STAR	282	284	12%	22%
Lighting Specialty Lamp - LED - ENERGY STAR	254	266	11%	20%
CO2 Heat Pump Water Heater	185	0	8%	0%
Ceiling / Attic Insulation	131	5	6%	0%
Dryer - Heat Pump Dryer	97	0	4%	0%
Heat Pump Water Heater - Advanced Efficiency	89	0	4%	0%
Central Air Conditioner - ENERGY STAR Most Efficient	84	0	4%	0%
Multifunction Device - ENERGY STAR	82	82	4%	6%

Refrigerator Recycling without Replacement	69	77	3%	6%
Air Sealing	62	0	3%	0%
Duct Sealing	56	61	2%	5%
TV LCD - ENERGY STAR Most Efficient	54	0	2%	0%
Computer - ENERGY STAR	53	53	2%	4%
Central Air Conditioner - Quality Install	50	0	2%	0%
Showerhead Low Flow	49	91	2%	7%

Commercial

The commercial sector accounts for 28% of total economic potential. Cadmus disaggregated estimates of economic potential into the eleven building segments shown in Figure 22. Large offices account for roughly 21% of total commercial economic potential, followed by health care (13%), education (14%), large retail (12%), and miscellaneous (10%).

Figure 22. Commercial Economic Potential by Segment



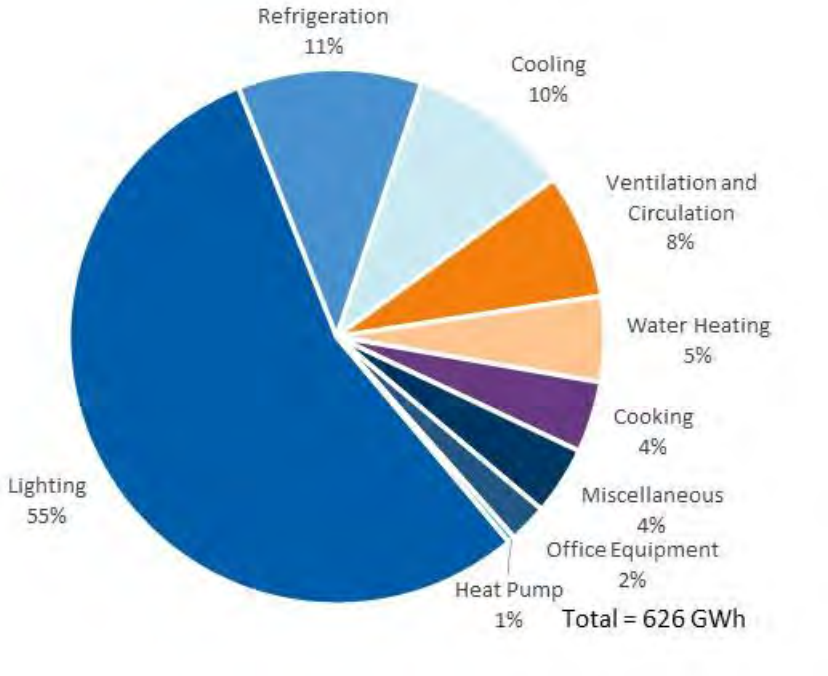
Energy savings potential varies by segment—both in GWh and when expressed as a fraction of the segment's baseline usage. Table 26 shows cumulative 2027 technical and economic potential for each commercial segment. Large offices and education have the highest overall technical and economic potential; collectively, these two segments account for 35% of total economic potential. However, lodging, grocery, restaurants, and retail have the highest technical and economic when expressed as a fraction of the segments baseline usage. This is because these segments have relatively higher usage in end uses that have higher potential, such as lighting, refrigeration, and cooling.

Table 26. Commercial Technical and Economic Potential by Segment

Segment	Baseline	GWh – Cumulative 2018-2027		% of Baseline	
		Technical Potential	Economic Potential	Technical Potential	Economic Potential
Education	620	162	89	26%	14%
Grocery	247	77	59	31%	24%
Health Care	631	137	78	22%	12%
Large Office	1,157	248	131	21%	11%
Large Retail	407	111	75	27%	18%
Lodging	80	23	11	29%	14%
Miscellaneous	340	83	61	24%	18%
Restaurant	259	79	59	30%	23%
Small Office	148	34	22	23%	15%
Small Retail	151	35	26	23%	17%
Warehouse	116	28	15	24%	13%
Total	4,157	1,016	626	24%	15%

Cadmus estimated economic potential for several end uses, which we summarized by the end use groups shown in Figure 23. Over half (55%) of commercial economic potential comes from lighting end uses, such as linear fixtures, HIDs, screw base fixtures, and exterior lighting. The cooling, refrigeration, and ventilation and circulation end uses account for 10%, 11%, and 8% of economic potential. A couple factors drive high lighting savings; lighting makes up a significant share of usage in commercial buildings, and lighting efficiency measures are generally both high-saving and low-cost.

Figure 23. Commercial Economic Potential by End Use Group



High-saving commercial measures include various lighting upgrades, including controls and equipment upgrades, continuous building commissioning, and heat pump water heaters. Table 27 lists the top-fifteen saving commercial measures.

Table 27. Top Commercial Measures

Measure Name	GWh – Cumulative 2018- 2027		% of Total	
	Technical	Economic	Technical	Economic
Occupancy Sensor Control	111	92	11%	15%
Continuous Commissioning	96	0	9%	0%
Dimming-Continuous Fixtures	71	70	7%	11%
Lighting Interior - TLED - Above Standard	47	45	5%	7%
CO2 Heat Pump Water Heater	41	6	4%	1%
Daylighting Controls, Outdoors (Photocell)	38	38	4%	6%
Motor - Pump & Fan System - Variable Speed Control	36	36	4%	6%
Lighting Interior - Screw Base LED - Above Standard	28	28	3%	4%
Advanced Power Strip - Occupancy Sensor	27	0	3%	0%
Automated Ventilation VFD Control (Occupancy Sensors / CO2 Sensors)	23	8	2%	1%
Lighting Package - Advanced Efficiency	22	22	2%	3%
Convert Constant Volume Air System to VAV	21	0	2%	0%
Exit Sign - Electroluminescent	20	20	2%	3%
Solar Hot Water (SHW)	18	0	2%	0%
Outside Air Economizer with Dual-Enthalpy Sensors	16	14	2%	2%

Industrial

The industrial sector accounts for 14% of total economic potential, with the food manufacturing, miscellaneous manufacturing, and transportation equipment manufacturing segments accounting for most of total industrial sector potential. These three segments represent 24%, 20%, and 16% of industrial sector potential, respectively (Figure 24).

Figure 24. Industrial Economic Potential by Segment

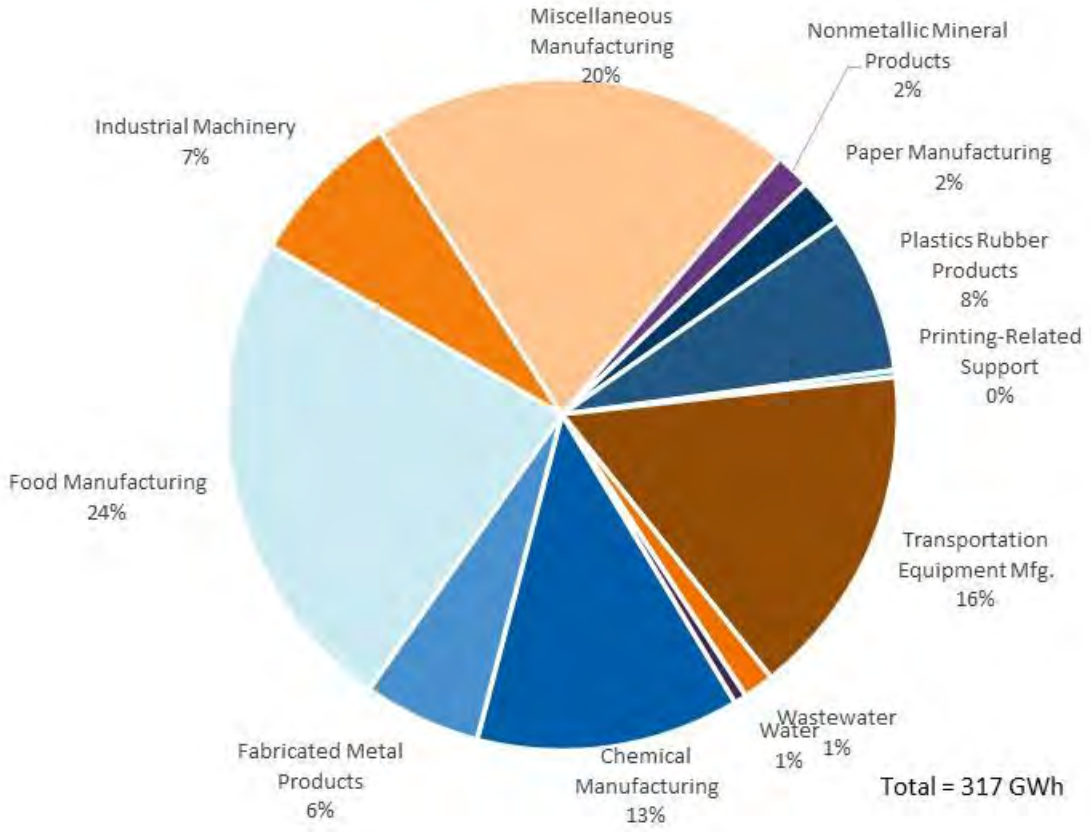


Table 28 show cumulative 10-year industrial technical and economic potential by segment. Food manufacturing not only has the highest economic potential, but its economic potential also represents the largest portion of the segment's baseline usage.

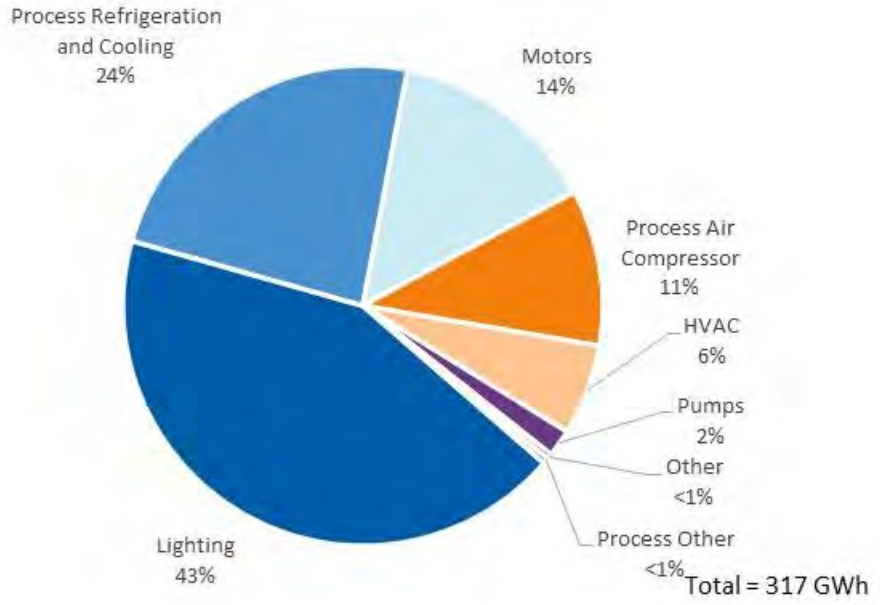
Table 28. Industrial Technical and Economic Potential Segment

Segment	Baseline	GWh – Cumulative 2018-2027		% of Baseline	
		Technical Potential	Economic Potential	Technical Potential	Economic Potential
Chemical Manufacturing	640	75	40	12%	6%
Fabricated Metal Products	309	38	18	12%	6%
Food Manufacturing	565	96	75	17%	13%
Industrial Machinery	330	41	24	12%	7%
Miscellaneous Manufacturing	861	103	64	12%	7%
Nonmetallic Mineral Products	126	13	6	10%	4%
Paper Manufacturing	136	12	7	9%	5%
Plastics Rubber Products	386	42	24	11%	6%
Printing-Related	17	2	1	10%	6%

Support					
Transportation Equipment Mfg.	744	94	51	13%	7%
Wastewater	82	9	5	10%	6%
Water	69	4	2	6%	3%
Total	4,266	529	317	12%	7%

Figure 25 shows the distribution of industrial economic potential by end use. Lighting measures, including LEDs for high bay, linear, and lamp-type fixtures, accounts for 43% of total industrial economic potential.

Figure 25. Industrial Economic Potential by End-Use Group



Of the 15 industrial measures with the highest technical potential, 10 also have economic potential. Aside from Integrated Plant Energy Management, which was the highest share of the "other" end use in the previous figures, the three top measures for technical potential are all lighting measures. The top measures in the industrial sector are notable because all of the technical potential is also economic potential. In terms of individual measures, the measure with the most technical and economic potential is "lighting"—specifically, "High Bay LED packages," which makes up 19% of industrial technical potential band 31% of industrial economic potential. Table 29 shows the technical and economic potential in GWh for the top 15 industrial measures and the percentage of total technical and economic potential held by those measures.

Table 29. Top Industrial Measures

Measure Name	GWh – Cumulative 2018-2027		% of Total	
	Technical	Economic	Technical	Economic
Lighting - High Bay LED Packages	98	98	19%	31%
Integrated Plant Energy Management	89	0	17%	0%
Lighting - LED Linear Packages	38	0	7%	0%
Lighting - LED Lamp Packages	29	29	6%	9%
Air Compressor Optimization	23	23	4%	7%
VFD Controlled Compressor	23	6	4%	2%
Material Handling	23	0	4%	0%
Chiller - Water Piping Loop with VSD Control	17	17	3%	5%
Variable Speed Drive Control	14	14	3%	5%
Motor Management Plan	14	14	3%	4%
Variable Speed Compressor Systems	14	14	3%	4%
Floating Head Pressure Controller	13	13	2%	4%
VFD on Cooling Tower Fans	11	11	2%	3%
Lighting - High Bay High Output Packages	11	0	2%	0%
Chiller Water-Cooled	10	10	2%	3%

Achievable Potential

This study defines "achievable potential" as the portion of economic potential that customers' would be willing to adopt if the financial barriers to purchasing energy efficiency measures are reduced through incentives. Therefore, Cadmus measures and expresses achievable potential as a fraction (i.e., percentage) of economic potential. Although estimating technical and economic potentials remains a fundamental engineering and accounting endeavor, based on industry standard practices and methodologies, achievable potential is more difficult to quantify and reliably predict because it depends on many behavioral factors that tend to change unpredictably over time.

Several factors account for the gap between economic and achievable potential, including customer awareness, perceptions of energy efficiency's value, and the upfront costs of energy efficiency measures. In terms of new measures and programs, there are additional practical constraints regarding availability of delivery infrastructure. These barriers have been well documented in energy efficiency literature.[7]

The utility can mitigate some of these market barriers through program design and delivery processes, while other barriers remain out of a utility's reach. For example, a utility can reduce first-cost barriers by providing financial incentives to lower upfront costs and improve customer paybacks. However, because utility incentives only cover a portion of the incremental costs for most measures, incentives may not be sufficient to motivate a customer to adopt energy efficiency measures. This especially holds true for the commercial sector and large equipment in the residential sector, where upfront costs tend to be high. Thus, the task becomes one of assessing which barriers a company can overcome over the course of the planning horizon and how much economic potential can be deemed reasonably achievable.

Willingness to Adopt Efficiency Measures

To assess the fraction of customers who would likely adopt an energy efficiency measure, the phone surveys included a battery of questions to elicit information about customers' willingness to adopt measures under different *hypothetical* incentive scenarios. For several measure types (e.g., heating, cooling, lighting, and weatherization), we asked survey participants if they would adopt efficient measures if DP&L provided an incentive equal to 25% of the incremental cost (corresponding to the low-achievable scenario). Cadmus then asked if the customer would adopt the efficient measure if the company covered 50% of the measure's incremental cost (i.e., the cost to upgrade) (corresponding to the medium-achievable scenario). We then asked if the customer would adopt the efficient measure if the utility covered 75% of the incremental cost (corresponding to the high-achievable scenario). Finally, the surveys asked if a customer would adopt the efficient measure if the company covered 100% of the

[7] See, for example, William H. Golove and Joseph H. Eto, "Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency," LBL-38059 UC-1322, March 1996.

measure's incremental cost (corresponding to the maximum achievable scenario). Table 30 summarizes the assumptions for each achievable scenario.

Table 30. Achievable Incentive Scenarios

Scenario	Incentive
Low	0%
Medium	50%
High	75%
Max	100%

Figure 26 and Figure 27 show residential and commercial customers' willingness to adopt efficient measures under the different incentive scenarios.

Figure 26. Residential Willingness to Adopt

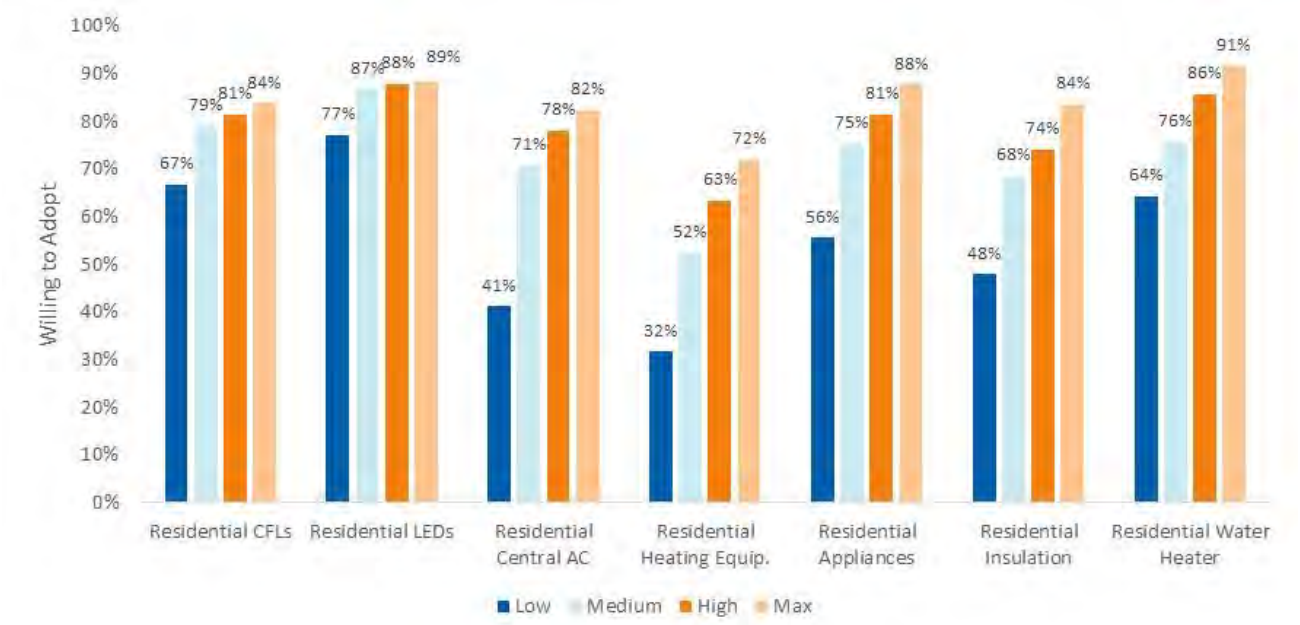
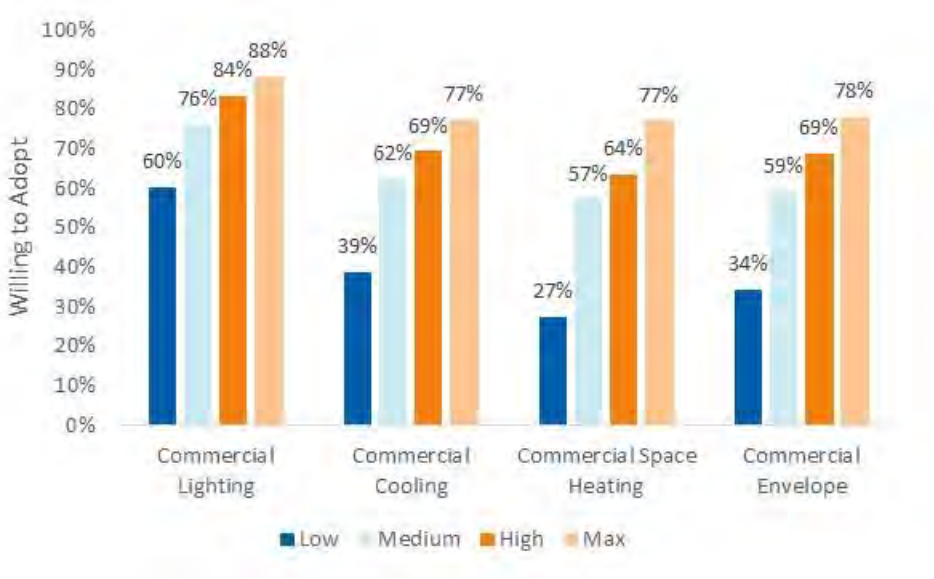


Figure 27. Commercial Willingness to Adopt



Ramp Rates

Energy efficiency measures generally fall into one of two discretionary (retrofit) or nondiscretionary (lost opportunity) groups. Discretionary measures (e.g., lighting upgrades in the commercial sector) may be implemented immediately, financial and practical considerations notwithstanding. Nondiscretionary measures include measures that are typically implemented only upon burnout of the existing equipment (normal turnover) and new construction. The key difference between the two measure types is that, unlike retrofit measures, the availability of lost-opportunity resources is determined by market forces that are outside of the program administrator's control. Cadmus used 10-year ramp rates for discretionary measures. For lost opportunity measures, natural replacement rates determine the timing of savings.

Achievable Potential

By combining customers' willingness-to-adopt efficiency measures and ramp rates, Cadmus calculated achievable potential for low, medium, high, and max scenarios. As shown in Table 31, cumulative achievable potential can account for between 8% and 13% of projected sales by 2027; this is equivalent to average annual savings of between 0.8% and 1.3% of baseline sales.

Table 31. Achievable Energy Efficiency Potential - Energy

Sector	Baseline Sales	Cumulative MWh - 2026				% of Baseline			
		Low	Medium	High	Max	Low	Medium	High	Max
Residential	6,006	718	949	1,031	1,100	12%	16%	17%	18%
Commercial	4,157	252	399	447	503	6%	10%	11%	12%
Industrial	4,266	128	202	226	254	3%	5%	5%	6%
Total	14,429	1,098	1,550	1,704	1,857	8%	11%	12%	13%

Table 32 shows estimates of achievable demand savings by 2027 for each scenario.

Table 32. Achievable Energy Efficiency Potential - Demand

Sector	Cumulative MW – 2018-2027			
	Low	Medium	High	Max
Residential	122	161	175	187
Commercial	38	60	68	76
Industrial	19	30	34	38
Total	179	252	276	301

Combined Heat and Power Potential

Methodology

Although renewable and non-renewable customer-sited CHP generation may not reduce a building's energy consumption or peak demand, it provides benefits to the electric grid by reducing the amount of energy required from utility-owned resources. Traditionally, CHP has fallen outside the standard classification of energy efficiency resources for two main reasons: it reduces utility-provided electricity consumption at the building level or at an end-use level and the certain CHP technologies rely on renewable resources such as biomass or biogas. With that said, CHP is a topic of interest of DP&L's stakeholders and DP&L is currently piloting a CHP program. This study investigates this supplemental resource—in addition to energy efficiency—to inform DP&L of the available potential and to address stakeholder needs.

Cadmus assessed the applicable technical and market CHP potential for commercial and industrial sectors as well as for landfills, farms, and wastewater treatment facilities (WWTFs) within DP&L service territory. CHP systems generate electricity and use waste heat for thermal loads, such as space or water heating. CHP can be used in buildings with a fairly coincident thermal and electric load or in buildings producing combustible biomass or biogas, such as pulp and paper manufacturing facilities or landfills.

CHP represents total electric generation that could be offset if all resources were installed in all technically feasible applications. Technical potential assumes that every customer in the DP&L service territory that meets a CHP's energy demand requirements would have a system installed. This largely unrealizable potential should be considered a theoretical construct.

The next potential level is market potential. Market potential measures the likely penetration within DP&L's service territory given existing (or projected) market conditions. Cadmus applied a market penetration rate on the technical potential data to determine market potential or likely installations in future years. The study based the assumed annual market penetration rate on secondary research of market acceptance curves from payback models and California customer surveys conducted as part of a report for the California Energy Commission.[8] Cadmus assumed the base-case scenario assumption of 0.66% (annual percentage of technical to market penetration) because it best represented the current regulatory and federal incentive conditions. Cadmus also benchmarked the estimated market

[8] Combine Heat and Power Market Assessment for the California Energy Commission prepared by ICF, April 2010: CEC-500-2009-094-F. ICF estimated the rate of market penetration from the economic market potential based on a Bass diffusion curve.

penetration rate with other CHP potential study reports[9] and found that the market penetration rate used for DP&L fell within these two studies (0.39% to 0.82%).

Technologies Assessed

CHP systems generate electricity and use waste heat for thermal loads, such as space or water heating. They can be used in buildings with a fairly coincident thermal and electric load or in buildings producing combustible biomass or biogas, such as lumber mills or landfills.

Traditionally, CHP systems have been installed in hospitals, schools, and manufacturing facilities; however, they can be used across nearly all commercial and industrial market segments with average monthly energy loads greater than about 30 kW. CHP can be broadly divided into subcategories based on fuels used; (1) non-renewable CHP typically runs on natural gas and (2) renewable CHP runs on a biologically derived fuel (biomass or biogas).

Cadmus analyzed the following non-renewable natural gas-consuming CHP systems:

- Reciprocating engines,
- Microturbines,
- Gas turbines, and
- Fuel cells.

Reciprocating engines cover a wide size range, whereas gas turbines typically are large systems. Fuel cells and microturbines represent newer technologies with higher capital costs, although fuel cells have the highest electrical conversion efficiency.

[9] PacifiCorp's Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, 2013-2032 Volume I, http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/DSM_Potential_Study/PacifiCorp_DSMPotential_FINAL_Vol%20I.pdf and Efficiency Maine Trust's Assessment of Energy Efficiency and Distributed Generation Baseline and Opportunities, 2012, http://www.efficiencymaine.com/docs/Cadmus-Baseline-Opps.pdf

The renewable CHPs Cadmus analyzed were industrial biomass systems and anaerobic digester biogas systems, described as follows:

- Industrial biomass systems are used in industries such as lumber or pulp and paper manufacturing in which site-generated waste products can be combusted in place of natural gas or other fuels. This analysis assumed that the combustion process includes a CHP system (generally, steam turbines) to generate electricity on site. Industrial biomass systems generally operate on large scales, with a capacity greater than 1 MW.
- Anaerobic digesters create methane gas (biogas fuel) by breaking down liquid or solid biological waste. Anaerobic digesters can be coupled with a variety of generators, including REs and MTs, and are typically installed at landfills, WWTFs, and livestock farms.

The study did not include waste heat-to-power (WHP) systems because initial research identified the following challenges:

- The United States currently has very little WHP systems installed (33 sites, 557 MW, excluding landfill gas);
- WHP systems can only be applied in industries producing high-temperature heat (e.g., metal and chemical manufacturing); and
- WHP systems present significant technical barriers (e.g., space limitations, dispersed waste heat sources, and low-volume/seasonal operations).

Although WHP systems offer potential energy savings, low market awareness and willingness to adopt this technology at this time coupled with relatively significant technical barriers suggest small market potential for these applications.

Levelized Cost

For each technology, Cadmus calculated a levelized cost from a total resource or utility perspective, depending on the technology. Although variations in assumptions exist between technologies, overall TRC levelized costs included the following:

- Utility costs other than incentives and interconnection for CHP;
- Operation and maintenance (O&M) costs assumed to occur annually, adjusted to the net present value; and
- Fuel costs for CHP, which use the NYMEX natural gas futures forecast.

Note: Because this study period begins in 2018, the federal investment tax credit (ITC) for systems was not incorporated into the analysis. This assumes that the ITC expires as planned on December 31, 2016. State tax credits and utility incentives are not deducted from the installation cost because the TRC test counts these as benefits to customers installing the systems. They are also included as costs to the state's taxpayers, resulting in a zero net effect.

For both perspectives, the Cadmus used DP&L's 1.2% inflation rate to adjust future costs to present dollars. Costs were then divided by the system's energy production over its lifespan, obtaining the levelized cost of energy (LCOE). Energy production includes a line loss factor of 5.21%. These line loss values represent avoided losses on the utility system, not energy loss from the customer-sited unit to the facility (which is assumed to be zero). Energy production over the system's life accounted for system performance degradation, as applicable.

Data Sources

Cadmus reviewed many data sources to determine inputs that were most appropriate for CHP analysis. As shown in Table 33, U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) reports on CHP technologies provided many inputs, with other sources used for additional inputs, as appropriate.

Table 33. CHP Data Sources

Source	Inputs	Website Link
Catalog of CHP Technologies, U.S. EPA	System size, installed cost, heat rate, O&M cost	www.epa.gov/chp/documents/catalog_chptech_full.pdf
Biomass Combined Heat and Power Catalog of Technologies, U.S. EPA	System size, heat rate, O&M cost, WWTF data	www.epa.gov/chp/documents/biomass_chp_catalog.pdf
R.S. Means	State cost adjustment	N/A
Combined Heat and Power Partnership, U.S. EPA	Federal ITC	www.epa.gov/chp/incentives/
Gas-Fired Distributed Energy Resource Technology Characterizations, U.S. DOE	Measure life	www.nrel.gov/docs/fy04osti/34783.pdf
California Self-Generation Incentive Program (SGIP) 10th Impact Evaluation Report	Capacity factor	www.cpuc.ca.gov/PUC/energy/DistGen/sgip/
California SGIP Combined Heat and Power Performance Investigation	Performance degradation	www.cpuc.ca.gov/PUC/energy/DistGen/sgip/
Landfill Methane Outreach Program (LMOP), U.S. EPA	Landfill gas data	www.epa.gov/lmop/
Cadmus CHP Potential Study Inputs	CHP eligibility by facility type and size	Based on previous studies
Combine Heat and Power Market Assessment for the California Energy Commission	Annual market penetration rate	http://www.energy.ca.gov/2009publications/CEC-500-2009-094/CEC-500-2009-094-F.PDF
Combined Heat and Power Installation Database	Existing CHP installations	www.eea-inc.com/chpdata/
DP&L Inputs	Nonresidential customer forecast, nonresidential customer baseline sales, line losses	N/A

CHP Inputs

The CHP list of assumptions (installation costs, O&M costs, net heat rate, assumed performance degradation, capacity factors, and measure life) used in this study for nonrenewable fuel systems by technology and size range can be found in Table 34, Table 35, Table 36, and Table 37. The list assumptions for renewable fuel systems by fuel and technology are shown in Table 38 and Table 39.

O&M costs represent typical maintenance costs and do not include fuel costs. The net heat rate, measured in Btu/kWh, equals the increased system fuel use (total fuel input to the CHP system minus the fuel normally used to generate the same thermal output) divided by the electricity output. In biogas systems, the analysis assumed waste heat fed back to the anaerobic digester for biogas generation; therefore, the total heat rate was used, rather than the net heat rate.

For biogas systems, the cost shown represents the generator cost. Additional expenses for building digesters have not been included because could be completed independently of the CHP system. Similar to biomass systems, the study assumed that boiler and fuel processing systems would already be in place at large industrial facilities; therefore, only CHP generator costs have been included.

Table 34. Inputs for Natural Gas Fuel Cells

Input	100kW	250kW	750kW
National average installation cost ($/kW)	$10,000	$7,000	$4,600
Annual O&M cost ($/kWh)	$0.045	$0.036	$0.04
Net heat rate (Btu/kWh)	7,260	9,948	8,028
Annual performance degradation			0.05
Capacity factor			0.72
Measure life (years)			10

Table 35. Inputs for Natural Gas-Fired Gas Turbines

Input	<3,000 kW	≥3,000 kW
National average installation cost ($/kW)	$3,381	$2,080
Annual O&M cost ($/kWh)	$0.0126	$0.0123
Net heat rate (Btu/kWh)	6,810	5,689
Annual performance degradation		0
Capacity factor		0.83
Measure life (years)		20

Table 36. Inputs for Natural Gas-Fired Microturbines

Input	<50 kW	50–150 kW	>150 kW
National average installation cost ($/kW)	$4,300	$3,220	$2,270
Annual O&M cost ($/kWh)	$0.02	$0.013	$0.11
Net heat rate (Btu/kWh)	6,211	5,983	6,405
Annual performance degradation			0.05
Capacity factor			0.37
Measure life (years)			10

Table 37. Inputs for Natural Gas-Fired Reciprocating Engines

Input	<200 kW	200–500 kW	500–2,000 kW	2,000–4,000 kW	>4,000 kW
National average installation cost ($/kW)	$2,900	$2,837	$2,366	$1,801	$1,433
Annual O&M cost ($/kWh)	$0.024	$0.021	$0.019	$0.016	$0.009
Net heat rate (Btu/kWh)	4,500	4,641	5,422	5599	5,049
Annual performance degradation					0.06
Capacity factor					0.44
Measure life (years)					20

Table 38. Inputs for Industrial Biomass Steam Turbine Systems

Input	<2,000 kW	2,000–5,000 kW	>5,000 kW
National average installation cost ($/kW)	$1,117	$475	$429
Annual O&M cost ($/kWh)	$0.01	$0.009	$0.006
Heat rate (Btu/kWh)	4,541	4,540	4,442
Annual performance degradation			0.01
Capacity factor			0.9
Measure life (years)			25

Table 39. Inputs for Biogas Systems

Input	Fuel Cell	Gas Turbine	Microturbine	Reciprocating Engine
National average installation cost ($/W)	$5,713	$2,319	$2,633	$1,610
Annual O&M cost ($/kWh)	$0.025	$0.0085	$0.014	$0.0165
Heat rate (Btu/kWh)	8,705	12,400	12,703	10,357
Annual performance degradation	0.05	0	0.05	0.06
Capacity factor	0.72	0.83	0.37	0.44
Measure life (years)	10	20	10	20

Technical Potential

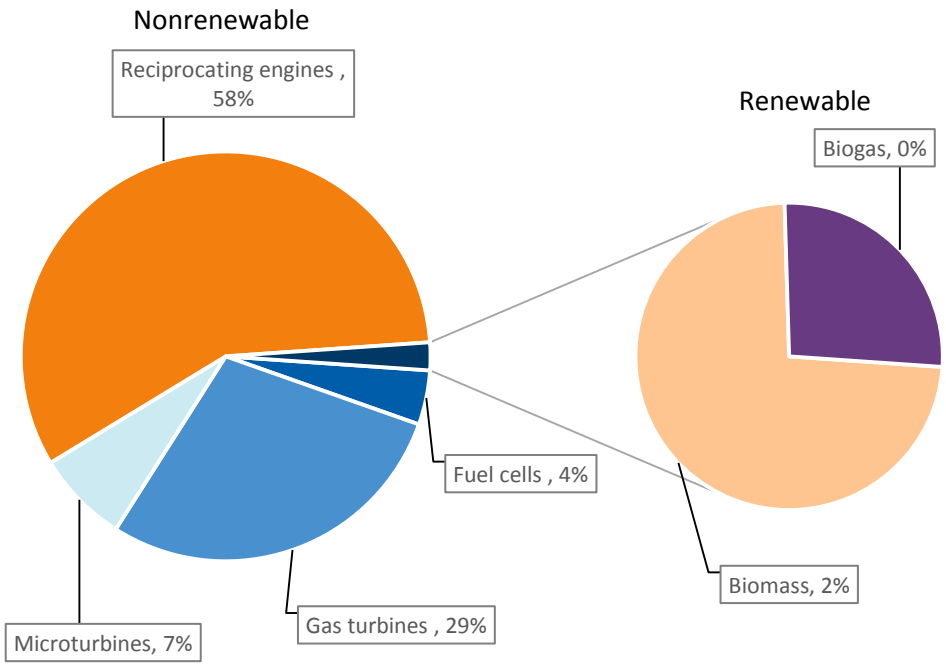
Cadmus calculated technical CHP potential based on the sources described in the Methodology section, including DP&L commercial and industrial customer data and data on farms, landfills, and WWTFs within DP&L service territory, resulting in a total estimated 10-year system-wide technical potential of 1,060 MW as measured at generator. Table 40 details technical potential by fuel (in MW).

Table 40. CHP Technical Potential by Fuel (Cumulative MW in 2027)

DP&L	Technical Potential
Commercial	
Natural gas MW	545
Number of sites	1,223
Industrial	
Natural gas MW	492
Number of sites	374
Biomass and biogas MW	23
Number of sites	27
Industrial total MW	515
Industrial total number of sites	402
Total	
Total MW	1,060
Total number of sites	1,624

The study based average energy production on the unique capacity factors of each system type. To avoid double-counting opportunities across technologies, the study divided total potential for each size range into different technologies. Figure 28 shows the distribution of technical potential as a percentage of 2027 technical potential in MW by these different technologies (reciprocating engine, microturbine, gas turbine, fuel cell, biomass, and biogas).

Figure 28. Percentage of 2027 CHP Technical Potential in MW by Technology



Market Potential

Cadmus applied a market penetration rate on the technical potential data to determine market potential or likely installations in future years. The study based the assumed annual market penetration rate on secondary research of market acceptance curves from payback models and California customer surveys conducted as part of a report for the California Energy Commission.[10] Cadmus assumed the base-case scenario assumption of 0.66% (annual percentage of technical to market penetration) because it best represented the current regulatory and federal incentive conditions. Cadmus also combined the estimated market penetration rate with other CHP potential study reports[11] and found

[10] Combine Heat and Power Market Assessment for the California Energy Commission prepared by ICF, Oct. 2009: CEC-500-2009-094-D. ICF estimated the rate of market penetration from the economic market potential based on a Bass diffusion curve.

[11] PacifiCorp's Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources, 2013-2032 Volume I, http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/DSM_Potential_Study/PacifiCorp_DSMPotential_FINAL_Vol%20I.pdf and Efficiency Maine Trust's Assessment of Energy Efficiency and Distributed Generation Baseline and Opportunities, 2012, http://www.efficiencymaine.com/docs/Cadmus-Baseline-Opps.pdf

that the market penetration rate used for DP&L fell within these two studies (0.39% to 0.82%). The market penetration rate was applied to the technical potential for each year to calculate market potential over the next 10 years, as shown in Table 41. The study estimated a cumulative 10-year market potential of 69.7MW at generator. The DP&L line loss assumption used for this study was 5.21%.

Table 41. 2027 Cumulative Market Potential (MW)

Technology	2027 MW at Site	2027 MW at Generation	# of Sites
Nonrenewable - Natural Gas (Total)	**64.6**	**68.1**	**99.5**
30–99 kW	0.67	0.70	10
100–199 kW	5.10	5.38	34
200–499 kW	10.88	11.48	31
500–999 kW	10.88	11.48	15
1–4.9 MW	23.28	24.56	8
5 MW+	13.76	14.52	2
Renewable - Biomass (Total)	**1.1**	**1.1**	**1**
< 500 kW	0.06	0.06	1
500-999 kW	0.09	0.09	0
1–4.9 MW	0.60	0.63	0
5 MW+	0.32	0.34	0
Renewable - Biogas (Total)	**0.4**	**0.4**	**1**
Landfill	0.17	0.18	0
Farm	0.17	0.18	1
Wastewater	0.04	0.04	0
Total CHP	66.0	69.7	101.2

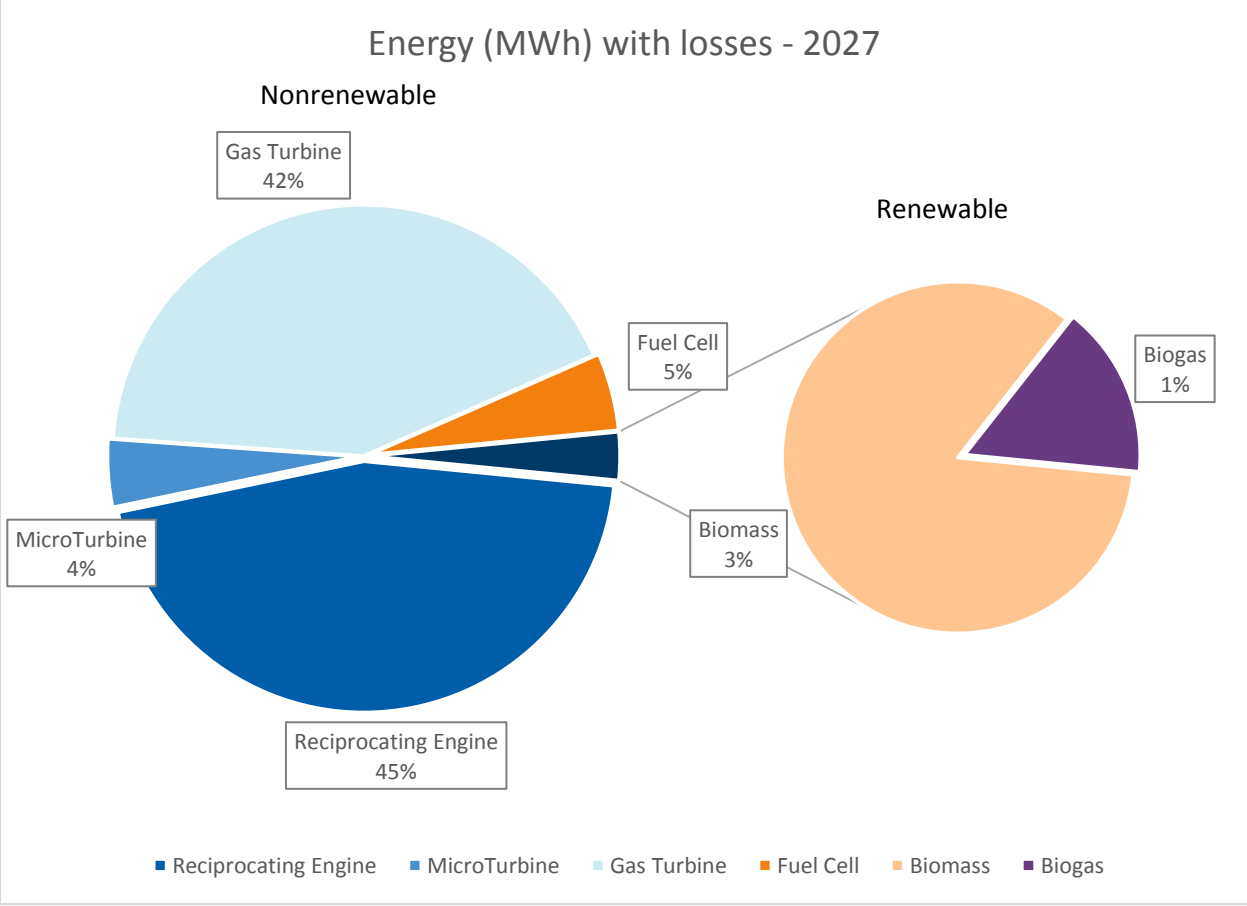
The CHP market potential did not assume ramping. That is, each year's incremental potential is roughly one-tenth of the total 10-year potential. Therefore, the market potential annual participation is roughly 10 installations (sites) per year. Because DP&L's load growth forecast was incorporated into the analysis, the incremental potential was slightly lower in the earlier years, as shown in Table 42.

Table 42. Incremental Market Potential by Year at Generation (MW)

Technology	2018	2019	2020	2021	2022	2023	2024	2025	2027	2027
Nonrenewable (Total)	**6.60**	**6.67**	**6.71**	**6.74**	**6.80**	**6.89**	**6.99**	**7.07**	**7.14**	**7.21**
Fuel cell	0.29	0.29	0.29	0.30	0.30	0.30	0.31	0.31	0.31	0.32
Gas turbine	1.93	1.95	1.97	1.97	1.99	2.02	2.04	2.07	2.09	2.11
Microturbine	0.49	0.50	0.50	0.50	0.51	0.51	0.52	0.53	0.53	0.54
Reciprocating engine	3.89	3.93	3.95	3.97	4.01	4.06	4.11	4.16	4.20	4.25
Renewable (Total)	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**	**0.16**
Biomass	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12
Biogas	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total CHP	6.75	6.82	6.86	6.89	6.95	7.04	7.14	7.23	7.30	7.37

Cadmus calculated the market potential GWh that the CHP generates. The total cumulative 2027 GWh generated across all technologies was 308.5 GWh (nonrenewable, 299.0 GWh, and renewable, 9.5 GWh). The market potential cumulative 2027 GWh by each CHP technology is shown in Figure 29.

Figure 29. 2027 Cumulative Market Potential with Line Losses (GWh)



Levelized Cost of Energy Results

Cadmus calculated the levelized cost of energy (LCOE) for each technology configuration for each installation year (2018 to 2027). Table 43 shows the cumulative results for units installed through the study period. The calculated levelized cost is based on the TRC perspective to be consistent with other resources within this study. The annual LCOE varies slightly by year because the energy production over the system's life accounts for system performance degradation.

Table 43. LCOE by Technology Configuration and Installation Year

Technology	Description	Ohio									
		2018	2019	2020	2021	2022	2023	2024	2025	2027	2027
Microturbine	Microturbine <50 kW	$0.23	$0.23	$0.23	$0.23	$0.23	$0.23	$0.23	$0.24	$0.24	$0.24
	Microturbine 51–150 kW	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.19	$0.19	$0.19
	Microturbine 151+ kW	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15
Fuel cell	Fuel Cell 100 kW	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.31
	Fuel Cell 150 kW	$0.26	$0.26	$0.26	$0.26	$0.26	$0.27	$0.27	$0.27	$0.27	$0.27
	Fuel Cell 750 kW	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.21	$0.21	$0.21	$0.21
Reciprocating engine	Reciprocating <200 kW	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12
	Reciprocating 201–500 kW	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12	$0.12
	Reciprocating 501–2000 kW	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
	Reciprocating 2001–4000 kW	$0.09	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
	Reciprocating 4000+ kW	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
Gas turbine	Gas Turbine <3000 kW	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
	Gas Turbine 3000+ kW	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.09
Biomass - steam turbine	Biomass <2000 kW	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
	Biomass 2001–5000 kW	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
	Biomass 5000+ kW	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
Biogas	Biogas - microturbine	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14
	Biogas - fuel cell	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17
	Biogas - reciprocating	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07
	Biogas - gas turbine	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04

The technologies with the lowest levelized cost tend to be renewable applications because fuel costs are typically a process byproduct and are considered zero cost. Larger systems, such as reciprocating engines and gas turbines, also have low LCOE. The market potential for these larger systems is much higher than for the renewable applications. Smaller systems such as fuel cells and microturbines have the highest material cost per kW, resulting in high levelized costs.

Conclusion

Study Findings

Achievable energy efficiency could produce average annual savings of between 0.9% and 1.4% of DP&L's baseline sales. However, these estimates do not account for program design considerations, such as budgets, measure bundling, and requirements to serve specific market segments, such as low-income customers. As noted previously, this study is meant to inform program design and is a reference point or guide for program development, but it does not set program targets. As with any potential study, this assessment requires broad assumptions about program expenditures and cost-effectiveness (as discussed above); DP&L refines these assumptions as they plan specific programs. Because of these differences, achievable potential may not equal DP&L's planned savings.

Overall, Cadmus identified a number of measures with significant cost-effective savings potential including following:

- LED lighting, low flow showerheads, ENERGY STAR multifunction devices, and refrigerator recycling offer high cost-effective savings potential in the residential sector. However, LED lighting potential does diminish after 2020 due to federal lighting standards enacted in the Energy Independence and Security Act (EISA).
- LED linear lighting, lighting controls, screw base LED lighting, and efficient ventilation and circulation systems offer high savings potential for the commercial sector. Various lighting control measures, including occupancy sensors, daylighting controls, and continuous dimming fixtures collectively account for 28% of economic potential in the commercial sector.
- High-saving industrial measures depend on the mixture of industries for each respective utility. DP&L customers are largely manufacturing customers, which have high lighting and process potential.
- The CHP potential estimated a cumulative 10-year market potential of 69.7MW at generator. The technologies with the lowest levelized cost tend to be renewable applications because fuel costs are typically a process byproduct and are considered zero cost. Larger systems, such as reciprocating engines and gas turbines, also have low LCOE. The market potential for these larger systems is much higher than for the renewable applications. Smaller systems such as fuel cells and microturbines have the highest material cost per kW, resulting in high levelized costs.

Appendix A. Primary Data Collection Results

Residential Phone Survey Results

This appendix summarizes findings from 210 residential phone surveys (116 single-family homes, 70 multifamily homes, and 24 manufactured homes) completed by Cadmus and VuPoint Research to inform the following topics of energy efficiency potential study and program planning:[12]

- Assess saturation of various technologies related to energy efficiency,
- Assess efficiency program awareness and perceptions,
- Assess key factors affecting program participation, and
- Characterize customers' willingness to adopt and pay for energy efficiency measures.

Cadmus identified the distribution of residential configuration, saturation of measures, fuel shares for equipment and appliances, and age of equipment and summarized the findings of customers' program awareness and overall perception of DP&L.

Because the sample size for manufactured homes is very small, the manufactured homes sample was combined with the single-family homes sample and weighted across the entire residential population, given the similarities in ownership for these home segments. Table 44 lists the population by housing segments, the size of survey samples, and the weighting of each segment compared to the total population.

Table 44. Segmentation and Weighting by Population

Segment Type	Population	Sample Size	Ratio	Weighting
Single family	414,088	116	3569.72	0.57
Manufactured	19,349	24	806.20	0.13
Multifamily	135,925	70	1941.78	0.31

All data provided in the tables and figures within this section correspond to survey questions that can be found in Appendix B. To that end, where applicable, figures and tables refer to the actual response name and ID that can be found in the survey. For example, survey respondents choose the types of cooling equipment from a list of equipment names with IDs, such as 1-centeral air condition, 2-window air conditioner, 3-ceiling fans, 4-no cooling equipment, or 997-other equipment.

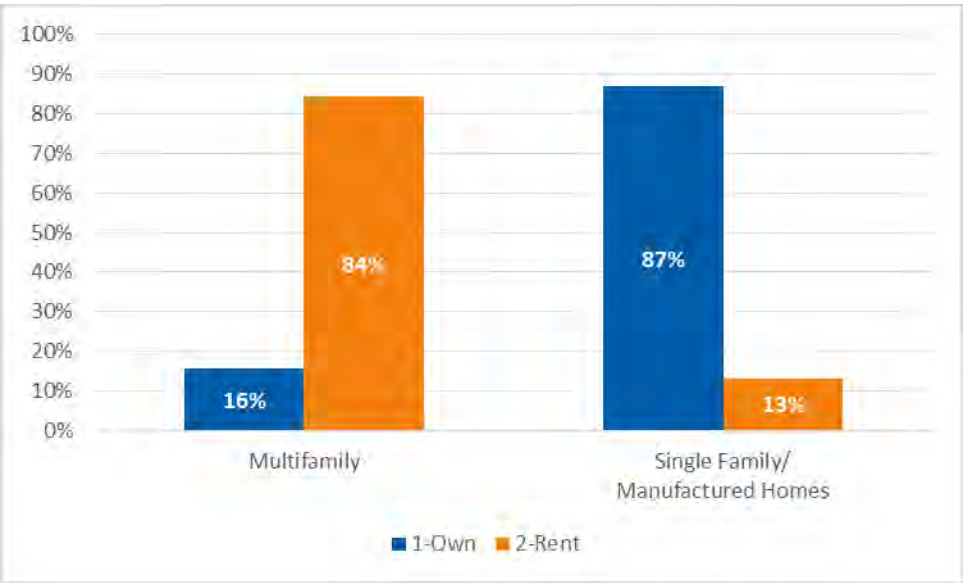
Residential Configuration and Demographics

Cadmus asked customers to identify the configuration of their homes (Figure 30). As shown, 87% of single-family residents and manufactured/mobile home residents and 16% of multifamily home

[12] Sample sizes for individual survey questions vary because of non-response and/or non-relevance.

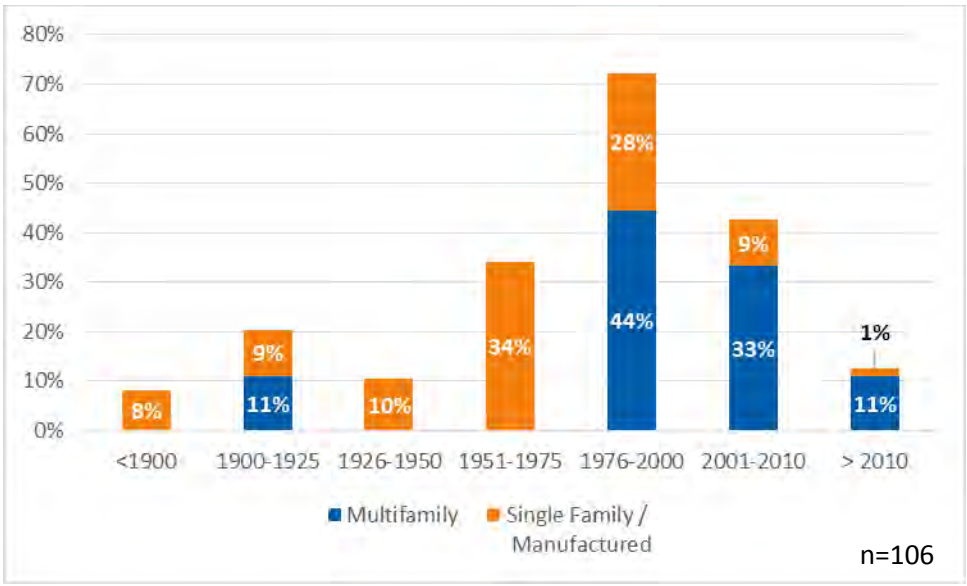
residents indicated that they own their residence. It is not surprising that most of the manufactured/mobile homes and single-family homes are owned, whereas the majority of multifamily residences are rented apartments.

Figure 30. Breakdown of Ownership by Type of Residence



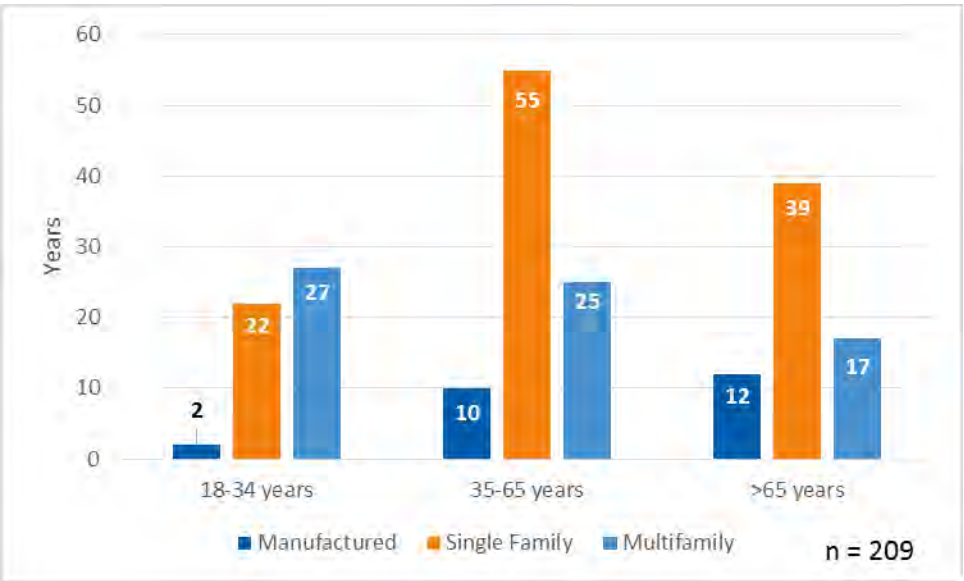
As shown in Figure 31, 57% of the population did not know what year their home was built. The majority of single-family homes were built between 1951 and 2000 and the majority of multifamily homes were built in the last 40 years.

Figure 31. Age of Home



Approximately 24% of all the surveyed population was between 18 and 24 years old, of which 43% were between 35 and 65 years old and 32% were over 65 years. The majority of single-family residents were between 35 and 65 years old. Distribution of multifamily residents was more evenly spread out between the 18-to-34-year and 35-to-65-year age groups, as shown in Figure 32.

Figure 32. Number of Residents by Age and Segment

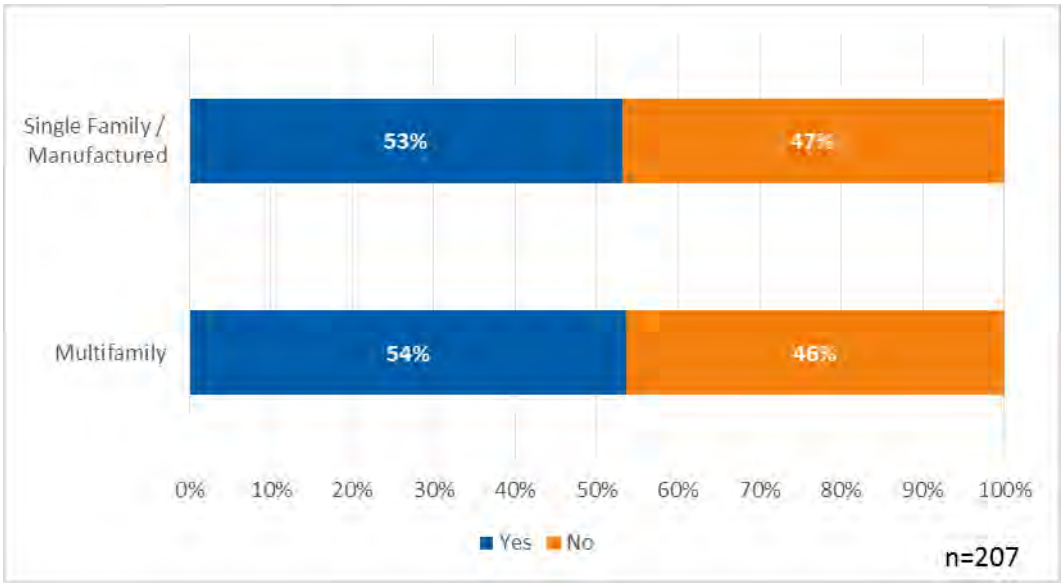


Of the surveyed population, 41% have an annual household income under $35,000, 12% have an annual household income between $35,000 and $50,000, 36% have income greater than $50,000, and approximately 11% of the participants either did not know or chose not to identify their annual household income range.

Program Awareness and Perception

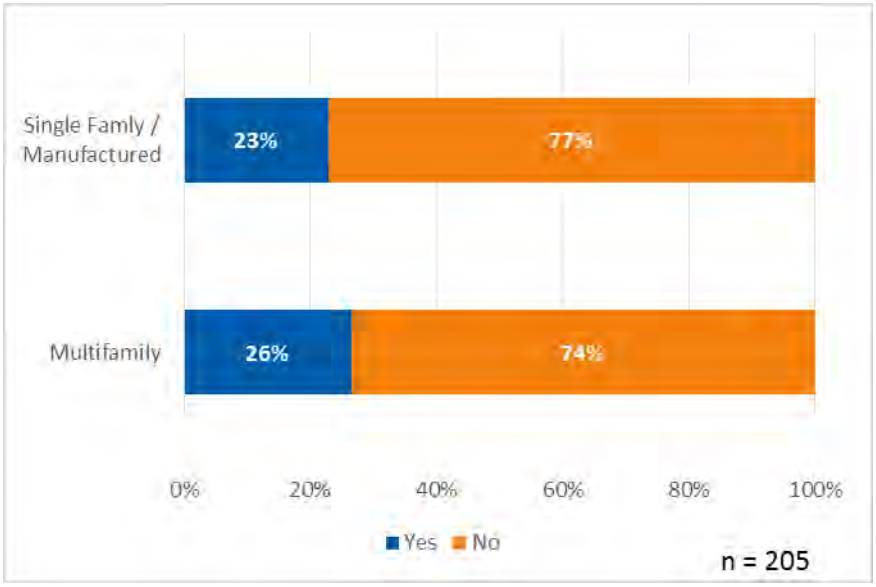
When asked about awareness of DP&L's programs or rebates that help customers reduce their energy consumption and save money on their energy bills, awareness among all three residential segments was very comparable at 53% to 54%, as shown in Figure 33. Of the total of 112 residents that indicated that they were aware of DP&L's rebate programs, 70 (11 manufactured, 35 single family, and 24 multifamily) residents indicated that their perception of DP&L was positive (63%).

Figure 33. Awareness of DP&L Programs and Rebates



Cadmus further asked residents whether they have seen or heard DP&L's Saving Champion Residential advertisement: 23% of single-family/manufactured home residents and 26% of multifamily residents had either seen or heard the advertisement, as shown in Figure 34.

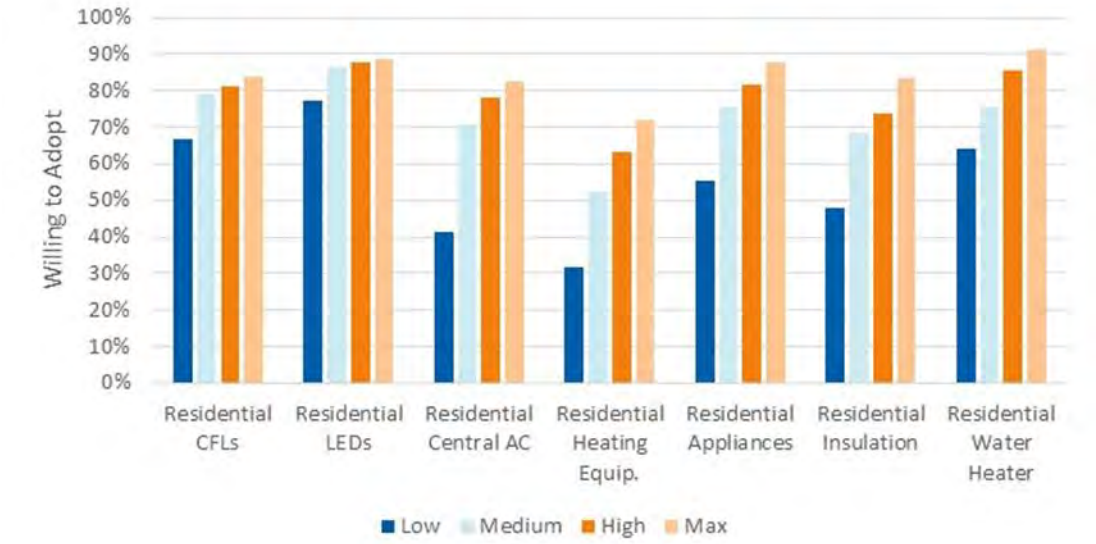
Figure 34. DP&L's Saving Champion Ad Awareness



Willingness to Pay

Cadmus asked survey participants about their likelihood of adopting energy-efficient lighting, appliances, and equipment within the next five years. Among CFL lighting, LED lighting, central air conditioning, heating equipment, appliances, insulation, and water heaters, participants revealed the highest likelihood of adopting LED lighting, followed by appliances, water heaters, and CFL bulbs. We then assessed their likelihood of adopting these technologies based on incremental subsidy/rebate amounts offered by DP&L of 50%, 75%, and 100% of the equipment cost. Figure 35 shows the cumulative likelihood of customers' willingness to pay based on incremental rebate offering amounts.

Figure 35. Willingness to Pay for Various Technologies in Next Five Years



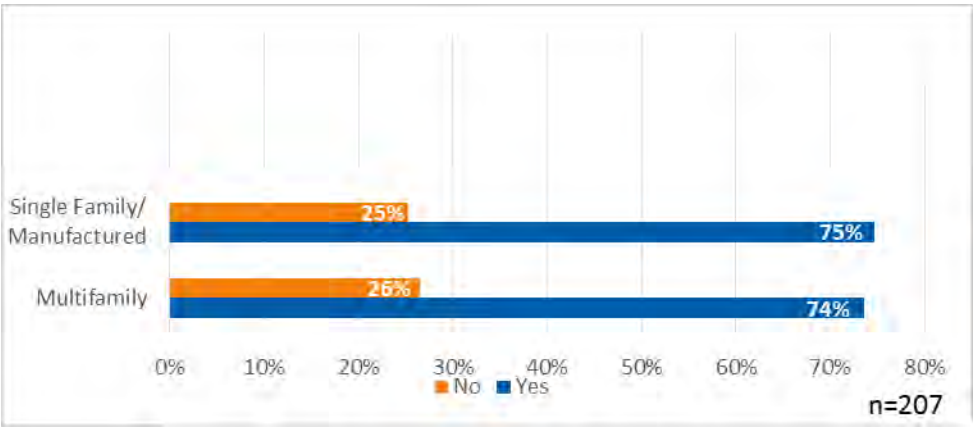
This shows that customers' willingness to adopt central air conditioning measures is relatively lower compared to other measures even with an offer of 100% of incremental costs. This low willingness to participate in prescriptive programs is typical for measures with higher upfront costs, such as HVAC equipment.

Measure Saturation and Intentions to Purchase

Cadmus asked participants various questions pertaining to residential equipment and appliances in their homes to gauge measure-level saturation. This section outlines the fuel shares for various equipment and appliances as well as the appliance types within each appliance category.

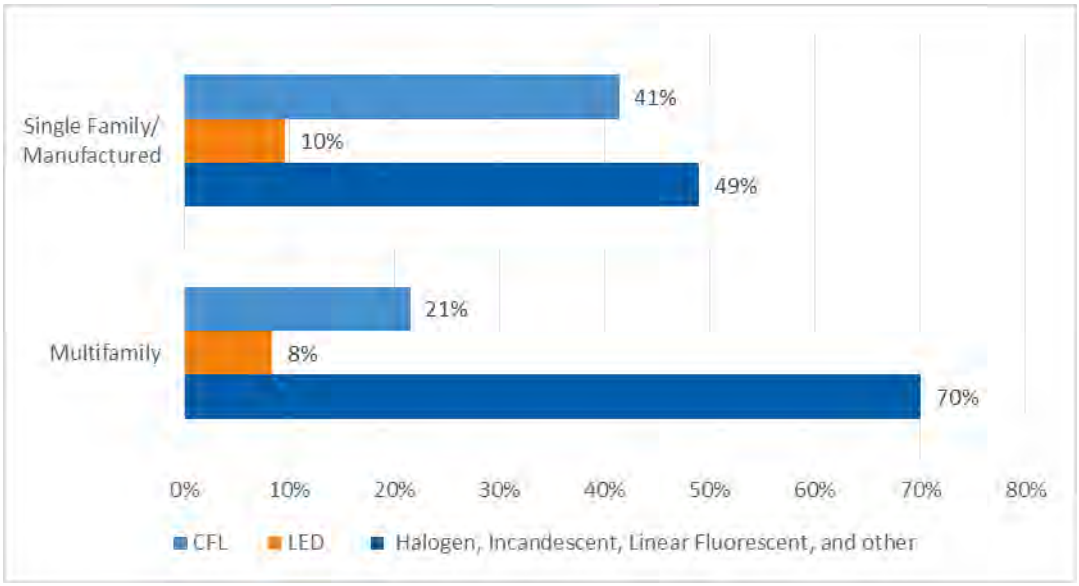
Cadmus asked residential customers about their awareness of LED lighting technologies: 74% of the surveyed multifamily residents and 75% of the single-family and manufactured homes were familiar with LED lighting technology, indicating that the majority of the residential population is familiar with LED lighting technology (Figure 36).

Figure 36. Awareness of LED Lighting Technology



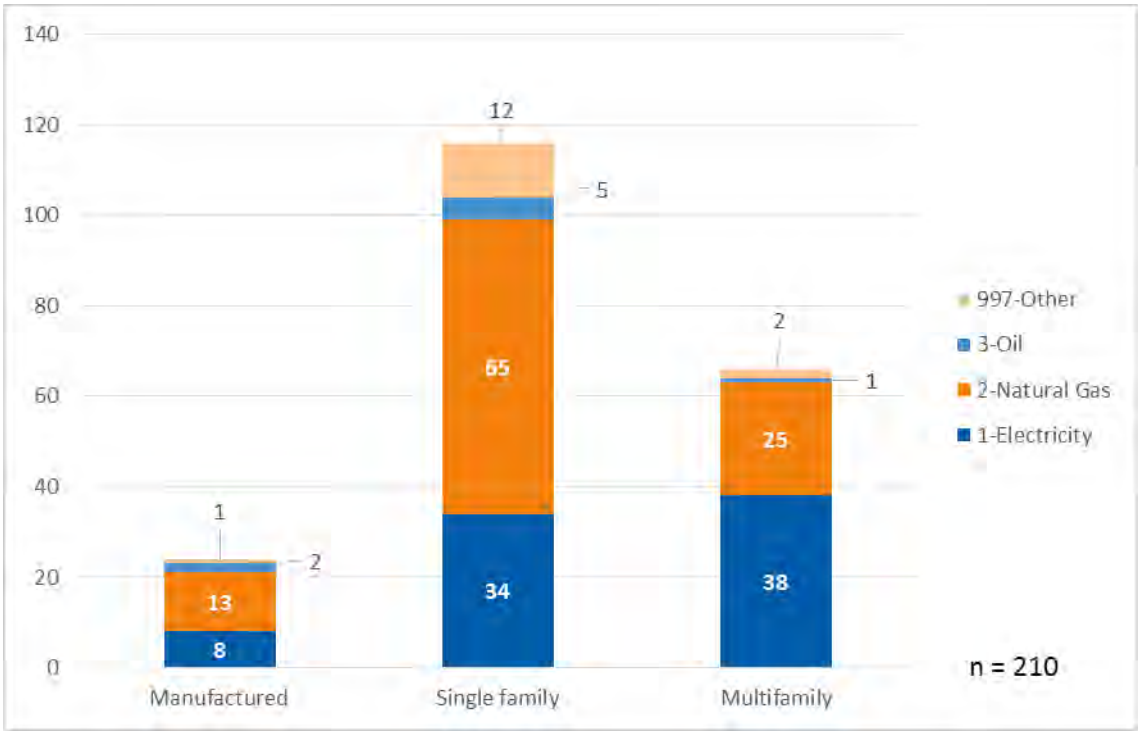
Based on the total quantities of light bulbs described by surveyed customers, 49% of light bulbs in single-family and manufactured homes and 70% of light bulbs in multifamily homes are incandescent, linear fluorescent, halogen, and so on. CFLs contribute to 41% and 21% of the light bulbs used in single-family/manufactured homes and multifamily homes, respectively. Bulbs with LED technology represent 8% of light bulbs in multifamily homes and 10% in single-family/manufactured homes, as shown in Figure 37.

Figure 37. Distribution of Lighting Technologies



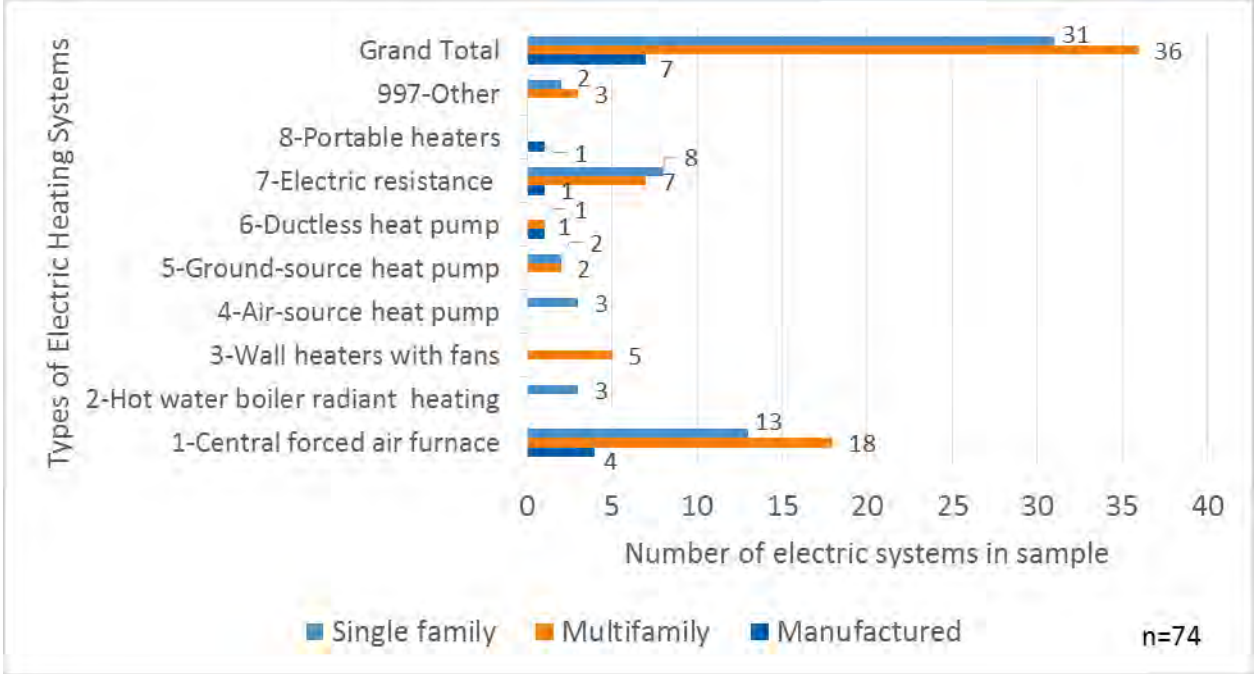
When asked what type of fuel their main heating equipment uses, 58% of multifamily residents, 29% of single-family residents, and 33% of residents in manufactured homes indicated electricity as their primary heating fuel. Natural gas is the primary fuel used for heating purposes in approximately 55% of the single-family and manufactured homes and 38% of the multifamily homes. Approximately 10% of single-family homes rely on other fuels for their primary heating needs as shown in Figure 38.

Figure 38. Breakdown of Heating Equipment Fuel Type



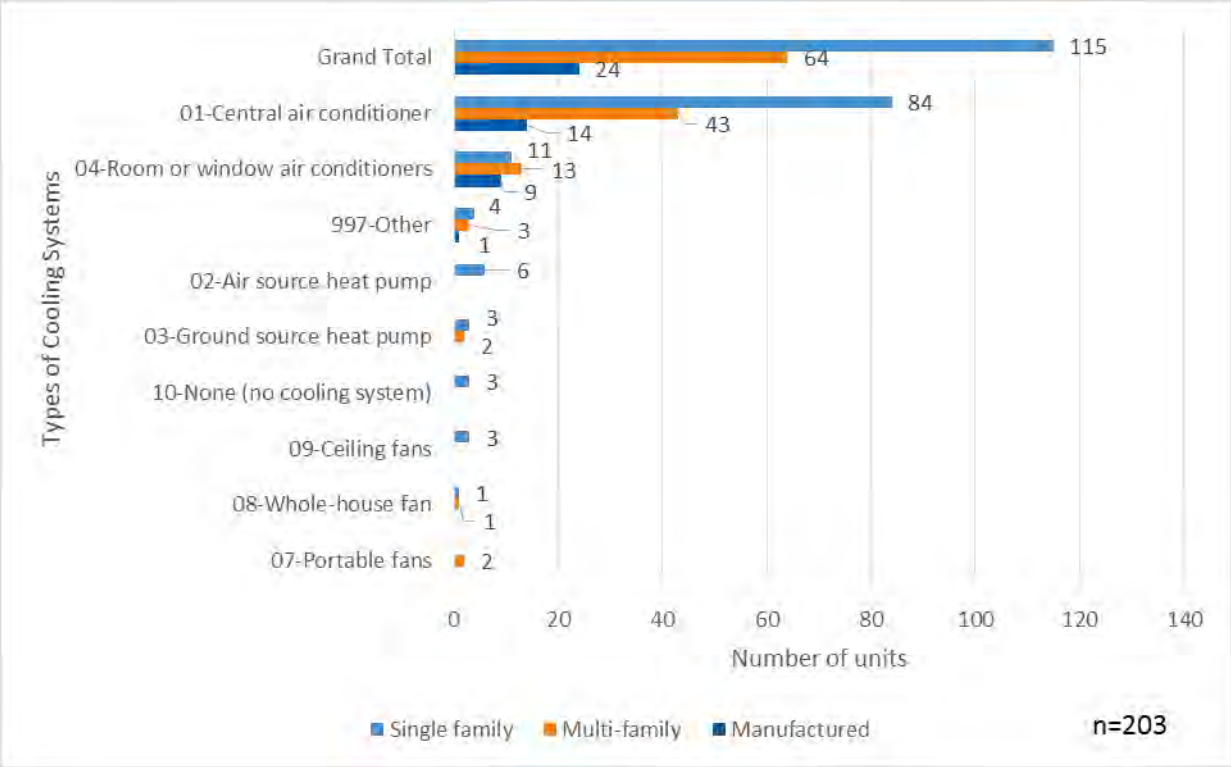
Of the 210 surveyed residential customers, 80 indicated their heating system was electric. Among these 80 residential customers (six of whom did not know their electric heating system type), 50% of the multifamily homes, 57% of the manufactured homes, and 42% of the single-family homes have electric central forced air furnaces as their primary heating equipment. About 26% of single-family homes, 19% of multifamily homes, and 14% of manufactured homes have electric resistance heating (i.e., baseboard heaters). Wall heaters with fans represent 14% of heating systems in multifamily residences. Portable heater and ductless heat pumps each represent about 14% of heating equipment in manufactured homes. Only three single-family homes had air source heat pumps as shown in Figure 39.

Figure 39. Sample Distribution of Types of Electric Heating Systems



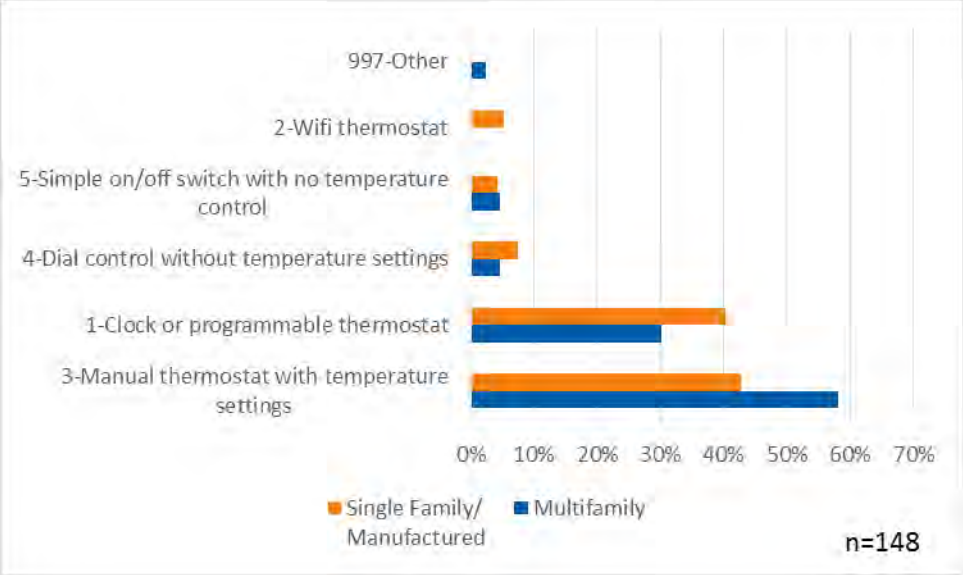
As for cooling equipment, out of the 203 residents that indicated they have a cooling system, 67% of multifamily residents, 73% of single-family residents, and 58% of manufactured home residents stated that they have a central air conditioner. Room or window air conditioners represented 38% of the manufactured homes, 20% of the multifamily homes, and 10% of the single-family homes. Out of the total sample of 203 homes (all segments combined), three single-family home residents stated that they did not have a cooling system in their home. In Figure 40, single-family residences that indicated they had window/room air conditioners (RACs) had, on average, three RAC units in their homes. The average number of room RAC units that manufactured homes had was two; for multifamily residences, the average number was 1.3.

Figure 40. Sample Distribution of Types of Cooling Equipment



Among the various types of cooling equipment control technologies, manual thermostats were the most common, being present in 58% of multifamily residences and 43% in single-family and manufactured homes. Programmable thermostats were the second most common control technology, with 30% of multifamily homes and 40% of single-family/manufactured homes having one. Simple on/off switches with no temperature controls or dial controls with no temperature controls were some of the least commonly found control technologies. Of the survey sample, only single-family homes showed the presence of WiFi thermostat technology, as shown in Figure 41.

Figure 41. Types of Controls for Cooling Equipment



Cadmus asked residents about the typical age of their heating (i.e., gas and electric), cooling, and water heating equipment. Figure 42 shows the age of heating equipment by residential segments (multifamily and single-family/manufactured homes). In multifamily homes where residents knew the age of their heating equipment, 45% of the heating equipment was less than or equal to five years old. Twenty-seven percent of the heating equipment was between six to 10 years old and 27% of the heating equipment was more than 10 years old. In single-family/manufactured homes, one-third of the heating equipment was less than or equal to five years old, 29% was within six to 10 years old, and 37% of the heating equipment was more than 10 years old.

Figure 42. Age of Heating Equipment

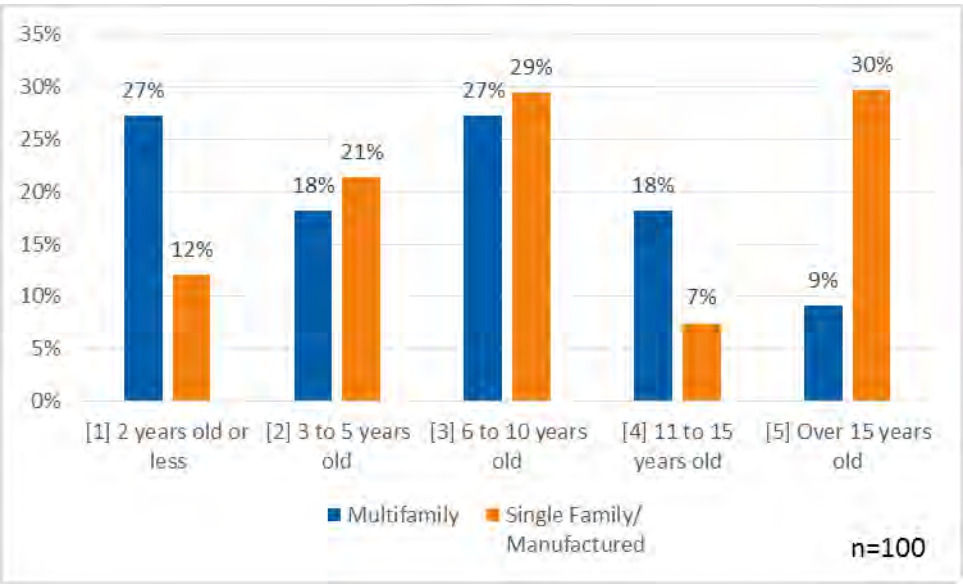


Figure 43. shows the age of cooling equipment by residential segments (multifamily and single-family/ manufactured homes). In multifamily homes where residents knew the age of their cooling equipment, 40% of the cooling equipment was less than or equal to five years old. Forty percent of the cooling equipment was between six to 10 years old and 20% of the cooling equipment was more than 10 years old. In single-family/ manufactured homes, 41% of the cooling equipment was less than or equal to five years old, 27% was within six to 10 years old, and 32% was more than 10 years old.

Figure 43. Age of Cooling Equipment

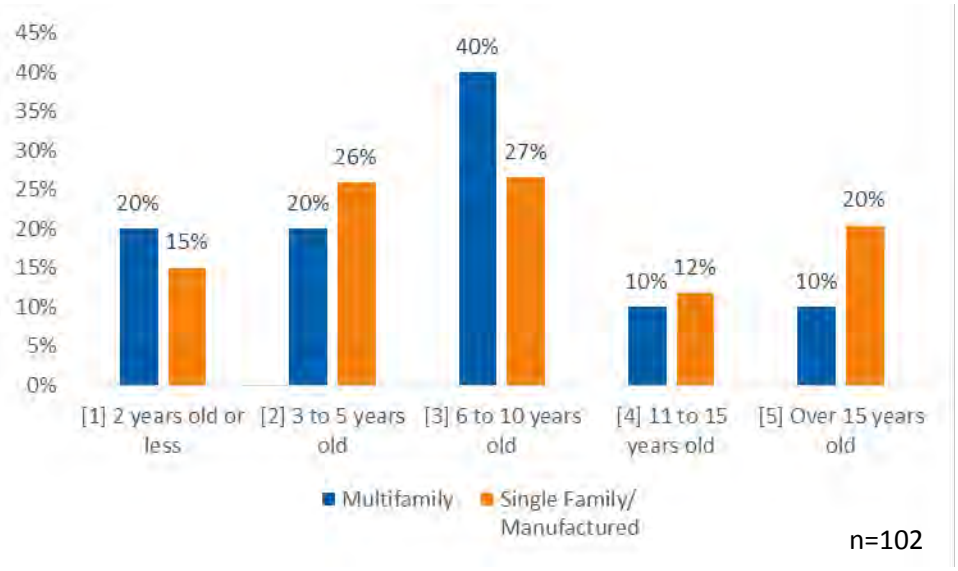
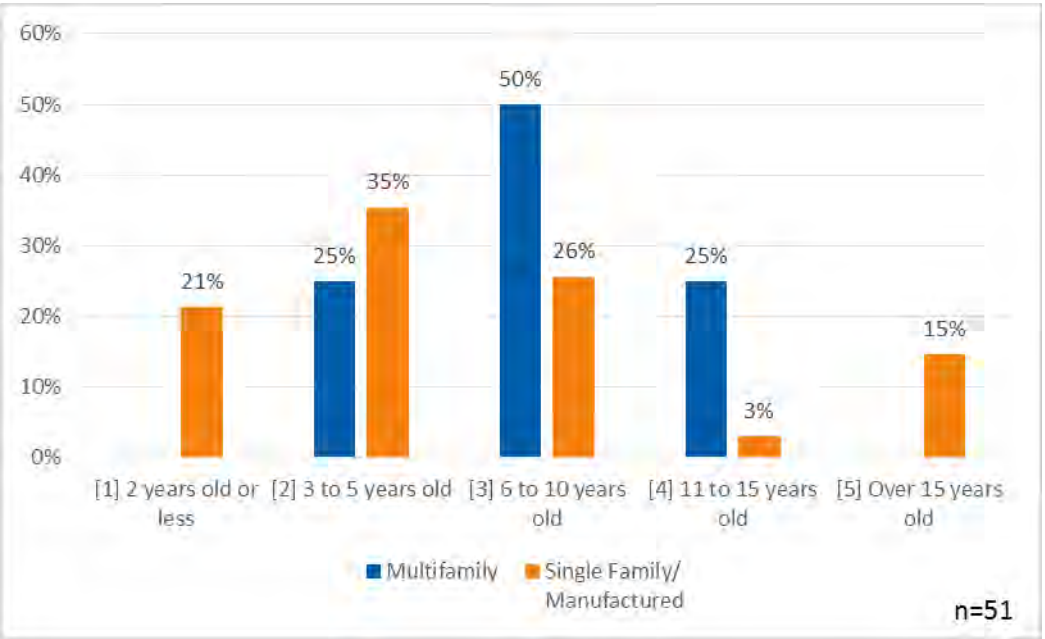


Figure 44 shows the age of water heating equipment by residential segments (multifamily and single-family/manufactured homes) for homes that are owned by their residents and where the type of water heating is electric.

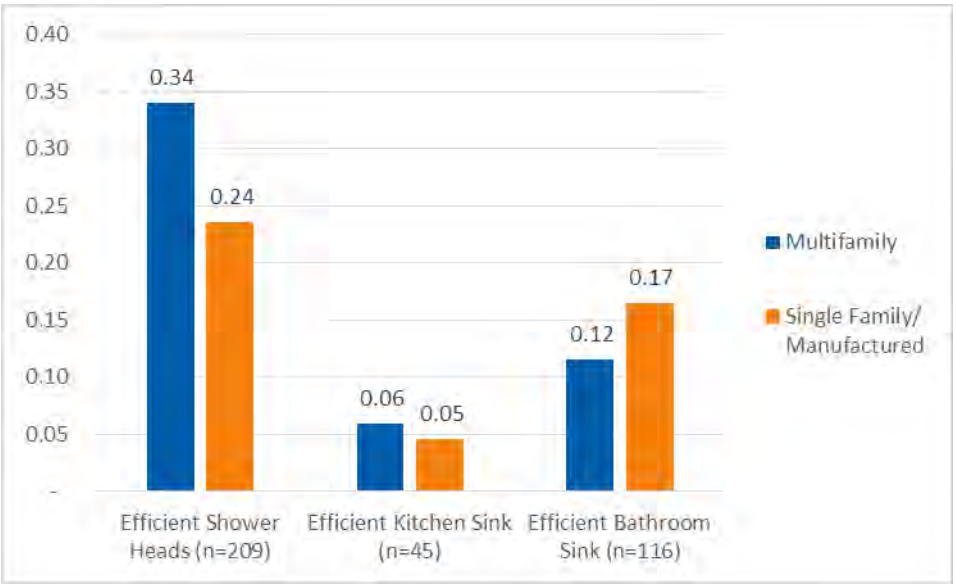
In multifamily homes where residents knew the age of their electric water heating equipment (n = 51), 56% of single-family and manufactured home residents stated that their equipment was less than or equal to five years old, 26% stated that is was between six and 10 years old, and 18% of residents stated that their equipment was more than 10 years old. The number of multifamily residents who knew the age of their water heating equipment was very low; however, of the residents who knew the age of their water heating equipment, 25% indicated that their water heating equipment was less than or equal to five years old, 50% of the residents indicated their equipment was between six to 10 years old, and 25% indicated their equipment was more than 10 years old. Seventy-three percent of electric water heaters were storage tanks, whereas 18% of the surveyed population did not know the type of electric water heater they had. This may be attributable to the high volume of rented multifamily residences.

Figure 44. Age of Electric Water Heating Equipment



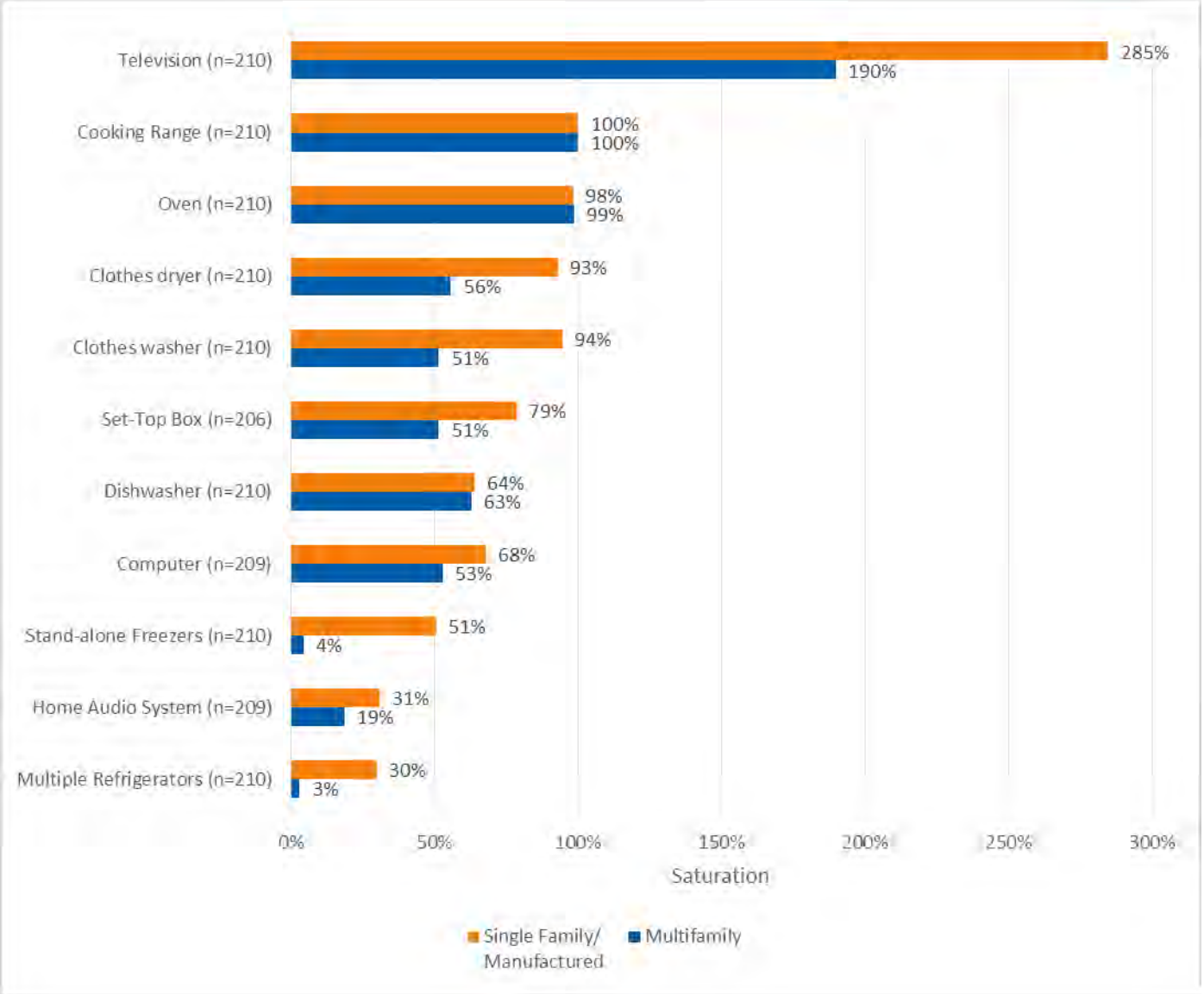
Cadmus asked residents to identify the total number of showerheads, kitchen sink faucets, and bathroom sink faucets in their homes, and to further classify whether these fixtures had conventional flow or low flow. As shown in Figure 45, in multifamily residences, 34% of all showerheads, 6% of all kitchen sink faucets, and 12% of all bathroom sink faucets have low-flow fixtures. For single-family/ manufactured homes, 24% of all showerheads, 5% of all kitchen sink faucets, and 17% of all bathroom sink faucets have low-flow fixtures.

Figure 45. Comparison of Water Efficient Plumbing Fixtures



To gauge saturation of appliances, Cadmus asked residents which common household appliances they had, as shown in Figure 46. The majority of single-family/manufactured homes had more than one television, computer, refrigerator, and set top box.

Figure 46. Appliance Saturations*

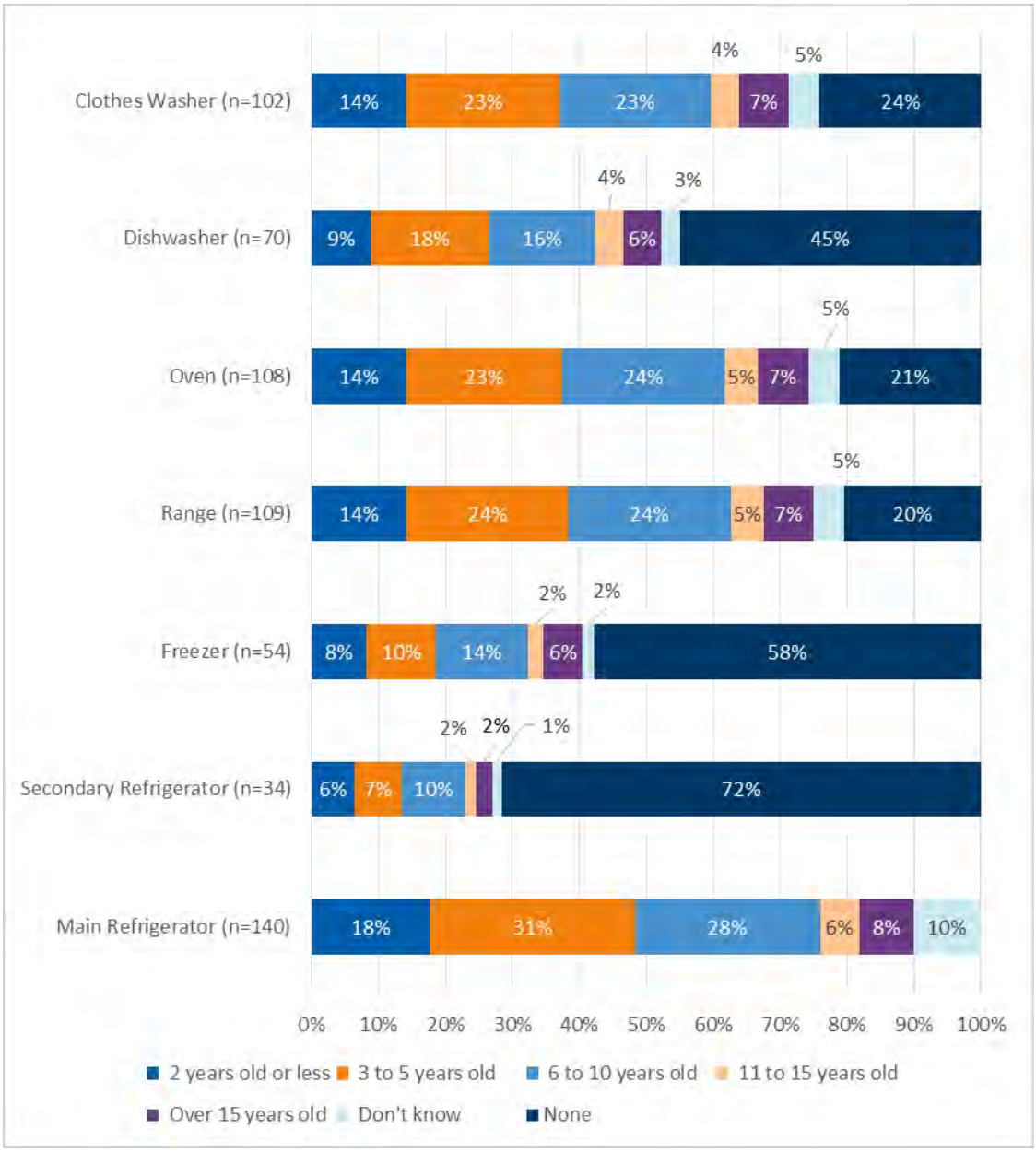


*Note: Saturation percentages exceeding 100% indicate the presence of more than one appliance per household in each appliance category.

In Figure 47 the majority of multifamily homes do not have freezers, laundry appliances, cooking appliances, and second refrigerators. The majority of the multifamily residents did not know the age of their appliances because they did not purchase them themselves.

In single-family/manufactured homes, the majority of the population do not have freezers, second refrigerators, or even dishwashers. The majority of the household appliances are less than or equal to five years old. In general, the majority of the appliances are less than 10 years old.

Figure 47. Age of Appliances in Single-Family/Manufactured Residences

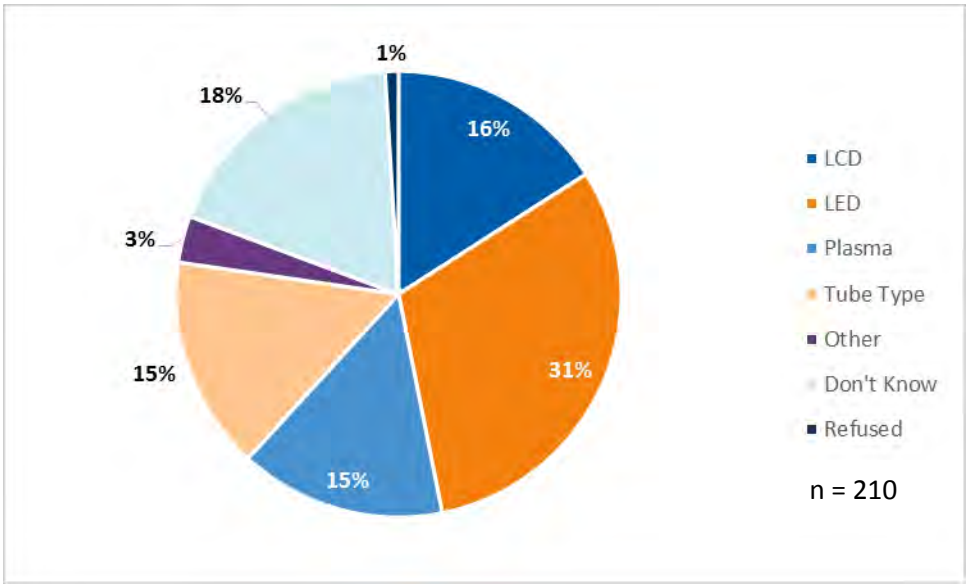


Approximately 80% of the 210 sampled households indicated having a clothes washer and dryer. Of the 168 households with a dryer, 95.24% of those dryers are electric. Of the 166 households with a clothes

washer, 79% of those washers are top loaders, 20% are front loaders, and 0.6% of the residents could not identify the type of washer. Approximately 60% of the clothes washers are less than 10 years old.

Cadmus asked participants to identify the number and type of televisions in their households. The average respondent has 2.44 televisions in their household, and 69% have at least one set-top box in their home (with an average of 1.73 across the sample population). When asked to identify their televisions' technology, 31% said LED, 16% said LCD, 15% each said plasma and tube type, 3% indicated another technology type, and 19% did not know (Figure 48).

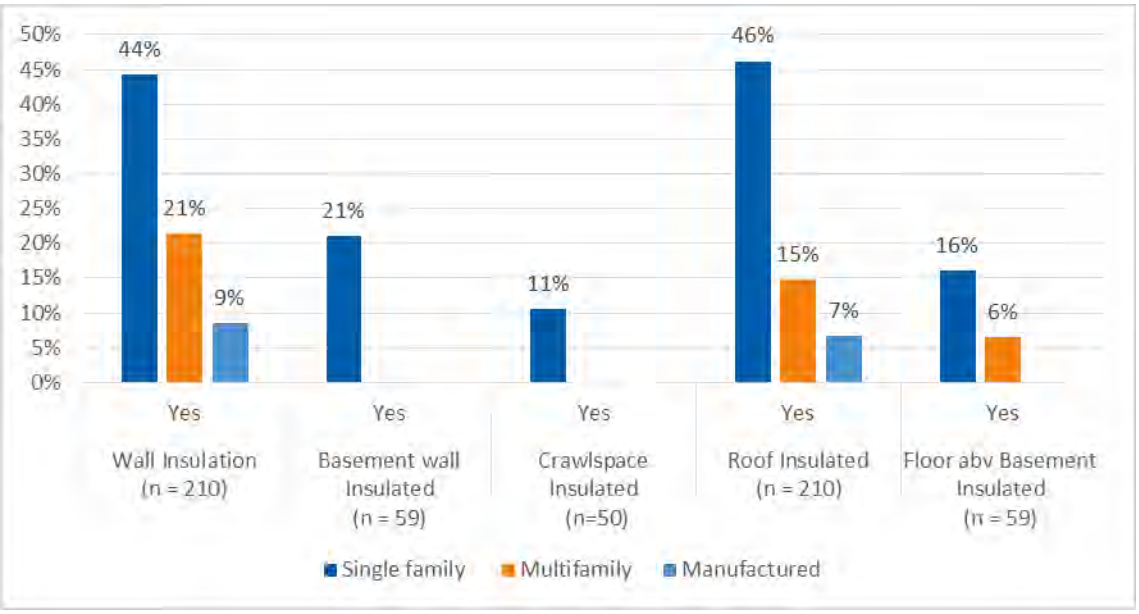
Figure 48. Distribution of Television Technology



Cadmus sought to understand the condition and age of household building envelope systems. To this end, we asked respondents how old their windows are and whether they had films. Only 12% of all respondents said their windows have films.

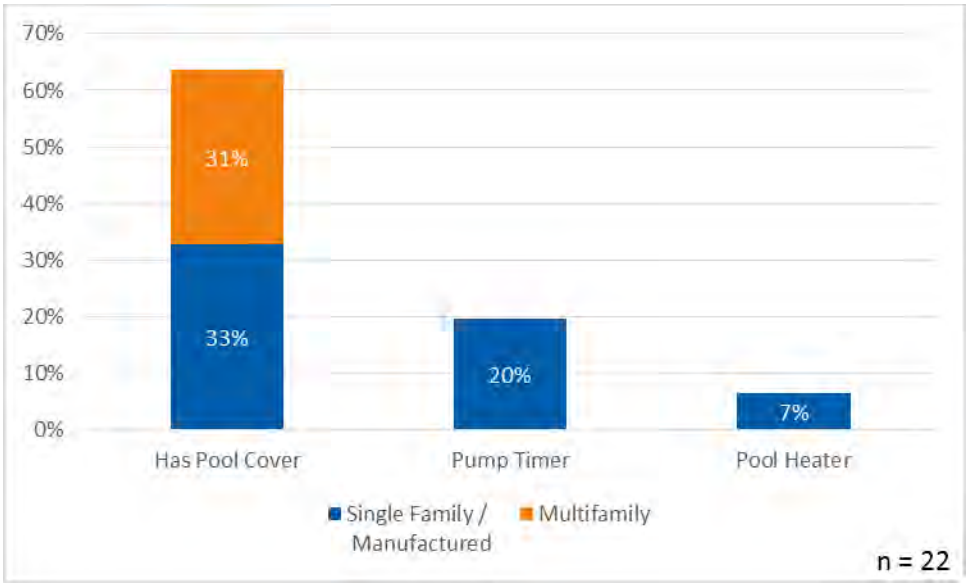
Cadmus asked residents about their knowledge of the presence of insulation in the envelope assembly. Figure 49 below shows all the multifamily homes and single-family homes that indicated the presence of insulation in various envelope components (e.g., walls, roof, floor, etc.). The "n" in each bar indicates the number of homes that had those envelope components. The value at the top of each bar identifies the percentage of home segment where the particular envelope component was insulated. For example, although the total sample size was 210, only 59 homes had basements, out of which 21% of single-family homes with basement walls indicated insulating these walls. Overall, the majority of the exterior walls and roofs in single-family homes appear to be insulated. A substantial portion of residents did not know whether their envelopes were insulated.

Figure 49. Breakdown of Residences with the Presence of Envelope Insulation



To understand how residents set up their swimming pool system, Cadmus asked whether their residence or residence complex has any swimming pools. Cadmus further asked residents who had pools to identify whether they had pool pumps, whether these pumps had timers, and whether the pools had pool covers. Thirty-six residents out of 210 indicated that they had a pool. Figure 50. Swimming Pools with Pool Cover, Pump Timer identifies the percentage of residences in each segment that indicated the presence of a swimming pool and the respective quantities of pools with pool covers, pump timers, and pool heaters.

Figure 50. Swimming Pools with Pool Cover, Pump Timer, and Pool Heater



Commercial Phone Survey Results

Cadmus and VuPoint Research conducted 200 commercial phone surveys to inform DP&L program planning and Cadmus' assessment of those programs' energy efficiency potential:[13] As summarized in this report, survey questions covered the following topics:

- Saturation of energy-consuming equipment and efficient technologies,
- Energy efficiency program awareness and perceptions,
- Factors affecting program participation, and
- Customers' willingness to adopt energy efficiency measures.

To create a list of survey customers, Cadmus developed a stratified sample spanning DP&L's five highest consuming commercial segments—office, health care, education, retail, and grocery (Table 45).

Table 45. Consumption by Segment

Segment	Consumption	
	kWh	Percentage
Office	753,659,242	21.9%
Health care	368,947,237	10.7%
Education	360,420,466	10.5%
Retail	336,810,948	9.8%
Grocery	138,494,512	4.0%
Total (five highest segments)	**1,958,332,405**	**56.90%**
Overall total (all segments)	**3,437,927,811**	**100.0%**

Sample Design and Weighting

Sample Design and Dispositions

Table 46 shows the final phone survey dispositions.

[13] The sample size(s) for individual survey questions vary because of non-response and/or non-relevance. The actual sample sizes are included in each figure and table, as needed.

Table 46. Survey Dispositions

Disposition	Total
Starting Sample	**4,396**
Bad number (e)	156
Refusal (R)	445
Incomplete (partial surveys; NC)	9
Incapable/incoherent or language barrier/non-English (NC)	4
Unknown eligibility non-interview (U)	3,582
Completed Surveys (I)	**200**
Response rate	**5.6%**
Cooperation rate	**30.4%**

The 5.6% survey response rate reflects the number of completed interviews (200) divided by the total number of potentially eligible respondents in the sample (3,582). This calculation follows the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR).[14] Cadmus used the following formulas to calculate AAPOR Response Rate 3 (RR3). RR3 includes an estimate of eligibility for these unknown sample units. (Table 46 includes the definitions of letters used in the formulas.)

$$RR3 = \frac{I}{\big((I + R + NC) + (E * U)\big)}$$

Where E is calculated using values from Table 45 above.

$$E = \frac{(I + R + NC)}{(I + R + NC + e)}$$

The 30.4% cooperation rate reflects the number of completed interviews (200) divided by the total number of eligible customers contacted (445+9+4+200). Cadmus used AAPOR Cooperation Rate 3 (COOP3), calculated as follows:

$$COOP3 = \frac{I}{(I + R + NC)}$$

Weighting

Based on the small sample sizes in the education, grocery, and health care segments, this report shows results of the office and retail segments, followed by results of all five segments combined and weighted

[14] American Association for Public Opinion Research. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys. 8th Edition*. 2015. Available online: http://www.aapor.org/AAPORKentico/Communications/AAPOR-Journals/Standard-Definitions.aspx.

across the entire commercial population. Table 47 lists the population and ratio[15] by commercial segments, along with the survey sample size and the weighting of each segment compared to the total population.

Table 47. Segmentation and Weighting by Population

Segment	Population	Ratio	Sample Size	Weighting
Office	3,730	52.54	71	0.24
Retail	3,025	38.78	78	0.18
Health Care	929	61.93	15	0.28
Education	763	36.33	21	0.16
Grocery	462	30.80	15	0.14

Building Characteristics

The average building covered in the commercial survey was approximately 34,300 square feet. Retail buildings averaged approximately 10,600 square feet, whereas offices averaged approximately 32,300 square feet (Table 48).

The combined commercial sector has an average of two buildings per facility, whereas offices average three buildings per facility and the retail segment averages one building per facility (Table 49). Offices averaged two floors tall, whereas buildings in the retail and combined commercial segments averaged one floor.

Overall, an average of 79% of the square footage of buildings in the combined commercial sector are air conditioned (Table 50).

Table 48. Average Gross Square Footage by Segment

Segment	n	Average Gross Square Footage
Retail	57	10,610
Office	49	32,302
Combined Commercial Sector	**139**	**34,319**

[15] The ratio is the population divided by the sample size. This is used for calculating the weights, which are the ratio for a segment divided by the sum of the ratios for all segments. For example, Health Care = 0.28 = 61.93/220.38. Health Care makes up 7.5% of the sample (15/200) but 10.4% of the population (929/8909) therefore the weight of 0.28 is used to better reflect the total population.

Table 49. Average Number of Buildings per Facility

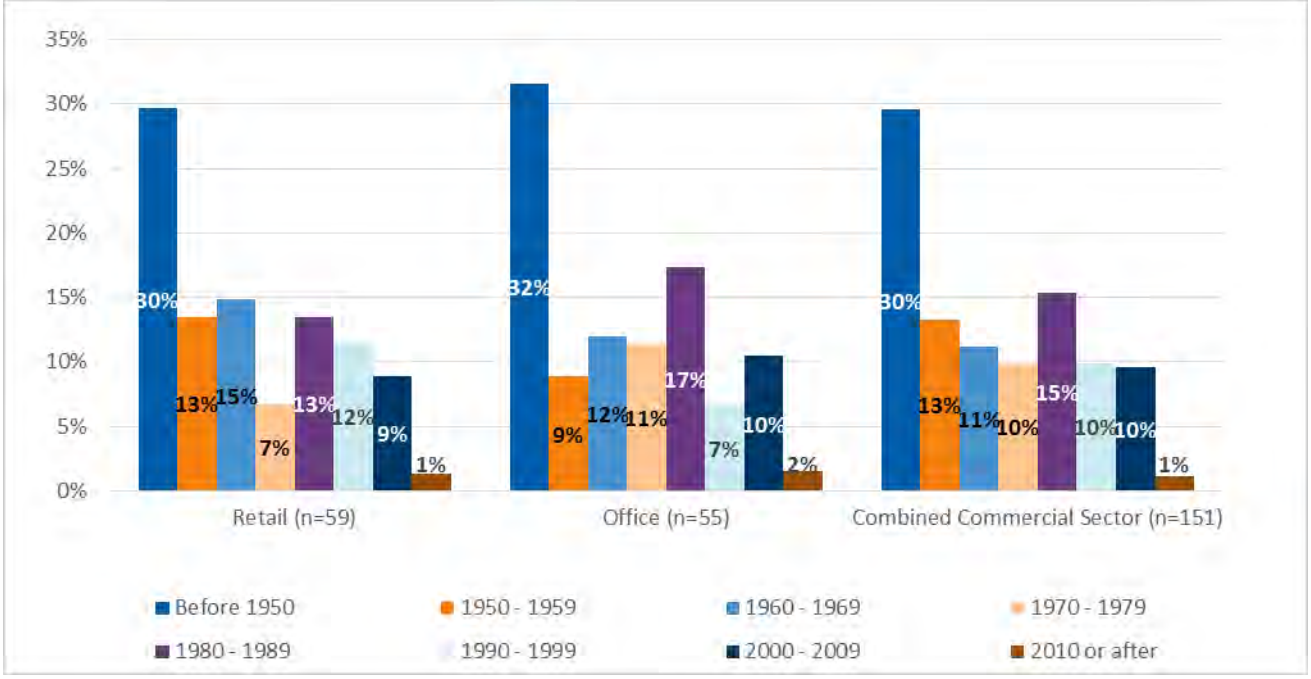
Segment	n	Average Number of Buildings
Retail	77	1
Office	69	3
Combined Commercial Sector	**197**	**2**

Table 50. Average Percentage of Air-Conditioned Square Footage

Segment	n	Average Percentage Air Conditioned
Retail	55	71%
Office	59	76%
Combined Commercial Sector	**152**	**79%**

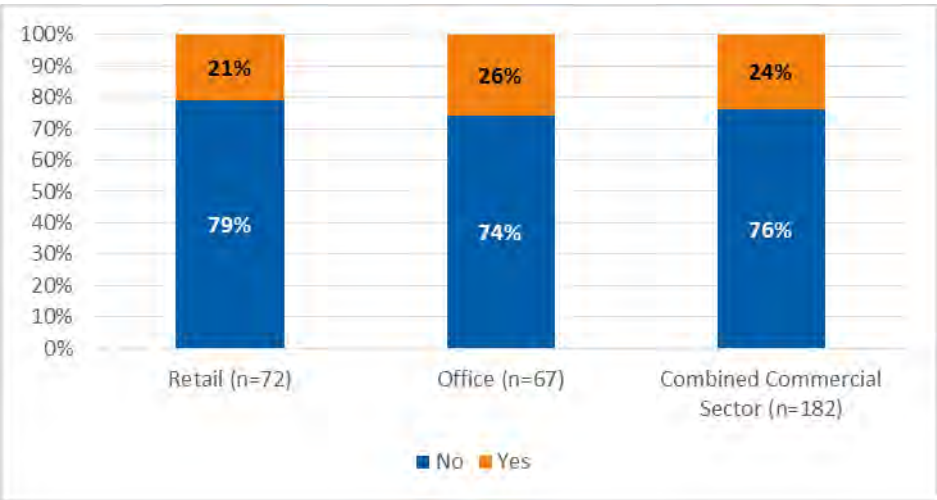
For the combined commercial sector, 30% of buildings were constructed before 1950, 13% between 1950 and 1959, 11% between 1960 and 1969, 10% between 1970 and 1979, 15% between 1980 and 1989, 10% between 1990 and 1999, 10% between 2000 and 2009, and approximately 1% were constructed in 2010 or later. The distribution of building ages is similar for the office and retail segments (Figure 51).

Figure 51. Distribution of Building Construction Vintage by Segment



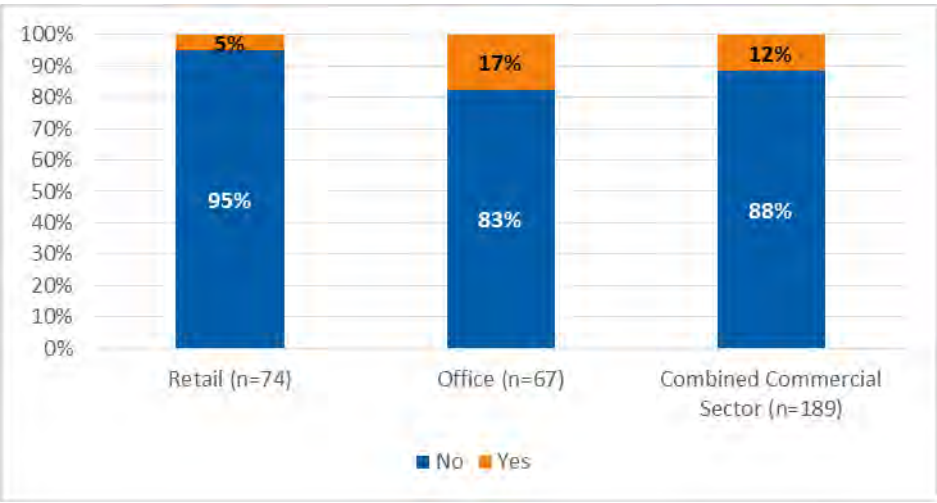
Most commercial customers have not upgraded the insulation in their building within the last five years; indeed, this was accomplished by just 24% of combined commercial sector respondents, 26% of offices, and 21% of retail segment respondents (Figure 52).

Figure 52. Insulation Installation in the Last Five Years



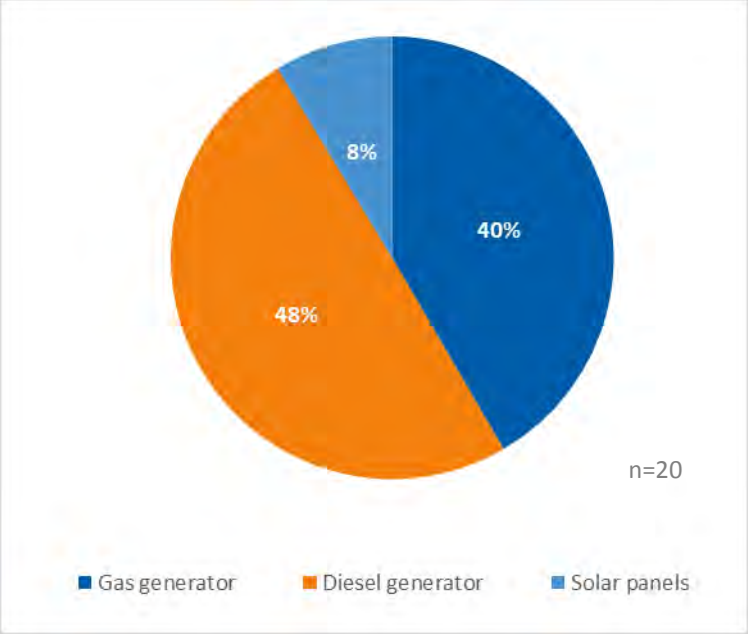
Only 4% of customers in the combined commercial sector—including 2% in the office segment and 2% in the retail segment—reported having a building commissioned within the last year. Overall, 12% of commercial customers have on-site electric generation capability, including 17% of office customers and only 5% of retail customers (Figure 53).

Figure 53. On-Site Electric Generation Capability



Of the customers who have on-site electric generation and responded to the question of on-site generation technology, 42% use a gas generator, 50% use a diesel generator, and 9% have solar panels (Figure 54).

Figure 54. Type of On-Site Generation



Overall, the commercial businesses surveyed have an average of approximately 27 employees. Businesses in the retail sector average approximately 10 employees and office facilities average roughly 26 employees (Table 51).

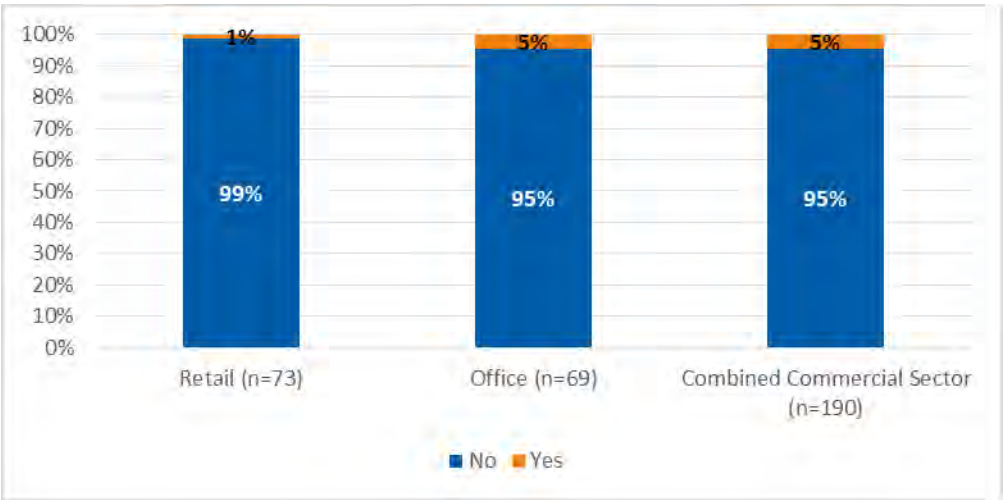
Table 51. Average Number of Employees by Segment

Segment	n	Average Number of Employees
Retail	77	9.9
Office	69	26.2
Combined Commercial Sector	**197**	**26.7**

Energy Management

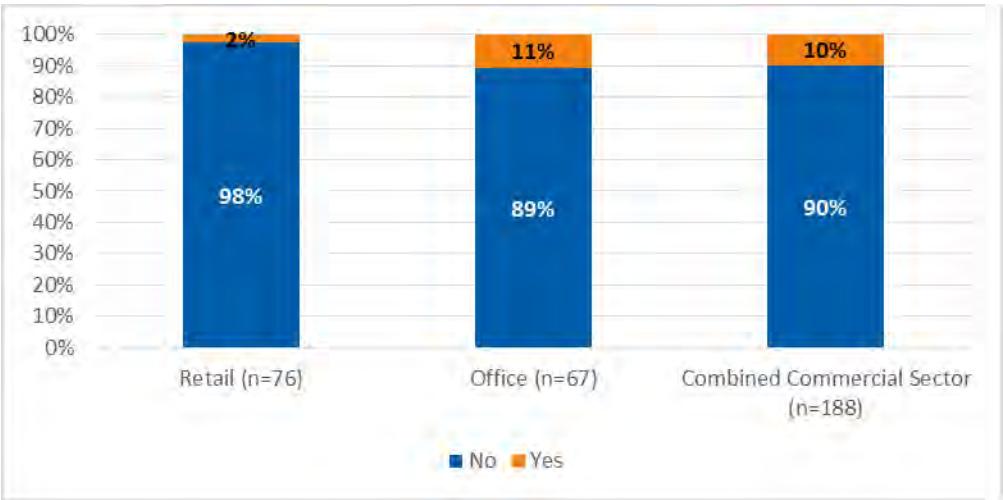
Cadmus asked commercial customers to identify the energy management characteristics of their buildings (Figure 55). As shown, 99% of retail businesses, 95% of offices, and 95% of the combined commercial sector indicated that they do not have an energy-efficient certification (such as LEED) for their building.

Figure 55. Energy Efficient Building Certifications by Segment



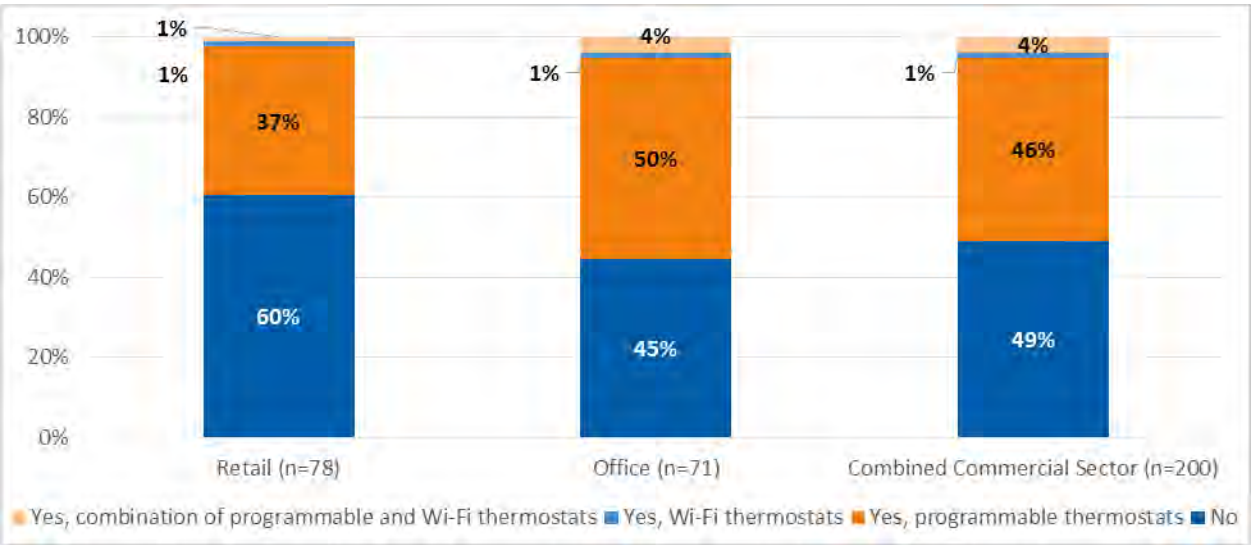
As shown in Figure 56, the majority of buildings do not have energy management system controls: 2% of retail businesses, 11% of offices, and 10% of the combined commercial sector have these controls in their facilities.

Figure 56. Buildings with Energy Management System Controls by Segment



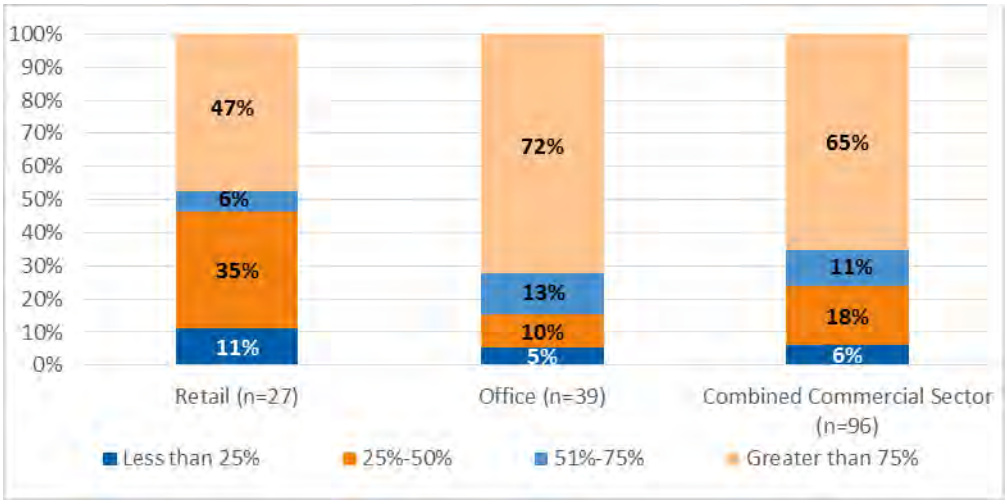
Approximately half of all buildings in the sample have some type of programmable or Wi-Fi thermostat: 60% of retail buildings, 45% of office buildings, and 49% of combined commercial sector buildings do not have a programmable or Wi-Fi thermostat. Figure 57 shows the breakdown of buildings with a programmable thermostat, Wi-Fi thermostat, or combined programmable/Wi-Fi thermostat.

Figure 57. Percentage of Programmable and Wi-Fi Thermostats by Segment



Of the combined commercial respondents who have programmable thermostats, 65% use them to heat more than 75% of their building, 11% use them to heat between 51% and 75% of their building, 18% use them to heat between 25% and 50% of their building, and 6% use them to heat less than 25% of their building. In general, offices use programmable thermostats to heat a larger percentage of floor space than retail businesses (Figure 58).

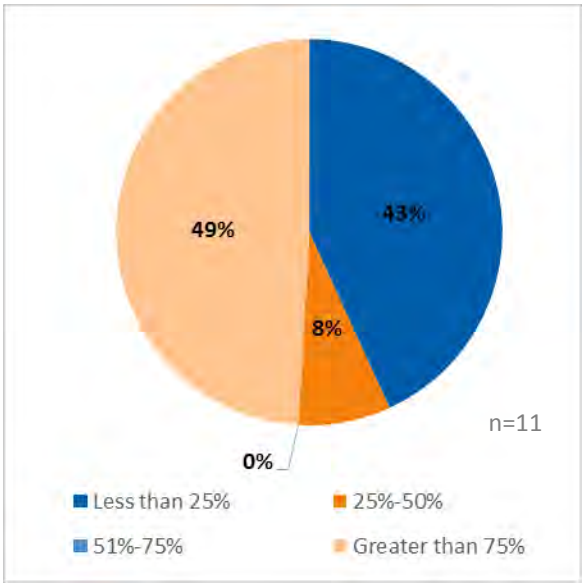
Figure 58. Building Controlled by Programmable Thermostats



The size of the subsample for Wi-Fi thermostats is too small to make meaningful comparisons between individual commercial segments; therefore, only the combined commercial sector is reported (Figure 59. Percentage of Building Controlled by Wi-Fi Thermostats for Combined Commercial Sector. As shown, 49% use a Wi-Fi thermostat to heat more than 75% of their building, none heat between 51% and 75%

of their building, 8% use one to heat between 25% and 50% of their building, and 43% use one to heat less than 25% of their building.

Figure 59. Percentage of Building Controlled by Wi-Fi Thermostats for Combined Commercial Sector

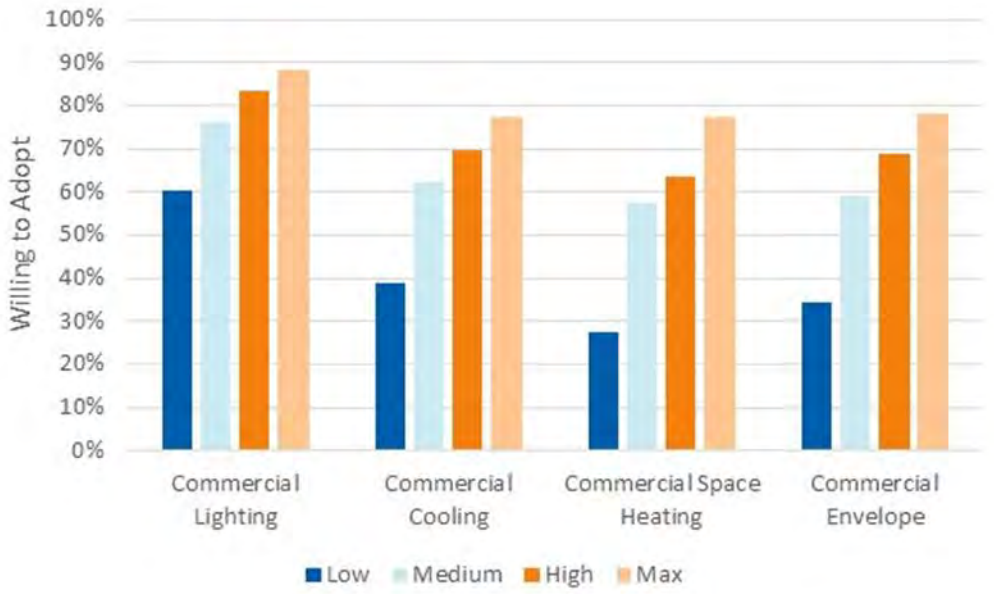


Willingness to Pay

Cadmus asked survey respondents about the likelihood that they would adopt one of four types of energy-saving improvements under four different incentive structures: 0% utility incentive, 50% utility incentive, 75% utility incentive, and 100% utility incentive. The distribution of all "very likely" and "somewhat likely" responses are shown in Figure 60.[16] In general, responses to the willingness-to-pay questions followed the law of demand: that is, the percentage of "likely" responses increased with the overall utility incentive.

[16] See the included Excel workbook (Question 9) for details of the "unlikely" responses from each willingness-to-pay question.

Figure 60. Distribution of "Likely" Willingness-to-Pay Responses for Combined Commercial Sector



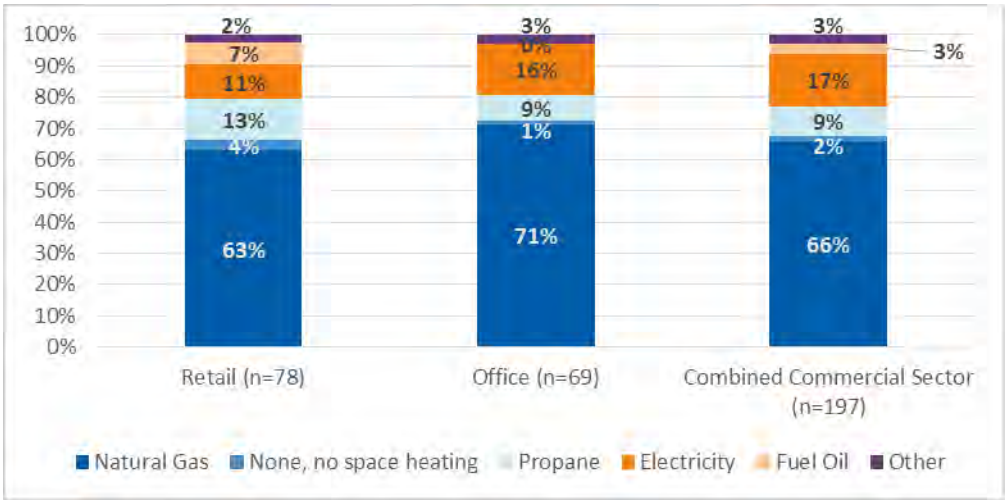
Measure Saturation Data

Cadmus asked commercial survey respondents a series of questions related to equipment and appliances in their buildings to gauge measure-level saturation. This section outlines fuel shares for various equipment and appliances as well as the appliance types within each category and a list of other metrics.

Fuel Shares

Approximately 66% of all commercial customers use natural gas as their primary fuel for heating, whereas 17% use electricity, 9% use propane, and the remaining 8% use fuel oil, another fuel type, or have no space heating. This breakdown is similar for both retail and office segments, although a higher proportion of retail customers use propane (13%) and fuel oil (7%), whereas a higher proportion of office customers use natural gas (71%; Figure 61).

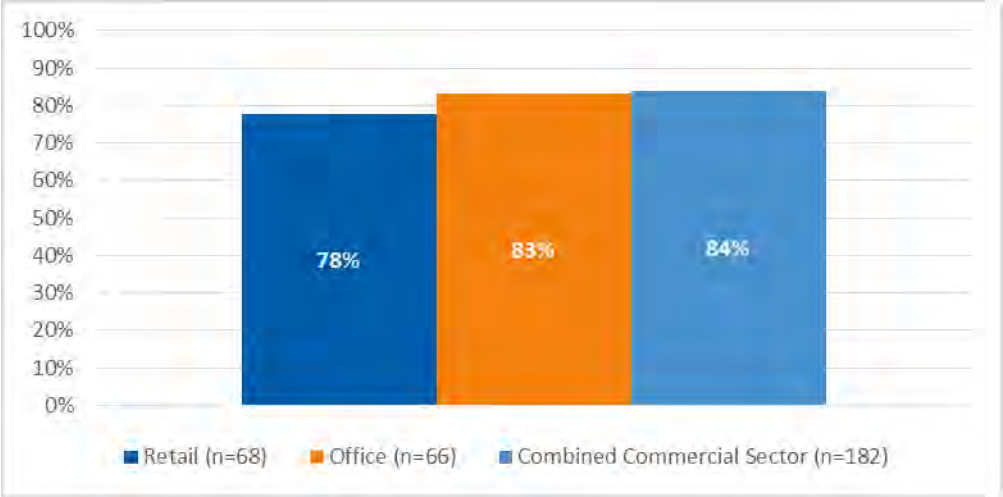
Figure 61. Distribution of Fuel Types for Primary Heating



Percentage of Floor Space Heated

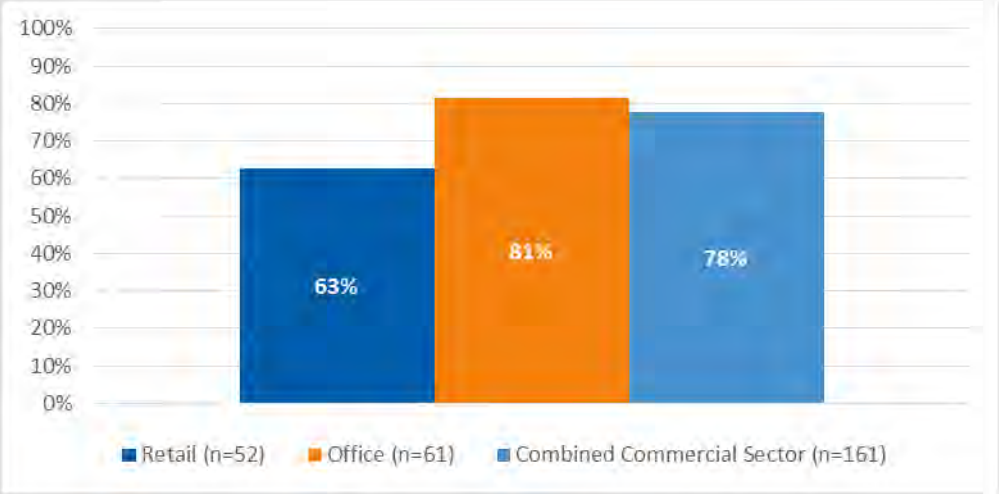
Cadmus further asked commercial customers what percentage of their total floor space is heated. On average, 84% of floor space is heated for the combined commercial sector, including 78% of retail floor space and 83% of office floor space (Figure 62).

Figure 62. Average Percentage of Floor Space Heated



We also asked commercial customers what percentage of their total floor space is cooled. On average, 78% of floor space is cooled for the combined commercial sector, including 63% of retail floor space and 81% of office floor space (Figure 63).

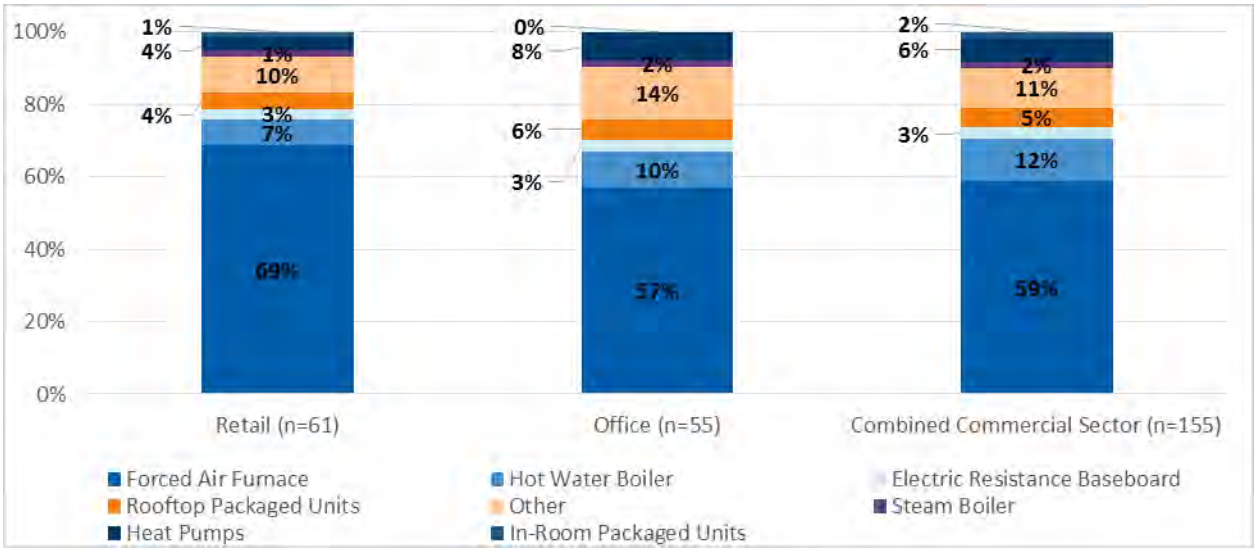
Figure 63. Average Percentage of Floor Space Cooled



Equipment Types

Of the 155 commercial customers surveyed, 59% indicated that their primary heating system was a forced air furnace, compared to 57% for offices and 69% for the retail segment. Also, 12% of the combined commercial sector, 10% of office customers, and 7% of retail customers use a hot water boiler. Approximately 11% of the overall sample, 14% of office customers, and 10% of retail customers use a system other than those mentioned in the survey and outlined in Figure 64.

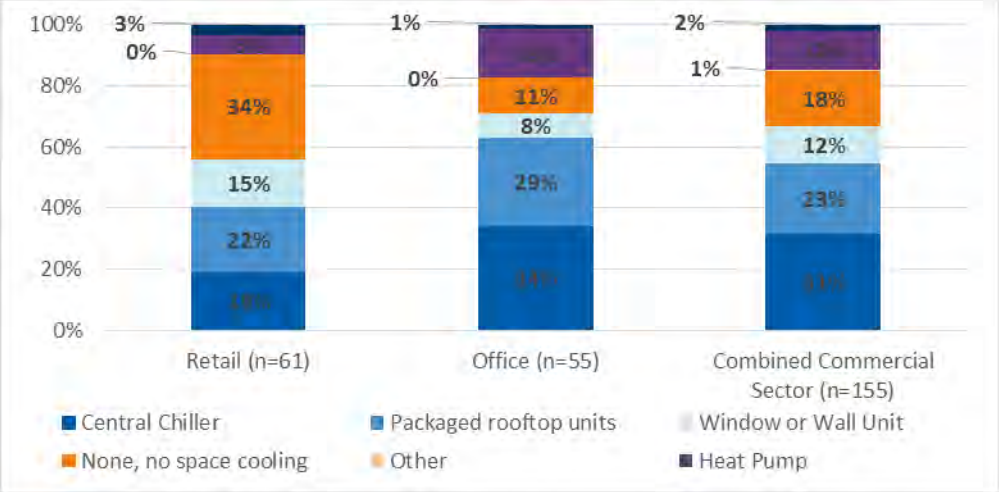
Figure 64. Main Heating System Types



Cadmus also asked commercial survey respondents about their main cooling equipment. Figure 65 shows the distribution of equipment types across the sample. Out of 155 businesses that answered the cooling question, 31% of the combined commercial sector, 34% of offices, and 19% of retail use central chillers for main cooling. Also, 23% of the combined sector, 29% of offices, and 22% of retail businesses

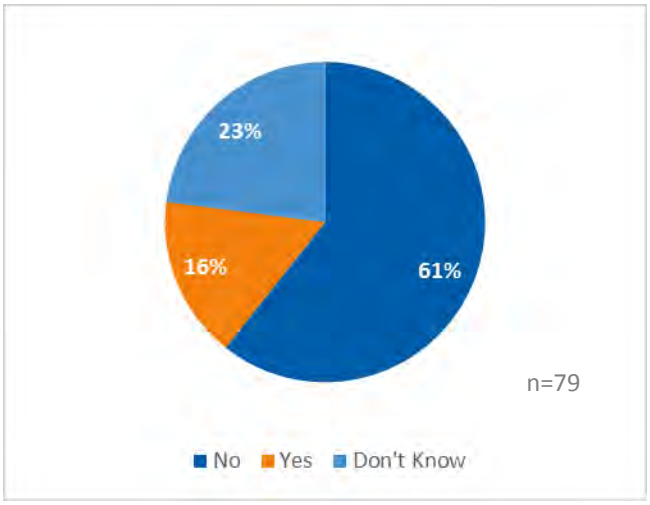
use packaged rooftop units. Window or wall units accounted for 12% of equipment in the combined commercial sector, 8% in offices, and 15% in retail locations. Heat pumps accounted for 12% of the overall total, including 16% and 6% in the office and retail segments, respectively.

Figure 65. Main Cooling Equipment Types



Seventy-nine commercial customers answered the question of whether their cooling systems use an economizer or free cooling. As a result, the sample sizes for each segment are too small for meaningful comparisons and results are reported in aggregate. In the combined commercial sector, 16% of respondents have either an economizer or free cooling, 23% do not, and 61% do not know (Figure 66).

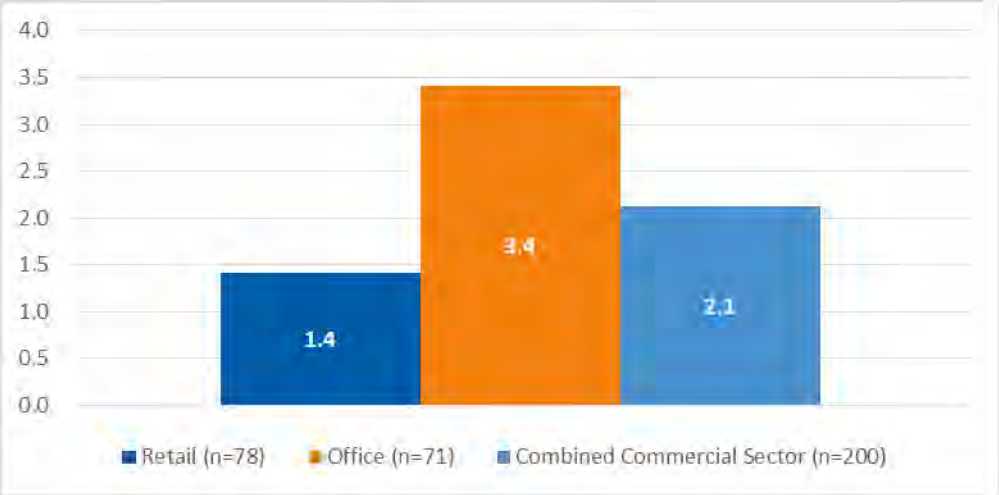
Figure 66. Distribution of Economizers or Free Cooling in Combined Commercial Sector



Cadmus asked commercial respondents a series of questions about the water heaters used in their facilities. Their responses are detailed in Figure 67 through Figure 69 and Figure 73.

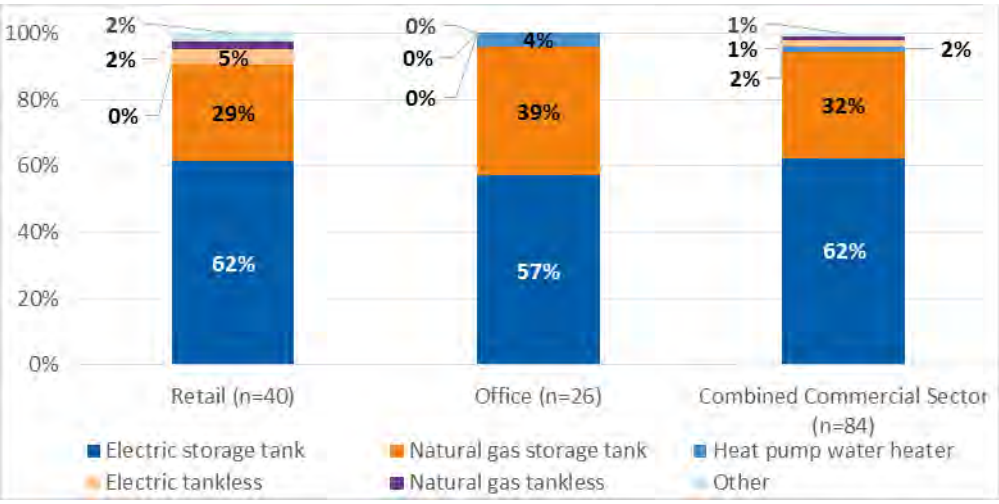
Figure 67 shows that the average facility in the combined commercial sector has 2.1 water heaters, with an average of 3.4 in offices and 1.4 in retail businesses.

Figure 67. Average Number of Water Heaters by Commercial Segment



The majority (62%) of commercial customers in the combined commercial sector use electric storage tank water heaters, compared to 57% for offices and 62% for retail customers. Natural gas storage tank water heaters account for the second largest share, comprising 32% of all water heaters in the combined commercial sector, 39% for offices, and 29% for retail customers. "Heat pump," "tankless", and "other" account for the remaining 6% of water heaters in the combined commercial sector, including 4% for offices and 9% for the retail segment (Figure 68).

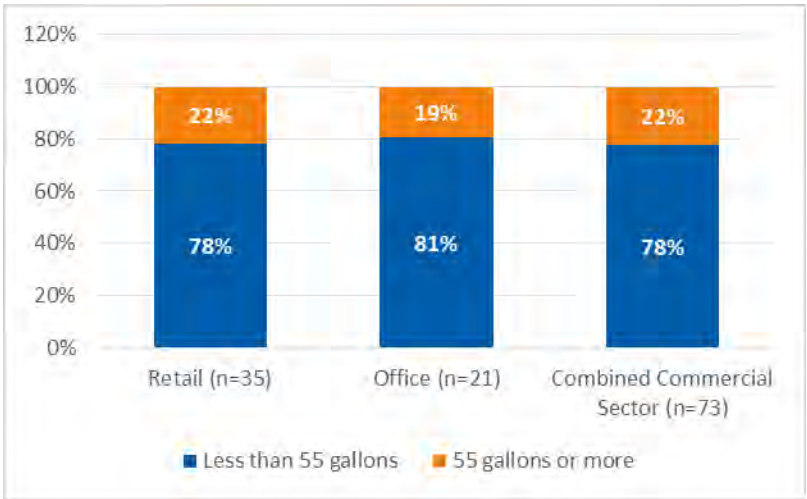
Figure 68. Distribution of Water Heaters by Segment



Respondents also provided information regarding the size of their water heaters. The distributions for the combined commercial sector and retail segment were the same, with 78% of hot water heaters having a capacity of less than 55 gallons and 22% having a capacity of 55 gallons or more. For offices,

81% of water heaters have a capacity under 55 gallons and 19% have capacity of 55 gallons or more (Figure 69).

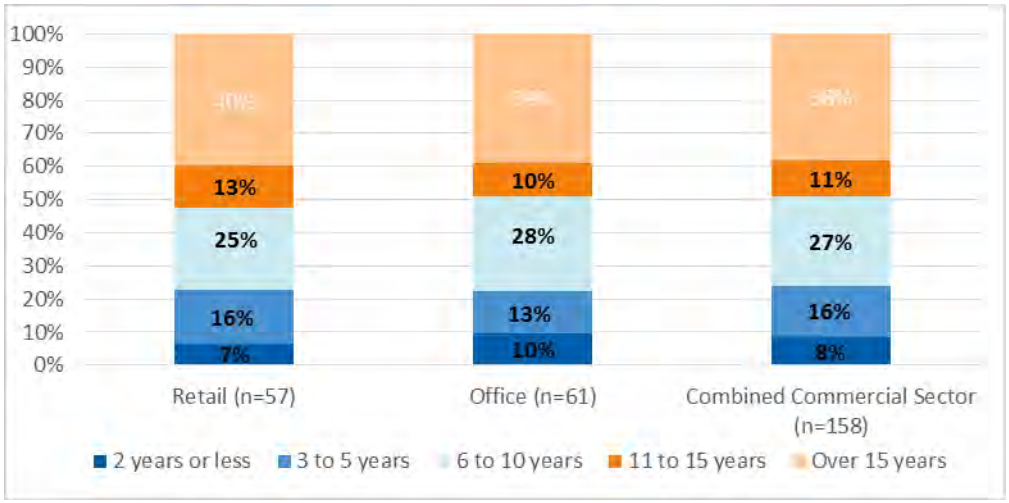
Figure 69. Water Heater Tank Size by Segment



Equipment Age

Approximately 38% of all commercial customers surveyed have main heating equipment that is over 15 years old, while 11% have heating equipment between 11 and 15 years old, 27% have equipment between six and 10 years, 16% have equipment between three and five years, and 8% have equipment that is two years or less. The distributions for office and retail are similar to that of the combined commercial sector (Figure 70).

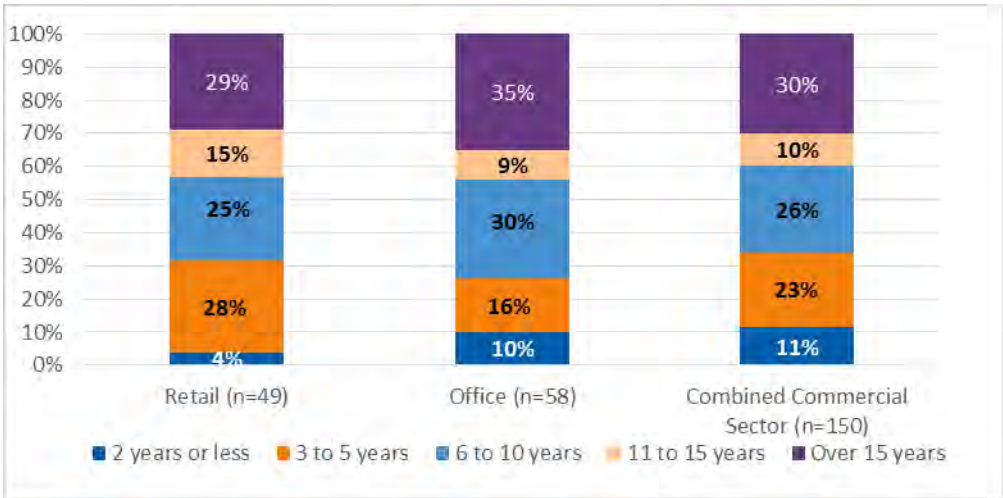
Figure 70. Age of Main Heating Equipment



Approximately 30% of all commercial customers surveyed have main cooling equipment that is over 15 years old, while 10% have cooling equipment between 11 and 15 years of age, 26% have equipment

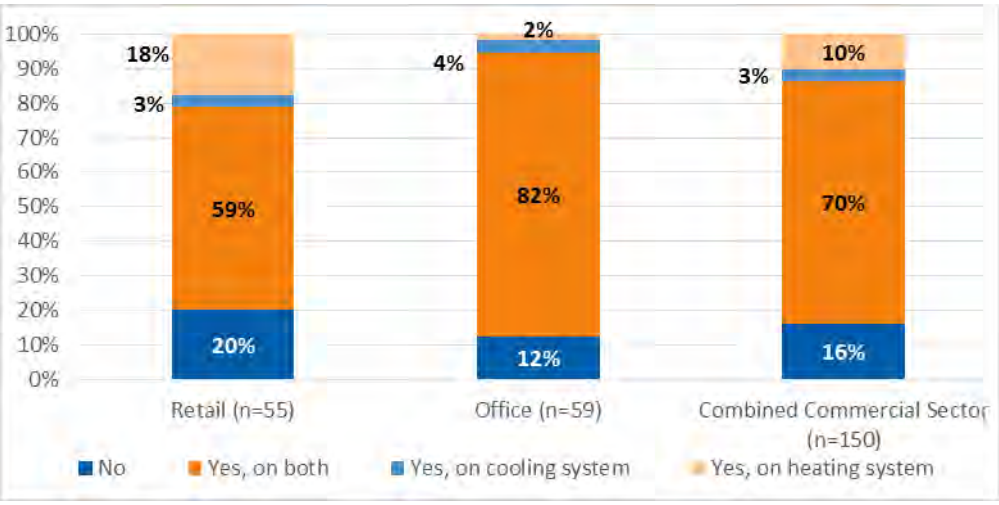
between six and 10 years, 23% have equipment between three and five years, and 11% have equipment that is two years or less. The distributions for office and retail are similar to that of the combined commercial sector (see Figure 71).

Figure 71. Age of Main Cooling Equipment



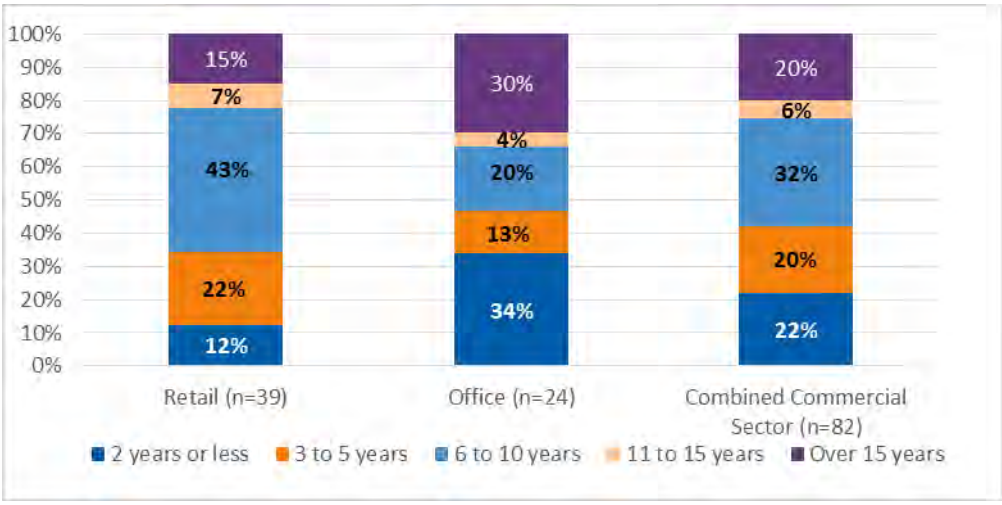
Cadmus asked 150 commercial business respondents if they had performed maintenance on their heating or cooling system in the last year (the distribution of responses is shown in Figure 72). Approximately 70% of the combined commercial sector, 82% of offices, and 59% of retail businesses had conducted maintenance on both systems within the last year. Sixteen percent of the combined commercial sector, 12% of offices, and 20% of retail businesses had not conducted maintenance on either system in the last year. Ten percent of all businesses, 2% of offices, and 18% of retail businesses had performed maintenance only on their heating system within the last year.

Figure 72. Distribution of Heating and Cooling Maintenance in Last Year



Cadmus asked all commercial customers with water heaters to provide the age of that equipment. Approximately 20% of all commercial customers have main heating equipment that is over 15 years old, while 6% have heating equipment between 11 and 15 years of age, 32% have equipment between six and 10 years old, 20% have equipment between three and five years old, and 22% have equipment that is two years old or less. See Figure 73 for details about office and retail segment customers.

Figure 73. Age of Water Heating Equipment

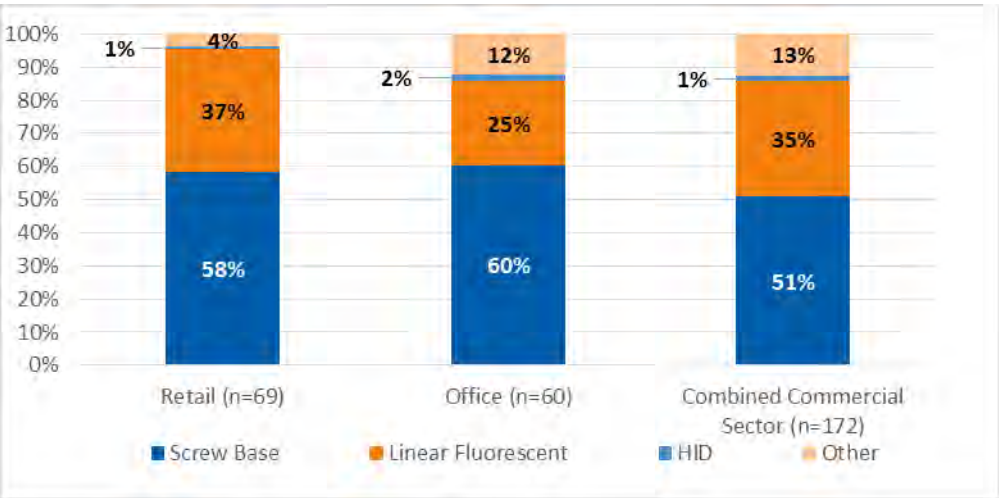


Lighting

Cadmus asked commercial customers about the mix of lighting used in their facilities. The distributions of their responses are reflected in Figure 74 through Figure 76.

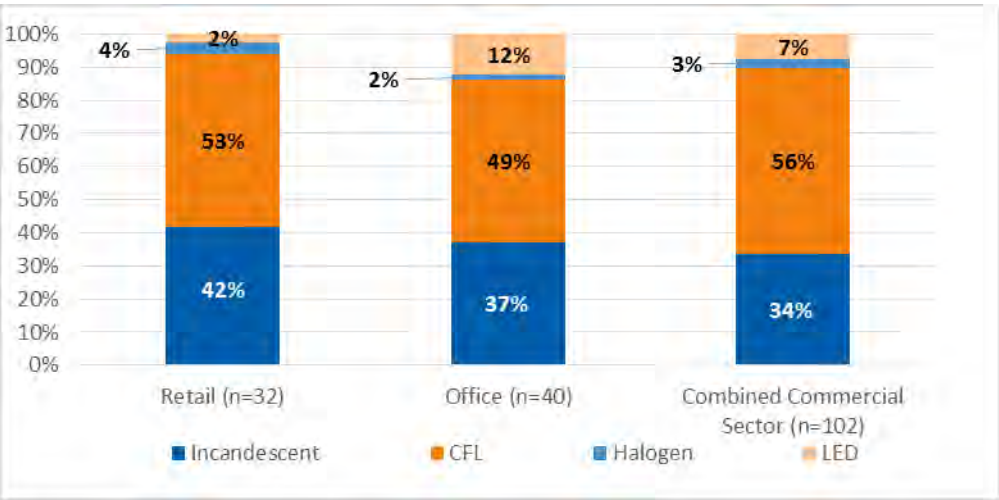
Screw-base fixtures account for 51% of all fixtures in the combined commercial sector, 60% of fixtures in offices, and 58% of fixtures in the retail segment (Figure 74). Linear fluorescent fixtures comprise 35% of fixtures in the combined commercial sector, including 25% for offices and 37% for retail customers. High-intensity discharge fixtures account for 1% of fixtures in the combined commercial sector, 2% of fixtures in offices, and 1% of fixtures in retail facilities. The remaining 13%, 12%, and 4% of fixtures in the combined commercial, office, and retail sectors, respectively, are other than those described above.

Figure 74. Distribution of Lighting Fixture Types by Segment



Of the screw-base fixtures detailed in Figure 74, incandescents account for 34% of all lamps in the combined commercial sector, including 37% in offices and 42% in the retail segment (Figure 75). CFLs comprise 56% of lamps for the combined commercial sector, 49% for offices, and 53% for retail. Halogens account for 3% of lamps in the combined commercial sector, 2% in offices, and 4% in retail facilities. LEDs make up the remaining 7%, 12%, and 2% of lamps in screw-base fixtures in the combined commercial, office, and retail sectors, respectively.

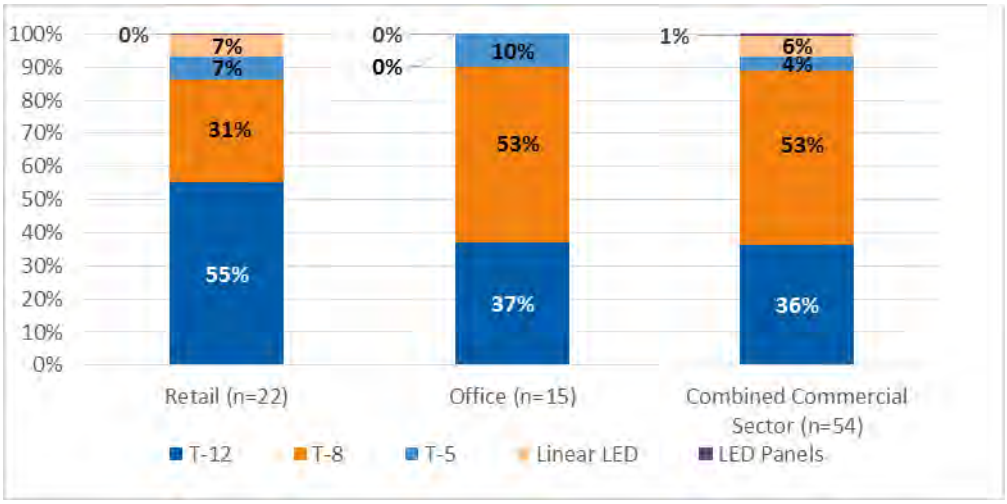
Figure 75. Distribution of Lamp Types in Screw-Base Fixtures



Of the linear fixtures detailed in Figure 74, T-12s account for 36% of all lamps in the combined commercial sector, 37% in offices, and 55% in the retail segment. T-8s comprise 53% of lamps in the combined commercial sector, 53% in offices, and 31% for retail customers. T-5s account for 4% of lamps in the combined commercial sector, 10% in offices, and 7% in retail facilities. Linear LEDs make up 6%, 0%, and 7% of lamps in linear fixtures in the combined commercial, office, and retail sectors,

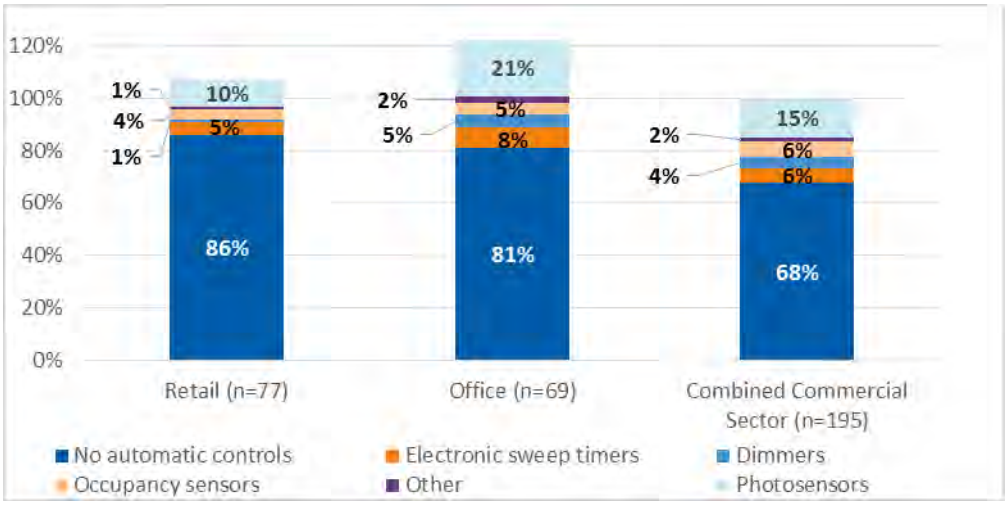
respectively, while LED panels account for 1% of lamps in linear fixtures in the combined commercial sector and 0% in both the office and retail segments (Figure 76).

Figure 76. Distribution of Lamp Types in Linear Fixtures by Segment



Commercial survey respondents shared the distribution of lighting controls in their buildings: 68% of the combined commercial sector, 81% of offices, and 86% of retail facilities use standard light switches that have no automatic lighting controls. As shown in Figure 77, 15% of the combined commercial sector, 21% of offices, and 10% of retail facilities use photosensors; 6% of the combined commercial sector, 8% of offices, and 5% of retail use electronic sweep timers; 6% of the combined commercial sector, 5% of offices, and 4% of retail use occupancy sensors; and 4% of the combined commercial sector, 5% of offices, and 1% of retail customers use dimmers. Finally, 2%, 2%, and 1% for the combined commercial sector, office, and retail, respectively, use other lighting controls not listed here.

Figure 77. Distribution of Lighting Controls by Segment*



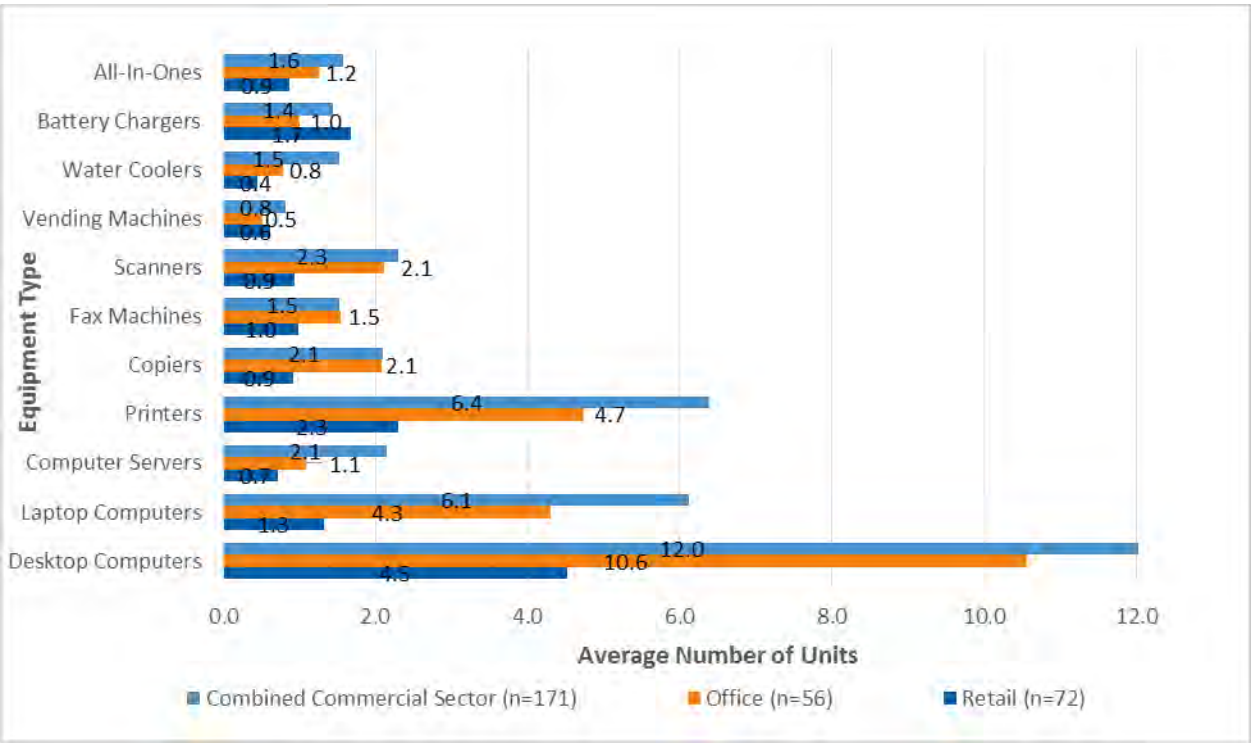
* Multiple responses allowed; therefore, responses may sum to greater than 100%.

Plug Load

Cadmus asked commercial survey respondents for information on the numbers of units of equipment that do not fall into any of the end-use categories described above. This equipment includes, but is not limited to, computers, servers, vending machines, water coolers, printers, and other office equipment, as listed in Figure 78.

On average, retail customers have fewer of each of these types of equipment than office customers, who, in turn, tend to have fewer than the average for all commercial customers. Note that the combined commercial sector data includes the education segment, which, on average, has larger amounts of computer equipment.

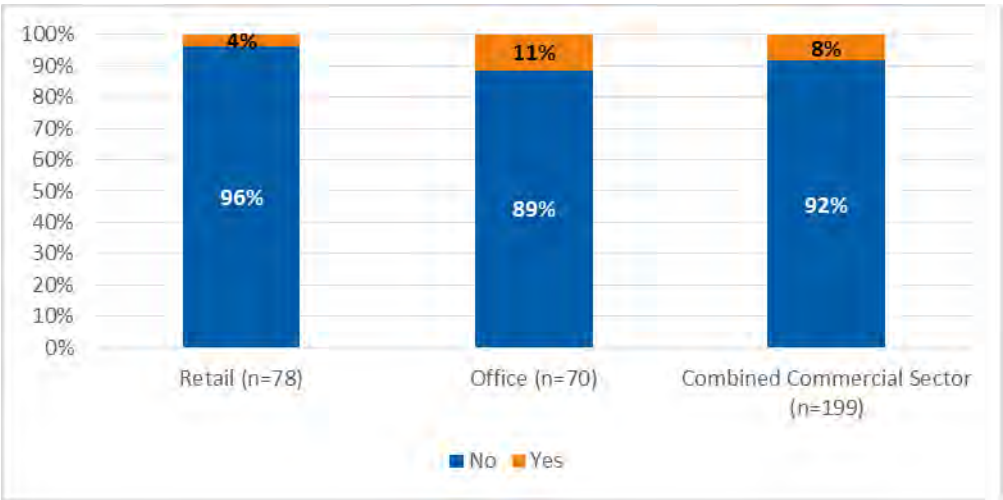
Figure 78. Average Number of Units for Plug Load Equipment by Segment



Dishwashers and Clothes Washers

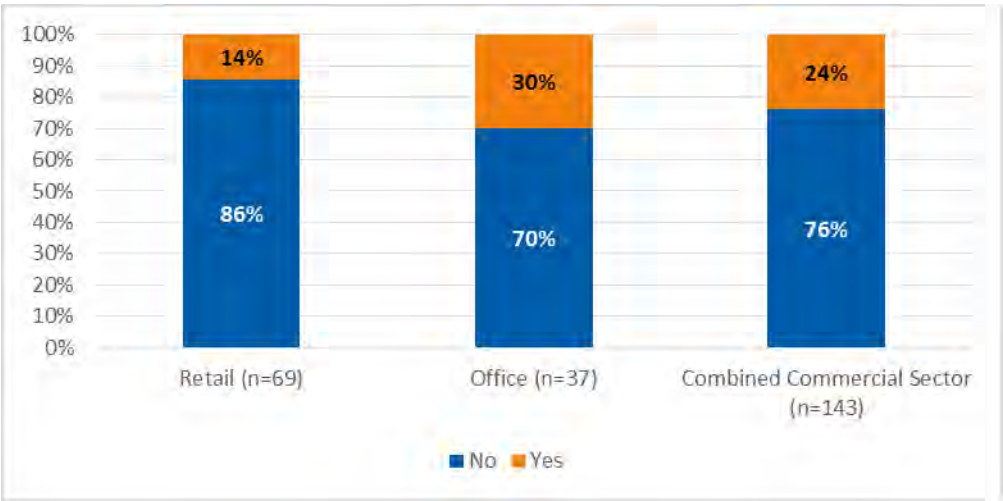
Some of the surveyed customers (8% of the combined commercial sector, 11% of offices, and 4% of retail customers) reported having a residential dishwasher(s) in their facility (Figure 79).

Figure 79. Distribution of Residential Dishwashers by Segment



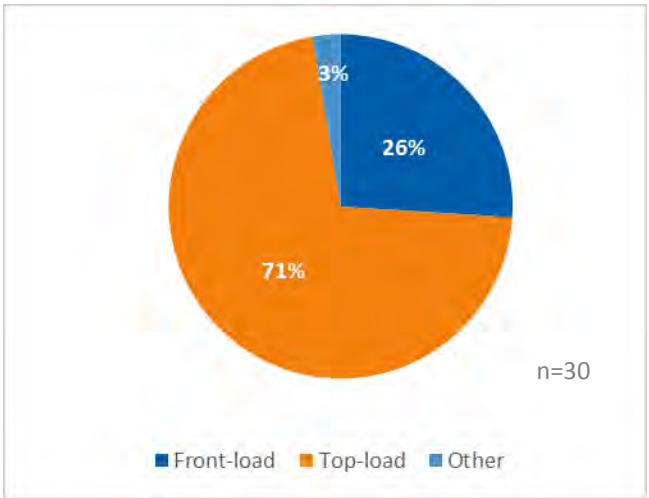
In addition, 24% of the combined commercial sector, 30% of offices, and 14% of retail customers reported using either a commercial or residential clothes washer (Figure 80).

Figure 80. Distribution of Clothes Washers by Segment



Of the commercial customers with a clothes washer, 30 were able to identify the type: 26% of combined commercial respondents have a front-loading machine, 71% have a top-loading machine, and 3% have a machine other than those listed (Figure 81).

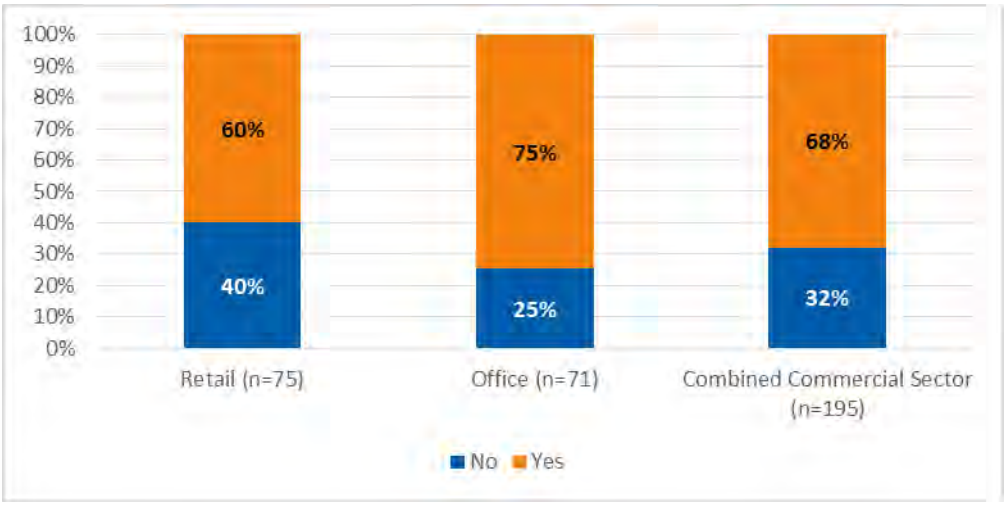
Figure 81. Distribution of Clothes Washer Type for Combined Commercial Sector



Program Awareness and Perception

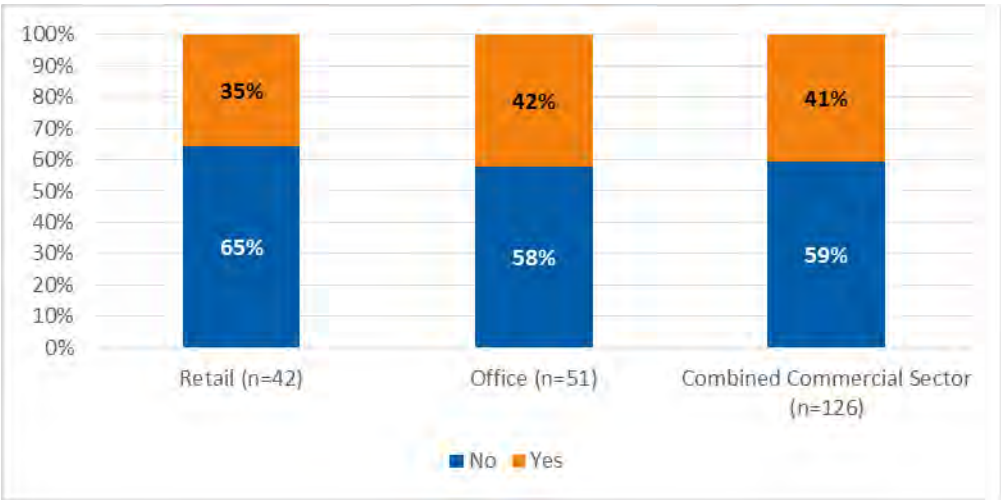
When asked about their awareness of DP&L programs or rebates that help customers reduce their energy consumption and save money on their energy bills, respondents revealed some differences between commercial segments. Sixty-eight percent of the combined commercial sector, 75% of offices, and 60% of retail customers were aware of DP&L programs (Figure 82). Of the 130 total commercial customers aware of DP&L programs, 64% had a positive perception, 35% were neutral, and less than 1% had a negative perception.

Figure 82. Awareness of DP&L Programs and Rebates



Finally, Cadmus asked commercial customers if they had seen or heard DP&L advertisements for commercial energy-saving programs: 41% of all commercial customers, 42% of offices, and 35% of retail customers had seen or heard the advertisements (Figure 83).

Figure 83. DP&L Commercial Ad Awareness



Summary: Application of The Dayton Power and Light Company for Approval of Its Energy Efficiency and Peak Reduction Program Portfolio Plan for 2018 through 2020 electronically filed by Mr. Tyler A. Teuscher on behalf of The Dayton Power and Light Company