CADMUS

# 2018 Vectren Demand-Side Management Portfolio Process and Electric Impacts Evaluation

May 30, 2019

**Prepared for:**

Vectren Energy Delivery of Indiana
1 Vectren Square
Evansville, Indiana

# Table of Contents

# Figures

## Tables

# Acronyms

| Acronym | Definition |
|---|---|
| AFUE | Annual fuel utilization efficiency |
| AHRI | Air Conditioning, Heating, & Refrigeration Institute |
| ANSI | American National Standards Institute |
| AIC | Akaike information criteria |
| AMI | Advanced metering infrastructure |
| ANSI | American National Standards Institute |
| ARP | Appliance Recycling Program |
| ASHP | Air-source heat pump |
| BTUH | British thermal units per hour |
| C&I | Commercial and industrial |
| CAC | Central air conditioner |
| CAPE | Community Action Program of Evansville |
| CDD | Cooling degree days |
| CF | Coincidence factor |
| CFL | Compact fluorescent lamp |
| CFM | Cubic feet per minute |
| CLSD | Calibrated DSMore Load-Shape Differences |
| COP | Coefficient of precision |
| CVR | Conservation Voltage Reduction |
| DEM | Demand elasticity modeling |
| DHP | Ductless heat pump |
| DHW | Domestic hot water |
| D-in-D | Difference in differences |
| DK/RF | Don't know/refused |
| DOE | U.S. Department of Energy |
| DSM | Demand-side management |
| ECM | Electronically commutated motor |
| EER | Energy efficiency ratio |
| EF | Efficiency factor |
| EFLH | Effective full-load hours |
| eHER | Electronic home energy report |
| EISA | Energy Security and Independence Act of 2007 |
| EPA | U.S. Environmental Protection Agency |
| ESF | Energy saving factor |
| EUI | Energy use intensity |
| FLH | Full load hours |
| HDD | Heating degree days |
| HEA Program | Home Energy Assessments Program |
| HERS | Home Energy Rating System |

| Acronym | Definition |
|---|---|
| HID | High-intensity discharge |
| HOU | Hours of use |
| hp | Horsepower |
| HSPF | Heating seasonal performance factor |
| IPLV | Integrated part load value |
| IQW Program | Income Qualified Weatherization Program |
| ISR | In-service rate |
| kBtu | Kilowatt per British thermal unit |
| KPI | Key performance indicator |
| kSF | Thousand square feet |
| kW | Kilowatt |
| kWh | Kilowatt per hour |
| LED | Light-emitting diode |
| LPD | Lighting power density |
| MMBtu | One million British thermal units |
| NEF | National Energy Foundation |
| NPSO | Nonparticipant spillover |
| NTG | Net to gross |
| OLS | Ordinary least square |
| RBS Program | Residential Behavioral Savings Program |
| RECS | Residential Energy Consumption Survey |
| RESNET | Residential Energy Services Network |
| RNC | Residential New Construction |
| SEER | Seasonal energy efficiency ratio |
| SKU | Stock keeping unit |
| TE | Thermal efficiency |
| TMY3 | Typical meteorological year 3 |
| TRM | Technical reference manual |
| UEC | Unit energy consumption |
| UMP | Uniform Methods Project |
| V | Volt |
| VFD | Variable frequency drive |
| VIF | Variance inflation factor |
| WHF | Waste heat factor |

# Executive Summary

Vectren Energy Delivery of Indiana's demand-side management (DSM) portfolio contains 17 programs, 15 of which contribute electric energy savings and demand reductions to the portfolio,[1] that Vectren administers in conjunction with several third-party implementers. The programs serve the residential, multifamily, commercial, and industrial sectors.

This report provides the results of Cadmus' assessment of Vectren's 2018 DSM electric portfolio.[2] It presents the key evaluation findings related to program operations, performance, electric and demand impacts, and market effects.

The DSM portfolio affected more than 80,000 residential and 500 commercial and industrial customers. Cadmus interviewed more than 1,200 participant customers, trade allies, and program staff about program performance. Cadmus also measured and verified the electric and demand impacts for each program.

## *Portfolio-Level Impacts*

Table 1 and Table 2 present the electric savings and demand reduction achieved by the 2018 Vectren DSM Portfolio.[3] Overall, the portfolio achieved 43,753,106 kWh of evaluated, net electric savings and 8,049 kW evaluated, net demand reduction.

1 The Targeted Income and Multifamily Direct Install programs are gas only.

2 Natural gas impacts are reported separately in the *2018 Vectren Demand-Side Management Portfolio Natural Gas Impacts Evaluation.*

3 Reported electric and demand savings are derived from the 2018 DSM scorecard.

**Table 1. 2018 Vectren DSM Program Portfolio Electric Savings**

| Program | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rate (kWh) | NTG Ratio | Evaluated Net Savings (kWh) | Net Savings Goal (kWh) | Percent Net Savings Goal Achieved |
|---|---|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | | | |
| **Residential Programs** | | | | | | | | | |
| Residential Prescriptive | 3,127,784 | 3,127,784 | 3,105,646 | 3,326,588 | 106% | 68% | 2,277,461 | 1,679,673 | 136% |
| Residential New Construction | 317,480 | 317,480 | 317,480 | 162,407 | 51% | 54% | 87,700 | 112,714 | 78% |
| Home Energy Assessment 2.0 | 290,521 | 290,521 | 284,509 | 341,133 | 117% | 75% | 256,938 | 207,996 | 124% |
| Income Qualified Weatherization | 856,620 | 856,867 | 824,312 | 931,314 | 109% | 100% | 931,314 | 639,780 | 146% |
| Online Home Energy Audit | N/A | N/A | N/A | 2,022,364 | N/A | N/A | 2,022,364 | N/A | N/A |
| Energy Efficient Schools | 1,059,801 | 844,504 | 683,972 | 712,638 | 67% | 100% | 712,638 | 1,059,360 | 67% |
| Residential Behavioral Savings | 7,212,935 | 7,212,935 | 7,212,935 | 7,063,475 | 98% | N/A | 7,063,475 | 7,526,777 | 94% |
| Residential Lighting | 8,302,409 | 8,270,806 | 7,758,400 | 8,136,654 | 98% | 58% | 4,706,664 | 6,609,545 | 71% |
| Appliance Recycling | 1,239,491 | 1,239,491 | 1,239,491 | 1,326,520 | 107% | 67% | 891,359 | 808,107 | 110% |
| Food Bank LED Distribution | 1,495,959 | 1,495,959 | 926,257 | 921,588 | 62% | 100% | 921,588 | 1,495,959 | 62% |
| Smart Cycle (Smart Thermostats)[1] | 193,050 | 206,514 | 206,514 | 379,779 | 197% | 100% | 379,779 | 198,000 | 192% |
| **Commercial and Industrial Programs** | | | | | | | | | |
| C&I Prescriptive | 19,401,443 | 19,401,443 | 19,401,443 | 18,605,544 | 96% | 84% | 15,628,657 | 6,560,000 | 238% |
| C&I Custom | 2,735,821 | 2,735,821 | 2,735,821 | 2,512,038 | 92% | 85% | 2,135,232 | 5,175,000 | 41% |
| C&I Small Business Direct Install | 3,817,158 | 3,817,158 | 3,817,158 | 3,813,515 | 100% | 101% | 3,837,960 | 847,000 | 453% |
| **Cross-Sector Program** | | | | | | | | | |
| Conservation Voltage Reduction | N/A | N/A | N/A | 887,414 | N/A | 100% | 887,414 | N/A | N/A |
| **Total** | **50,050,471** | **49,817,282** | **48,513,937** | **51,142,971** | **102%** | **84%** | **42,740,542** | **32,919,912** | **130%** |
| Nonparticipant Spillover[2] | N/A | N/A | N/A | N/A | N/A | 105% | 1,012,564 | N/A | N/A |
| **Total Adjusted Portfolio** | **50,050,471** | **49,817,282** | **48,513,937** | **51,142,971** | **102%** | **86%** | **43,753,106** | **32,919,912** | **133%** |

[1] The Smart Cycle Program is a demand response program. This report includes year-round energy and demand impacts from the smart thermostats installed as part of the Smart Cycle Program. Energy and demand impacts resulting from the program's load control events are reported separately in the *Smart Cycle Program 2018 Evaluation Report*. Details regarding the Smart Cycle energy savings can be found in Appendix A. Impact Evaluation Methodology.

[2] Cadmus calculated nonparticipant spillover as part of the 2017 portfolio evaluation.

**Table 2. 2018 Vectren DSM Program Portfolio Demand Reduction**

| Program | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rate (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) | Net Savings Goal (Coincident Peak kW) | Percent Net Savings Goal Achieved |
|---|---|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | | | |
| **Residential Programs** | | | | | | | | | |
| Residential Prescriptive | 1,570 | 1,724 | 1,719 | 1,667 | 106% | 66% | 1,098 | 849 | 129% |
| Residential New Construction | 204 | 190 | 190 | 62 | 31% | 54% | 34 | 72 | 47% |
| Home Energy Assessment (HEA 2.0) | 23 | 23 | 22 | 31 | 133% | 74% | 23 | 23 | 99% |
| Income Qualified Weatherization | 451 | 94 | 90 | 100 | 22% | 100% | 100 | 200 | 50% |
| Online Home Energy Audit | N/A | N/A | N/A | 567 | N/A | N/A | 567 | N/A | N/A |
| Energy Efficient Schools | 106 | 106 | 77 | 76 | 72% | 100% | 76 | 106 | 72% |
| Residential Behavioral Savings | 1,481 | 1,481 | 1,481 | 1,839 | 124% | N/A | 1,839 | 1,481 | 124% |
| Residential Lighting | 1,019 | 992 | 933 | 1,121 | 110% | 58% | 649 | 805 | 81% |
| Appliance Recycling | 158 | 158 | 158 | 169 | 107% | 67% | 114 | 104 | 110% |
| Food Bank LED Distribution | 206 | 206 | 128 | 127 | 62% | 100% | 127 | 206 | 62% |
| Smart Cycle (Smart Thermostats)[1] | N/A | N/A | N/A | 0 | N/A | N/A | 0 | N/A | N/A |
| **Commercial and Industrial Programs** | | | | | | | | | |
| C&I Prescriptive | 2,732 | 2,732 | 2,732 | 2,713 | 99% | 84% | 2,279 | 1,809 | 126% |
| C&I Custom | 365 | 365 | 365 | 324 | 89% | 85% | 276 | 500 | 55% |
| C&I Small Business Direct Install | 597 | 597 | 597 | 619 | 104% | 101% | 623 | 72 | 861% |
| **Cross-Sector Program** | | | | | | | | | |
| Conservation Voltage Reduction | N/A | N/A | N/A | 14 | N/A | 100% | 14 | N/A | N/A |
| **Total** | **8,912** | **8,667** | **8,492** | **9,430** | **106%** | **83%** | **7,818** | **6,227** | **126%** |
| Nonparticipant Spillover[2] | N/A | N/A | N/A | N/A | N/A | 105% | 231 | N/A | N/A |
| **Total Adjusted Portfolio** | **8,912** | **8,667** | **8,492** | **9,430** | **106%** | **85%** | **8,049** | **6,227** | **129%** |

[1] The Smart Cycle Program is a demand response program. This report includes year-round energy and demand impacts from the smart thermostats installed as part of the Smart Cycle Program. Energy and demand impacts resulting from the program's load control events are reported separately in the *Smart Cycle Program 2018 Evaluation Report*. Details regarding the Smart Cycle energy savings can be found in Appendix A. Impact Evaluation Methodology.

[2] Cadmus calculated nonparticipant spillover as part of the 2017 portfolio evaluation.

## Summary of Recommendations

Based on the findings from the 2018 evaluation, Cadmus has proposed several recommendations to improve Vectren's DSM portfolio. Detailed findings and conclusions in support of these recommendations are included in the individual program chapters. Table 3 lists the evaluation recommendations.

**Table 3. 2018 Recommendations by Program**

| Program | Recommendations |
|---|---|
| **Residential Programs** | |
| Residential Prescriptive | Continue to use and promote the online portal with contractors. Send quarterly emails to contractors with program updates and resources such as case studies of residential efficiency projects and best practices for marketing energy efficient equipment to customers. Include links to the contractor portal in the emails where contractors can go to download the marketing materials and add program updates to the contractor portal when applicable. |
| | Assume no peak demand savings for Nest thermostats for planning purposes for now. |
| | Collect clean air delivery rates (CADR) of rebated air purifiers to increase the accuracy of the evaluation. |
| | Collect cooling capacity of rebated central air conditioners to bring central air conditioner data into line with other measures (such as air source heat pumps [ASHPs] and furnaces) and with previous evaluation years. |
| Residential New Construction | Increase program communication to builders about rebate applications. Send quarterly reminders to builders to submit their rebate applications and contact builders quickly, via email, if an issue arises with their application. Consider setting a target timeline for processing rebate applications so builders will quickly receive notification if their application needs to be fixed. |
| | Consider educating builders on how to cost-effectively achieve lower HERs scores by building more energy efficient homes and to overcome their perceived barriers to achieving Platinum Star certification. If builder attendance is a concern, consider offering breakfast, lunch, or an incentive to builders for attending the educational seminar. Consider raising the incentive for Platinum Star certification if achieving a certain percentage of Platinum Star certified homes becomes a priority. |
| Home Energy Assessment 2.0 | If Vectren decides to increase future participation goals, consider accommodating customer schedules by offering appointments on one or two weekends a month or offering evening appointments one day a week. Streamlining the process for eligibility verification and scheduling assessments may also help the program meet any future goal expansions. The signup form for customers could automatically reference a secure list of current Vectren customer accounts, which Vectren could update monthly. |
| | Provide auditors with best practices for how to discuss rebates for Vectren's other residential programs and to provide estimated payback calculations with and without those rebates. |
| | Email customers one week or one month after the assessment with a copy of the report, reminders of no- to low-cost energy-saving tips, and links to Vectren's webpages for its other residential programs. This reminder will keep the assessment fresh in their mind and encourage them to participate in other Vectren programs. |
| | Claim electric cooling savings for thermostats and filter whistles that are installed in homes with central air conditioning. Currently, the program does not claim savings for these measures in homes with gas heat and central air conditioning, only homes with electric heat and cooling. |
| | Track measure-level demand savings for future years to allow for a more accurate analysis of program performance. |
| Income Qualified Weatherization | Prioritize installation of phase 2 and phase 3 measures in participant homes to achieve greater program savings and make a deeper impact on individual customers. |
| | Research partnerships with local state and federal programs to help fund additional health and safety improvements that can help increase the penetration of phase 2 and phase 3 measures and better serve low-income customers. In addition, to ensure that all home types are eligible for phase 2 or phase 3 measures, Vectren should recruit contractors qualified to install weatherization in multifamily and manufactured homes. |
| | To ensure maximum lifetime savings, Vectren should ensure that energy auditors are taking the time to thoroughly educate the customers on how a smart thermostat or smart strip works while on site. If |

| Program | Recommendations |
|---|---|
| | current education is comprehensive, additional or alternate methods of education should be explored. Vectren should also consider developing educational materials specifically for smart thermostats and smart strips that can be left behind to remind customers how to use these measures so that they continue saving energy over time. Vectren recently developed an educational thermostat postcard for Residential Prescriptive customers that may be relevant to this program as well. |
| | To evaluate savings more accurately, it is important to have reliable information about the existing R-value for all attic insulation installations. |
| | For air sealing and attic insulation installed in electrically heated homes, use historical evaluated savings averages for program planning and reported savings. Ensure weatherization contractors collect and track this data for the program |

| Program | Recommendations |
|---|---|
| Online Home Energy Audit | Market the online audit on the home page of the web portal, instead of requiring customers to first click on the "Ways to Save" section before finding any information about the online audit. For customers who do not complete the online audit after they start it, send a reminder email one day later to prompt them to finish it. |
| | Promote the online audit program to Vectren's entire customer base during summer months so customers can take energy-saving actions during warm weather as well as during the winter. In addition to promoting the program via home energy reports and the high bill alerts, promote the program via bill inserts, emails, and web banners. |
| | Vectren should claim savings from customers who completed an Online Home Energy Audit. Only 9.5% of Online Home Energy Audit savings are from customers participating in Vectren rebate programs, therefore, most of the program's savings are not claimed through Vectren rebate programs. |
| | Because evaluated savings are associated with self-selecting and highly motivated customers, results may not represent the average Vectren residential customer. To better understand program impacts, Vectren can also measure savings for customers who start the online audit but do not finish it. |
| | By conducting post-audit surveys and an analysis of online audit responses, Vectren can better determine exactly how participation in the Online Home Energy Audit leads to energy savings. |
| Energy Efficient Schools | If the program remains cost-effective at higher participation levels, consider increasing the kit distribution goal in future program years. |
| Residential Behavioral Savings | If it becomes a priority to better understand historical uplift and how treatment group customer participation in Vectren's other DSM programs have changed over time, build a tracking database prior to the 2019 RBS Program savings analysis to track every customer's previous cross-program participation (since the beginning of the program in 2012) and incorporate Vectren's updated effective useful life values for each measure. This tracking database will allow Vectren to include customers' installed measures from previous years that still are deemed to be saving energy, hence better comparing cumulative uplift over the lifetime of the program. Most measures have an effective useful life of more than one year. |
| | Consider refilling the population with a new wave of customers to help achieve the energy savings goals in future program years and improve the overall relative precision of evaluated net savings. Refilling the treatment group can offset customers who leave the program because of moving homes or who shut down electric service for vacant homes. The instances of customers actively opting out of the program (i.e. requesting to no longer receive reports) are not widespread. |
| Residential Lighting | Use the UMP recommended lumens binning approach, combined with Indiana TRM values for HOU, WHF and CF, to generate ex ante savings for each lamp in the program, ensuring that the program gets fuller credit for higher wattage, specialty, and reflector LEDs and realization rates are closer to 100%. |
| | Refocus program incentives away from general service lamps, which are unlikely to qualify as eligible for the program once EISA 2020 is in effect and increase the per-unit incentives on LED reflectors and specialty lamps, which are not anticipated to be affected by the updated EISA baselines at this time. |
| Food Bank LED Distribution | Provide information (such as a small flyer in the box of bulbs or on the packaging) that promotes Vectren-discounted lighting products at nearby participating retailers, while continuing to cross-promote the Income Qualified Weatherization Program. |
| | To reduce leakage, partner only with food banks in Vectren's electric territory. Ensure that partner food banks are giving LEDs to Vectren's electric customers by restricting distribution sites to addresses within a 15- or 20-minute drive from the service territory border |
| **Commercial and Industrial Programs** | |
| C&I Prescriptive | Update the baseline efficiencies (and ENERGY STAR requirements, if applicable) for commercial air conditioners, heat pumps, refrigerated cases, and ice machines to match the current federal standards. To accurately estimate savings, in the absence of an updated Indiana TRM, Vectren and its implementer should consider using the UMP, Illinois TRM V7, or Iowa TRM V3 for planning purposes in future program years. Because Vectren plans to use 2017 ex post savings as the 2019 ex ante savings, these problems will persist. That is, the federal standards used in the 2017 ex post savings, though current at the time, will be out of date in 2019 and the realization rates for HVAC and kitchen equipment will continue to be lower than planned. |
| | Be prepared for the reduction in savings for T12s and T8s to LEDs and furnace fans on residential-sized furnaces in 2019 and 2020, respectively. For T12s and T8s to LEDs, there was no effect this year, but next year, savings may be lowered. For furnace fans on residential-sized furnaces, savings will be impacted in 2020. Because retailers can sell existing product stocks, both federal standard updates will likely have partial year effects. |

| Program | Recommendations |
|---|---|
| | Several measures require more information in the tracking database to accurately calculate *ex post* savings:<br>• Air conditioner or air source heat pump (all size ranges):<br>▪ Indicate if the installed equipment is an air conditioner or air source heat pump (as opposed to grouping them together as the measure name does). The difference between heat pumps and air conditioners is critical because each has different efficiency requirements.<br>▪ Indicate if the equipment is a split system or single-package system.<br>▪ Indicate the baseline efficiency information used in the *ex ante* analysis. This allows the evaluation team to identify discrepancies between *ex ante* and *ex post* estimates.<br>• Electric chiller tune-up:<br>▪ Indicate the equipment type; see page 218 of the 2015 Indiana TRM<br>• Electrically commutated motor (ECM) (all types):<br>▪ Track the horsepower of the motor. In the current tracking database, the reference for *ex ante* savings was from the Illinois TRM V5. Savings for ECMs have been updated in the next two versions (V6 and V7) and now require only the horsepower of the motor. |
| | Collect and track the following baseline conditions of sites receiving thermostats:<br>• Type of existing thermostat (manual, programmable, smart)<br>• Current building HVAC schedule or temperature setpoints (heating and cooling) |
| C&I Custom | Consider reaching out directly to C&I Prescriptive and C&I Custom program participants who installed projects in the past several years. Document these outreach efforts and determine the necessary frequency of the outreach by the level of customer interest in future projects. Previous customers may wish to hear about the new building tune-up and the upcoming strategic energy management offerings. |
| C&I Small Business Direct Install | Encourage trade ally staff to keep an inventory of no-cost measures with them when conducting site assessments. Although site assessors may not have adequate storage space, or the experience needed to install all of the no-cost measures, most should be able to maintain an adequate supply of and feel comfortable with installing LEDs, aerators, and pre-rinse sprayers. In return for performing these installations and managing the paperwork involved, consider offering trade allies a small incentive for projects that never advance to a paying project. |
| | Add the waste heat factors and coincidence factors for energy and demand to the program tracking data. |
| **Cross-Sector Program** | |
| Conservation Voltage Reduction | Although Vectren designed its program to claim only first-year savings, it should revise this approach to claim annual savings, assuming the utility maintains CVR at its Buckwood substation in future years. Not only can this multiyear approach be used for the Buckwood substation, it can also be used when Vectren implements CVR at its East Side substation in 2020. |
| | To better isolate peak demand savings and minimize potential effects in savings estimates resulting from changes in consumption on each feeder, perform the alternating on/off cycling of the CVR system at three-day intervals for a complete summer peak period. |

# Introduction

Vectren tasked Cadmus with evaluating its 2018 demand-side management (DSM) programs. Cadmus evaluated 15 electric-saving programs, which involved conducting process and impact evaluations and a market effects assessment for most of the programs (each program chapter describes the specific evaluation activities Cadmus performed).

## *Program Descriptions*

The following section briefly summarizes each program.

### Residential Programs

- Through the ***Residential Prescriptive Program,*** Vectren seeks to achieve energy savings by influencing residential customers to purchase energy-efficient residential products such as smart and programmable thermostats, heat pumps, air conditioners, and insulation. All residential customers are eligible to participate in the program and receive rebates that vary by measure.
- Through the ***Residential New Construction Program,*** Vectren provides incentives to builders who construct homes that receive a Home Energy Rating System (HERS) score of 63 or lower. All builders constructing high-efficiency homes in Vectren's service territory can participate in the program.
- Through the ***Home Energy Assessment 2.0 Program***, Vectren offers a walk-through home energy audit to analyze participant energy use. The assessor recommends efficiency upgrades and facilitates the direct installation of energy-saving measures, including energy-efficient showerheads, LEDs, hot water pipe wrap, and faucet aerators.
- Through the ***Income Qualified Weatherization Program***, Vectren offers its low-income customers a walk-through home energy audit that includes full diagnostic testing for the home. Auditors recommend weatherization measures or upgrades that facilitate the installation of energy-saving measures at no cost to the customer.
- Through the ***Online Home Energy Audit Program***, customers can engage with an interactive tool to answer simple questions about their energy habits and their home's attributes. The program aims to provide customers with an engaging energy experience and to better personalize energy-savings tips offered through an online web portal available to all Vectren residential customers.
- Through the ***Energy Efficient Schools Program,*** Vectren works with fifth-grade teachers to educate students about energy efficiency and how they can make an impact at school and at home. Participating teachers receive classroom curriculum and take-home efficiency kits to distribute to their students.
- Through the ***Residential Behavioral Savings Program,*** Vectren uses home energy reports to educate customers about their energy consumption patterns. Customers receive a targeted, individualized report that is intended to motivate them to engage in energy-saving behaviors.

The report displays customers' monthly energy use, compares this use to similarly sized homes nearby, and provides customized energy-saving tips.

- Through the ***Residential Lighting Program,*** Vectren provides upstream discounts on a variety of lighting products (LEDs and lighting fixtures). Vectren works with retailers and manufacturers to offer reduced prices at the point of sale.
- Through the ***Appliance Recycling Program***, Vectren provides removal and recycling services for operable refrigerators and freezers. This program prevents older units from remaining in service at a participant's premise or elsewhere in Vectren's service territory.
- Through the ***Food Bank LED Distribution Program,*** Vectren partners with food banks in its electric service territory to give away one 4-pack of general purpose, 9-watt LED bulbs at no cost to qualifying food bank patrons.
- Through the ***Smart Cycle Program***, Vectren direct installed smart thermostats for residential customers to call load control events during the summer peak season. Although the program targets demand reductions during peak summer hours, the program also achieves energy savings from the smart thermostats throughout the year.

## Commercial and Industrial Programs

- Through the ***Commercial and Industrial Prescriptive Program,*** Vectren provides prescriptive rebates to facilities, based on the installation of energy efficiency equipment and system improvements. All nonresidential customers are eligible to participate in the program and receive rebates that vary by measure.
- Through the ***Commercial and Industrial Custom Program,*** Vectren focuses on energy-savings opportunities unique to the commercial participant's application or process. Customers and/or their trade allies submit engineering analyses showing first-year savings to qualify for program incentives.
- Through the ***Small Business Direct Install Program,*** Vectren helps qualifying businesses identify savings opportunities by providing free on-site energy assessments, free installation of energy-efficient measures, and low-cost pricing for energy-efficient upgrades recommended in the assessments.

## Cross-Sector Program

- Through the ***Conservation Voltage Reduction Program,*** Vectren seeks to achieve end-user energy and demand savings by reducing the voltage on distribution feeders while remaining above the American National Standards Institute allowable minimum voltage. Under this approach end-user's energy consumption is reduced without altering behavior or equipment; savings are generated unbeknownst to customers.

## *Evaluation Activities*

For the evaluation, Cadmus investigated three areas:

- Through the ***process evaluation***, Cadmus examined the program from the perspective of customers, trade allies, and program staff and sought to determine the aspects of the program that worked well, areas that may need improvement, and recommendations to refine the program. Process evaluation activities varied depending on the level of rigor:
    - ***Detailed process evaluations*** consisted of interviews with program staff, trade allies, and/or market actors. Surveys with participants had a greater focus on the customer experience in addition to measure verification and net-to-gross (NTG) analysis.
    - ***Condensed process evaluations*** consisted of interviews with program staff to follow up on previous years' evaluation recommendations and monitor program activities and changes. Surveys with participants focused primarily on measure verification and NTG analysis.
- Through the ***impact evaluation***, Cadmus verified measure installation, determined freeridership and spillover (NTG ratio), and reviewed deemed savings and assumptions. Cadmus calculated electric impacts for all programs and natural gas impacts for a subset of programs and measures. Natural gas impacts are reported separately in the *2018 Vectren Demand-Side Management Portfolio Natural Gas Impact Evaluation Report.*
- To determine ***market effects,*** the program impact on relevant markets, Cadmus developed logic models to map each program's design and activities and established key performance indicators (KPIs) to track market transformations over time.

Table 4 shows the evaluation tasks completed for each of Vectren's energy efficiency programs.

**Table 4. 2018 Evaluation Tasks by Program**

| Program | Detailed Process Evaluation | Condensed Process Evaluation | Impact Evaluation | Market Effects |
|---|---|---|---|---|
| **Residential Programs** | | | | |
| Residential Prescriptive | ✓ | | ✓ | ✓ |
| Residential New Construction | | ✓ | ✓ | ✓ |
| Home Energy Assessment 2.0 | ✓ | | ✓ | ✓ |
| Income Qualified Weatherization | ✓ | | ✓ | ✓ |
| Online Home Energy Audit | | ✓ | ✓ | ✓ |
| Energy Efficient Schools | | ✓ | ✓ | ✓ |
| Residential Behavioral Savings | | ✓ | ✓ | ✓ |
| Residential Lighting | | ✓ | ✓ | ✓ |
| Appliance Recycling | | ✓ | ✓ | ✓ |
| Food Bank LED Distribution | | ✓ | ✓ | ✓ |
| **Commercial and Industrial Programs** | | | | |
| C&I Prescriptive | | ✓ | ✓ | ✓ |
| C&I Custom | | ✓ | ✓ | ✓ |
| C&I Small Business Direct Install | | ✓ | ✓ | ✓ |
| **Cross-Sector Program** | | | | |
| Conservation Voltage Reduction | | ✓ | ✓ | |

# Research Approach

Cadmus conducted a process, impact, and market effects evaluation for Vectren's electric-saving DSM programs.

## *Process Evaluation*

For the process evaluation of the 2018 Vectren DSM portfolio, Cadmus assessed program strengths, areas for improvement, and best practices to optimize the customer experience. Table 5 lists the process evaluation research topics by data collection activity. In addition to interviews and surveys, Cadmus also reviewed status reports and other program materials to obtain a complete understanding of all activities conducted to reach program goals.

**Table 5. Process Evaluation Topics by Research Activity**

| Process Evaluation Research Activity | Research Topics | |
|---|---|---|
| In-Depth Program Staff Interviews | • Evaluation goals and research questions<br>• Program goals and objectives<br>• Implemented and proposed program changes<br>• Program design and delivery<br>• Program administration<br>• Quality control | • Marketing strategies and effectiveness<br>• Program tracking and key performance indicators (KPIs)<br>• Market barriers and reasons for nonparticipation<br>• Target audiences and program participation |
| Trade Ally and Market Actor Interviews | • Program awareness<br>• Reasons for participation<br>• Aspects of program delivery and program process effectiveness<br>• Interactions with program staff<br>• Market barriers and reasons for nonparticipation (among trade allies and customers) | • Program satisfaction and value<br>• Effectiveness of marketing materials and channels<br>• Changes in business practices or performance as a result of program participation<br>• Program strengths and suggestions for improvement |
| Participant Surveys | • Program awareness<br>• Reasons for participation and installation of specific measures<br>• Customer experience including program satisfaction and likelihood to recommend | • Trade ally experience<br>• Program value<br>• Freeridership and spillover<br>• Verification of measure installation<br>• Program strengths and suggestions for improvement |

Table 6 shows the number of interviews and surveys Cadmus completed for the 2018 Vectren DSM portfolio evaluation. Cadmus conducted staff interviews for all programs but conducted trade ally surveys for only a subset. Cadmus conducted customer surveys for nearly all programs.

**Table 6. Survey Respondent Groups by Program**

| Respondent Group | Population | Included in Sample Frame[1] | Target Completes | Achieved Completes |
|---|---|---|---|---|
| **Residential Programs** | | | | |
| **Residential Prescriptive** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| CLEAResult Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 9,811 | 7,441 | 630 | 711 |
| Participating Contractors | 1,339 | 220 | Census | 22 |
| **Residential New Construction** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| CLEAResult Staff | N/A | 1 | 1 | 1 |
| Participating Builders | 46 | 43 | 10 | 10 |
| **Home Energy Assessment 2.0** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| J.E. Shekell Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 350 | 262 | 70 | 72 |
| **Income Qualified Weatherization** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| CLEAResult Staff | N/A | 1 | 1 | 1 |
| Participating Assessors | 3 | 3 | Census | 3 |
| Participating Trade Allies | 3 | 3 | Census | 3 |
| Participating Customers | 2,138 | 876 | 70 | 92 |
| **Online Home Energy Audit** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| Oracle Staff | N/A | 1 | 1 | 1 |
| **Energy Efficient Schools** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| National Energy Foundation Staff | N/A | 1 | 1 | 1 |
| **Residential Behavioral Savings** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| Oracle Staff | N/A | 1 | 1 | 1 |
| **Residential Lighting** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| CLEAResult Staff | N/A | 1 | 1 | 1 |
| **Appliance Recycling** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| ARCA Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 1,300 | 1,062 | 120 | 113 |
| **Food Bank LED Distribution** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| CLEAResult Staff | N/A | 1 | 1 | 1 |

| Respondent Group | Population | Included in Sample Frame[1] | Target Completes | Achieved Completes |
|---|---|---|---|---|
| Participating Customers | 12,624 | 803 | 70 | 70 |
| **Commercial and Industrial Programs** | | | | |
| **C&I Prescriptive** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| Nexant Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 350 | 238 | 70 | 70 |
| **C&I Custom** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| Nexant Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 40 | 29 | Census | 10 |
| **C&I Small Business Direct Install** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |
| Nexant Staff | N/A | 1 | 1 | 1 |
| Participating Customers | 146 | 77 | Census | 27 |
| **Cross-Sector Program** | | | | |
| **Conservation Voltage Reduction** | | | | |
| Vectren Staff | N/A | 1 | 1 | 1 |

[1] Cadmus removed customers from the sample frames if they were contacted about their participation in another program, they had been recently surveyed through another evaluation effort, or if they had missing contact information.

In 2018, Cadmus introduced mixed-mode (online and phone) surveys for the participant surveys where email contacts were available to increase the number of customer responses per program. Table 7 shows the programs with mixed-mode surveys and the results by response type.

**Table 7. Mixed Mode Survey Results by Program**

| Respondent Group | Target Completes | Achieved Completes |
|---|---|---|
| **Residential Prescriptive** | | |
| Online | 315 | 474 |
| Phone | 315 | 237 |
| **Total** | **630** | **711** |
| **Home Energy Assessment 2.0** | | |
| Online | 35 | 42 |
| Phone | 35 | 30 |
| **Total** | **70** | **72** |
| **Income Qualified Weatherization** | | |
| Online | 35 | 57 |
| Phone | 35 | 35 |
| **Total** | **70** | **92** |

## Impact Evaluation

As a part of the impact evaluation, Cadmus reviewed gross savings values, verified measure installation, and determined freeridership and spillover to calculate an NTG ratio and estimated realized program savings. Cadmus defined these key savings terms for the impact evaluation:

- **Reported *ex ante* savings.** Annual gross savings for the evaluation period, as reported by Vectren in the 2018 DSM Scorecard.
- **Audited savings.** Annual gross savings after deemed calculations and measure counts were confirmed by Cadmus.
- **Verified savings.** Annual gross savings adjusted for the installation rate (percentage).
- **Evaluated *Ex post* savings.** Annual gross savings adjusted for installation rate (percentage) and savings adjustments resulting from the deemed savings review.
- **Realization rate (percentage).** The percentage of savings the program actually realized, calculated as follows:

$$Realization\ Rate = \frac{Ex\ Post\ Savings}{Ex\ Ante\ Savings}$$

- **Evaluated net savings.** Evaluated *ex post* savings, adjusted for NTG (i.e., freeridership and spillover)

### Gross Savings Review

Appendix A. Impact Evaluation Methodology details the specific methodology Cadmus used to determine savings and its associated assumptions. Table 8 lists the evaluation activities Cadmus performed for each program, including these:

- ***Engineering analysis.*** To assess Vectren's claimed measure energy savings and coincident peak demand reduction, Cadmus conducted an engineering desk review for most of Vectren's 2018 DSM programs. Cadmus used utility program data, assumptions from technical reference manuals (TRMs) from Indiana and other states, and industry studies to determine inputs to the savings estimates, which were calibrated with survey results where possible. Cadmus also determined if any additional savings were generated from the early replacement of measures installed through the residential and commercial and industrial (C&I) prescriptive programs, based on program data and survey results.
- ***REM/Rate analysis.*** Cadmus conducted a REM/Rate analysis for the Residential New Construction Program, which entailed modeling several homes to calculate the energy savings of the program homes against Indiana's building code baseline. Cadmus relied on the HERS certificates for key data inputs modeling home savings.
- ***Regression/billing analysis.*** Through billing analyses of the Online Home Energy Audit, Residential Behavioral Savings, Appliance Recycling, and Conservation Voltage Reduction programs, Cadmus modelled savings by comparing monthly consumption of program participants before and after measure installation (or comparing consumption to

nonparticipants) while controlling for exogenous factors such as weather. These models made use of control groups and pre- and post-installation conditions to estimate program baselines.

- ***Site visits.*** For selected C&I Custom Program projects, Cadmus verified the presence of equipment at a project site and collected data through a variety of methods, such as installing data loggers or taking spot measurements of power usage. Cadmus also gathered data by reviewing daily operations and maintenance logs, gathering operations data from central energy management systems, and reviewing historical trend data.

**Table 8. Impact Evaluation Task by Program**

| Program | Engineering Desk Review | REM/Rate Analysis | Regression/ Billing Analysis | Site Visits |
|---|---|---|---|---|
| **Residential Programs** | | | | |
| Residential Prescriptive | ✓ | | | |
| Residential New Construction | | ✓ | | |
| Home Energy Assessment (HEA 2.0) | ✓ | | | |
| Income Qualified Weatherization | ✓ | | | |
| Online Home Energy Audit | | | ✓ | |
| Energy Efficient Schools | ✓ | | | |
| Residential Behavioral Savings | | | ✓ | |
| Residential Lighting | ✓ | | | |
| Appliance Recycling | | | ✓ | |
| Food Bank LED Distribution | ✓ | | | |
| **Commercial and Industrial Programs** | | | | |
| C&I Prescriptive | ✓ | | | |
| C&I Custom | ✓ | | | ✓ |
| C&I Small Business Direct Install | ✓ | | | |
| **Cross-Sector Program** | | | | |
| Conservation Voltage Reduction | | | ✓ | |

## Measure Verification

Cadmus reviewed tracking data to verify measure installations for all programs. As shown in Table 9, for most programs, Cadmus conducted telephone and/or online surveys with program participants to confirm customer participation status, the number and type of measures that received program incentives, and the persistence of installations. Cadmus used this equation to calculate the installation rate for each program:

$$Installation\ \text{Rate} = \frac{\text{Verified Installations}}{\text{Reported Installations}}$$

**Table 9. Measure Verification Method by Program**

| Program | Tracking Data Review | Participant Surveys |
|---|---|---|
| **Residential Programs** | | |
| Residential Prescriptive | ✓ | ✓ |
| Residential New Construction | ✓ | |
| Home Energy Assessment (HEA 2.0) | ✓ | ✓ |
| Income Qualified Weatherization | ✓ | ✓ |
| Online Home Energy Audit | ✓ | |
| Energy Efficient Schools[1] | ✓ | |
| Residential Behavioral Savings | ✓ | |
| Residential Lighting | ✓ | |
| Appliance Recycling | ✓ | ✓ |
| Food Bank LED Distribution | ✓ | ✓ |
| **Commercial and Industrial Programs** | | |
| C&I Prescriptive | ✓ | ✓ |
| C&I Custom | ✓ | ✓ |
| C&I Small Business Direct Install | ✓ | ✓ |
| **Cross-Sector Program** | | |
| Conservation Voltage Reduction | ✓ | |

[1] Because household survey samples have been historically low for the Energy Efficient Schools Program, Cadmus used benchmarked installation rates from past evaluations.

## Net-to-Gross

Cadmus calculated the savings that were directly attributable to Vectren's programs (net savings) by estimating program-specific (or measure-specific, where applicable) NTG ratios. The NTG ratios were used to adjust the verified gross savings estimates to account for freeridership and spillover.

For Vectren's portfolio of programs, Cadmus used three methods for determining NTG ratios:

- ***Demand elasticity modeling*** draws upon the same economic principle that drives the program's design—changes in price and merchandising generate changes in quantities sold (i.e., the upstream buy-down approach). Cadmus performed demand elasticity modeling for the Residential Lighting Program using sales tracking data, examining lighting products that incur price changes and promotion during the program period to determine the correlation between sales and prices. Through this analysis, Cadmus applied a net-of-freeridership rate.
- ***Self-report surveys*** for most residential and C&I programs. Cadmus utilized survey results to derive net savings by adjusting *ex post* gross savings to account for an NTG ratio. To mitigate self-report bias, Cadmus used a battery of freeridership questions that collect data on each participant's *intention* and factors that might have had *influence*. The *intention* and *influence* scores contributed equally to the total freeridership score. Cadmus computed the overall freeridership score for each participant by calculating the arithmetic mean of the intention and influence scores. Cadmus implemented an expanded intention/influence method for several of

the programs in the portfolio, using the full pure intention method set of questions in combination with the influence set of questions.[4]

Cadmus also gathered the necessary data from the self-report surveys to calculate participant spillover—the program's influence on customers' decisions to invest in additional energy efficiency measures for which they did not receive any Vectren incentives. Cadmus included measures that are program eligible (known as like spillover) as well as any non-program-eligible measures (known as non-like spillover) for which Cadmus could provide a reasonable savings documentation.

- ***Nonparticipant Spillover (NPSO)*** is created when residential customers make energy-saving improvements to their home as a result of Vectren's marketing and education efforts but do not participate in any program. Cadmus applied a 5% NPSO across all residential programs using results from a residential nonparticipant survey conducted during the 2017 evaluation.

- ***Control Group*** for behavior-based programs. Cadmus used billing/regression analysis to estimate net impacts. In this method, Cadmus calculated net savings by developing a comparison (control) group, which isolates the program impacts from exogenous effects.

Table 10 lists the NTG approach Cadmus used for each program. The individual program chapters and Appendix B. Net-to-Gross Detailed Findings detail the specific methodology Cadmus used to determine each program's NTG ratio.

[4] Cadmus combined the two methods used in previous Vectren program evaluations (that is, both the pure intention method and intention/influence method) into each program's participant survey rather than implementing only one method per program.

**Table 10. Net-to-Gross Method by Program**

| Program[1] | Self-Report Surveys | Demand Elasticity Modeling | Control Group |
|---|---|---|---|
| **Residential Programs** | | | |
| Residential Prescriptive | ✓ | | |
| Residential New Construction | ✓ | | |
| Home Energy Assessment 2.0 | ✓ | | |
| Online Home Energy Audit | | | ✓ |
| Residential Behavioral Savings | | | ✓ |
| Residential Lighting | | ✓ | |
| Appliance Recycling | ✓ | | |
| **Commercial and Industrial Programs** | | | |
| C&I Prescriptive | ✓ | | |
| C&I Custom | ✓ | | |
| C&I Small Business Direct Install | ✓ | | |
| **Cross-Sector Program** | | | |
| Conservation Voltage Reduction | | | ✓ |

[1] Cadmus assumed an NTG ratio of 1.0 for Vectren's income-qualified and school kit programs.

## *Market Effects*

The primary objective of the market effects evaluation was to assess changes and historical trends in the market baselines and KPIs for the DSM programs in Vectren's territory. During interviews and surveys, Cadmus asked program staff, trade allies, and participants about fundamental shifts in the energy marketplace (market transformation) and current market practices and compared these responses with the KPIs and findings from previous evaluation years. Their responses to the market effects questions informed the development of program logic models.

The main objectives of creating and updating logic models were to develop an understanding of a program and define its underlying theory and assumptions. The logic models include market actors, market barriers uncovered by the evaluation, current intervention strategies and activities, and the expected outcomes if current program intervention strategies were implemented.

Cadmus assessed market effects for all Vectren DSM programs with available longitudinal data (exceptions are new programs for 2018). Because the Conservation Voltage Reduction Program is not a customer-facing program, Cadmus did not assess its market effects.

# Residential Prescriptive Program

The Residential Prescriptive Program encourages customers to purchase energy-efficient products by offering prescriptive rebates for a wide range of energy-efficient equipment, including Wi-Fi-enabled and smart thermostats, heat pumps, central air conditioners (CACs), weatherization, and pool equipment. All residential customers are eligible to participate in the program and receive rebates. CLEAResult is the program implementer overseeing program delivery.

## Accomplishments

Table 11 shows the program's achievements against goals in 2018. Vectren and the program implementer agreed that the Residential Prescriptive Program continues to be in high demand. The program had no trouble meeting its participation and savings goals in 2018, even after increasing its participation goal by 71% compared to 2017.

**Table 11. 2018 Residential Prescriptive Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 3,127,784 | 3,061,686 | 102% |
| Gross kW Savings | 1,570.03 | 1,489.50 | 105% |
| Participants (measures) | 6,960 | 6,603 | 105% |
| Program Expenditures | $1,177,131 | $1,205,219 | 98% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 12 lists the evaluated savings summary for the Residential Prescriptive Program. Overall, the program achieved a 106% realization rate for energy and a 106% realization rate for demand savings. The main driver for the 106% demand savings realization rate is the 16 SEER central air conditioner which has an audited measure-level demand realization rate of 139%. Cadmus discusses the reasons for the differences between ex post and ex ante savings for specific measures in the Gross Savings Review section.

**Table 12. 2018 Residential Prescriptive Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 3,127,784 | 3,127,784 | 3,105,646 | 3,326,588 | 106% | 68% | 2,277,461 |
| Total kW | 1,570 | 1,724 | 1,719 | 1,667 | 106% | 66% | 1,098 |

## *Conclusions and Recommendations*

## Contractor Engagement

**Contractors with lower program activity are seeking greater attention from program staff.** Ten surveyed contractors said they hear from program staff once a year or never (n=22), and most would like to hear from program staff monthly or quarterly (15, n=21). These ten contractors completed an average of 12.4 projects in 2018, with four contractors completing between 10 and 46 projects. Six contractors who heard from the program monthly or quarterly completed an average of 21.3 projects in 2018. Despite heavily promoting the online contractor portal as an easy way to submit and manage customer rebate applications, the program implementer said it does not use the contractor portal as a primary source of communication with contractors about program updates; instead, the portal ensures contractors have all current program documents and resources available to them. In 2019, the implementer plans to provide marketing material templates in the portal for contractors to easily use by inserting their own logo onto the marketing materials.

**Recommendation:** Continue to use and promote the online portal with contractors. Send quarterly emails to contractors with program updates and resources such as case studies of residential efficiency projects and best practices for marketing energy efficient equipment to customers. Include links to the contractor portal in the emails where contractors can go to download the marketing materials and add program updates to the contractor portal when applicable.

## Federal Standards Changes

**New federal standards for ECMs and pool pumps are expected to come into effect soon, and Vectren should be prepared to alter program offerings when and where appropriate**. While this is not an evaluation finding, federal standards are changing and will have an impact on measure savings. A federal standard requiring manufacturers to include ECMs in new central air systems is expected to come into effect on July 3, 2019. Savings for ECMs will persist until this date and probably through the end of 2019 because retailers will have to sell through their inventory of models manufactured before July 3, 2019. Early replacements of stand-alone furnace fans will still qualify for ECM savings for several years after this standard goes into effect. Vectren plans to discontinue offering the ECM HVAC motor measure or adapt it to early-replacement-only for stand-alone furnace fans in 2019.

Another federal standard requiring that pool pumps be variable speed is expected to come into effect on July 19th, 2021.[5] The regulation states that self-priming filtration pumps rated between 0.711 and 2.5 hydraulic horsepower must meet the performance standard. Converted to motor horsepower, the regulation applies to motors between approximately 1 and 5 horsepower.[6] Although the federal standard does not come into effect for a few years, Vectren is prepared to discontinue offering the variable speed pool pump on July 19, 2021. The program implementer has already started to ramp up marketing around variable speed pool pump rebates for 2019 through 2021 to encourage participation before Vectren can no longer claim energy-savings from the measure. Vectren will likely be able to claim savings through the end of 2021, as retailers sell through their stock of products.

---

5 Energy Conservation Standards for Dedicated-Purpose Pool Pumps. https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0109

6 Rebecca Robledo. Federal Pump Rule Established. https://www.poolspanews.com/business/legal-regulatory/federal-pump-rule-established_o

## Peak Demand Savings for Nest Thermostats

**There is not enough data to support peak demand savings for Nest thermostats that are not enrolled in a demand reduction program.** The 2015 Indiana TRM[7] assumes no coincident peak demand reduction for Nest thermostats; and there is no consensus to be derived from other TRMs or studies. Peak definitions are highly dependent on climate and region, so it is best to rely on peak demand factors from local TRMs. Without additional data from Vectren, Cadmus cannot evaluate demand savings for the measure. It may be feasible in future evaluations to use advanced metering infrastructure (AMI) data to assess peak demand savings more accurately. Vectren's full deployment of AMI was planned to be complete at the end of 2018.

**Recommendation:** Assume no peak demand savings for Nest thermostats for planning purposes for now.

## Data Tracking

**The evaluation would be more accurate if tracking data contained the clean air delivery rates (CADR) of the rebated air purifier, this would allow verification that rebated air purifiers are ENERGY STAR qualified.** Cadmus used the ENERGY STAR-qualified products list to determine the distribution of CADR for the air purifier measure.

**Recommendation:** Collect CADR of rebated air purifiers to increase the accuracy of the evaluation.

**Very few rebated central air conditioners had capacity data in the tracking database, which is abnormal compared to past years.** Of the 1,753 central air conditioner line items in the tracking data, only 29 (1.7%) had capacity data. Cadmus filled in the remaining data by researching model numbers from the tracking data, but this is not the preferred approach because we could not find a subset of the models.

**Recommendation:** Collect cooling capacity of rebated central air conditioners to bring central air conditioner data into line with other measures (such as air source heat pumps [ASHPs] and furnaces) and with previous evaluation years.

# *Process Evaluation*

Cadmus conducted these process evaluation activities for its evaluation of the 2018 program year:

- Interview with two Vectren program staff members
- Interview with one CLEAResult program staff members
- Participant mixed-mode online (n=474) and phone (n=237) survey for a total of 711 surveys
- Contractor online survey (n=22)

[7] Cadmus. July 28, 2015. *Indiana Technical Reference Manual Version 2.2.*

The program implementer provided data with contact information for 7,441 unique participating customers and 220 contractors. Cadmus tested for statistically significant differences in 2017 and 2018 customer survey results, as well as for significant differences between 2018 measure categories results, using a t-test set at the 95% ($p \leq 0.05$) significance level. Unless noted otherwise, all results were consistent with previous program years.

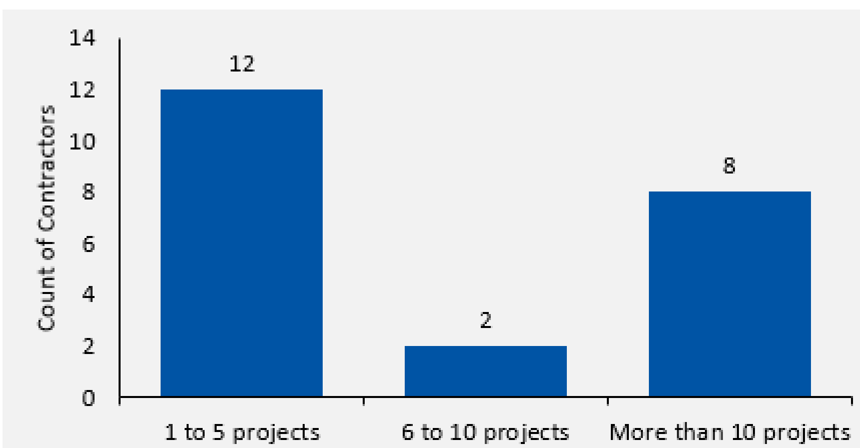
Table 13 shows projects by measure category for customer and contractor survey respondents. Cadmus stratified the customer samples by measure category but did not stratify the contractor sample. Instead, Cadmus conducted a census of all contractors participating in the program for whom the program implementer provided contact emails; many contractors installed multiple measure types through the program.

**Table 13. 2018 Residential Prescriptive Survey Completes by Respondent Type and Measure Category**

| Measure | Customer Survey Completes | Contractor Survey Completes |
|---|---|---|
| Furnace | 191 | 22 |
| Heat Pump/CAC | 58 | 2 air source heat pumps,<br>1 CAC, 1 ductless heat pump |
| Smart Thermostat | 282 | 10 |
| Wi-Fi-Enabled Thermostat | 108 | 7 |
| Weatherization | 24 | N/A |
| Other | 48 | N/A |
| **Total Program** | **711** | **22** |

Surveyed contractors' level of engagement with the program varied. In 2018, of 22 contractors, 12 completed one to four projects with Vectren, two completed six to 10 projects, and eight completed more than 10 projects. Surveyed contractors' program activity ranged from one to 74 projects completed in 2018.

**Figure 1. 2018 Program Projects Completed by Surveyed Contractors**




Source: 2018 Program Data

## Program Administration

Because of the high demand, Vectren increased program participation goals from 3,863 measures in 2017 to 6,603 measures in 2018. The program also made the following measure and incentive changes:

- Added an incentive for air purifiers
- Reduced the ECM incentive from $100 to $50
- Removed the incentive for programmable thermostats because of a market shift to smart or Wi-Fi-enabled thermostats
- Adopted an ENERGY STAR certification requirement for smart thermostats
- Removed the incentive for duct-sealing to redesign and reintroduce it for 2019. Vectren covered the full cost of duct sealing, up to $400, in 2017 and did not require a certain level of leakage reduction or verification. The 2019 program will require a minimum of 15% leakage reduction, pre- and post-installation blower door test, and a customer co-pay of $100.

## Program Delivery

The Residential Prescriptive Program is a contractor-driven program that offers a wide variety of rebates for high-efficiency measures. The program implementer provides fact sheets that trade allies can give to customers or incorporate into their own materials. The program manages an online portal on which contractors can submit rebate applications on behalf of customers or apply for reimbursement for instant rebates that they have given customers. The program implementer provides program updates to contractors via newsletters, mailers, and annual trade ally breakfasts in five Indiana cities, at which top-performing contracts are recognized.

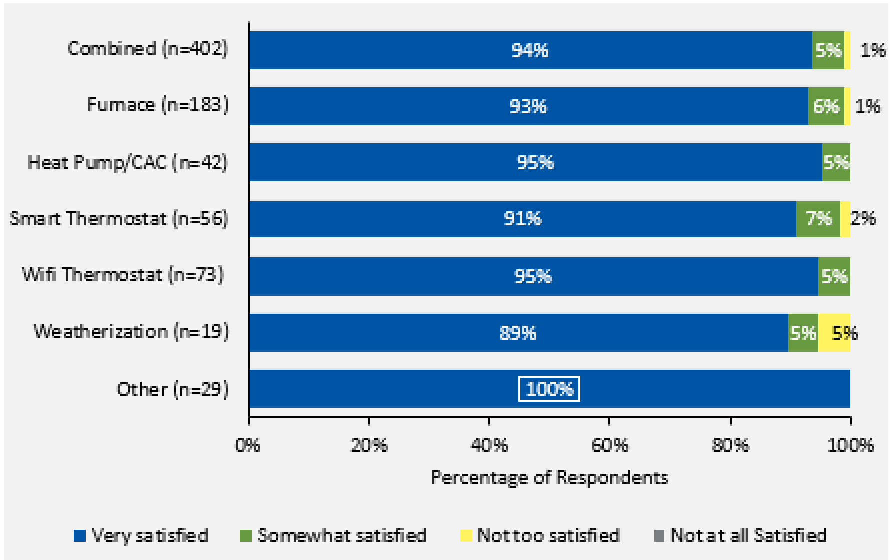
Starting in 2019, the implementer will add “plug-and-play” marketing materials to the online contractor portal that contractors can distribute to customers once they add their logo to the templates. The implementer also sends mailers to Vectren customers and coordinates with Vectren to conduct mass media campaigns via radio ads, TV ads, and social media. The program implementer also began providing point-of-purchase (POP) marketing for thermostats and air purifiers in retail stores.

Vectren’s website provides customers a list of 71 contractors who regularly participate in the program and who have access to Vectren’s Residential Rebate Contractor Portal. However, customers are not required to use contractors from that list. The program implementer reported that 806 contractors and 144 retailers participated in the 2018 program. The program requires contractor installation only for weatherization measures, but a majority of surveyed customers (61%, n=654) used a contractor to install their equipment. An exception was for smart thermostats. Of 277 customers who had a smart thermostat installed, just 21% used a contractor. In contrast, of 91 customers who had a Wi-Fi thermostat installed, 81% used a contractor.

Most surveyed customers (99%, n=400) were able to easily find a contractor. Customers most commonly chose to work with a contractor they already knew (48%, n=395), receive a referral from a friend or neighbor (22%), or conduct an internet search (15%) to find a contractor. Nearly all (99%, n=402) were satisfied with their contractor, similar to 2017 survey results.

Figure 2 shows participant satisfaction with their contractor by measure category. Responses for equipment in the "other" category differed significantly from the rest of the measure categories.[8] The "combined" category represents all customer responses across all measure categories.

**Figure 2. 2018 Participant Satisfaction with Contractor**




Source: 2018 participant survey. Question H5. How satisfied are you with the contractor who installed the equipment? Periods with boxed ratings significantly differed from the previous period results at the 95% level (p<0.05).

## Awareness and Motivation

Consistent with the program's design, surveyed customers most commonly learned of the program through a contractor (42%, n=637), followed by Vectren (36%). Significantly fewer 2018 customers learned about the program through a contractor than in 2017 (59%, n=369).[9] For two measure categories, customers more often heard about the program through Vectren rather a contractor. These measures were smart thermostat (58%, n=272) and weatherization (47%, n=15).

Most surveyed contractors relied on word of mouth (20, n=21) as a source of business rather than actively promoting the program through traditional marketing such as mailers, fliers, or advertisements. Eleven contractors did not report marketing the program to customers; these responses are not correlated with the number of projects completed by the contractors (their project numbers ranged from 1 to 46 for an average of 14.6 projects per contractor).Those who did actively market the program mostly did so through mailers (six), radio advertisements (five), and fliers (four). All contractors (21, n=21) reported discussing the program during sales and scoping discussions with customers *all the time* (nine), *frequently* (11), or *sometimes* (one), and almost all contractors reported that their customers expressed interest in the program (14, n=15). When pitching the program to customers, contractors

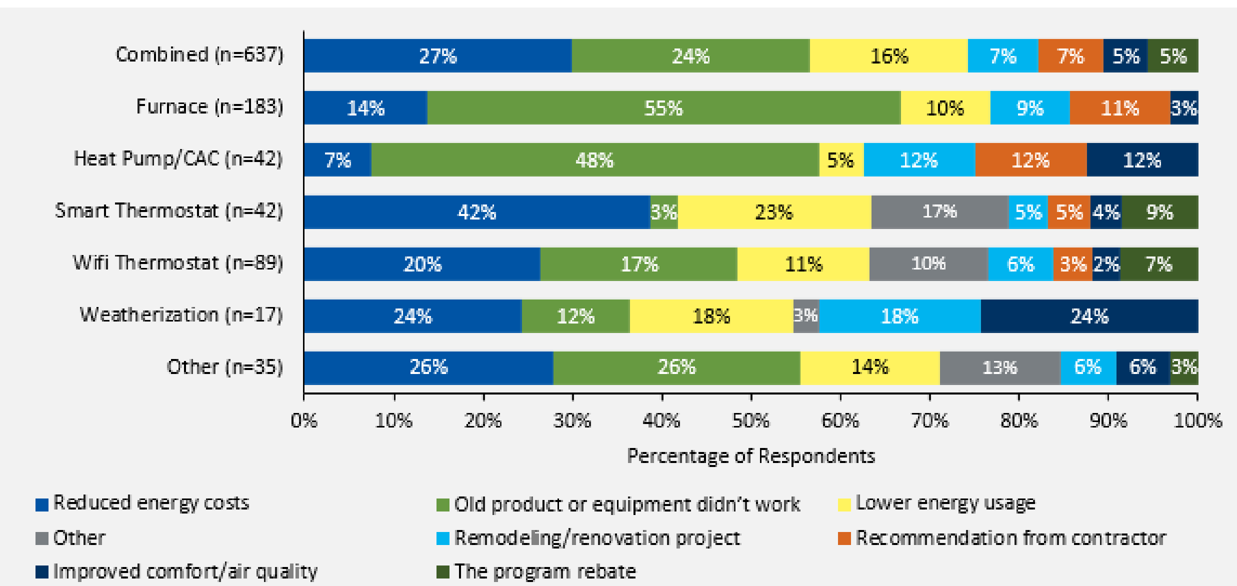
8 $p < 0.05$ using a binomial t-test.

9 $p < 0.05$ using a binomial t-test.

most commonly promoted the benefits of reduced energy costs (15, n=21), short simple payback period (14), or reduced energy use (13).

In 2018, most customers said they participated to reduce energy costs or replace old or nonworking equipment, as in 2017. Top motivations varied by measure for both 2018 and 2017 customers.[10] As shown in Figure 3, furnace customers (55%, n=183) and heat pump/central air conditioner customers (48%, n=42) most commonly participated to replace old or non-working equipment. Wi-Fi thermostat customers (20%, n=89) and smart thermostat customers (42%, n=271) most commonly participated to reduce energy costs, though significantly more Wi-Fi thermostat customers (17%) than smart thermostat customers (3%) participated to replace old, broken equipment.[11] Weatherization customers most commonly wanted to improve their home comfort or air quality (24%, n=17), reduce energy costs (24%), or complete a home renovation or remodel (18%). Unlike the other measures, no weatherization customers were motivated by a recommendation from their contractor.

**Figure 3. 2018 Residential Prescriptive Program Participant Motivations**




Source: 2018 participant survey. Question F2: "What is the most important reason why you purchased he…"

Surveyed contractors most commonly learned of the program from Vectren marketing materials (eight, n=22), Vectren's website (five), or a Vectren utility representative (five). Just three contractors learned of the program from the program implementer, although the program implementer is the main marketing mechanism for contractors. When asked how they prefer to receive program updates, nine

---

[10] The 2018 survey asked respondents to name their top motivation, while the 2017 asked respondents to list up to three motivations, which makes it difficult to test for significance between 2018 and 2017.

[11] $p < 0.01$ using a binomial t-test.

contractors (n=21) said emails, followed by Vectren's website (seven) and program staff (10). No contractors chose trade ally breakfasts as a preferred source of information.

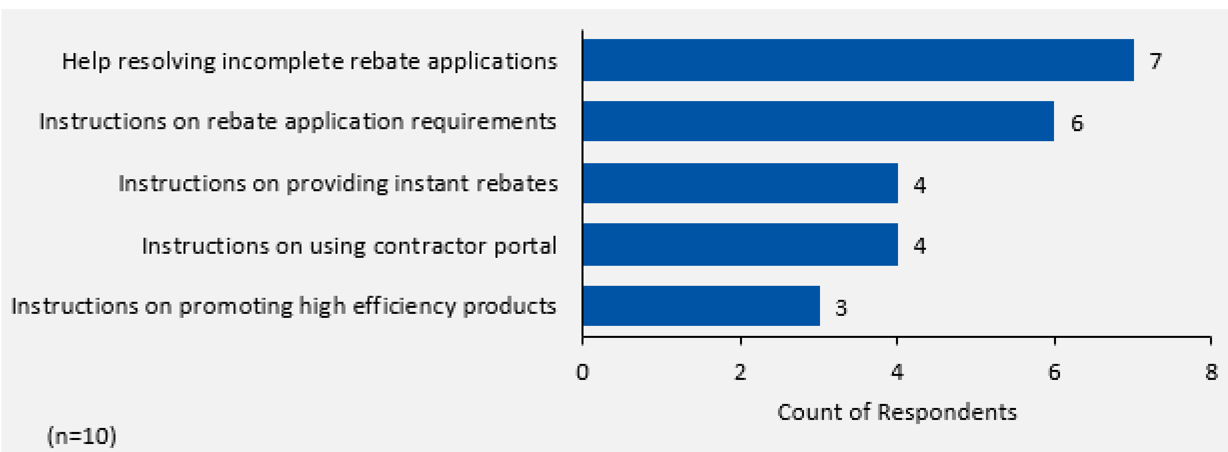
Almost three-quarters of contractors (15, n=21) would like to hear from Vectren or CLEAResult staff monthly or quarterly. Two-thirds (10, n=16) said they heard from the program *annually* (six contractors) or *never* (four contractors). The frequency of hearing from program staff, as reported by contractors, is correlated with annual program activity:

- Those who heard from program staff *monthly* or *quarterly* (six contractors) installed on average 21 projects in 2018.
- Those who heard from program staff *annually* installed on average 18.5 projects in 2018.
- Those who have never heard from program staff installed on average 3.25 projects in 2018.

Ten contractors (n=19) reported receiving support from program staff, and all of these were satisfied with the support they received from program staff. Those who reported receiving report installed on average 15.4 projects in 2018. However, those who reported they did not receive support installed on average 14.4 projects in 2018. As shown in Figure 4, the help contractors most often received was with incomplete applications or application requirements.

The program implementer reported that the program has a strong contractor pool, and the implementer worked to increase contractor engagement by reaching out to contractors who submitted 10 or fewer rebate applications in 2018. The program implementer met with these contractors to ensure they had the program materials and information necessary for program promotion.

**Figure 4. Support Received from Vectren or CLEAResult staff**




Source: 2018 Contractor survey. Question D7. "What type of support do you receive from program staff (CLEAResult or Vectren) regarding the Residential Rebate Program? Select all that apply." Multiple responses allowed.

## Application Process

Most customer respondents across all measure categories (71%, n=588) reported taking the lead in completing the rebate application. Respondents who installed a heat pump/central air conditioner (62%, n=39) and weatherization (67%, n=18) were most likely to report that their contractor report took the lead. (As previously stated, Vectren requires a contractor only for weatherization measures.)

Contractors reported they are very involved in the rebate application process as well. Almost two-thirds (n=18) said they assist customers with applications *all the time* (seven) or *frequently* (four). Just five contractors *never* assist customers.

Although the category of measures installed by contractors did not correspond with the frequency of contractor application assistance, contractor level of engagement with the program did. Of the five contractors who *never* assist customers, all completed four or fewer projects for the program in 2018. In contrast, the 11 contractors who *always* or *frequently* assist customers completed on average of 14 projects in 2018.

Most customers (96% n=488) found the application easy to complete, and most contractors (13, n=21) did not face challenges with the application. Four contractors reported the following challenges (multiples responses allowed): application requires too much information (three), application takes too long to complete (three), application requires too many supporting documents (one), and the program takes too long to send rebate payment (one).

Most customers (96%, n=508) were satisfied with the time it took to receive their rebate check. Responses were similar across measure categories. Approximately half (55%, n=436) said their rebate check took one to four weeks to arrive in the mail, 12% said it took five to six weeks, and just 5% said it took longer than six weeks. Vectren's rebate application instructs customers to wait up to six weeks to receive their rebate.

Thirteen customers and seven contractors provided suggestions for how to improve the rebate application, which are shown in Table 14.

**Table 14. 2018 Customer and Contractor Suggestions to Improve Rebate Application Process**

| Customer Suggestions (n=13) | Contractor Suggestions (n=7) |
|---|---|
| • Make application more user-friendly (10): respondents mentioned that the application had confusing or redundant wording (4), required too much documentation (5), and required the help of program representatives to complete (1)<br>• Improve the functionality of the website for the online rebate application (2).<br>• Improve communication around application requirements (2): one reported a broken link to the application, the other reported being kicked out of the website multiple times. | • Create an online portal for customers or contractors to submit applications (2)[1]<br>• Send confirmation emails to customers to confirm receipt of application (2)[1]<br>• When notifying contractors that an application error exists, specify the error so that contractors can quickly fix the application (1)<br>• Provide additional information about program requirements (1)<br>• Create a gas only rebate application form (1)[2] |

[1] It should be noted, these suggestions are already offered by Vectren, but may be unknown to contractor survey respondents.
[2] Vectren is already planning to implement this suggestion for the 2019 program year.

Most participants submitted their application online (55%, n=457) rather than mailing in paper applications. A higher proportion of heat pump/central air conditioner respondents (82%, n=22) and weatherization respondents (91%, n=11) completed paper applications, which relates to the fact that they most often let the contractors take the lead. Satisfaction with the application process did not differ significantly between online and paper applicants.

The program also allows contractors to choose whether to offer instant discounts (by applying for a rebate on behalf of the customer) or have customers apply for the rebates themselves. Vectren and the program implementer reported they encourage, but do not require contractors, to provide instant discounts because the upfront cost of the discount (while waiting for rebate reimbursement) and administrative responsibility of completing program paperwork could deter smaller contractors from participating in the program. The program implementer said 18% of the applications processed in 2018 used an instant discount.

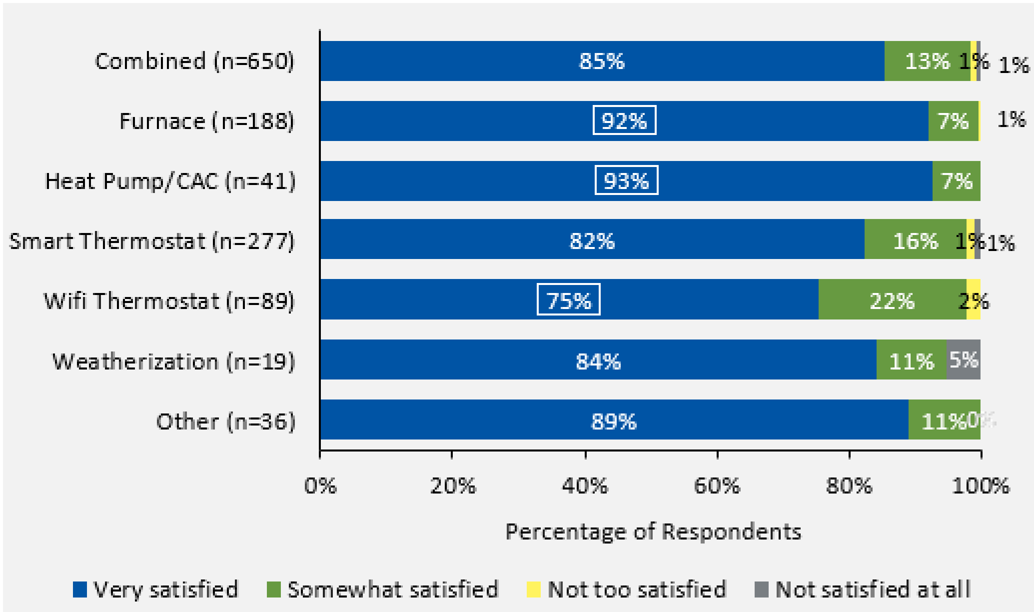
According to surveyed contractors, the primary barrier to offering instant rebates is the risk of not getting reimbursed if the customer is not eligible for the rebate (five contractors, n=13); one specified not being able to afford the upfront cost of offering instant discounts. The six surveyed contractors who offered instant discounts reported waiting three to eight weeks to receive rebate reimbursements. Three contractors received their reimbursement within three to four weeks and were satisfied with this timing. Two contractors who received their rebates within six to eight weeks were not satisfied. One contractor did not know how long the process took.

## Satisfaction

In 2018, most customers (98%, n=650) were satisfied with the measures for which they received incentives, consistent with 2017 survey results. Significantly more respondents who installed a furnace, heat pump/central air conditioner, and other equipment were satisfied with their equipment than were all respondents combined.[12]

[12] $p < 0.05$ using a binomial t-test.

**Figure 5. Participant Satisfaction with Installed Measure**




Source: 2018 participant survey. Question N1: "How satisfied are you with the equipment you installed?"
Periods with boxed ratings significantly differed from the previous period results at the 95% level ($p<0.05$).

Customer respondents also expressed high satisfaction with the program overall. Significantly more 2018 respondents (99%, n=650) were satisfied compared to 2017 respondents (97%, n=357). Significantly more (100%) of heat pump/central air conditioner (n=42), other equipment (n=36), and weatherization respondents (n=19) were satisfied with the program overall than were respondents of all measures combined.[13]

Most customer respondents (82%, n=571) had no suggestions for how to improve the program. Of the 98 who did, the most common suggestion was that the program increase the rebate amount (22%), add more energy-saving items (18%), and improve the application process (16%). Other recommendations were to improve customer service (10%), reduce rebate wait time (7%), other (7%), and apply rebate to utility bill (5%).

Most contractors (18, n=20) said it was easy to participate in the program. The two contractors who did not find it easy to participate were both furnace contractors. Of 21 contractors, all but one was satisfied with the program. One contractor said the paperwork process for the program took too long. Eighteen contractors were likely to recommend the program to a business colleague, and 20 were likely to recommend the program to customers.

[13] $p < 0.01$ using a binomial t-test. Note the small sample size of the weatherization category.

# Impact Evaluation

## Impact Evaluation Methods and Findings

The Residential Prescriptive Program impact evaluation included multiple data collection efforts and analysis tasks:

- Tracking database review
- Engineering analysis based on 2015 Indiana TRM v2.2 and other evaluation resources
- Mixed mode survey with 711 program participants, stratified by measure category

## Gross Savings Review

Cadmus assigned savings to each measure in the tracking database using savings analyses derived primarily from the 2015 Indiana TRM and participant survey data. Additional details regarding the calculations and assumptions used to estimate gross savings are provided in Appendix A. Impact Evaluation Methodology. Table 15 provides per-unit annual gross savings for each program measure.

**Table 15. 2018 Residential Prescriptive Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| **HVAC** | | | | |
| Air Source HP 16 SEER | 791 | 881 | 0.374 | 0.463 |
| Air Source HP 18 SEER | 1,617 | 1,590 | 0.479 | 0.530 |
| CAC 16 SEER | 300 | 435 | 0.389 | 0.540 |
| CAC 18 SEER | 705 | 666 | 0.710 | 0.577 |
| Dual Fuel Air Source HP 16 SEER | 1,089 | 695 | 0.389 | 0.330 |
| Dual Fuel Air Source HP 18 SEER | 1,499 | 992 | 0.127 | 0.325 |
| Ductless HP 17 SEER 9.5 HSPF | 3,625 | 3,804 | 0.440 | 0.406 |
| Ductless HP 19 SEER 9.5 HSPF | 3,675 | 3,066 | 0.449 | 0.380 |
| Ductless HP 21 SEER 10 HSPF | 3,770 | 2,932 | 0.421 | 0.368 |
| Ductless HP 23 SEER 10 HSPF | 3,788 | 4,306 | 0.342 | 0.711 |
| ECM HVAC Motor | 298 | 301 | 0.115 | 0.051 |
| **Thermostats** | | | | |
| Programmable Thermostats (2017 Carry Over)[2] | 185 | 209 | 0.000 | 0.000 |
| Nest On-Line Store (Dual Fuel) | 378 | 301 | 0.900 | 0.000 |
| Nest On-Line Store (Electric) | 467 | 772 | 0.900 | 0.000 |
| Smart Programmable Thermostat (Dual) | 370 | 299 | 0.000 | 0.000 |
| Smart Programmable Thermostat (Electric) | | 740 | | 0.000 |
| Wi Fi Thermostat | 405 | 295 | 0.000 | 0.000 |
| **Weatherization** | | | | |
| Duct Sealing (Dual Fuel, 2017 Carry Over)[3] | 239 | 218 | 0.401 | 0.382 |
| Attic Insulation (Electric) | 2,625 | 3,019 | 0.327 | 0.103 |
| Attic Insulation (Dual Fuel) | 296 | 304 | 0.274 | 0.464 |
| Wall Insulation (Electric) | 889 | 801 | 0.090 | 0.019 |
| Wall Insulation (Dual Fuel) | 59 | 29 | 0.039 | 0.259 |
| **Other** | | | | |
| Air Purifier | 493 | 681 | 0.056 | 0.078 |
| Heat Pump Water Heater | 2,295 | 2,557 | 0.324 | 0.349 |
| Pool Heater | 971 | 1,266 | 0.000 | 0.000 |
| Variable Speed Pool Pump | 1,220 | 1,173 | 1.716 | 1.716 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.
[2] Vectren discontinued programmable thermostats in 2018 due to a market shift to smart and Wi-Fi thermostats. This measure is the result of rebates filed in late 2017 that Vectren processed in early 2018.
[3] Vectren discontinued this measure in 2018 to redesign it for reintroduction in 2019. This measure is the result of rebates filed in late 2017 that Vectren processed in early 2018.

Vectren's *ex ante* savings are predominantly derived from the 2016 evaluated savings, though a handful of *ex ante* savings are from the 2015 evaluated savings. In general, Cadmus' 2018 evaluation used the same methodology as in 2016, so the differences between *ex ante* and *ex post* are because of differences in program tracking data and participant survey results.

Savings for programmable thermostats increased significantly because participant survey results regarding the correct use of the thermostats were much higher than in previous years.

A programmatic change influenced the per-unit savings of some thermostat measures. In the 2016 program, Vectren had only two categories of thermostats: programmable and smart Wi-Fi thermostats. In 2017, Vectren broke the smart Wi-Fi thermostat category into three separate thermostat categories: Nest on-line store, smart programmable, and Wi-Fi thermostats. Nest and smart programmable thermostats generally demonstrate learning capabilities, and therefore achieve a significantly higher savings rate than the generally non-learning Wi-Fi thermostats.

For the 2018 evaluation, Cadmus made an adjustment to the 2016 methodology for thermostat measures. Cadmus incorporated central air conditioner saturation from the participant survey into the cooling savings because the rebate application had no requirement for customers to own a central cooling system. This change decreased the cooling savings for thermostat measures by 7%. Although reported kW savings for most thermostat measures were consistent with the 2015 Indiana TRM and past evaluations, the value for Nest thermostats was not consistent. The 2015 Indiana TRM states a 0% coincident peak factor for smart thermostats. As a result, in the absence of conclusive results from empirical studies on peak savings, Cadmus conservatively assigned no peak kW savings. For planning purposes, Cadmus recommends Vectren continue to assume no peak demand savings for smart, Nest, and Wi-Fi thermostats.

Cadmus changed its approach for ductless heat pumps (DHP) for the 2018 evaluation by choosing to use the Illinois TRM V6.0 instead of the Illinois TRM v4.0, as in previous evaluations. The Illinois TRM updated its DHP approach in more recent versions, after acquiring DHP-specific full load hours. Despite the change in methodology, however, the differences between *ex ante* and *ex post* savings for the DHP measures are because of variations in equipment capacity from the program data. The Illinois TRM V6.0 approach yields similar (albeit slightly higher) results to the Illinois TRM V4.0 approach, all else being equal.

The difference between the *ex ante* and *ex post* savings for the dual fuel ASHP measures is because of differences in equipment capacity from the program tracking data. The average capacities from the 2018 data were significantly lower than in 2015 and 2016. The dual fuel ASHP 18 SEER measure *ex ante* savings are from the 2015 evaluated savings, and the dual fuel ASHP 16 SEER measure *ex ante* savings are from the 2016 evaluated savings.

All other differences between *ex ante* and *ex post* savings are from differences in yearly program tracking data (measure specifications) and participant survey results. This is also true when comparing 2018 evaluated savings to savings of previous evaluation years. The attic insulation (electric) measure had unusually high savings in 2017 because of an unusual occurrence of zero R-value baseline. In 2018, savings were back at expected levels. Conversely, the wall insulation (dual fuel) measure savings were lower than in previous years because of abnormally small conditioned square footage in the program tracking data for this measure. Table 16 lists the evaluated gross per-unit energy savings for each program measure by year.

**Table 16. Residential Prescriptive Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **HVAC** | | | | |
| Air Source HP 16 SEER | 1,155 | 852 | 694 | 881 |
| Air Source HP 18 SEER | 1,626 | 1,444 | 1,294 | 1,590 |
| CAC 16 SEER | 295 | 300 | 328 | 435 |
| CAC 18 SEER | 574 | 705 | 448 | 666 |
| Dual Fuel Air Source HP 16 SEER | 767 | 787 | 567 | 695 |
| Dual Fuel Air Source HP 18 SEER | 1,499 | 1,089 | 890 | 992 |
| Ductless HP 17 SEER 9.5 HSPF | 3,847 | 3,625 | 3,751 | 3,804 |
| Ductless HP 19 SEER 9.5 HSPF | 3,920 | 3,675 | 3,792 | 3,066 |
| Ductless HP 21 SEER 10 HSPF | 3,925 | 3,770 | 3,835 | 2,932 |
| Ductless HP 23 SEER 10 HSPF | 4,032 | 3,788 | 3,640 | 4,306 |
| ECM HVAC Motor | 385 | 298 | 303 | 301 |
| **Thermostats** | | | | |
| Programmable Thermostats (2017 Carry Over) | 185 | 152 | 138 | 209 |
| Nest On-Line Store (Dual Fuel) | N/A | N/A | 345 | 301 |
| Nest On-Line Store (Electric) | N/A | N/A | 987 | 772 |
| Smart Programmable Thermostat (Dual) | 412 | 370 | 344 | 326 |
| Smart Programmable Thermostat (Electric) | N/A | N/A | 937 | 740 |
| Wi Fi Thermostat | N/A | N/A | 311 | 295 |
| **Weatherization** | | | | |
| Duct Sealing (Dual Fuel, 2017 Carry Over) | 229 | 239 | 260 | 218 |
| Attic Insulation (Electric) | 3,383 | 2,625 | 4,260 | 3,019 |
| Attic Insulation (Dual Fuel) | 340 | 296 | 337 | 399 |
| Wall Insulation (Electric) | 1,158 | 889 | 782 | 801 |
| Wall Insulation (Dual Fuel) | 60 | 59 | 57 | 29 |
| **Other** | | | | |
| Air Purifier | N/A | N/A | N/A | 681 |
| Heat Pump Water Heater | 2,291 | 2,295 | 2,431 | 2,557 |
| Pool Heater | 667 | 971 | 1,135 | 1,266 |
| Variable Speed Pool Pump | 1,173 | 1,220 | 1,173 | 1,173 |

## Measure Verification

Cadmus calculated verified savings for the Residential Prescriptive Program by applying an installation rate by survey measure group, as shown in Table 17. The measure counts in the tracking data matched the scorecard perfectly. Installations rates below 100% are because of the in-service rates (ISRs) determined from the participant survey for each measure group.

**Table 17. 2018 Residential Prescriptive Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported | Audited | Verified | |
| **HVAC** | | | | |
| Air Source HP 16 SEER | 276 | 276 | 276 | 100% |
| Air Source HP 18 SEER | 55 | 55 | 55 | 100% |
| CAC 16 SEER | 1,616 | 1,616 | 1,616 | 100% |
| CAC 18 SEER | 137 | 137 | 137 | 100% |
| Dual Fuel Air Source HP 16 SEER | 10 | 10 | 10 | 100% |
| Dual Fuel Air Source HP 18 SEER | 1 | 1 | 1 | 100% |
| Ductless HP 17 SEER 9.5 HSPF | 11 | 11 | 11 | 100% |
| Ductless HP 19 SEER 9.5 HSPF | 58 | 58 | 58 | 100% |
| Ductless HP 21 SEER 10 HSPF | 19 | 19 | 19 | 100% |
| Ductless HP 23 SEER 10 HSPF | 26 | 26 | 26 | 100% |
| ECM HVAC Motor | 2,209 | 2,209 | 2,200 | 100% |
| **Thermostats** | | | | |
| Programmable Thermostats (2017 Carry Over) | 48 | 48 | 46 | 96% |
| Nest On-Line Store (Dual Fuel) | 181 | 181 | 178 | 98% |
| Nest On-Line Store (Electric) | 50 | 50 | 49 | 98% |
| Smart Programmable Thermostat (Dual) | 1,265 | 900 | 883 | 98%[1] |
| Smart Programmable Thermostat (Electric) | | 365 | 358 | 98%[1] |
| Wi Fi Thermostat | 542 | 542 | 521 | 96% |
| **Weatherization** | | | | |
| Duct Sealing (Dual Fuel, 2017 Carry Over) | 12 | 12 | 12 | 100% |
| Attic Insulation (Electric) | 23 | 23 | 23 | 100% |
| Attic Insulation (Dual Fuel) | 111 | 111 | 111 | 100% |
| Wall Insulation (Electric) | 15 | 15 | 15 | 100% |
| Wall Insulation (Dual Fuel) | 94 | 94 | 94 | 100% |
| **Other** | | | | |
| Air Purifier | 10 | 10 | 10 | 100% |
| Heat Pump Water Heater | 7 | 7 | 7 | 100% |
| Pool Heater | 7 | 7 | 7 | 100% |
| Variable Speed Pool Pump | 177 | 177 | 177 | 100% |
| **Total** | **6,960** | **6,960** | **6,900** | **99%** |

[1] Based on audited installations rather than reported (since reported installations were not recorded by fuel)

Table 18 shows historical installation rates for each program measure. These vary year to year because of yearly differences in reported to audited installations and participant survey self-report ISR data.

**Table 18. Residential Prescriptive Historical Installation Rates**

| Measure | Installation Rate[1] | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **HVAC** | | | | |
| Air Source HP 16 SEER | 100% | 103% | 97% | 100% |
| Air Source HP 18 SEER | 100% | 100% | 97% | 100% |
| CAC 16 SEER | 100% | 100% | 97% | 100% |
| CAC 18 SEER | 101% | 101% | 97% | 100% |
| Dual Fuel Air Source HP 16 SEER | 100% | 200% | 97% | 100% |
| Dual Fuel Air Source HP 18 SEER | 80% | 100% | 97% | 100% |
| Ductless HP 17 SEER 9.5 HSPF | 100% | 100% | 97% | 100% |
| Ductless HP 19 SEER 9.5 HSPF | 100% | 100% | 97% | 100% |
| Ductless HP 21 SEER 10 HSPF | 100% | 106% | 97% | 100% |
| Ductless HP 23 SEER 10 HSPF | 100% | 100% | 97% | 100% |
| ECM HVAC Motor | 100% | 100% | 99% | 100% |
| **Thermostats** | | | | |
| Programmable Thermostats (2017 Carry Over) | 100% | 103% | 97% | 96% |
| Nest On-Line Store (Dual Fuel) | N/A | N/A | 100% | 98% |
| Nest On-Line Store (Electric) | N/A | N/A | 100% | 98% |
| Smart Programmable Thermostat (Dual) | 100% | 102% | 100% | 98% |
| Smart Programmable Thermostat (Electric) | N/A | N/A | 99% | 98% |
| Wi Fi Thermostat | N/A | N/A | 99% | 96% |
| **Weatherization** | | | | |
| Duct Sealing (Dual Fuel, 2017 Carry Over) | 100% | 100% | 100% | 100% |
| Attic Insulation (Electric) | 103% | 92% | 100% | 100% |
| Attic Insulation (Dual Fuel) | 99% | 95% | 100% | 100% |
| Wall Insulation (Electric) | 100% | 114% | 100% | 100% |
| Wall Insulation (Dual Fuel) | 100% | 102% | 100% | 100% |
| **Other** | | | | |
| Air Purifier | N/A | N/A | N/A | 100% |
| Heat Pump Water Heater | 100% | 69% | 99% | 100% |
| Pool Heater | 100% | 99% | 94% | 100% |
| Variable Speed Pool Pump | 100% | 99% | 94% | 100% |

[1] Installation rates above 100% indicate audited installations are greater than reported installations.

## Net-to-Gross Analysis

Cadmus stratified the 2018 Residential Prescriptive Program participant survey by six measure categories to calculate NTG at the measure category level. The methodology and findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings. Cadmus weighted the measure category-level NTG estimates by the *ex post* population energy savings to arrive at an overall program-level NTG estimate of 62%, as shown in Table 19. The overall program NTG of 63% is weighted by the combination of electric and gas gross evaluated program population savings. However, the electric-specific NTG ratio of 68% is weighted specifically to electric savings due to the application of measure category level NTG estimates to evaluated gross population electric savings. The overall program NTG of 63% is heavily weighted toward the gas-specific NTG estimate of 62% because *ex post* gross gas savings account for 94% of the total 2018 Residential Prescriptive Program energy savings.

**Table 19. 2018 Residential Prescriptive Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio | Total Program *Ex Post* MMBTU Savings |
|---|---|---|---|---|
| Furnace (n=191) | 45% | 1% | 56% | 112,730 |
| Heat Pump/CAC (n=57) | 38% | 3% | 65% | 7,436 |
| Smart Thermostat (n=280) | 25% | 3% | 78% | 37,198 |
| Wi-Fi Enabled Thermostat (n=108) | 27% | 5% | 78% | 4,677 |
| Weatherization (n=26) | 34% | 2% | 68% | 4,627 |
| Other (n=47) | 32% | 1% | 69% | 1,464 |
| **Total Program (n=709)[2]** | **39%[1]** | **2%[1]** | **63%[1]** | **168,133** |
| **Electric-Specific NTG** | | | **68%** | **10,917** |
| **Gas-Specific NTG** | | | **62%** | **157,216** |

[1] Weighted by evaluated *ex post* program population MMBtu savings
[2] 709 respondents answered the NTG questions

Table 20 lists historical program-level NTG ratios by year. The primary factor accounting for the increase in overall program NTG from 2017 to 2018 is that furnace NTG and smart thermostat NTG each increased by at least 20 percentage points from 2017 to 2018. Furnace and smart thermostats accounted for 89% of the 2018 evaluated gross population energy savings and 84% of the 2017 evaluated gross population energy savings.

**Table 20. Residential Prescriptive Historical Net-to-Gross Ratios**

| Program Year | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| 2015 | 53% | 3% | 50% |
| 2016 | 50% | 3% | 53% |
| 2017 | 58% | 2% | 44% |
| 2018 | 39% | 2% | 63% |

## *Freeridership and Spillover Findings*

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[14]

[14] *Intention* and *influence* freeridership scores both have a maximum of 100%.

Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[15] as shown in the following equation:

$$\text{Final Freeridership \%} = \frac{\mathit{Intention}\ \text{FR Score}(0\%\ \text{to}\ 100\%) + \mathit{Influence}\ \text{FR Score}(0\%\ \text{to}\ 100\%)}{2}$$

Table 21 summarizes intention, influence, and overall freeridership scores for each measure category.

**Table 21. 2018 Residential Prescriptive Intention, Influence and Overall Freeridership Score by Measure Category**

| Measure Category | n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|---|
| Furnace | 191 | 75% | 15% | 45% |
| Heat Pump/CAC | 57 | 71% | 4% | 38% |
| Smart Thermostat | 280 | 39% | 10% | 25% |
| Wi-Fi Enabled | 108 | 44% | 10% | 27% |
| Weatherization | 26 | 57% | 11% | 34% |
| Other | 47 | 44% | 19% | 32% |

Thirty participants reported installing a total of 56 high-efficiency measures after participating in the program. These respondents did not receive an incentive and said participation in the program was very influential on their decision to install additional measures. Cadmus attributed spillover savings to measures including high-efficiency clothes washers, dishwashers, dehumidifiers, refrigerators, water heaters, insulation, windows, duct sealing, smart thermostats, and HVAC equipment.

Cadmus used *ex post* savings estimated for the 2018 Residential Prescriptive Program evaluation in combination with the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the program. Cadmus divided the total survey sample spillover savings for each measure category by the gross program savings from the survey sample to obtain the measure category spillover estimates in Table 22.

15 *Ex post* gross program savings.

**Table 22. 2018 Residential Prescriptive Program Spillover Estimates by Measure Category**

| Measure Category | Survey Sample Spillover MMBtu Savings | Survey Sample Program MMBtu Savings | Percentage Spillover Estimate |
|---|---|---|---|
| Furnace | 20.1 | 2,651.2 | 1% |
| Heat Pump/CAC | 7.4 | 229.6 | 3% |
| Smart Thermostat | 65.2 | 2,139.3 | 3% |
| Wi-Fi Enabled | 13.7 | 276.9 | 5% |
| Weatherization | 7.7 | 373.5 | 2% |
| Other | 2.0 | 273.4 | 1% |

Cadmus attempted to collect freeridership data from contractors during interviews, however, the data we received represented less than 2% of the program's furnace and thermostat sales and Cadmus did not apply these data to the measure-level freeridership findings.

## Evaluated Net Savings Adjustments

Table 23 and Table 24 list evaluated net savings for the Residential Prescriptive Program. The overall program NTG of 63% presented in the Net-to-Gross Analysis section is weighted by the combination of electric and gas gross evaluated program savings. However, the overall program-level NTG estimates presented in these tables are weighted specifically to electric savings due to the application of measure category level NTG ratios to evaluated gross population electric savings. The program achieved net savings of 2,180,300 kWh and 1,098.15 coincident kW demand reduction.

**Table 23. 2018 Residential Prescriptive Program Electric Savings (kWh)**

| Measure | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rate | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| **HVAC** | | | | | | | |
| Air Source HP 16 SEER | 218,426 | 218,426 | 218,426 | 243,104 | 111% | 65% | 158,018 |
| Air Source HP 18 SEER | 88,953 | 88,953 | 88,953 | 87,448 | 98% | 65% | 56,841 |
| CAC 16 SEER | 484,357 | 484,357 | 484,357 | 702,825 | 145% | 65% | 456,836 |
| CAC 18 SEER | 96,531 | 96,531 | 96,531 | 91,240 | 95% | 65% | 59,306 |
| Dual Fuel Air Source HP 16 SEER | 10,894 | 10,894 | 10,894 | 6,953 | 64% | 65% | 4,519 |
| Dual Fuel Air Source HP 18 SEER | 1,499 | 1,499 | 1,499 | 992 | 66% | 65% | 645 |
| Ductless HP 17 SEER 9.5 HSPF | 39,873 | 39,873 | 39,873 | 41,841 | 105% | 65% | 27,197 |
| Ductless HP 19 SEER 9.5 HSPF | 213,141 | 213,141 | 213,141 | 177,857 | 83% | 65% | 115,607 |
| Ductless HP 21 SEER 10 HSPF | 71,625 | 71,625 | 71,625 | 55,713 | 78% | 65% | 36,213 |
| Ductless HP 23 SEER 10 HSPF | 98,500 | 98,500 | 98,500 | 111,960 | 114% | 65% | 72,774 |
| ECM HVAC Motor | 657,430 | 657,430 | 654,736 | 661,088 | 101% | 65% | 429,707 |
| **Thermostats** | | | | | | | |

| Measure | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rate | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| 2017 Carry Forward Programmable Thermostats | 8,903 | 8,903 | 8,551 | 9,619 | 108% | 78% | 7,503 |
| Nest On-Line Store (Dual) | 68,366 | 68,366 | 67,100 | 53,424 | 78% | 78% | 41,671 |
| Nest On-Line Store (Electric) | 23,333 | 23,333 | 22,901 | 37,895 | 162% | 78% | 29,558 |
| Smart Programmable Thermostat (Dual) | 467,705 | 332,754 | 326,592 | 264,502 | N/A[1] | 78% | 206,312 |
| Smart Programmable Thermostat (Electric) | | 134,950 | 132,451 | 265,189 | N/A[1] | 78% | 206,847 |
| Wi-Fi Thermostat | 219,559 | 219,559 | 210,892 | 153,383 | 70% | 78% | 119,639 |
| **Weatherization** | | | | | | | |
| 2017 Carry Forward Duct Sealing Gas Heating w/A/C (Dual) | 2,867 | 2,867 | 2,867 | 2,610 | 91% | 68% | 1,775 |
| Attic Insulation – All EL | 60,378 | 60,378 | 60,378 | 69,429 | 115% | 68% | 47,212 |
| Attic Insulation – Dual Fuel | 32,873 | 32,873 | 32,873 | 33,699 | 103% | 68% | 22,915 |
| Wall Insulation – All EL | 13,341 | 13,341 | 13,341 | 12,015 | 90% | 68% | 8,170 |
| Wall Insulation – Dual Fuel | 5,512 | 5,512 | 5,512 | 2,758 | 50% | 68% | 1,875 |
| **Other** | | | | | | | |
| Air Purifier | 4,927 | 4,927 | 4,927 | 6,811 | 138% | 69% | 4,699 |
| HP Water Heater | 16,064 | 16,064 | 15,998 | 17,824 | 111% | 69% | 12,299 |
| Pool Heater | 6,797 | 6,797 | 6,797 | 8,865 | 130% | 69% | 6,117 |
| Variable Speed Pool Pump | 215,931 | 215,931 | 215,931 | 207,546 | 96% | 69% | 143,206 |
| **Total** | **3,127,784** | **3,127,784** | **3,105,646** | **3,326,588** | **106%** | **68%** | **2,277,461** |

[1] The scorecard did not break these measures out by fuel type. As a result, Cadmus cannot calculate a realization rate for these measures.

**Table 24. 2018 Residential Prescriptive Program Demand Reduction (Coincident Peak kW)**

| Measure | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rate | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported[1] | Audited | Verified | | | | |
| **HVAC** | | | | | | | |
| Air Source HP 16 SEER | N/A | 103.28 | 103.28 | 127.92 | N/A | 65% | 83.15 |
| Air Source HP 18 SEER | N/A | 26.36 | 26.36 | 29.16 | N/A | 65% | 18.95 |
| CAC 16 SEER | N/A | 627.98 | 627.98 | 872.94 | N/A | 65% | 567.41 |
| CAC 18 SEER | N/A | 97.31 | 97.31 | 79.01 | N/A | 65% | 51.36 |
| Dual Fuel Air Source HP 16 SEER | N/A | 3.89 | 3.89 | 3.30 | N/A | 65% | 2.14 |
| Dual Fuel Air Source HP 18 SEER | N/A | 0.13 | 0.13 | 0.32 | N/A | 65% | 0.21 |
| Ductless HP 17 SEER 9.5 HSPF | N/A | 4.84 | 4.84 | 4.46 | N/A | 65% | 2.90 |
| Ductless HP 19 SEER 9.5 HSPF | N/A | 26.04 | 26.04 | 22.01 | N/A | 65% | 14.31 |
| Ductless HP 21 SEER 10 HSPF | N/A | 8.00 | 8.00 | 6.99 | N/A | 65% | 4.55 |
| Ductless HP 23 SEER 10 HSPF | N/A | 8.90 | 8.90 | 18.50 | N/A | 65% | 12.02 |

| Measure | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rate | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported[1] | Audited | Verified | | | | |
| ECM HVAC Motor | N/A | 254.92 | 253.87 | 112.13 | N/A | 65% | 72.89 |
| **Thermostats** | | | | | | | |
| 2017 Carry Forward Programmable Thermostats | N/A | 0.00 | 0.00 | 0.00 | N/A | 78% | 0.00 |
| Nest On-Line Store (Dual) | N/A | 162.90 | 159.88 | 0.00 | N/A | 78% | 0.00 |
| Nest On-Line Store (Electric) | N/A | 45.00 | 44.17 | 0.00 | N/A | 78% | 0.00 |
| Smart Programmable Thermostat (Dual) | N/A | 0.00 | 0.00 | 0.00 | N/A | 78% | 0.00 |
| Smart Programmable Thermostat (Electric) | | 0.00 | 0.00 | 0.00 | N/A | 78% | 0.00 |
| Wi Fi Thermostat | N/A | 0.00 | 0.00 | 0.00 | N/A | 78% | 0.00 |
| **Weatherization** | | | | | | | |
| 2017 Carry Forward Duct Sealing Gas Heating w/A/C (Dual) | N/A | 4.81 | 4.81 | 4.58 | N/A | 68% | 3.11 |
| Attic Insulation – All EL | N/A | 7.51 | 7.51 | 2.36 | N/A | 68% | 1.60 |
| Attic Insulation – Dual Fuel | N/A | 30.40 | 30.40 | 51.46 | N/A | 68% | 34.99 |
| Wall Insulation – All EL | N/A | 1.34 | 1.34 | 0.28 | N/A | 68% | 0.19 |
| Wall Insulation – Dual Fuel | N/A | 3.65 | 3.65 | 24.31 | N/A | 68% | 16.53 |
| **Other** | | | | | | | |
| Air Purifier | N/A | 0.56 | 0.56 | 0.78 | N/A | 69% | 0.54 |
| HP Water Heater | N/A | 2.27 | 2.26 | 2.43 | N/A | 69% | 1.68 |
| Pool Heater | N/A | 0.00 | 0.00 | 0.00 | N/A | 69% | 0.00 |
| Variable Speed Pool Pump | N/A | 303.80 | 303.80 | 303.80 | N/A | 69% | 209.62 |
| **Total** | **1,570.03** | **1,723.88** | **1,718.97** | **1,666.74** | **106%** | **66%** | **1,098.15** |

[1] The 2018 DSM Scorecard did not report kW savings at the measure level.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated a logic model and key performance indicators (KPIs) for the Residential Prescriptive Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# RESIDENTIAL PRESCRIPTIVE PROGRAM

| | | | |
|---|---|---|---|
| **Market Actor** | **End-Use Customer** | Residential Customers | |
| **Market Barriers** | • Large upfront costs for efficient equipment<br>• Customer perception of application process as a hassle | • Lack of awareness of monetary and environmental benefits of high-efficiency equipment | • Lack of program awareness |
| **Intervention Strategies / Activities** | • Program information and eligibility requirements available on Vectren website | • Digital and broadcast program marketing<br>• Trade ally option to provide rebate as a direct discount to customers at time of purchase | • Multiple methods available for rebate submission, including mail and online applications<br>• Marketing campaigns coordinated with trade allies<br>• Rebates for energy-efficient products |
| **Outcomes** | • Increased program awareness<br>• Increased participation | • Increased availability of high-efficiency products in the marketplace | • Increased customer satisfaction<br>• Reduced energy use |
| **Key Indicators** | • Customer familiarity with marketing materials<br>• Program satisfaction rating | • Achievement of program participation and savings goals | • Likelihood to recommend ratings |

| | | | |
|---|---|---|---|
| **Market Actor** | **Trade Allies** | Installation Contractors | |
| **Market Barriers** | • Trade ally perception of application process is a hassle | | • Perceived risk of carrying upfront cost of instant discount |
| **Intervention Strategies / Activities** | • Multiple methods available for rebate submission, including mail and online applications | • Experienced program implementer who continually works with trade allies to promote program's success | • Program support with rebate applications<br>• Reliable and timely rebate payment |
| **Outcomes** | • Greater numbers of trade allies participating in program | • Greater trade ally satisfaction ratings | |
| **Key Indicators** | • Percentage of participants learning about the program through a contractor | • Trade ally satisfaction with program | • Number of trade allies participating in program |

## Program Performance

Cadmus measured 2015 to 2018 program performance against the KPIs listed in Table 25.

**Table 25. Residential Prescriptive KPIs and 2015-2018 Performance**

| KPI | Performance | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | 279% | 149% | 193% | 105% |
| Achievement of gross kWh savings goals | 251% | 154% | 233% | 105% |
| Achievement of gross kW savings goals | 252% | N/A | 193% | 106% |
| Customer familiarity with Vectren marketing materials | 16% | 19% | 21% | 36% |
| Program satisfaction rating (% very satisfied or somewhat satisfied) | N/A | 99% | 98% | 98% |
| Likelihood to recommend ratings | N/A | 96% | 100% | 98% |
| Percentage of participants learning about the program through a contractor | 53% | 55% | 51% | 42% |
| Trade ally satisfaction with program | N/A | N/A | N/A | 95% |
| Number of trade allies participating in program | 169[1] | 594 | 885 | 806 |

[1] Includes electric program participation only

One-third of surveyed contractors (eight, n=21) reported that customers are not knowledgeable about the benefits of energy efficient equipment, and almost all (14, n=15) reported that customers are very interested in participating in the program once the contractors explain the cost savings that can occur from upgrading their equipment. Most contractors (16, n=19) agreed that the program has increased customer awareness of energy efficiency in their homes.

When asked what benefits their companies have seen from promoting the program, most said providing financial incentives to customers (17, n=22) and increased sales (nine). Two contractors said promoting the program gave them a competitive advantage, and just two reported said they had not seen any benefits from promoting the program.

# Residential New Construction Program

The Residential New Construction (RNC) Program provides incentives to builders for constructing homes that meet a specified Home Energy Rating System (HERS) Index Score. The lower the score – the more energy efficient the home. For instance, a score of 100 represents the energy efficiency of a standard new home. Builders can submit applications for homes in both the Vectren South (dual-fuel) and North (gas only) territories.

HERS raters measure and verify participating home performance; under HERS, the lower the score the higher the efficiency. The U.S. Department of Energy has determined that a typical resale home scores 130 and a standard new home scores 100 on the HERS index.[16] In 2018, Vectren provided two incentive tiers: one for Gold Star homes (rating 61 to 63) and one for Platinum Star homes (rating 60 or less). Vectren decreased the maximum HERS rating to achieve the Gold Star standard from 65 in 2017 to 63 in 2018. The rating thresholds and incentive tiers are shown in Table 26.

**Table 26. 2018 Residential New Construction Program Incentive Summary**

| Tier | HERS Rating | Dual Fuel Incentive | Electric Only Incentive | Gas Only Incentive |
|---|---|---|---|---|
| Gold Star | 61 to 63 | $700 | $700 | $350 |
| Platinum Star | 60 or less | $800 | $800 | $400 |

Vectren works with CLEAResult to implement the RNC Program. CLEAResult markets the program, verifies program eligibility, processes rebates, and documents and tracks program performance.

## Accomplishments

In 2018, Vectren's RNC Program provided incentives to 16 builders for 145 dual fuel and electric only homes: 91 Gold Star and 52 Platinum Star dual fuel homes, as well as one Gold Star and one Platinum Star electric only home.[17] Gold Star homes made up a higher proportion of total dual fuel and electric only homes in 2018 (62%) compared to 2017 (37%) and 2016 (35%).[18]

Table 27 shows the program's electric and dual fuel achievements against goals in 2018. Even with higher performance targets (after strong program performance in 2017) and a lower maximum HERS rating eligible for incentives, the RNC Program met its 2018 participation and savings goals. CLEAResult attributed the success of the program to strong demand as well as marketing efforts.

16 Residential Real Energy Services Network. "What is the HERS Index?" https://www.resnet.us/hers-index

17 Gas only homes are evaluated in the *2018 Vectren DSM Portfolio Natural Gas Impacts Evaluation* report.

18 These program accomplishments represent the electric and dual fuel program only. The Market Effects section in this chapter monitors the number of homes and builders for the combined gas and electric programs to be consistent with prior KPI tracking.

**Table 27. 2018 Residential New Construction Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 317,480 | 313,095 | 101% |
| Gross kW Savings | 203.8 | 201.0 | 101% |
| Participants (Homes) | 145 | 143 | 101% |
| Program Expenditures | $147,367 | $148,550 | 99% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 28 shows the program's gross and net impacts in 2018. The program's realization rates were relatively low at 51% for energy and 31% for demand. The low realization rates were driven by high 2018 deemed savings, which were based on the 2016 program evaluation. The large size of homes in 2016 significantly increased electric savings in that year.

**Table 28. 2018 Residential New Construction Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 317,480 | 317,480 | 317,480 | 162,407 | 51% | 54% | 87,700 |
| Total kW | 203.8 | 189.7 | 189.7 | 62.4 | 31% | 54% | 33.7 |

# *Conclusions and Recommendations*

## Program Satisfaction

**Overall satisfaction remained high for the program in 2018.** Seven of 10 interviewed builders were satisfied with the program overall and eight of 10 were satisfied with the rebate application process. However, when asked how to improve the program, three builders recommended improvements to the application process. Similar to 2017, builders asked for more communication from program staff about rebate processing. One builder suggested that the program implementer email builders when rebate application issues occur to expedite the approval process. According to the program implementer, builders receive a letter if any information is missing from the rebate application they submit. Another builder suggested that the implementer set up a quarterly reminder mechanism for builders to submit rebate applications.

**Recommendation:** Increase program communication to builders about rebate applications. Send quarterly reminders to builders to submit their rebate applications and contact builders quickly, via email, if an issue arises with their application. Consider setting a target timeline for processing rebate applications so builders will quickly receive notification if their application needs to be fixed.

**The change in the program maximum HERS score of 63 from the prior requirement of 65 minimally impacted builder participation.** Despite the program eligibility change, Vectren met its program goals for the number of homes built. Homes were constructed very similarly in 2018 to 2017, when analyzing building practices such as insulation levels or heating and cooling system efficiencies. Sixteen builders submitted applications for electric or dual fuel homes, consistent with the 17 who participated in 2017. Just two builders were less than satisfied with the HERS rating process after the increased requirements. These two builders said that the HERS score of 63 is becoming difficult to obtain, in part because of larger home square footage and more windows. When asked for suggestions to improve the program, just one builder recommended that the program re-examine the increased program standards.

## Platinum versus Gold Homes

**Builders favor Gold Star homes over Platinum Star homes.** The proportion of Gold Star homes for the electric and gas programs has increased each year since 2015, from 47% in 2015 to 73% in 2018, and the average HERS rating of program homes has increased from 58 in 2015 to 61 in 2018. The program met its savings goals for 2018 despite the upward trend in the average HERS ratings for program homes, yet Vectren may want to consider educating builders on how to cost-effectively achieve lower HERS scores and overcome their perceived barriers to achieving Platinum Star certification.

**Recommendation:** Consider educating builders on how to cost-effectively achieve lower HERS scores by building more energy efficient homes and to overcome their perceived barriers to achieving Platinum Star certification. If builder attendance is a concern, consider offering breakfast, lunch, or an incentive to builders for attending the educational seminar. Consider raising the incentive for Platinum Star certification if achieving a certain percentage of Platinum Star certified homes becomes a priority.

## Post-EISA Program Considerations

**Vectren is adding a new incentive tier to account for electric savings adjustments after the EISA 2020 Backstop goes into effect.** The Department of Energy has not made a decision on (but is obligated to decide) whether to amend standards for general service and specialty lamps; therefore, the elimination of the backstop energy conservation standard has not yet been determined. However, if the EISA 2020 backstop goes into effect, the program may have a hard time maintaining program cost-effectiveness without either reducing incentives or increasing savings requirements.

To address this issue,  Vectren will add a Platinum Plus certification tier starting in 2019, which will have the same HERS rating requirements as Platinum Star but will require builders to install energy-efficient HVAC systems (including high-efficiency cooling for homes with electric service).

To ensure that electric savings remain for other tiers, such as Gold Star homes, Vectren will have to consider ways to increase savings from non-lighting measures. This could be achieved by either lowering the minimum HERS score requirement or by introducing prescriptive measure requirements for all program tiers.

Vectren plans to offer the RNC Program as long as it remains cost-effective. Although the program has traditionally resulted in high natural gas savings compared to electric savings, Vectren has not yet targeted one fuel type over the other.

## *Process Evaluation*

# RESIDENTIAL NEW CONSTRUCTION PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

10 participating homebuilder phone interviews

## 2018 Program Changes

Vectren increased 2018 savings goals by 111% and participation goal by 30% in response to strong 2017 program performance.

VECTREN decreased the HERS rating required for Gold Star homes from 65 to 63 to align program performance with program budget so that funds did not run out early

CLEAResult® worked with local realtors to educate them on how to sell energy efficient homes

## 2019 Planned Program Changes

Vectren will introduce a **Platinum Star Plus tier**– same HERs rating as Platinum (60 or less), but will **require the installation of energy-efficient HVAC measures:**

| 2019 Rebate Tier | HVAC Requirement | Rebate |
|---|---|---|
| Vectren natural gas and electric service | 97% AFUE furnace and 16 SEER A/C unit | $1,300 |
| Vectren electric service | 16 SEER heat pump indoor unit | $1,100 |
| Vectren natural gas service | 97% AFUE furnace | $700 |

Habitat for Humanity®: Vectren will provide energy-efficient kits for all Habitat for Humanity program homes. The kit will include a smart thermostat, aerators, and showerhead; LEDs in Vectren's electric territory.

## Key Process Evaluation Findings

15 builders participated in 2018 compared to 17 builders in 2017, yet the number of homes per builder stayed the same (10 homes per builder on average)

8/10 interviewed builders said they were likely to recommend the Residential New Construction program.

10/10 interviewed builders were repeat participants

8/10 builders were satisfied with the application process.

**Builders offered suggestions to improve the RNC program:**

Reduce delays in processing rebate by emailing builders to alert them of issues with their rebate application

Send builders monthly reminders to submit rebate applications

7/10 builders were satisfied with the program overall

The three builders who were less satisfied reported lower rebate amounts, the change of HERS Gold Star standards from 65 to 63, and perceived program limitations on how many rebates a builder can receive

8/10 builders were satisfied with HERS rating process

The builders who were less satisfied felt that HERS has become unrealistic for custom-built homes due to square footage and number of windows the homeowner selects.

# Impact Evaluation

## Impact Evaluation Methods and Findings

The impact evaluation of the RNC Program included these data collection efforts and analysis tasks:

- Review of a random sample of 52 builder applications (out of 145) for completeness and home characteristics
- Develop characteristic energy models using REM/Rate V15.7.1 to verify energy savings based on home characteristics from sample of 52 homes
- Conduct interviews with 10 builder participants to estimate self-report NTG

## Gross Savings Review

In 2018, the program realized 51% of its reported energy savings and 31% of its reported demand savings. Table 29 provides per-unit annual gross savings for each program measure.

**Table 29. 2018 Residential New Construction Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| Gold Star (Dual Fuel) | 2,020 | 1,033 | 1.2 | 0.4 |
| Gold Star (Electric Only) | 7,624 | 3,900 | 1.5 | 0.5 |
| Platinum Star (Dual Fuel) | 2,236 | 1,144 | 1.5 | 0.5 |
| Platinum Star (Electric Only) | 9,763 | 4,995 | 1.7 | 0.6 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.

Electrically heated homes, characterized as "Electric Only," produced the highest per-unit energy and demand savings because of the installation of electric heating equipment. Gas-heated homes had lower electric savings because electric savings derive only from cooling, lighting, and appliances.

Table 30 lists the evaluated gross per-unit energy savings for each incentive tier by year since 2015.[19] The highest evaluated per-unit savings for all program tiers was in 2016, which coincides with the fact that homes that year were very large (923 square feet larger, on average, than in 2018). Evaluated savings were significantly higher in 2016 than in 2015, 2017, and 2018, when evaluated savings were relatively similar. Note that the realization rate in 2018 is relatively low because *ex ante* savings are based on the 2016 evaluated savings.

Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

[19] The Residential New Construction Program was introduced as a pilot in 2013, and no evaluation of the program was conducted in 2014. The pilot offered only the Gold Star incentive tier.

**Table 30. RNC Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Gold Star (Dual Fuel) | 954 | 2,020 | 842 | 1,033 |
| Gold Star (Electric Only) | N/A | 7,624 | N/A | 3,900 |
| Platinum Star (Dual Fuel) | 1,419 | 2,236 | 1,252 | 1,144 |
| Platinum Star (Electric Only) | N/A | 9,763 | N/A | 4,995 |

## Measure Verification

After reviewing the program tracking data, the impact evaluation found a 100% installation rate for all home types in 2018. Table 31 lists the installation rates for each program measure.

**Table 31. 2018 RNC Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported | Audited | Verified | |
| Gold Star (Dual Fuel) | 91 | 91 | 91 | 100% |
| Gold Star (Electric Only) | 1 | 1 | 1 | 100% |
| Platinum Star (Dual Fuel) | 52 | 52 | 52 | 100% |
| Platinum Star (Electric Only) | 1 | 1 | 1 | 100% |
| **Total** | **145** | **145** | **145** | **100%** |

Table 32 shows that the program has achieved 100% installation rates since 2015. Electrically heated homes often have low rates of participation, and in some years, there was no participation of electric only homes. For example, Gold Star Electric Only homes had no participation in 2016,[20] and Gold and Platinum Star Electric Only homes had no participation in 2017.

**Table 32. RNC Historical Installation Rates**

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Gold Star (Dual Fuel) | 100% | 100% | 100% | 100% |
| Gold Star (Electric Only) | N/A | N/A | N/A | 100% |
| Platinum Star (Dual Fuel) | 100% | 100% | 100% | 100% |
| Platinum Star (Electric Only) | N/A | 100% | N/A | 100% |

[20] Cadmus was able to estimate the savings for these homes using a regression analysis using the square footage of the Platinum Star Dual Fuel home.

## Net-to-Gross Analysis

Cadmus analyzed NTG for the 2018 RNC Program through interviews with 10 of the 15 participating builders. Cadmus estimated freeridership using the intention/influence freeridership method. The intention freeridership score was calculated from builders' responses about how their organization's building practices would have differed in the absence of the program. The influence freeridership score was calculated by asking respondents to rate the influence of program elements on their building practices. Table 33 presents the NTG results for the program. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

**Table 33. 2018 Residential New Construction Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 46% | 0% | 54%[1] |

[1]Absolute precision at 90% confidence interval is ±6%.

Table 34 lists the freeridership, spillover, and NTG estimates for the RNC Program since 2015. Cadmus derived these estimates through interviews with participating builders—five in 2015, 10 in 2016, 10 in 2017, and 10 in 2018.

**Table 34. Residential New Construction Historical Net-to-Gross Ratios**

| Program Year | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| 2015 | 50% | 0% | 50% |
| 2016 | 64% | 0% | 36% |
| 2017 | 50% | 0% | 50% |
| 2018 | 46% | 0% | 54% |

### *Freeridership and Spillover Findings*

The intention freeridership score derives from builders' responses about how their organization's building practices would have differed in the absence of the program. Table 35 shows a wide difference between the intention and influence scores. This results from builders' reporting that their organization's building practices would not have differed much in the absence of the program then subsequently reporting, on average, that program-related factors were very influential on their decision to build homes to the RNC Program requirement of HERS 63 standard or lower. Program-related factors include program incentives, marketing, information about energy-efficient building practices provided by Vectren, information from a HERS rater, and previous participation in a Vectren energy efficiency program.

Table 35 lists the program's intention, influence, and freeridership scores for the 2018 program year.

**Table 35. 2018 Residential New Construction Program Intention/Influence Freeridership Scores**

| n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|
| 10 | 45% | 1% | 46% |

The 2018 RNC Program spillover estimate is 0%. None of the interviewed builders said they had voluntarily raised the energy efficiency standard of the appliances or materials they used to build homes that were not eligible for the Vectren program.

## Evaluated Net Savings Adjustments

Table 36 and Table 37 list evaluated net savings for the RNC Program. The program achieved net savings of 87,700 kWh and 33.7 coincident kW demand reduction.

**Table 36. 2018 Residential New Construction Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Gold Star (Dual Fuel) | 183,797 | 183,797 | 183,797 | 94,022 | 51% | 54% | 50,772 |
| Gold Star Electric Only | 7,624 | 7,624 | 7,624 | 3,900 | 51% | 54% | 2,106 |
| Platinum Star (Dual Fuel) | 116,296 | 116,296 | 116,296 | 59,491 | 51% | 54% | 32,125 |
| Platinum Star Electric Only | 9,763 | 9,763 | 9,763 | 4,995 | 51% | 54% | 2,697 |
| **Total** | **317,480** | **317,480** | **317,480** | **162,407** | **51%** | **54%** | **87,700** |

**Table 37. 2018 Residential New Construction Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported[1] | Audited | Verified | | | | |
| Gold Star (Dual Fuel) | N/A | 110.5 | 110.5 | 36.3 | N/A | 54% | 19.6 |
| Gold Star Electric Only | N/A | 1.5 | 1.5 | 0.5 | N/A | 54% | 0.3 |
| Platinum Star (Dual Fuel) | N/A | 76.0 | 76.0 | 25.0 | N/A | 54% | 13.5 |
| Platinum Star Electric Only | N/A | 1.7 | 1.7 | 0.6 | N/A | 54% | 0.3 |
| **Total** | **203.8** | **189.7** | **189.7** | **62.4** | **31%** | **54%** | **33.7** |

[1] The 2018 DSM Scorecard did not report kW savings at the measure level.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the Residential New Construction Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies

## Logic Model

# RESIDENTIAL NEW CONSTRUCTION

### Market Actor: End-Use Customer — Homebuyers

**Market Barriers**

- Lack of program awareness
- Upfront cost of high-efficiency construction and equipment
- Low prioritization of energy efficiency when buying a home
- Difficulty locating participating builders
- Low demand for HERS-rated homes
- Lack of understanding about benefits of energy-efficient home construction and efficient appliances

**Intervention Strategies / Activities**

- Incentives to builders to construct and market efficient homes
- Trainings to builders on energy-efficient homes, e.g., building practices and marketing strategies
- Incentives help offset increased costs passed on to homebuyer
- Vectren presence at home shows, providing energy education to attendees
- Vectren outreach to local builders and HERS raters

**Outcomes**

- Increased awareness of energy-efficient building practices
- Increased demand for energy-efficient homes
- Increased availability of energy-efficient homes
- Increased program participation
- Increased energy savings

**Key Indicators**

- Achievement of participation and savings goals
- Percentage of homebuyers seeking energy-efficient homes
- Saturation of homes more efficient than Indiana residential energy code
- Average HERS rating of homes built through the program
- Number of participating builders

### Market Actor: Trade Allies — Builders

**Market Barriers**

- Lack of program awareness
- Higher construction costs
- Lack of understanding of energy-efficient building practices
- Time constraints, lengthy paperwork and certification process before rebate is received and home can go on market
- Upfront cost of HERS certification
- Low demand for HERS-rated homes
- Low customer awareness of HERS ratings, etc.

**Intervention Strategies / Activities**

- Builder incentives to offset higher construction costs and cost of HERS rating
- Program promotion through homebuilders' association and other industry groups
- Program information and material readily available on Vectren website
- Trainings to builders on energy-efficient homes, e.g., building practices and marketing strategies
- Builders encouraged to use low HERS rating as selling point
- Program staff assist with paperwork
- Streamlined application for builders with multiple submissions

**Outcomes**

- Increased program awareness
- Increased program satisfaction
- Increased program participation and uptake (lower HERS rating, additional high-efficiency measures installed, etc.) per builder
- Increased energy savings
- Increased builder participation

**Key Indicators**

- Number of builders participating
- Number of builders constructing ≤60 HERS-rated homes
- Percent of ≤60 HERS-rated homes in program
- Home builder attendance at outreach events
- Builder satisfaction with the program ratings
- Achievement of participation and savings goals
- Average number of homes per builder

## Program Performance

Cadmus measured 2015 to 2018 program performance against the KPIs listed in Table 38. This table shows metrics for both the gas and electric programs combined to be consistent with reporting for prior years. HERS scores in this table are an average from all program homes, including homes with no Vectren electric service. The HERS scores for homes with only Vectren electric service may differ. REM/Rate software versions may also impact HERS scores over time. For example, software updates in 2015 were estimated to increase HERS scores by several points in 2016.[21]

**Table 38. Residential New Construction Program KPI and 2015-2018 Performance**

| KPI | Performance | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Achievement of electric program participation goals | 86% | 124% | 155% | 101% |
| Achievement of gross kWh savings goals | 70% | 137% | 143% | 101% |
| Achievement of gross kW savings goals | N/A | N/A | N/A | 101% |
| Percent of ≤60 HERS rated homes in program (all fuels) | 53% | 40% | 29% | 27% |
| Average HERS rating of homes (all fuels) | 58 | 59 | 59 | 61 |
| Number of participating builders (all fuels) | 47 | 56 | 48 | 47 |
| Builder satisfaction with the program ratings (number of interviewed builders satisfied out of total number of interviewed builders, all fuels) | 4 out of 5 | 8 out of 10 | 10 out of 10 | 7 out of 10 |
| Average number of homes per builder (all fuels) | 20 | 17 | 17 | 18 |
| Number of home builders building homes to ≤60 HERS score through the program (all fuels) | N/A | 12 | 31 | 33 |
| Home builder attendance at outreach events (all fuels) | N/A | 28–38[1] | 107—127[2] | 20-48[3] |
| Saturation of homes more efficient than Indiana residential energy code in Vectren territory | N/A | N/A | N/A | Track in future years |
| Percentage of home buyers seeking energy-efficient homes | N/A | N/A | N/A | Track in future years |

[1] Vectren provided attendance estimate of 20 to 30 builders for the first of two outreach events in 2016. CLEAResult reported that eight builders attended the second event.
[2] CLEAResult reported that seven builders attended a focus group. Vectren sponsored four Builder Association events that had attendance of between 25 and 30 builders according to CLEAResult.
[3] CLEAResult reported presenting at Builders Association events in five Indiana cities, with four events having an attendance count of 20-26 builders and one event having an attendance count of 48 builders.

---

[21] Schwarz, Robby. November 14, 2016. "HERS Energy Rating Index Scores Are Going Up." Energy Logic blogpost. https://nrglogicblog.com/hers-energy-rating-index-scores-are-going-up

## Home Energy Assessment (HEA 2.0) Program

The Home Energy Assessment (HEA) 2.0 Program offers a walk-through audit and direct installation of energy efficiency measures for single-family homes at no cost to the customer. In 2018, Vectren revamped the 2017 version of the program to reset savings goals and focus on fewer participants who could bring deeper savings. The HEA 2.0 Program ran as a pilot in 2018 and will be an official program in 2019.

Energy auditors evaluate the energy performance of participating customers' homes and directly install energy efficiency measures such as LED lighting and water-saving devices. While at the home, energy auditors provide energy education, a detailed report about the home's energy use, and suggestions for further actions to reduce energy consumption. A local contracting company, J.E. Shekell, implemented the program in 2018 and was responsible for recruiting participants, conducting on-site home energy assessments, installing program measures, and recommending further energy-saving home improvements.

The HEA 2.0 Program installed the following measures with attributable electric savings:

**Lighting**
- Exterior LED lamp
- LED 6W globe
- LED 9W bulb
- LED R30 dimmable
- LED downlight retrofit
- LED candelabra
- LED .5W night light

**Plug load reduction**
- Smart power strips

**HVAC and water heating measures**
- Filter whistle
- Pipe wrap
- Water heater temperature setback
- Smart thermostat

**Water-saving devices**
- Bathroom aerator
- Kitchen aerator
- Efficient showerhead
- Thermostatic shower valve

### Accomplishments

Table 39 shows the program's achievements against goals in 2018. The program met its participation and kW savings goals, exceeded its energy-savings goals, and came in at 90% of its budget. The program implementer said the program's thorough audits and education were all key to the program meeting its 2018 savings goals. In 2019, the participation goal will increase from 350 customers to 400 customers.

**Table 39. 2018 HEA 2.0 Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 290,521 | 233,703 | 124% |
| Gross kW Savings | 23 | 23 | 100% |
| Participants (households) | 350 | 350 | 100% |
| Program Expenditures | $150,752 | $166,823 | 90% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 40 lists the evaluated savings summary for the HEA 2.0 Program. Overall, the program achieved an energy realization rate of 117% and a demand realization rate of 133%. These realization rates were driven primarily because Cadmus applied electric cooling savings to thermostats installed in homes with central air conditioners. These electric cooling savings were not claimed for Vectren electric customers who had natural gas heat with central air conditioning. Most other measures were at or near 100% and had a lesser overall impact.

**Table 40. 2018 HEA 2.0 Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 290,521 | 290,521 | 284,509 | 341,133 | 117% | 75% | 256,938 |
| Total kW | 23 | 23 | 22 | 31 | 133% | 74% | 23 |

## *Conclusions and Recommendations*

### Program Administration and Delivery

**The program could benefit from adding additional time slots for assessments or streamlining the sign-up process if it plans to expand future participation.** The program offered assessments during normal business hours on weekdays, but the program implementer made some exceptions to schedule assessments on weeknights or weekends. Almost one-quarter of participants reported waiting longer than a month for their assessment, and several recommended that the program offer more alternatives for appointment times or hire more auditors to reduce the wait time for the assessment. The program implementer also reported on the complex process for scheduling assessments. Vectren must verify customer eligibility after customers sign up for the program, so customers cannot schedule their assessment upon enrollment. Instead, the implementer must contact customers after they sign up and are confirmed eligible to attempt to schedule an assessment.

**Recommendation:** If Vectren decides to increase future participation goals, consider accommodating customer schedules by offering appointments on one or two weekends a month or offering evening appointments one day a week. Streamlining the process for eligibility verification and scheduling assessments may also help the program meet any future goal expansions. The signup form for customers could automatically reference a secure list of current Vectren customer accounts, which Vectren could update monthly.

## Conversion to Other Vectren Programs

**The HEA 2.0 Program assessment report is useful to customers, but additional help is needed to support customers in acting upon the report's energy-saving recommendations.** Thirty-five percent of customers said they had not implemented the report's behavioral or energy efficiency recommendations**,** most commonly because of cost. Customers also reported forgetting the recommendations. The report lists Vectren's residential rebates but does not include rebate amounts in the estimated payback for recommended upgrades. During 2018, only 3% of HEA 2.0 participants also participated in Vectren's Appliance Recycling or Residential Prescriptive programs.

**Recommendation:** Provide auditors with best practices for how to discuss rebates for Vectren's other residential programs and to provide estimated payback calculations with and without those rebates.

**Recommendation:** Email customers one week or one month after the assessment with a copy of the report, reminders of no- to low-cost energy-saving tips, and links to Vectren's webpages for its other residential programs. This reminder will keep the assessment fresh in their mind and encourage them to participate in other Vectren programs.

## Data Tracking

**Vectren is not claiming electric cooling savings for the thermostat and furnace filter whistle measures.** Vectren claimed electric heating savings only for thermostats and furnace filter whistles when the customer's primary heating system was electric. However, these measures also impact homes with central cooling systems. These cooling savings could be claimed in the electric portfolio, assuming the customer is a Vectren electric customer. Cadmus evaluated an overall energy realization rate of 117% with HVAC cooling savings included. Without these cooling savings, the overall energy realization rate was 99%.

**Recommendation:** Claim electric cooling savings for thermostats and filter whistles that are installed in homes with central air conditioning. Currently, the program does not claim savings for these measures in homes with gas heat and central air conditioning, only homes with electric heat and cooling.

**Measure-level demand savings are unknown.** Demand savings were not recorded in the tracking data by measure. Measure-level demand savings should be tracked for the measures installed in the home, even if the savings are a deemed value.

**Recommendation:** Track measure-level demand savings for future years to allow for a more accurate analysis of program performance.

# Process Evaluation

## Process Evaluation Methodology

Cadmus conducted these process evaluation activities for its evaluation of the 2018 program year:

- Interview with three Vectren program staff members
- Interview with one J.E. Shekell program staff member
- Participant customer mixed-mode online (n=42) and phone (n=30) survey

Vectren provided data for 262 unique participating customers. Cadmus completed a phone survey with 30 participants and an online survey with 42 participants for a total of 72 completed surveys. Cadmus tested for statistically significant differences in 2017 and 2018 survey results (with a t-test set at the 95% significance level). Unless noted otherwise, all results were consistent with the 2017 results.

## Program Administration

In 2018, Vectren revamped the previous program, renaming it HEA 2.0 Program. Vectren reset the program objective to generate deeper savings per home because the 2017 program, with higher participation but less savings per household, was becoming less cost-effective. Vectren decreased the participation goal from 2,100 participants (528 gross kWh/home) in 2017 to 350 participants (668 gross kWh/home) in 2018.

Vectren also hired a new program implementer. In March 2018, J.E. Shekell, a local contractor, began marketing the program and training its staff on program delivery. The program implementer conducted the first HEA 2.0 home assessment in June 2018. Vectren and the program implementer communicate biweekly about the program via phone, and Vectren can monitor the program data daily by accessing a Google Documents spreadsheet.

## Program Delivery

The HEA 2.0 Program is available to all single-family residential homes in the Vectren South electric service territory if the following requirements are met:

- Home was not built within the last five years.
- Home has not had an audit within the last three years.
- Is owner occupied or authorized non-owner occupied where the occupants have the electric service in their name.

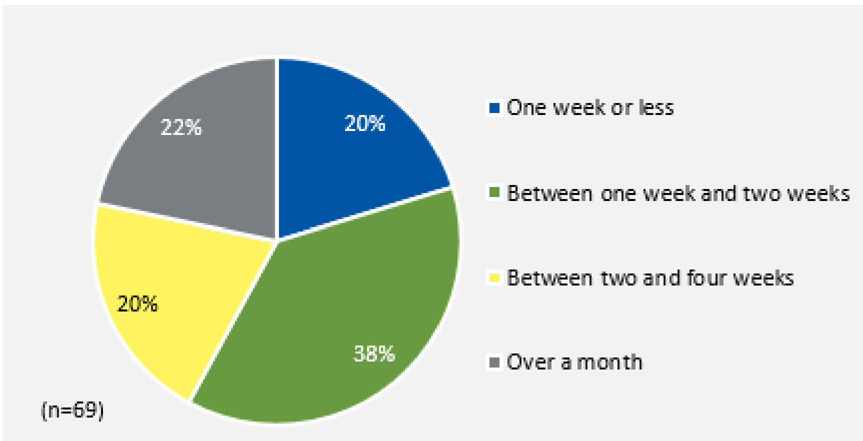
Any customer who qualifies for the Income Qualified Weatherization Program is referred to that program instead.

### *Enrollment and Scheduling*

Customers sign up for a home energy assessment by visiting the program implementer’s website and completing a form with their contact information. Vectren then verifies that the customer is eligible to participate. The program implementer attempts to contact customers via phone or email within one to two days to schedule an assessment. The program implementer said it was sometimes challenging to contact customers. If customers could not be reached after six attempts, they were put on a list to contact again in 2019. The sign-up form does not let customers schedule the assessment upon enrollment.

All surveyed participants (100%, n=72) found it easy to schedule their home energy assessment. Most (58%, n=69) said they received their assessment within two weeks of signing up, but some (22%) waited more than a month.

**Figure 6. Customer Wait Times for HEA 2.0 Assessment after Scheduling**




Source: 2018 Participant survey question D3. How long did it take between the time you signed up to have the Energy Efficiency Technician visit your home and when they conducted the assessment?

Even though almost one-quarter of participants waited longer than a month for their assessment, 95% (n=69) said they were satisfied with the timing of the assessment. Only 12 respondents made suggestions for improving the appointment scheduling process:

- Offer more appointment times/hire more auditors (eight respondents)
- Contact customers more quickly after they sign up (two respondents)
- Offer weekend appointments (two respondents)

The program implementer noted it offered home energy assessment appointments on weekdays only but made some exceptions for weeknights or weekends, as needed.

### *Home Energy Assessment*

All home energy auditors employed by the program are certified as BPI Building Analyst Professionals. As part of revamping the HEA 2.0 Program design, the home energy auditors can conduct more thorough assessments than in the previous program. The program implementer estimated that two home energy auditors visit each home for a total of four hours. In the 2017 program, one auditor visited the home for two hours. Customers are encouraged to accompany the home energy auditors during the visit to learn about their home's efficiency characteristics.

While at the home, the auditors may install the following energy efficiency measures:

**Lighting**

- Exterior LED lamp
- LED 6W globe
- LED 9W bulb
- LED R30 dimmable
- LED downlight retrofit
- LED candelabra
- LED 0.5W night light

**Water-saving devices**

- Bathroom aerator
- Kitchen aerator
- Efficient showerhead
- Thermostatic shower valve

**HVAC and water heating measures**

- Filter whistle
- Pipe wrap
- Water heater temperature setback
- Smart thermostat (learning)

**Appliance and plug load reduction**

- Tier 1 advanced (smart) power strip

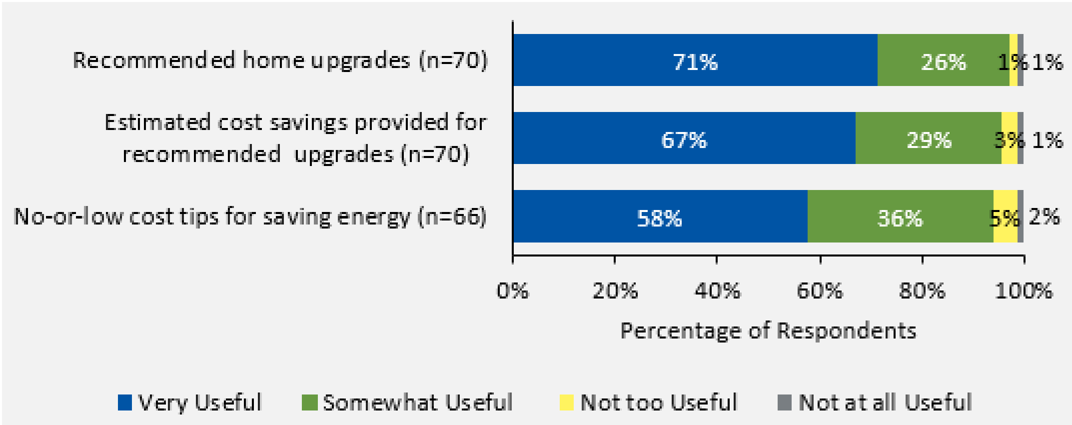
Vectren instructs auditors to install as many of each measure type as possible, up to a specified maximum (leaving no measures behind for the customer to install) and record all installed measures in the program tracking database. These measures are installed at no cost to the customer.

The tier 1 advanced power strips and thermostatic shower valves were new to the HEA 2.0 Program in 2018. Vectren also changed the types of LED bulbs offered in 2018, switching a 5W globe LED for a 6W globe and adding an LED downlight retrofit, LED candelabra, and exterior LED lamp. The HEA 2.0 Program did not offer the air sealing or duct sealing measures that the 2017 program offered. Note that participation in these measures has been historically low.

At the end of the assessment, the auditors give the occupants a detailed report with recommendations for additional low- to no-cost upgrades and energy-saving actions as well as for higher-cost upgrades. Auditors use software to calculate simple payback for each recommended upgrade to help customers prioritize their next steps, but the report does not include any rebate amounts for these upgrades. If a home is eligible for air sealing, duct sealing, and/or insulation, the customer is referred to the Residential Prescriptive Program. The report also describes all Vectren DSM programs.

Most (99%, n=72) customers were satisfied with home energy auditor who visited their home, and 86% were *very* or *somewhat involved* while the home energy auditor conducted the assessment and installed the equipment. As shown in Figure 7, 97% (n=70) of respondents found the information in their report to be useful.

**Figure 7. Participant Usefulness Ratings for Home Energy Assessment Report**




Source: 2018 Participant survey question E3. "How was useful was the following information included in the written audit report that you received after the Home Energy Assessment?"

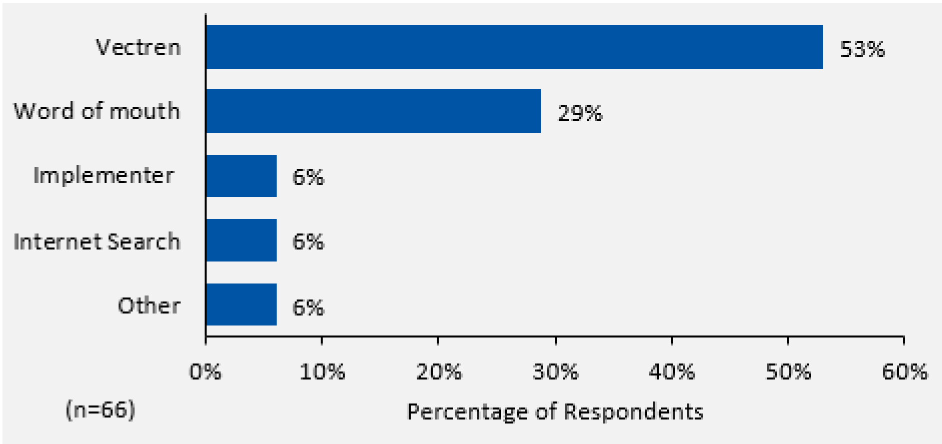
Almost half of the respondents (47%, n=72) recalled that their home energy auditors referred them to other Vectren programs that provide rebates for energy-efficient equipment. Cadmus cross-referenced HEA 2.0 Program participants with other Vectren program participant records to identify a conversion rate from the HEA 2.0 Program to the other programs. Only 3% of HEA 2.0 Program customers participated in another Vectren program—eight participated in the Appliance Recycling Program and one in the Residential Prescriptive Program.

## Marketing and Outreach

During the 2018 program year, Vectren marketed the program by creating fliers to distribute at home improvement stores. Vectren's website also featured a link to the implementer's HEA 2.0 Program enrollment website. The implementer's home energy auditors received leads from customers by handing out Vectren program fliers during service calls.

The implementer also relied on word of mouth referrals and said this type of marketing was the most effective strategy in 2018. The participant survey found, however, that customers more often reported learning of the program through Vectren (53%, n=66), as shown in Figure 8.

**Figure 8. Customer Sources of Program Awareness**




Source: 2018 Participant survey question D1. "How did you first learn about Vectren's Home Energy Assessment Program?"

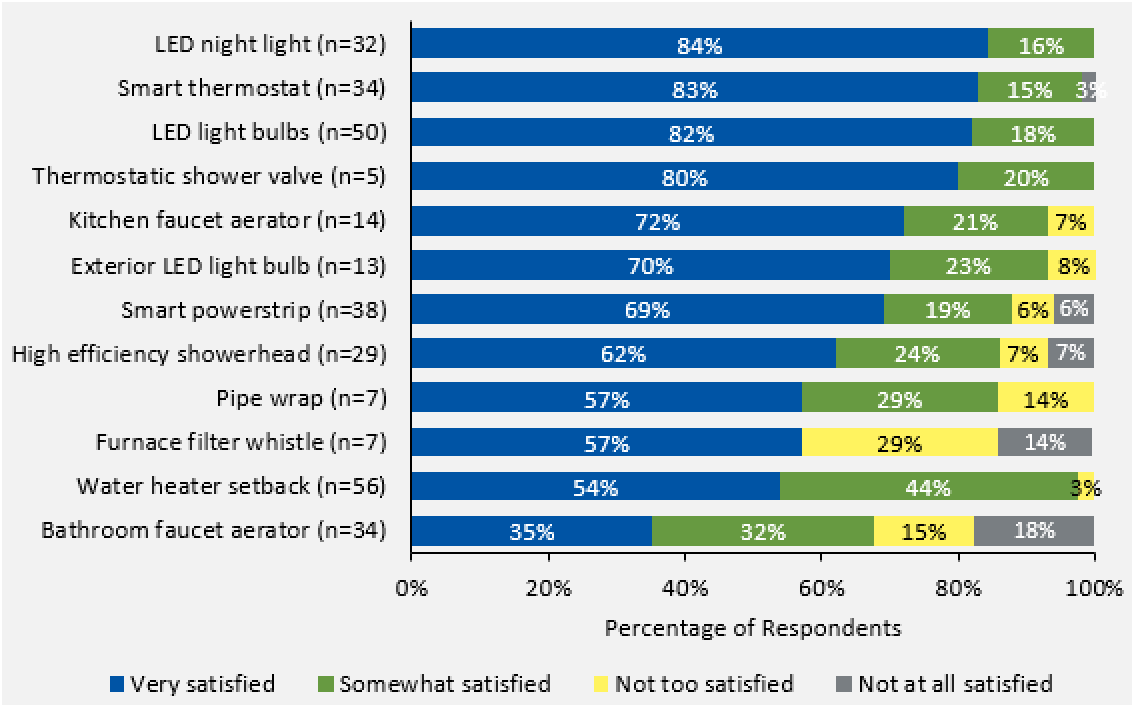
## Customer Satisfaction

Nearly all respondents were satisfied with the program overall (97%, n=61) and 100% (n=72) said they would likely recommend the program to a neighbor. Two respondents gave reasons for lower satisfaction ratings with the program overall. One had not noticed a reduction in their energy bill. This respondent received the home energy assessment five months before completing the survey. The other respondent said the program implementer did not follow up about an issue that was discussed during the home visit (but provided no additional information on the issue).

Figure 9 shows respondents' satisfaction ratings for the measures they received through the program. Respondents expressed the highest satisfaction with LED night lights (100%), LED light bulbs (100%), and the thermostatic shower valve (100%). Respondent satisfaction ratings are lowest for the furnace filter whistle (57%, n=7) and bathroom faucet aerator (67%, n=34), and these ratings are significantly lower than the 2017 ratings for the furnace whistle (100%, n=4) and bathroom faucet aerator (92%, n=37).[22]

[22] $p < 0.05$ using a binomial t-test. Due to the small sample size furnace whistle respondents, tested differences should be considered with caution.

**Figure 9. 2018 Participant Satisfaction with Home Energy Assessment Measures**




Source: 2018 Participant Survey Question T4. "Using the same scale, please rate how satisfied you are with the…"

For measures with less than 100% satisfaction, the reasons varied and are summarized in Table 41.

**Table 41. 2018 Participant Reasons for Lower Satisfaction Ratings**

| Measure | Total *n* | Reasons for Lower Satisfaction |
|---|---|---|
| Bathroom faucet aerator(s) | 8 | • Not enough water pressure (n=8) |
| High-efficiency showerhead(s) | 4 | • Not enough water pressure (n=4) |
| Smart strip | 3 | • Don't know how to use it (n=2)<br>• Does not have enough "always on" outlets (n=1) |
| Furnace filter whistle | 3 | • Don't need it (n=1)<br>• The sound was unpleasant (n=1)<br>• Seemed to whistle from the start with higher quality filters (n=1) |
| Exterior LED light bulb(s) | 1 | • Too bright (n=1) |
| Kitchen faucet aerator(s) | 1 | • Not enough water pressure (n=1) |
| Pipe Wrap | 1 | • Level of insulation (n=1) |
| Thermostat | 1 | • Could not get it to work (n=1) |

Participants were also asked about their satisfaction with Vectren's program offerings in general, and these questions were worded to match the J.D Power survey questions.[23]

- 99% of participants (n=69) were satisfied with the variety of energy efficiency programs offered by Vectren.
- 96% of participants (n=71) were satisfied with Vectren's efforts to manage their monthly usage.
- 94% of participants (n=72) found Vectren's suggestions on ways they could reduce their energy usage and lower their monthly bills useful.

## *Impact Evaluation*

### Impact Evaluation Methods and Findings

The HEA 2.0 Program impact evaluation included multiple data collection efforts and analysis tasks:

- A tracking database review of the number of measures installed
- A survey of 72 program participants to verify number of measures installed
- An engineering analysis of ex ante energy savings per measure and per home
- A freeridership and spillover analysis to calculate an NTG ratio

### Gross Savings Review

Cadmus conducted an engineering desk review to assess energy and demand savings for the electric-saving measures distributed through the HEA 2.0 Program. Cadmus also assessed the savings achieved by participants' implementation of additional recommendations from the assessment. Table 42 provides per-unit annual gross savings for each program measure. Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

[23] J.D. Power administers a quarterly, nationwide survey to assess residential electric utility customer satisfaction.

**Table 42. 2018 HEA 2.0 Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported *Ex Ante* | Evaluated *Ex Post* | Reported *Ex Ante* | Evaluated *Ex Post* |
| **Audit Education** | | | | |
| Audit Fee – Electric | 61 | 63 | 0.003 | 0.007 |
| **Lighting** | | | | |
| LED 9W Bulb (Exterior) | 92 | 84 | 0.000 | 0.000 |
| LED 9W Bulb | 32 | 32 | 0.003 | 0.004 |
| LED 6W Globe | 10 | 21 | 0.003 | 0.003 |
| LED 8W Bulb | 53 | 53 | 0.003 | 0.007 |
| LED Downlight Retrofit | 35 | 42 | 0.003 | 0.005 |
| LED Candelabra | 41 | 33 | 0.003 | 0.004 |
| LED Nightlight | 14 | 13 | 0.000 | 0.000 |
| **Plug Load Reduction** | | | | |
| Smart Strips | 103 | 26 | 0.003 | 0.002 |
| **HVAC and Water Heating Measures** | | | | |
| Filter Whistle – Electric | 61 | 239 | 0.003 | 0.050 |
| Filter Whistle – Dual Fuel (Gas Heat with CAC) | 0 | 63 | 0.003 | 0.002 |
| Pipe Wrap – Electric | 65 | 75 | 0.003 | 0.009 |
| Smart Thermostat – Electric | 370 | 1,224 | 0.000 | 0.000 |
| Smart Thermostat – Dual Fuel (Gas Heat with CAC) | 0 | 277 | 0.000 | 0.000 |
| Water Heater Setback – Electric | 87 | 66 | 0.003 | 0.008 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator – Electric | 9 | 24 | 0.003 | 0.003 |
| Kitchen Aerator – Electric | 115 | 163 | 0.003 | 0.007 |
| Showerhead – Electric | 206 | 259 | 0.003 | 0.015 |
| Thermostatic Shower Valve – Electric | 85 | 46 | 0.003 | 0.003 |

Cadmus used inputs and algorithms from the 2015 Indiana TRM with the following exceptions:

- For lighting measures, the baseline wattage was determined following guidelines from the UMP based on the type of bulb and lumen output.
- For the water heater temperature setback measure as well as the thermostatic shower valve, Cadmus used the Illinois TRM Version 6.0 to evaluate savings.
- For smart thermostats, Cadmus used an evaluation from 2013–2014 of programmable and smart thermostats in Vectren South Territory. For electric heating savings, the Indiana TRM was applied.

- For pipe wrap, Cadmus found that the TRM algorithm made assumptions that most likely led to overestimating savings, and instead used an energy savings factor of 3%[24].

Several measures had realization rates above or below 100%, for the following reasons:

- **Audit education.** Audit education savings were adjusted to take into account all efficient equipment that was installed, such as lighting, showerheads, and thermostats. For example, if a home received a smart thermostat then it was not eligible to receive savings for correctly programming the thermostat. The percentage of customers who took the recommended actions was generally higher than in 2016, which reported savings is based on.
- **Lighting.** Lighting measures generally had very comparable *ex ante* and *ex post* values, with an overall realization rate of 95% for the lighting category. Globes, candelabras, and exterior lighting had the largest differences, which could have been because of different methodologies to determine baseline wattages. Cadmus used guidelines in the UMP that are based on the style and lumen output of the bulb. Measure-level assumptions for these lighting types were not available so differences for these bulb types were difficult to predict; nevertheless, these differences were generally not large.
- **Plug load reduction.** Tier 1 smart strips had lower evaluated savings than reported savings. This could be because of different methodology in evaluating savings. Cadmus used the Indiana TRM and the average of computer and television savings. Vectren did not provide measure-level assumptions so it was difficult to predict differences between reported and evaluated savings.
- **HVAC and water heating measures.** For filter whistles in electrically heated homes, evaluated savings were higher than reported savings and driven primarily by the additional electric heating savings. Reported savings used the 2016 HEA furnace whistle savings, which had been based primarily on gas-heated homes and therefore savings were almost entirely produced by cooling only. For furnace whistles installed in gas-heated homes with central air conditioning, no savings were claimed by Vectren. These installations had no claimed electric cooling savings, resulting from the increased efficiency of the central cooling system (from the furnace whistle). To correct for this, Cadmus evaluated 63 kWh of electric cooling savings for homes that were confirmed to have central air conditioning in the tracking data.

  Higher evaluated savings for thermostats installed in electrically heated homes were because reported savings were mostly cooling savings only. Reported savings were based on the 2016 Residential Prescriptive Program smart programmable thermostat savings, which were installed mostly in homes with natural gas heating and central air conditioning. The additional heating savings evaluated for thermostats installed in electrically heated homes was the primary driver for this measure's higher evaluated savings. Like furnace whistles, for thermostats installed in gas-heated homes with central cooling systems, only gas savings were claimed. The tracking

[24] ACEEE Report Number E093. Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy in Pennsylvania. April 2009

data showed there were 190 smart thermostats that were installed in gas heated homes which had central air conditioning. These 190 installations had no claimed electric cooling savings, resulting from the central cooling system operating more efficiently (from the smart thermostat). To correct for this, Cadmus evaluated cooling savings of 277 kWh, for homes that were confirmed to have central air conditioning in the tracking data. These additional thermostat cooling savings were the primary driver of the overall program realization rate of 117%. Without these thermostat savings, the overall program realization rate was 99%.

- **Water-saving devices.** The direct install water saving devices had different *ex post* and *ex ante* savings because of differences in survey responses and baseline assumptions. Survey responses included people per home, bathroom faucets per home, and showers per home. Evaluated thermostatic shower valve savings were nearly half reported savings because of adjusting the baseline gallons per minute (gpm) to match that of the installed efficient showerhead. This adjustment applied to all but one installed thermostatic shower valve. Evaluated savings for bathroom aerators were also significantly higher because reported savings were based on installation of a 1.5 gpm bathroom aerator rather than the actual 1.0 gpm bathroom aerator.

Table 43 lists the evaluated gross per-unit energy savings for each program measure by year. Differences from year to year are described as follows:

- **Audit education.** Audit education savings changed from year to year because of the percentage of people who followed the auditor's recommendations (according to survey results).
- **Lighting.** Lighting savings stayed relatively consistent over time. The difference for the R30 bulb was because of a change from a 12W bulb in 2017 to an 8W bulb in 2018.
- **HVAC and water heating measures.** Filter whistles change over time because heating and cooling system saturations differ from year to year. In particular, in 2018, the electric heating saturation was higher, which led to higher electric savings for furnace whistles. Thermostat savings were higher in 2018 because of a shift to smart thermostats from programmable thermostats, which have significantly higher savings.
- **Water-saving devices.** In general, water-savings devices change from year to year based on differing survey results for number of people, number of showers, and number of bathroom aerators. For bathroom aerators in particular, savings increased starting in 2017 because of the shift from a 1.5 gpm bathroom aerator to a 1.0 gpm aerator.

**Table 43. HEA 2.0 Historical Per-Unit Savings[1]**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **Audit Education** | | | | |
| Audit Education – All sites | 113 | 61 | 32 | 63 |
| **Lighting** | | | | |
| LED 9W Bulb (Exterior) | - | - | - | 84 |
| LED 9W Bulb (interior) | - | 32 | 33 | 32 |
| LED 8W Bulb (R30 Dimmable) | - | - | 32 | 53 |

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| LED 6W Globe | - | - | 19 | 21 |
| LED Downlight Retrofit | - | - | - | 42 |
| LED Candelabra | - | - | - | 33 |
| LED Night Light | - | 14 | 14 | 13 |
| **Plug Load Reduction** | | | | |
| Smart Strips | - | 23 | - | 26 |
| **HVAC and Water Heating Measures** | | | | |
| Filter Whistle | 64 | 61 | 52 | 84[2] |
| Pipe Wrap (Electric) (per home) | 114 | 65 | 83 | 75 |
| Water Heater Temperature Setback | - | 87 | 82 | 66 |
| Thermostat (Dual Fuel) | - | 161 | 161 | 277 |
| Thermostat (Electric) | - | 161 | 279 | 1,224 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | 11 | 9 | 23 | 24 |
| Kitchen Aerator | 150 | 115 | 148 | 163 |
| Efficient Showerhead | 249 | 206 | 254 | 259 |
| Thermostatic Shower Valve | - | - | - | 46 |

[1]In 2018 the program design changed, however many measures remained the same and were included for comparison from year to year.
[2]This is the weighted average of furnace whistles installed in electrically heated homes and gas heated homes to compare from year to year.

## Measure Verification

Cadmus calculated verified savings for the HEA 2.0 Program by applying a persistence rate to program measure savings. The persistence rate is an indicator of the number of measures that remained installed in homes after initial participation. Cadmus used the persistence rate as the in-service rate (ISR), assuming that reported installations were accurate because the program implementer's quality control process ensured that actual and reported measure installations matched. Table 44 lists the ISR for each program measure.

**Table 44. 2018 HEA 2.0 Measure Verification Results – Installation Rates**

| Measure | Reported Installations | Audited Installations | Verified Installations | Installation Rate |
|---|---|---|---|---|
| **Audit Education** | | | | |
| Audit Fee – Electric | 350 | 350 | 350 | 100% |
| **Lighting** | | | | |
| LED 9W Bulb (Exterior) | 194 | 194 | 194 | 100% |
| LED 9W Bulb | 2,768 | 2,768 | 2,721 | 98% |
| LED 6W Globe | 713 | 713 | 701 | 98% |
| LED 8W Bulb | 992 | 992 | 975 | 98% |
| LED Downlight Retrofit | 204 | 204 | 201 | 98% |

| Measure | Reported Installations | Audited Installations | Verified Installations | Installation Rate |
|---|---|---|---|---|
| LED Candelabra | 1,114 | 1,114 | 1,095 | 98% |
| LED Nightlight | 473 | 473 | 468 | 99% |
| **Plug Load Reduction** | | | | |
| Smart Strips | 181 | 181 | 167 | 93% |
| **HVAC and Water Heating Measures** | | | | |
| Filter Whistle – Electric | 6 | 6 | 3 | 57% |
| Filter Whistle – Gas | 37 | 37 | 21 | 57% |
| Pipe Wrap – Electric | 16 | 16 | 16 | 100% |
| Smart Thermostat – Electric | 16 | 16 | 16 | 100% |
| Smart Thermostat – Gas | 190 | 190 | 190 | 100% |
| Water Heater Setback – Electric | 70 | 70 | 70 | 100% |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator – Electric | 75 | 75 | 63 | 84% |
| Kitchen Aerator – Electric | 25 | 25 | 25 | 100% |
| Showerhead – Electric | 40 | 40 | 36 | 89% |
| TSV – Electric | 9 | 9 | 9 | 100% |
| **Total** | **7,473**[1] | **7,473** | **7,322** | **98%** |

[1]The number of reported installations in the 2018 DSM Scorecard was based on number of households served (n=350). The reported total here represents the number of measures installations included in the 2018 program tracking data.

Table 45 shows historical installation rates for each program measure. Installation rates were generally comparable from 2017 to 2018, except for filter whistles. There are not many survey respondents (or installations) for this measure, so installation rates can differ widely. In Cadmus' experience, persistence rates and installation rates for these measures tend to be on the low side.

**Table 45. HEA 2.0 Historical Installation Rates**

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **Audit Education** | | | | |
| Audit Fee – Electric | 100% | 100% | 100% | 100% |
| **Lighting** | | | | |
| LED 9W Bulb (Exterior) | 94% | 100% | - | 100% |
| LED 9W Bulb | 94% | 100% | 92% | 98% |
| LED 6W Globe | 94% | 97% | 92% | 98% |
| LED 8W Bulb | 94% | 97% | 92% | 98% |
| LED Downlight Retrofit | 94% | 97% | - | 98% |
| LED Candelabra | 94% | 97% | - | 98% |
| LED Nightlight | 94% | 100% | 91% | 99% |
| **Plug Load Reduction** | | | | |

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Smart Strips | - | 100% | - | 93% |
| **HVAC and Water Heating Measures** | | | | |
| Filter Whistle – Electric | 100% | 44% | 71% | 57% |
| Filter Whistle – Gas | 100% | 44% | 71% | 57% |
| Pipe Wrap – Electric | 100% | 100% | 100% | 100% |
| Smart Thermostat – Electric | - | 88% | 100% | 100% |
| Smart Thermostat – Gas | - | 88% | 100% | 100% |
| Water Heater Setback – Electric | 100% | 100% | 100% | 100% |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator – Electric | 100% | 93% | 95% | 84% |
| Kitchen Aerator – Electric | 87% | 93% | 100% | 90% |
| Showerhead – Electric | 83% | 96% | 90% | 89% |
| TSV – Electric | - | - | - | 1 |

## Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the HEA 2.0 Program as a whole using findings from a survey conducted with 72 program participants. The overall program NTG of 78% is weighted by the combination of electric and gas gross evaluated program population savings. However, the electric-specific NTG ratio of 75% is weighted specifically to electric savings due to the application of measure category level NTG estimates to evaluated gross population electric savings. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings. Table 46 presents the NTG results for the program.

**Table 46. 2018 Home Energy Assessment Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio | Total Program *Ex Post* MMBTU Savings |
|---|---|---|---|---|
| **Total Program** | **25%**[1] | **3%**[1] | **78%**[1] | **2,585** |
| **Electric-Specific NTG** | | | **75%** | **1,164** |
| **Gas-Specific NTG** | | | **82%** | **1,421** |

[1] Weighted by evaluated *ex post* program population MMBtu savings.

Table 47 lists historical program-level NTG ratios by year. The primary factor accounting for the decrease in overall program NTG from 2017 to 2018 is that smart thermostats were added as a program measure in 2018. Smart thermostats account for 47% of the 2018 evaluated gross population energy savings and the overall program level NTG estimate of 78% is heavily weighted towards the smart thermostat NTG estimate of 76%. In 2017 efficient showerheads represented the highest percentage of evaluated gross population energy savings of any measure type at 24% and the NTG estimate was 106%, resulting from a 9% freeridership estimate and a 15% participant spillover estimate. An additional factor contributing to the lower overall program NTG in 2017 compared to 2018 is participant spillover for the overall program dropped from 9% in 2017 to 3% in 2018.

**Table 47. Home Energy Assessment Historical Net-to-Gross Ratios**

| Program Year | Freeridership | Spillover | NTG Ratio |
| --- | --- | --- | --- |
| 2015 | 5% | 3% | 98% |
| 2016 | 13% | 5% | 92% |
| 2017 | 7% | 9% | 102% |
| 2018 | 25% | 3% | 78% |

### *Freeridership and Spillover Findings*

Cadmus estimated freeridership using a pure intentions-based method.[25] Cadmus asked respondents questions then weighted their measure-level freeridership scores by their verified installed units to arrive at measure-level freeridership estimates. Some respondents had multiple measures installed and were asked freeridership questions about each measure, which allowed for the estimation of measure level freeridership. Cadmus then weighted these estimates by the evaluated *ex post* gross population savings for each measure type. The resulting program NTG ratio is 78% after including spillover of 3%. Table 48 lists NTG results by measure.

---

25 An *influence* score component is not included in the freeridership methodology of direct install measures. The exclusion of an *influence* score component aligns with the 2019 Illinois Statewide Technical Reference Manual (IL TRM) for NTG evaluation of no-cost, direct install measures delivered through a single-family home energy audit program. 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency. Version 7.0. Volume 4: Cross-Cutting Measures and Attachments. Section 4.5. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_4_X-Cutting_Measures_and_Attach_092818_Final.pdf

**Table 48. Home Energy Assessment Program NTG by Measure**

| Measure | n | Freeridership | Spillover | NTG | Evaluated *Ex Post* Population Savings (MMBtu) |
|---|---|---|---|---|---|
| Smart Strips | 36 | 25% | 4% | 79% | 15 |
| Audit Fee[1] | 0 | 0% | 0% | 100% | 251 |
| LED Light Bulbs | 48 | 34% | 4% | 70% | 727 |
| LED Nightlight[1] | 0 | 0% | 0% | 100% | 21 |
| Filter Whistle | 4 | 5% | 4% | 99% | 40 |
| Pipe wrap (number of jobs) | 9 | 2% | 4% | 102% | 22 |
| Smart Thermostat | 33 | 28% | 4% | 76% | 1,215 |
| Water Heater Setback[1] | 0 | 0% | 0% | 100% | 62 |
| Bathroom Aerator | 31 | 12% | 4% | 92% | 24 |
| Kitchen Aerator | 15 | 20% | 4% | 84% | 58 |
| Efficient Showerhead | 25 | 17% | 4% | 87% | 146 |
| TSV | 5 | 13% | 4% | 92% | 4 |
| **Overall** | **N/A** | **25%[2]** | **3%[2]** | **78%** | **2,584** |

[1] No NTG surveys completed, assuming 0% freeridership.
[2] Weighted by evaluated ex post program population MMBtu savings.

Three participants reported that after participating in the HEA 2.0 Program they installed additional high-efficiency measures for which they did not receive an incentive.[26] These respondents said participation in the program was very important in their decision.

Cadmus used *ex post* savings estimated from the 2018 Residential Prescriptive Program along with the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the HEA 2.0 Program. Cadmus divided the total survey sample spillover savings by the gross program savings from the survey sample to obtain the 4% spillover estimate for the program, as shown in Table 49.

**Table 49. Home Energy Assessment Program Spillover Estimate**

| Survey Sample Spillover MMBtu Savings | Survey Sample Program MMBtu Savings | Spillover Percentage Estimate |
|---|---|---|
| 22 | 518[1] | 4% |

[1] 2018 evaluated gross energy savings.

## Evaluated Net Savings Adjustments

Table 50 and Table 51 list evaluated net savings for the HEA 2.0 Program. The overall program NTG of 78% presented in the Net-to-Gross Analysis section is weighted by the combination of electric and gas gross evaluated program savings. However, the overall program-level NTG estimates presented in Table

[26] These measures were a gas tank-less water heater, clothes washer, refrigerator, and attic insulation.

50 and Table 51 are weighted specifically to electric and demand savings. The program achieved net savings of 256,938 kWh and 22.57 coincident kW demand reduction.

**Table 50. 2018 Home Energy Assessment Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| **Audit Education** | | | | | | | |
| Audit Fee – Electric | 21,424 | 21,424 | 21,424 | 22,095 | 103% | 100% | 22,095 |
| **Lighting** | | | | | | | |
| LED 9W Bulb (Exterior) | 17,844 | 17,844 | 17,844 | 16,325 | 91% | 70% | 11,428 |
| LED 9W Bulb | 87,358 | 87,358 | 85,890 | 86,304 | 99% | 70% | 60,413 |
| LED 6W Globe | 7,393 | 7,393 | 7,269 | 14,924 | 202% | 70% | 10,447 |
| LED 8W Bulb | 52,553 | 52,553 | 51,670 | 51,298 | 98% | 70% | 35,909 |
| LED Downlight Retrofit | 7,126 | 7,126 | 7,006 | 8,377 | 118% | 70% | 5,864 |
| LED Candelabra | 45,815 | 45,815 | 45,045 | 35,965 | 78% | 70% | 25,175 |
| LED Nightlight | 6,450 | 6,450 | 6,380 | 6,148 | 95% | 100% | 6,148 |
| **Plug Load Reduction** | | | | | | | |
| Smart Strips | 18,643 | 18,643 | 17,245 | 4,285 | 23% | 79% | 3,385 |
| **HVAC and Water Heating Measures** | | | | | | | |
| Filter Whistle – Electric | 365 | 365 | 209 | 818 | 224% | 99% | 810 |
| Filter Whistle – Gas | 0 | 0 | 0 | 1,329 | N/A | 99% | 1,316 |
| Pipe Wrap – Electric | 1,046 | 1,046 | 1,046 | 1,197 | 114% | 102% | 1,221 |
| Smart Thermostat – Electric | 5,916 | 5,916 | 5,916 | 19,587 | 331% | 76% | 14,886 |
| Smart Thermostat – Gas | 0 | 0 | 0 | 52,659 | N/A | 76% | 40,021 |
| Water Heater Setback – Electric | 6,057 | 6,057 | 6,057 | 4,619 | 76% | 100% | 4,619 |
| **Water-Saving Devices** | | | | | | | |
| Bathroom Aerator – Electric | 675 | 675 | 567 | 1,495 | 222% | 92% | 1,381 |
| Kitchen Aerator – Electric | 2,863 | 2,863 | 2,863 | 4,072 | 142% | 84% | 3,420 |
| Showerhead – Electric | 8,228 | 8,228 | 7,313 | 9,221 | 112% | 87% | 8,023 |
| TSV – Electric | 765 | 765 | 765 | 415 | 54% | 92% | 379 |
| **Total** | **290,521** | **290,521** | **284,509** | **341,133** | **117%** | **75%** | **256,938** |

**Table 51. 2018 Home Energy Assessment Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| **Audit Education** | | | | | | | |
| Audit Fee – Electric | 1.22 | 1.22 | 1.22 | 2.56 | 210% | 100% | 2.56 |
| **Lighting** | | | | | | | |
| LED 9W Bulb (Exterior) | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 70% | 0.00 |
| LED 9W Bulb | 9.65 | 9.65 | 9.48 | 11.28 | 117% | 70% | 7.90 |
| LED 6W Globe | 2.48 | 2.48 | 2.44 | 1.97 | 79% | 70% | 1.38 |
| LED 8W Bulb | 3.46 | 3.46 | 3.40 | 6.78 | 196% | 70% | 4.75 |
| LED Downlight Retrofit | 0.71 | 0.71 | 0.70 | 1.09 | 153% | 70% | 0.76 |
| LED Candelabra | 3.88 | 3.88 | 3.82 | 4.76 | 122% | 70% | 3.33 |
| LED Nightlight | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 100% | 0.00 |
| **Plug Load Reduction** | | | | | | | |
| Smart Strips | 0.63 | 0.63 | 0.58 | 0.31 | 49% | 79% | 0.25 |
| **HVAC and Water Heating Measures** | | | | | | | |
| Filter Whistle – Electric | 0.02 | 0.02 | 0.01 | 0.17 | 828% | 99% | 0.17 |
| Filter Whistle – Gas | 0.13 | 0.13 | 0.07 | 0.04 | 27% | 99% | 0.03 |
| Pipe Wrap – Electric | 0.06 | 0.06 | 0.06 | 0.14 | 245% | 102% | 0.14 |
| Smart Thermostat – Electric | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 76% | 0.00 |
| Smart Thermostat – Gas | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 76% | 0.00 |
| Water Heater Setback – Electric | 0.24 | 0.24 | 0.24 | 0.53 | 216% | 100% | 0.53 |
| **Water-Saving Devices** | | | | | | | |
| Bathroom Aerator – Electric | 0.26 | 0.26 | 0.22 | 0.16 | 63% | 92% | 0.15 |
| Kitchen Aerator – Electric | 0.09 | 0.09 | 0.09 | 0.17 | 200% | 84% | 0.15 |
| Showerhead – Electric | 0.14 | 0.14 | 0.12 | 0.53 | 377% | 87% | 0.46 |
| TSV – Electric | 0.03 | 0.03 | 0.03 | 0.03 | 88% | 92% | 0.03 |
| **Total** | **23.00** | **23.00** | **22.49** | **30.51** | **133%** | **74%** | **22.57** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus developed a logic model and KPIs for the HEA 2.0 Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# HOME ENERGY ASSESSMENT PROGRAM 2.0

### Market Actor

**End-Use Customer** | Single Family Residents

### Market Barriers

- Lack of program awareness
- Upfront cost of energy efficiency upgrades
- Lack of energy efficiency awareness
- Lack of understanding about payback period for energy efficiency upgrades
- Lack of awareness of other Vectren program offerings
- Skepticism of true energy savings
- Lack of time available for assessment and installation process

### Intervention Strategies / Activities

- Program marketing (mailings, bill inserts, email, events, digital)
- Information on implementer website
- Products and installation offered free of charge
- Energy education provided during in-home assessment
- Estimated payback period for recommended upgrades included in assessment report
- Description of all Vectren programs included in each assessment report
- Turnkey installation services
- Implementer arranges a convenient assessment time with customers who sign up online or via phone

### Outcomes

- Increased awareness
- Increased participation
- Increased customer satisfaction
- Increased participation in other Vectren programs
- Increased energy savings
- Improved customer perception of energy efficient programs
- Increased adoption of energy efficiency measures
- Increased adoption of energy-saving behaviors
- Spillover occurs

### Key Indicators

- Achievement of program participation and savings goals
- Number of participating households
- Persistence of measures
- Measure satisfaction ratings
- Program satisfaction ratings
- Likelihood to recommend ratings
- Program spillover
- Percentage of participants who adopted energy-saving behaviors
- Conversion rate to other Vectren DSM programs

### Market Actor

**Program Implementer** | Assessors & Installers

### Market Barriers

- Assessor qualifications
- Participant concerns of implementer entering home

### Intervention Strategies / Activities

- RFPs to attract qualified program implementer
- Implementer-employed assessors are BPI-certified
- Open communication with participants to address concerns
- Direct contact with participant customers

### Outcomes

- Assurance of quality work
- Increased market saturation of energy efficiency
- Increased customer satisfaction

### Key Indicators

- Achievement of program participation and savings goals
- Number of participating households
- Installation experience satisfaction
- Efficient product saturation in Vectren's territory

## Program Performance

Cadmus measured 2015 to 2018 program performance against the KPIs listed in Table 52. The table shows historical KPIs for the previous versions of the program for reference, but Cadmus recognizes that the program design changed in 2018.

**Table 52. Home Energy Assessment Program KPI and 2012-2018 Performance**

| KPI | Performance | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | 118% | 123% | 87% | 100% |
| Achievement of gross kWh savings goals | 89% | 69% | 77% | 124% |
| Achievement of gross kW savings goals | N/A | N/A | N/A | 100% |
| Number of participating households | 2,366 | 1,850 | 1,819 | 350 |
| Program satisfaction rating | 90% (n=89) | 89% (n=71) | 97% (n=69) | 97% (n=72) |
| Likelihood to recommend rating | N/A | N/A | 97% (n=70) | 100% (n=72) |
| Program spillover | 3% | 5% | 9% | 4% |
| Persistence of Measures | 93% | 98% | 93% | 95% |
| Percentage of participants who adopted energy-saving behaviors | 30% (n=89) | 49% (n=61) | 54% (n=61) | 60% (n=71) |
| Conversion rate to other DSM programs | N/A | N/A | N/A | 3%[1] |
| Installation experience satisfaction | N/A | N/A | N/A | 99% (n=71) |
| Efficient product saturation in Vectren's territory | N/A | N/A | N/A | Track in future years |
| **Participant Measure Satisfaction[1]** | | | | |
| Light Bulbs | CFLs: 86% | CFLs: 81% | LEDs: 95% | LED: 100% |
| LED Night Light | N/A | 90% | 95% | 100% |
| Showerhead | 72% | 87% | 89% | 62% |
| Aerators | 84% | 92% | 94% | 75% |
| Smart Thermostat | N/A | N/A | N/A | 97% |
| Filter Whistle | 38% | N/A | N/A | N/A |
| Water Heater Setback | N/A | N/A | N/A | 97% |
| Smart Power Strip | N/A | N/A | N/A | 84% |
| Pipe Wrap | 88% | 100% | N/A | N/A |

[1]Cadmus calculated the conversion rate by comparing how many HEA participants also participated in Appliance Recycling or Residential Prescriptive programs during 2018.

In 2017, Vectren expressed concern that the program was reaching saturation in its service territory, and the 2017 evaluation found that from 2012 to 2017,[27] the HEA Program served approximately 16% of Vectren's total electric customers. In 2018, Vectren redesigned the program to focus on generating deeper savings for fewer homes. The program implementer said market saturation was not a concern in

[27] In 2012-2014, the Home Energy Assessment Program was part of the statewide Energizing Indiana portfolio of programs.

2018 or the near future, because Vectren plans to target only 300 to 400 audits a year, far fewer than in previous program years due to a more holistic program approach moving forward. The program implementer thought that significant savings potential remains for the program and said the challenge to any future expansion of the program was finding the best way to market and provide energy efficiency information to new customers.

## Income-Qualified Weatherization Program

The Income Qualified Weatherization (IQW) Program offers a walk-through audit and direct installation of energy efficiency measures for income-qualified, single-family homes at no cost to the customer. Program eligibility extends to homeowners and tenants who have a total household income up to 300% of the federal poverty level. The program implementer, CLEAResult, was responsible for recruiting participants and providing turnkey implementation services. Its energy auditors conducted on-site assessments, installed phase 1 program measures (including LEDs, showerheads, aerators, and smart thermostats), and recommended phase 2 measures (air and duct sealing) and phase 3 measures (insulation, and refrigerator and air conditioner replacements) for deeper household energy savings. Phase 2 measures were installed by CLEAResult field technicians and phase 3 measures by a participating trade ally.

### Accomplishments

Table 53 shows the program's achievements against goals in 2018. The Program exceeded its participation and savings goals. The participation goal may have exceeded because the program implementer continued canvassing and attending neighborhood events to recruit participants in 2018.

**Table 53. 2018 Income Qualified Weatherization Goals and Achievements**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 856,620 | 639,780 | 134% |
| Gross kW Savings | 451.05 | 200.00 | 226% |
| Participants (Households) | 2,138 | 948 | 226% |
| Program Expenditures | $951,754 | $954,119 | 100% |

Table 54 lists the evaluated savings summary for the IQW Program. Overall the program achieved an energy realization rate of 109% and a demand realization rate of 22%.[28] Higher realization rates for attic insulation and thermostats were the primary drivers for the overall program realization rate.

For thermostats, this was because of differences in the assumed baseline thermostat technology (reported savings relied on a mixed baseline of manual and programmable, and evaluated savings assumed a manual baseline for this evaluation).

For attic insulation, this was because of differences in the existing R-values and square footage installed (reported savings were based on installing 815 square feet of insulation with a baseline of R-11, evaluated savings were based on installing 1400 square feet of insulation with a baseline of R-6). Most other measures' audited per-unit savings aligned with the evaluated savings and were near 100%.

28 Realization rates are based on reported values in the 2018 DSM Scorecard. If compared to audited savings from the 2018 program tracking data, the demand realization rate would be 106%.

**Table 54. 2018 Income Qualified Weatherization Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 856,620 | 856,867 | 824,312 | 931,314 | 109% | 100% | 931,314 |
| Total kW | 451.05 | 93.96 | 90.48 | 99.52 | 22% | 100% | 99.52 |

# *Conclusions and Recommendations*

## Program Administration and Delivery

**Health and safety issues are preventing installation of phase 2 and phase 3 measures, which are necessary to achieve deeper savings per household.** Gross kWh savings per home declined 37% from 2017 to 2018, after a 50% decline from 2016 to 2017.

Only 5% of homes in 2018 received phase 2 or phase 3 measures, such as insulation, air sealing, and refrigerator/air conditioner replacement, compared to 22% in 2017. In 2018, the average home receiving phase 2 and phase 3 measures saved 951 kWh compared to 392 kWh for phase 1 homes. The program made a greater marketing effort to target manufactured homes, which typically provide less opportunity for weatherization measures, but only 2% of participants lived in manufactured homes in 2018.[29]

The program implementer reported that the measure mix installed in each home produced lower than expected savings in 2018, in part because of health and safety issues, such as asbestos or ventilation, which prevented the blower door test from being conducted (and is required for recommendation of many phase 2 and phase 3 measures). Although Vectren changed the $250 health and safety cap to a soft cap, allowing for more health and safety funding to be awarded on a case-by-case basis, only two homes in 2018 received this additional funding. Overcoming health and safety issues in income-qualified households is a common barrier in weatherization programs across the country. Based on Cadmus' experience with other income-qualified programs, we understand that $250 is a standard health and safety budget per home. However, more funding may be required to address additional concerns and allow deeper savings per home. According to Vectren staff, the IQW Program design is being updated in 2019 to focus on deeper retrofit measures per household.

**Recommendation:** Prioritize installation of phase 2 and phase 3 measures in participant homes to achieve greater program savings and make a deeper impact on individual customers.

**Recommendation:** Research partnerships with local state and federal programs to help fund additional health and safety improvements that can help increase the penetration of phase 2 and phase 3

29 Cadmus was able to determine the type of home (single-family, multifamily, or manufactured home) for 2,128 (out of 2,138) participants.

measures and better serve low-income customers. In addition, to ensure that all home types are eligible for phase 2 or phase 3 measures, Vectren should recruit contractors qualified to install weatherization in multifamily and manufactured homes.

## Marketing and Outreach

**Neighborhood canvassing successfully increased participation.** The program achieved 226% of its electric participation goal despite Vectren more than doubling the participation target compared to 2017. At the beginning of 2017, the program implementer made a major marketing and outreach change by canvassing in neighborhoods with eligible customers, including targeting neighborhoods with manufactured homes. The program implementer also began partnering with neighborhood associations and attending neighborhood events to set up recruitment and information tables about the IQW Program.

## Satisfaction

**Customers and trade allies are highly satisfied with the IQW program.** Most surveyed participants said they were satisfied with the program overall (93%, n=85) and that it was likely they would recommend the IQW program to a neighbor (93%, n=86). Nearly all respondents (98%, n=84) found it easy to participate. One energy auditor (n=3) and all trade allies (n=3) said when they received feedback from a customer, it was typically positive. Similarly, all trade allies interviewed (n=3) said they were satisfied with the level of support they received from program staff and the program overall. All three were likely to recommend the IQW Program to both their business colleagues and their customers, and two said they would be eager to take on more work through the program.

**Measures with smart technology can be difficult for some customers to adopt.** Although satisfaction with all program measures was high, smart thermostats and smart strips both had satisfaction scores below 90% (84%, n=19 and 83%, n=68, respectively). Satisfaction with smart strips was statistically lower than it was in 2017.[30] Participants who were less satisfied with the smart measures said the measures did not work properly or were too technical for them to use. However, the in-service rates (ISRs) for both smart strips (96%) and thermostats (100%) were high, suggesting that these problems were not enough to uninstall these measures. Therefore, customers may not be using these measures correctly, resulting in lower energy savings over time.

**Recommendation:** To ensure maximum lifetime savings, Vectren should ensure that energy auditors are taking the time to thoroughly educate the customers on how a smart thermostat or smart strip works while on site. If current education is comprehensive, additional or alternate methods of education should be explored. Vectren should also consider developing educational materials specifically for smart thermostats and smart strips that can be left behind to remind customers how to use these measures so that they continue saving energy over time. Vectren recently developed an educational thermostat postcard for Residential Prescriptive customers that may be relevant to this program as well.

---

[30] $p < 0.05$ using a binomial t-test. In 2017, 98% of participants were satisfied with their smart strips.

**Although savings for audit education is increasing, customers still want more support from the program**. As evidenced by the evaluated audit savings, more customers are undertaking energy-saving behavior recommendations. However, many participant survey respondents provided feedback regarding the information and services provided by their energy auditor. Most of the respondents who did not act on recommendations said they could not recall receiving any recommendations or they could not afford the recommendations. Respondents who suggested improvements said more advice and assistance from the energy auditor would have improved their program experience. Some participants said they felt they did not receive complete follow-up from their energy auditor after phase 1 of their assessment. Participants who were dissatisfied with the program said they were not provided with enough information or services to feel their participation made a difference in their energy consumption. In 2019, Vectren said it plans to update delivery of the IQW Program to direct more focus on the audit to provide more services to individual customers and achieve deeper savings per home.

## Data Tracking

**Tracking data for existing thermostats will improve accuracy of the impact evaluation.** In 2018, no information was collected on the existing thermostat technology for participants who receive smart thermostats. Without these data, Cadmus used a proxy input for baseline technology. According to the program implementer, the program began collecting the existing thermostat type for homes who receive smart thermostats for the 2019 program year.

**Improved tracking of existing attic insulation is necessary for accurate savings estimation.** For attic insulation installations**,** Cadmus found that 46% of attics in the tracking data had no existing insulation at all. This is a significant increase from 4% in 2016 and 20% in 2017. Such dramatic changes in baseline conditions indicate potential data collection inconsistencies. To avoid over-estimating savings, Cadmus used 2016 tracking data where only 4% of homes were recorded to have no existing insulation, to approximate the R-0 values in 2018. This changed the overall baseline R-value in 2018 from R-3 to R-6.

**Recommendation:** To evaluate savings more accurately, it is important to have reliable information about the existing R-value for all attic insulation installations. Ensure weatherization contractors collect and track this data for the program.

## Program Planning

**Weatherization measures in electrically heated homes have low sample sizes.** Because of the infrequency with which attic insulation and air sealing are installed in electrically heated homes, evaluated savings vary widely from year to year for these measures.

**Recommendation:** For air sealing and attic insulation installed in electrically heated homes, use historical evaluated savings averages for program planning and reported savings.

**If the program decides to offer additional comprehensive measures with higher expected savings, such as weatherization, in the future, it may be more appropriate to evaluate program savings using billing analysis.** According to Vectren staff, the IQW Program design is being updated in 2019 to focus on deeper retrofit measures per household. To evaluate installations of major measures such as insulation, air sealing, and duct sealing, a billing analysis has the advantage of accounting for all interactive effects between installed measures. Billing analysis also accounts for the non-additive effects of each additional measure installed. However, if the program continues to be based largely on direct install measures then it may be most appropriate to continue using the current engineering algorithm approach, because a billing analysis is less effective when expected savings are lower. Billing analyses also require a year of post-installation billing data to fully evaluate savings, so all program year evaluations would lag by one year.

## *Process Evaluation*

### Process Evaluation Methodology

Cadmus conducted these process evaluation activities for its evaluation of the 2018 program year:

- Interview with three Vectren program staff members
- Interview with two CLEAResult program staff members
- Participant mixed-mode online (n=57) and phone (n=35) survey
- Interviews with the three CLEAResult energy auditors and three participating trade allies

Vectren provided data for 876 unique participating customers. Cadmus completed a phone survey with 35 participants and an online survey with 57 participants for a total of 92 completed surveys. Cadmus tested for statistically significant differences in 2017 and 2018 survey results (with a t-test set at the 95% ($p \leq 0.05$) significance level). Unless noted otherwise, all results were consistent with previous program years.

### Process Evaluation Findings

The following sections describe the detailed process evaluation findings.

#### *Program Administration and Delivery*

Through the IQW Program, energy auditors employed by the implementer, CLEAResult, evaluate the energy performance of participating customers' homes and, while at the home, install measures such as energy-efficient lighting and water-saving devices. Energy auditors call the participant the day before to confirm an appointment and help minimize cancelled assessments. Typically, surveyed participants reported they had to wait one to two weeks before receiving their assessment (51%, n=88), and 95% (n=88) said they were satisfied with this wait time.

Customers can enroll in the program several different ways. They can self-enroll using an online scheduling tool found on Vectren's website, call Vectren (or the program implementer), or can be recruited through canvassing and other face-to-face marketing techniques. Ninety-nine percent of participants (n=83) found it easy to enroll in the program.

**Phase 1 Assessment**

Energy auditors complete an audit on the home and use an online tool to help decide what measures are needed. Energy auditors (n=3) are satisfied with the tool; however, two suggested including more fields to allow them to input additional heating, cooling, and pool information. Vectren instructs energy auditors to install as many no-cost measure types as possible, up to a specified maximum (leaving no measures behind for the customer to install), and to record all installed measures in the program tracking database. Auditors can install a maximum number of these products during the phase 1 assessment:

- 16 LEDs (10 A-line, 2 globe, 2 R30, 2 exterior LEDs)
- 2 smart strips
- 4 bathroom aerators
- 1 kitchen aerator
- 1 furnace filter whistle
- 6 feet of pipe wrap
- 4 LED night lights
- 4 energy-efficient showerheads
- 1 smart thermostat

Energy auditors may also set back the temperature of customers' water heaters. Energy auditors (n=2) and trade allies (n=3) were asked if there were additional measures the program should include. One trade ally suggested adding a bath fan. Both energy auditors suggested adding combination smoke and carbon monoxide detectors. (However, these would be considered health and safety measures because they do not contribute program energy savings).

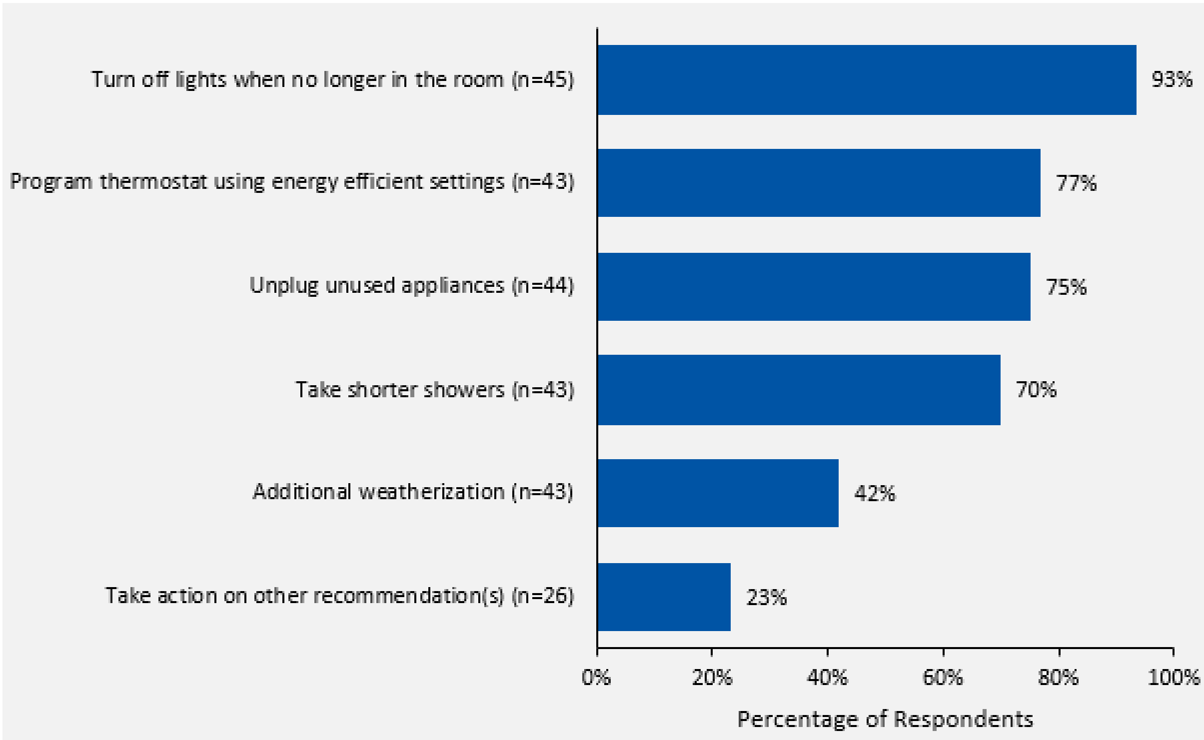
**Energy Education**

While on site during the phase 1 assessment, energy auditors also provide energy efficiency education by explaining how customers' homes use energy and what the customer can do to reduce their usage. Customers receive a report about their homes' energy use and suggestions for further actions to reduce energy consumption. Although some general recommendations are given to most customers, other recommendations are customized to the participant based on the age of the house or type of resident (i.e., owner versus renter, family structure, or resident behavior) in the home.

Nearly two-thirds (61%, n=75) of surveyed participants said they took action on the energy-saving recommendations they received at the time of their assessment. Most received recommendations such as turning off lights when no longer in the room, unplugging unused appliances, or taking shorter showers. Some respondents said they took action on other recommendations such as getting their roof repaired or getting their furnace inspected. Of the respondents who took action on a recommendation. Figure 10 shows a full breakdown of the recommendations.

Respondents who said they did not act on the energy auditor's recommendations were asked why (39%, n=75). Of these 21 respondents, 43% said they could not recall receiving any recommendations and 29% said they could not afford the recommendations they were given. Other reasons included that they were a renter and unable to execute the recommendations (10%), they already acted on the recommendations (10%), they were too busy to act on the recommendations (5%), or they did not want to alter their home for aesthetic reasons (5%).

**Figure 10. Recommendations Adopted by 2018 Participants**




**Phase 2 and Phase 3 Measures**

During phase 1, the energy auditors conduct the initial audit and use the blower door test to determine phase 2 and phase 3 eligibility. Homes that are eligible for phase 2 can receive free air and duct sealing through a follow-up appointment conducted by a CLEAResult field technician. Similarly, homes that are eligible for phase 3 can receive free attic insulation, air conditioning retrofit, and a refrigerator and/or central air conditioner replacement installed in a follow-up appointment with a participating trade ally.

Vectren also offers a flexible $250 budget for measures that address health and safety concerns. Homes are evaluated on a case-by-case basis if such additional health and safety funds are needed. Energy auditors identified the most common health and safety issues as asbestos tape on ducts, clogged water heater vents, and improperly vented flu pipes.

To initiate phase 3 the program implementer contacts approved trade allies (chosen through an RFP process) via email and passes on project information. Trade allies then follow up with the customer to schedule the appointment and install any applicable phase 3 measures. One trade ally mentioned occasionally going to a home ineligible to receive phase 3 measures and said better screening in phase 1 could help alleviate that problem. Vectren has already moved the blower door test to phase 1 to minimize the number of ineligible homes passed on to trade allies.

To understand how installing phase 2 and phase 3 measures impacts overall program savings, Cadmus analyzed the average per-household savings by participant type and home type, as shown in Table 55.

**Table 55. Savings by Participant Type**

| Home Type | 2017 Participation[1] | 2018 Participation[2] | 2018 Savings (kWh) |
|---|---|---|---|
| **Phase 1** | | | |
| Single-Family | N/A | 1,763 | 407 |
| Manufactured Home | N/A | 50 | 454 |
| Multifamily | N/A | 207 | 247 |
| **Total** | **594 (78%)** | **2,020 (95%)** | **392** |
| **Phase 2 and Phase 3** | | | |
| Single-Family | N/A | 104 | 964 |
| Manufactured Home | N/A | 0 | N/A |
| Multifamily | N/A | 3 | 502 |
| Total | **172 (22%)** | **107 (5%)** | **951** |

[1] 2017 data did not provide information at the home type level.
[2] 2018 participation does not add up to 2,138 because home types were not available for all participants.

Phase 1 participants are defined as those who received only direct install measures such as lighting, water-saving measures and smart thermostats. Phase 2 and phase 3 participants are defined as those who received major measures such as air sealing, insulation, duct sealing, refrigerators, and central air conditioners. Although overall program participation was significantly higher in 2018, fewer phase 2 and phase 3 jobs were performed. In 2018, only 107 phase 2 and phase 3 jobs were performed, representing 5% of total jobs, compared to 2017, with 172 phase 2 and phase 3 jobs, representing 22% of total jobs.

As expected, in 2018 phase 2 and phase 3 jobs saved significantly more (951 kWh) than phase 1 jobs (392 kWh). Single-family homes represented the most significant housing type in 2018 (88% of all jobs). The remaining 12% of homes were either multifamily or manufactured homes. Although these home types have limited potential for most phase 2 and phase 3 measures, in particular weatherization measures, single-family homes still represented the large majority of the program population, indicating there is still be substantial potential for phase 2 and phase 3 measures.

The program implementer said that to advance more eligible participants to phase 2 or phase 3 and achieve deeper savings per household more funding was needed to address the health and safety hazards in customer homes. Cadmus asked energy auditors (n=3) what could be done to achieve deeper savings per home. One suggested expanding the list of available measures to include furnace replacements or smoke and carbon monoxide detectors. Another noted, during some audits, being unable to discuss all health and safety hazards in a home (such as mold) because of a lack of certification. This auditor added that certification would allow auditors to address additional health and safety measures and determine what needed to be fixed so additional efficiency measures could be installed.

### *Marketing and Outreach*

In 2018, the program implementer expanded on Vectren's marketing efforts by canvassing in neighborhoods with qualified customers and ran recruitment and information tables at other neighborhood events over the course of the year. The implementer targeted manufactured homes in particular because this type of home had been difficult to reach with more traditional marketing efforts. In 2018, although only 2% of participant homes were manufactured, by targeting harder-to-reach populations, the implementer successfully engaged these customers with face-to-face marketing.[31]

In interviews, energy auditors said some customers were aware of the program but decided not to participate because some household members did not agree.

### *Satisfaction*

Cadmus asked participants and trade allies to rate their satisfaction with several program components and the program overall.

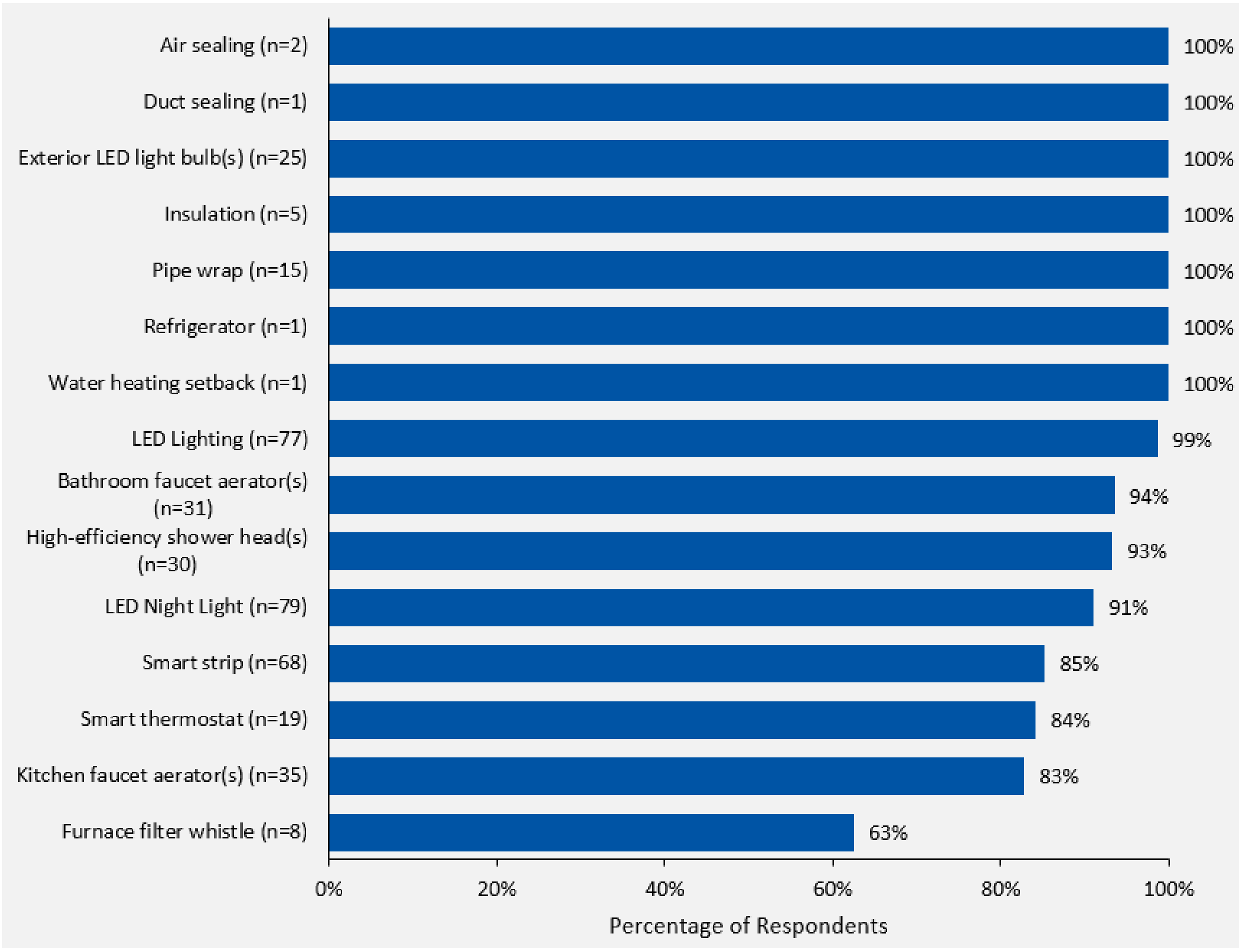
**Participant Satisfaction**

Most participants said they were satisfied with the program overall (93%, n=85) and were likely to recommend the IQW program to a neighbor (93%, n=86). Respondents who were not as satisfied said they felt they were not provided with enough information or services to make a difference in their energy consumption. Nearly all respondents (98%, n=84) found it easy to participate in the program.

Participants were also asked about their satisfaction with each of the measures they received through the program. Their satisfaction ratings are presented in Figure 11.

[31] Cadmus was able to determine the type of home (single-family, multifamily, or manufactured home) for 2,128 participants.

**Figure 11. 2018 Participant Satisfaction with Program Measures**




In 2018, most measure ratings were consistent with 2017, with three exceptions:[32]

- LED lighting recipients were statistically more satisfied in 2018 (99%, n=77) than in 2017 (92%, n=64).
- Smart strip recipients were statistically less satisfied in 2018 (85%, n=68) than in 2017 (98%, n=41).
- Furnace filter whistle recipients were statistically less satisfied in 2018 (63%, n=8) than in 2017 (100%, n=8).[33]

For measures that did not reach 100% satisfaction, reasons for lower satisfaction varied and are summarized in Table 56.

---

32 $p < 0.05$ using a binomial t-test.

33 Due to the small sample size of furnace filter whistle participants, any statistical significance test results should be interpreted with caution.

**Table 56. 2018 Participant Reasons for Lower Measure Satisfaction**

| Measure | N | Reason for Lower Satisfaction |
|---|---|---|
| LED Lighting[1] | 1 | • Light bulb blew out quickly (n=1) |
| LED Night Light | 6 | • Too dim (n=4)<br>• Too bright (n=1)<br>• Did not work properly (n=1) |
| Thermostat | 3 | • Did not work properly (n=2)<br>• Too technical (n=1) |
| Smart Strip[1] | 10 | • Not enough outlets (n=2)<br>• Does not work properly (n=2)<br>• Does not fit needs (n=2)<br>• Did not need (n=2)<br>• Too technical (n=1)<br>• Aesthetics (n=1) |
| High-Efficiency Shower Head(s) | 1 | • Not enough water pressure (n=1) |
| Kitchen Faucet Aerator(s) | 6 | • Clogging (n=4)<br>• Not enough water pressure (n=1)<br>• Did not need (n=1) |
| Bathroom Faucet Aerator(s) | 2 | • Clogging (n=1)<br>• Incorrect installation (n=1) |
| Furnace Filter Whistle[1] | 2 | • Too loud (n=1)<br>• Fear of breaking (n=1) |

[1] Indicates statistically significant differences from 2017 results.

Participants were also asked about their satisfaction with Vectren's other energy efficiency offerings, and these questions were worded to match the J.D Power survey questions:[34]

- 93% of participants (n=75) were satisfied with the variety of energy efficiency programs offered by Vectren.
- 87% of participants (n=83) were satisfied with Vectren's efforts to manage their monthly usage.
- 83% of participants (n=88) found Vectren's suggestions on ways they can reduce their energy usage and lower their monthly bills useful.

### Energy Auditors and Trade Allies

Energy auditors and trade allies were asked about their satisfaction with different aspects of the program:

- All energy auditors (n=3) and trade allies (n=3) indicated they were satisfied with the IQW Program overall and that it is easy for them to participate in the program.
- All trade allies (n=3) indicated that they would be very likely to recommend the IQW Program to both their business colleagues and their customers.

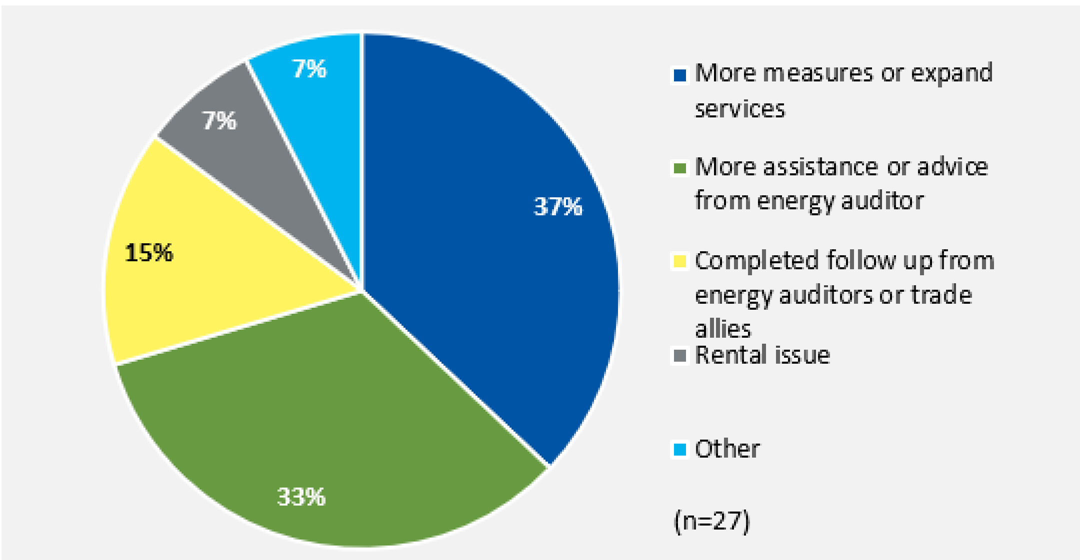
[34] J.D. Power administers a quarterly, nationwide survey to assess residential electric utility customer satisfaction.

- Two trade allies (n=2) reported they are very satisfied with the level of support they receive from program staff, indicating that their questions are always answered.[35]
- Two trade allies indicated they would be eager to take on more work through the program.

**Suggested Program Improvements**

Seventy-one percent of survey participants had no suggestions to improve the IQW program (n=92). Respondents who provided suggestions (n=27) wanted more measures and services added to the program (37%) or to receive more assistance and advice from the energy auditor who came to their home (33%). Some said they felt they did not receive the follow-up they needed from their energy auditor and said that the program could be improved by ensuring follow-up was completed (15%) or providing assistance with landlords or property management companies to complete weatherization upgrades (7%). Those who said "other" (7%) suggested more advertising for the program and greater capabilities from the energy auditor. Figure 12 presents participants' suggested improvements.

**Figure 12. Participant Suggested Program Improvements**




## Impact Evaluation

### Impact Evaluation Methods and Findings

The IQW impact evaluation included multiple data collection efforts and analysis tasks:

- A tracking database review of the number of measures installed
- A survey of 92 program participants to verify number of measures installed
- An engineering analysis of *ex ante* energy savings per measure and per home

---

35 The remaining interviewed trade ally did not respond to this question.

## Gross Savings Review

Cadmus conducted an engineering desk review to assess energy and demand savings for the electric-saving measures distributed through the IQW Program. Cadmus also assessed the savings achieved by participants' implementation of additional energy saving actions recommended during the walk-through audit. Table 57 provides per-unit annual gross savings for each program measure.

**Table 57. 2018 IQW Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| **Audit Education** | | | | |
| Audit Fee (Dual Fuel) | 68 | 83 | 0.008 | 0.003 |
| Audit Fee (Electric) | 68 | 102 | 0.008 | 0.000 |
| **Lighting** | | | | |
| Exterior LED Lamps | 92 | 99 | 0.000 | 0.000 |
| LED 5W Globe | 10 | 20 | 0.001 | 0.002 |
| LED 9W Bulb (Multifamily [MF]) | 19 | 33 | 0.003 | 0.004 |
| LED 9W Bulb (Manufactured home [MH]) | 19 | 24 | 0.003 | 0.004 |
| LED 9W Bulb (Single-family [SF]) | 32 | 33 | 0.004 | 0.004 |
| LED R30 Dimmable | 53 | 33 | 0.007 | 0.004 |
| LED Nightlight | 14 | 14 | 0.000 | 0.000 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | 12 | 35 | 0.001 | 0.003 |
| Kitchen Flip Aerator | 120 | 146 | 0.007 | 0.007 |
| Efficient Showerhead | 300 | 343 | 0.015 | 0.015 |
| **HVAC and Water Heating Measures** | | | | |
| Central Air Conditioner 16 SEER | 300 | 587 | 0.389 | 1.047 |
| Filter Whistle | 54 | 46 | 0.000 | 0.076 |
| Pipe Wrap, per home (Electric) | 148 | 99 | 0.019 | 0.011 |
| Smart Thermostat (Dual Fuel) | 378 | 429 | 0.000 | 0.000 |
| Smart Thermostat (Electric) | 378 | 1,580 | 0.000 | 0.000 |
| Water Heater Temperature Setback (Electric) | 86 | 82 | 0.010 | 0.009 |
| **Appliance and Plug Load Reduction** | | | | |
| Refrigerator Replacement | 442 | 360 | 0.065 | 0.053 |
| Smart Power Strip | 23 | 26 | 0.002 | 0.002 |
| **Weatherization Measures** | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | 103 | 125 | 0.285 | 0.162 |
| Air Sealing 10% Infil. Reduction (Electric) | 4,688 | 1,132 | 0.921 | 0.000 |
| Attic Insulation (Dual Fuel) | 122 | 383 | 0.123 | 0.378 |
| Attic Insulation (Electric) | 828 | 3,917 | 0.030 | 0.762 |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | 210 | 155 | 0.368 | 0.269 |
| Wall Insulation (Dual fuel)[2] | 56 | 58 | 0.037 | 0.042 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.
[2] The measure name indicated that wall insulation installations were gas only measures and not dual. These participants had claimed electric savings and were verified to have central air conditioning and were Vectren customers.

Cadmus used inputs and algorithms from the 2015 Indiana TRM with the following exceptions:

- For lighting measures, the baseline wattage was determined following guidelines from the UMP based on the type of bulb and lumen output.
- For the water heater temperature setback measure, Cadmus used the Illinois TRM Version 6.0 to evaluate savings because it is not included in the 2015 Indiana TRM.
- For smart thermostats, Cadmus used an evaluation from 2013–2014 of programmable and smart thermostats in Vectren South Territory.[36]
- For pipe wrap, Cadmus found that the Indiana TRM algorithm had assumptions that overestimated savings, and instead used an energy savings factor of 3%[37].

Several measures had realization rates above or below 100%, for the following reasons:

- **Audit education.** The savings for the audit education measure category vary from year to year depending on how many surveyed participants respond that they implemented energy-saving actions. Compared to the 2015 program year, on which reported savings are based, a higher percentage of the surveyed participants in 2018 said they had implemented the recommended energy-saving action, which led to higher evaluated savings than reported savings.
- **Lighting.** The R30 dimmable LED and 5-watt globe had very different *ex ante* and evaluated savings because the methodology used in determining the baseline wattage was different. The *ex ante* savings include an approach from the Indiana TRM that uses a multiplier of the efficient bulb to determine the baseline value, while evaluated savings used guidelines in the UMP that are based on the style and lumen output of the bulb. 9-watt LEDs installed in manufactured homes had lower evaluated savings than multifamily and single-family because of a significantly higher prevalence of electric heating. Additionally, for the 9-watt LED installed in manufactured and multifamily homes assumptions for these lighting types were not available so differences were difficult to predict.
- **Water-saving devices.** The bathroom aerator evaluated savings differed significantly from the reported savings because the reported savings were based on the installation of a 1.5 gpm faucet aerator; however, beginning in 2017 the program began installing 1.0 gpm faucet aerators. This was the primary driver for higher evaluated savings in 2018. Kitchen aerators and showerheads also had differences; however, these were primarily driven by differences in inputs gathered in the surveys, such as people per home and showers per home. In 2018, the number of people per home was 2.5 compared to 2.1 in 2015, leading to higher evaluated savings.
- HVAC and water heating measures. For dual fuel participants (homes with gas heating and electric cooling), evaluated savings for smart thermostats were higher than ex ante savings

[36] Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. January 29, 2015.

[37] ACEEE Report Number E093. *Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy in Pennsylvania.* April 2009

because of differences in assumed baseline technology. The reported savings are derived from the Residential Prescriptive Program, which had a mixed baseline of manual and programmable thermostats. Given the low propensity of installed thermostats (17%) relative to IQW Program population, Cadmus assumed it was likely that the majority of installed thermostats were replacing manual thermostats, leading to higher evaluated savings. In future evaluations, these data should be collected during the on-site assessment if possible. In the absence of this, the survey should ask participants who received smart thermostats to assess the existing thermostat baseline.

In 2018, one central air conditioner was installed. The reason for its higher evaluated savings compared to reported savings was the assumption it replaced an operable central air conditioner. This assumption was because the IQW Program targets the low-income population who are not necessarily actively purchasing a new air conditioner. If possible, data should be collected on the home's existing cooling system, particularly if the unit is still operational. Data such as existing age, size, and efficiency would also be helpful in evaluating savings more accurately.

- **Appliance and plug load reduction.** Evaluated savings for refrigerators were lower than reported savings because a larger number of non-ENERGY STAR refrigerators were installed in 2018 compared to 2015. The unit energy consumption (UEC) for average baseline refrigerator and existing refrigerator have also gone down since 2015.
- **Weatherization measures.** The *ex ante* and evaluated savings for weatherization measures differed widely because each installation had site-specific data that affected the amount of savings given to each home. Air sealing in electrically heated homes had significantly lower evaluated savings than reported savings. The reported savings estimate was based on one household with a reduction of 2,000 CFMs. The evaluated savings estimate was based on one household with a reduction of 500 CFMs. For gas-heated homes, CFM reductions also differed, leading to slightly higher evaluated savings, but the differences were not nearly as large as for electrically heated homes.

  Higher evaluated savings for attic insulation were primarily because of a lower existing R-value and higher square footages of insulation installed in 2018 than in 2015. The average existing R-value was approximately 6 in 2018, compared to 11 in 2015. Installed insulation was 1,400 square feet in 2018 compared to 815 square feet in 2015. For attic insulation, an unreasonably high number of participants (46%) had an existing R-value of 0. Cadmus made an adjustment using data from the 2016 program year, in which 4% of participants had 0 R-values, under the assumption that the overall existing R-value between the two years should be very similar. The adjustment raised the overall installed R-value from 3.4 to 6.2.

  Duct sealing had a lower increase in duct efficiencies than expected in the *ex ante* methodology. Weatherization measures also depend on the type of heating and cooling for the home in which they are installed, which can affect the savings given each home if these are not accounted for.

Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

Table 58 shows the per-unit savings for measures offered from 2015-2018. Evaluated per-unit savings vary over time because of the following:

- **Audit education.** Audit education savings change each year because of the percentage of people who reported following the auditor's recommendations.
- **Lighting.** Lighting savings have remained consistent over past program years.
- **Water-saving devices.** Water measure savings have changed somewhat because survey results differ in the number of people per home and number of aerators installed per home, as well as changes in the efficiency of the installed aerator over time. In 2017, the installed efficiency of the bathroom aerator changed from 1.0 gpm to 1.5 gpm.
- **HVAC and water heating measures.** Filter whistle savings change from year to year depending on the distribution of heating and cooling type.
- **Appliance and plug load reduction.** Refrigerator savings changed more in 2018 primarily because a larger number of non-ENERGY STAR refrigerators were installed in 2018 compared to the prior years; therefore, evaluated savings were lower. Standard baseline refrigerator UEC and existing refrigerator UEC have gone down as time passes, leading to lower savings every year.
- **Weatherization measures.** Weatherization measures also changed substantially year to year because calculations rely on site-specific data. In 2018, dual fuel attic insulation installations had lower existing R baseline and were installed in larger homes, causing higher savings than in 2017. Differences in heating and cooling saturations and system types from year to year also affect savings and lead to more variation over time. For example, in 2017 electric air sealing measures were installed in two homes with heat pumps, while in 2018 air sealing was installed in one home with an electric furnace. Air sealing savings are considerably lower for homes with heat pumps because they are more efficient, leading to significantly higher savings.

**Table 58. IQW Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **Audit Education** | | | | |
| Audit Education – All sites | 68 | 46 | 32 | 83 |
| **Lighting** | | | | |
| Exterior LED Lamp | - | 99 | 99 | 99 |
| LED 5W Globe | - | - | 19 | 20 |
| LED 9W Bulb | - | - | 32 | 33[1] |
| LED R30 Dimmable | - | - | 32 | 33 |
| LED Night Light | - | 14 | 14 | 14 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | 12 | 17 | 38 | 37 |
| Kitchen Flip Aerator | 120 | 136 | 155 | 155 |
| Low Flow Showerhead | 300 | 362 | 369 | 343 |
| **HVAC and Water Heating Measures** | | | | |
| Central Air Conditioner 16 SEER[2] | - | - | - | 587 |
| Filter Whistle | 55 | 119 | 44 | 46 |
| Pipe Wrap (Electric) (Per Home) | 148 | 166 | 104 | 104 |
| Smart Thermostat (Dual Fuel) | - | - | 429 | 429 |
| Water Heater Temperature Setback (Electric) | - | 87 | 82 | 82 |
| **Appliance and Plug Load Reduction** | | | | |
| Refrigerator Replacement | 442 | 420 | 414 | 360 |
| Smart Power Strips | - | 23 | 25 | 26 |
| **Weatherization Measures** | | | | |
| Air Sealing (Dual Fuel) | -[3] | 227 | 137 | 125 |
| Air Sealing (Electric) | -[3] | 227 | 325 | 1132 |
| Attic Insulation (Dual Fuel) | -[3] | 253 | 365 | 383 |
| Attic Insulation (Electric) | -[3] | 253 | 5,664 | 3,917 |
| Duct 10% leakage Reduction (Dual Fuel) | - | 251 | 162 | 155 |
| Wall Insulation – Gas Heated – South (Dual Fuel) | - | - | - | 58[2] |

[1] In 2018 this represents the weighted average of evaluated savings across single-family, multifamily, and manufactured homes.
[2] Central air conditioners and wall insulation were not offered in prior years, so there are no historical per-unit values.
[3] Air sealing and attic insulation were offered in 2015 but categorized differently by heating and cooling type as opposed to by fuel type

## Measure Verification

Cadmus calculated verified savings for the IQW Program by applying survey-gathered persistence rates to program measure savings. The persistence rate is an indicator of the number of measures that remained installed in homes after initial participation. Cadmus used the persistence rate as the ISR, assuming that reported installations were accurate because the program implementer's quality control process ensured that actual and reported measure installations matched. Table 59 lists the installation rates for each program measure.

**Table 59. 2018 IQW Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported[1] | Audited | Verified | |
| **Audit Education** | | | | |
| Audit Fee (Dual Fuel) | N/A | 1,826 | 1,826 | 100% |
| Audit Fee (Electric) | N/A | 54 | 54 | 100% |
| **Lighting** | | | | |
| Exterior LED Lamps | N/A | 500 | 500 | 100% |
| LED 5W Globe | N/A | 1,260 | 1,175 | 93% |
| LED 9W Bulb (Multifamily) | N/A | 577 | 538 | 93% |
| LED 9W Bulb (Manufactured home) | N/A | 284 | 265 | 93% |
| LED 9W Bulb (Single-Family) | N/A | 9,509 | 8,871 | 93% |
| LED R30 Dimmable | N/A | 596 | 556 | 93% |
| LED Nightlight | N/A | 3,597 | 3,400 | 95% |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | N/A | 167 | 156 | 93% |
| Kitchen Flip Aerator | N/A | 148 | 140 | 95% |
| Efficient Showerhead | N/A | 126 | 115 | 91% |
| **HVAC and Water Heating Measures** | | | | |
| Central Air Conditioner 16 SEER | N/A | 1 | 1 | 100% |
| Filter Whistle | N/A | 171 | 86 | 50% |
| Pipe Wrap, Per Home (Electric) | N/A | 74 | 74 | 100% |
| Smart Thermostat (Dual Fuel) | N/A | 372 | 372 | 100% |
| Smart Thermostat (Electric) | N/A | 5 | 5 | 100% |
| Water Heater Temperature Setback (Electric) | N/A | 12 | 12 | 100% |
| **Appliance and Plug Load Reduction** | | | | |
| Refrigerator Replacement | N/A | 26 | 26 | 100% |
| Smart Power Strips | N/A | 1,089 | 1,044 | 96% |
| **Weatherization Measures** | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 30 | 30 | 100% |
| Air Sealing 10% Infil. Reduction (Electric) | N/A | 1 | 1 | 100% |
| Attic Insulation (Dual Fuel) | N/A | 60 | 60 | 100% |
| Attic Insulation (Electric) | N/A | 1 | 1 | 100% |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 12 | 12 | 100% |
| **Total** | **N/A** | **20,520** | **19,342** | **94%** |

[1]The number of reported installations in the 2018 DSM Scorecard was based on number of households served (n=2,138). The audited and verified totals here represent the number of measures installations included in the 2018 program tracking data.

Table 60 shows historical installation rates for each program measure. Most installation rates are nearly identical except for filter whistles. The primary reason for this is the low sample size in both 2017 (n = 14) and 2018 (n = 4), leading to more variability in ISR.

**Table 60. IQW Historical Installation Rates**

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| **Audit Education** | | | | |
| Audit Fee (Dual Fuel) | - | 100% | 100% | 100% |
| Audit Fee (Electric) | - | 100% | 100% | 100% |
| **Lighting** | | | | |
| Exterior LED Lamps | - | - | 96% | 100% |
| LED 5W Globe | - | - | 100% | 93% |
| LED 9W | - | - | 100% | 93% |
| LED R30 Dimmable | - | - | 100% | 93% |
| LED Nightlight | - | - | 92% | 93% |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | 99% | 100% | 98% | 93% |
| Kitchen Flip Aerator | 99% | 94% | 93% | 95% |
| Low Flow Showerhead | 100% | 92% | 92% | 91% |
| **HVAC and Water Heating Measures** | | | | |
| Central Air Conditioner 16 SEER | - | - | - | 100% |
| Filter Whistle | 97% | 50% | 71% | 50% |
| Pipe Wrap, Per Home (Electric) | - | - | 100% | 100% |
| Smart Thermostat (Dual Fuel) | - | 88%[1] | 100% | 100% |
| Smart Thermostat (Electric) | - | 88%[1] | 100% | 100% |
| Water Heater Temperature Setback (Electric) | 91% | 100% | 100% | 100% |
| **Appliance and Plug Load Reduction** | | | | |
| Refrigerator Replacement | 100% | 100% | 100% | 100% |
| Smart Power Strips | - | 100% | 100% | 96% |
| **Weatherization Measures** | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | 100% | 100% | 100% | 100% |
| Air Sealing 10% Infil. Reduction (Electric) | 100% | 100% | 100% | 100% |
| Attic Insulation (Dual Fuel) | 100% | 100% | 100% | 100% |
| Attic Insulation (Electric) | 100% | 100% | 100% | 100% |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | 100% | 100% | 100% | 100% |
| Wall Insulation (Dual Fuel)[1] | - | - | - | 100% |

[1] These were all programmable thermostats in 2016.

## Net-to-Gross Analysis

Evaluations generally assume that most income-qualified customers would not have the discretionary income to install measures on their own outside of the financial support of the program. Consequently, the NTG ratio for income-qualified programs is assumed to be 1.0 and net savings are calculated the same as *ex post* savings.

To give Vectren a sense of the level of energy efficiency action its income-qualified population takes as a result of program participation, Cadmus included spillover questions in its participant survey. Since Cadmus did not assess freeridership, it did not apply the spillover results to the evaluated net savings and is reporting them for planning purposes only.

**Spillover Findings**

Four participants reported that after participating in the program they installed an additional high-efficiency measure for which they did not receive an incentive. These measures were a clothes washer, central air conditioner, a refrigerator, and insulation. They said participation in the program was very important in their decision. Cadmus used the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the program. Cadmus divided the total survey sample spillover savings by the gross program savings from the survey sample to obtain an estimate of 1% spillover for the program, as shown in Table 61.

**Table 61. 2018 IQW Program Spillover Estimate**

| Survey Sample Spillover MMBtu Savings | Survey Sample Program MMBtu Savings | Spillover Percentage Estimate |
|---|---|---|
| 4.7 | 626.6[1] | 1% |

[1] 2018 evaluated gross energy savings.

## Evaluated Net Savings Adjustments

Table 62 and Table 63 list evaluated net savings for the IQW Program for electric energy and demand. The program achieved net savings of 931,314 kWh and 99.52 coincident kW demand reduction.

**Table 62. 2018 IQW Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh)[1] | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| **Audit Education** | | | | | | | |
| Audit Fee (Dual Fuel) | N/A | 123,934 | 123,934 | 151,350 | N/A | 100% | 151,350 |
| Audit Fee (Electric) | N/A | 3,665 | 3,665 | 5,517 | N/A | 100% | 5,517 |

| Energy Savings Unit | *Ex Ante* Savings (kWh)[1] | | | Evaluated *Ex* | Realization | NTG | Evaluated |
|---|---|---|---|---|---|---|---|
| **Lighting** | | | | | | | |
| Exterior LED Lamps | N/A | 45,990 | 45,990 | 49,500 | 108% | 100% | 49,500 |
| LED 5W Globe | N/A | 13,065 | 12,188 | 23,018 | N/A | 100% | 23,018 |
| LED 9W Bulb (Multifamily [MF]) | N/A | 10,769 | 10,046 | 17,930 | N/A | 100% | 17,930 |
| LED 9W Bulb (Manufactured home [MH]) | N/A | 5,301 | 4,945 | 6,394 | N/A | 100% | 6,394 |
| LED 9W Bulb (Single-family [SF]) | N/A | 300,104 | 279,966 | 296,238 | N/A | 100% | 296,238 |
| LED R30 Dimmable | N/A | 31,574 | 29,456 | 18,124 | N/A | 100% | 18,124 |
| LED Nightlight | N/A | 49,050 | 46,358 | 46,358 | N/A | 100% | 46,358 |
| **Water-Saving Devices** | | | | | | | |
| Bathroom Aerator | N/A | 2,009 | 1,875 | 5,397 | N/A | 100% | 5,397 |
| Kitchen Flip Aerator | N/A | 17,764 | 16,829 | 20,425 | N/A | 100% | 20,425 |
| Efficient Showerhead | N/A | 37,782 | 34,544 | 39,467 | N/A | 100% | 39,467 |
| **HVAC and Water Heating Measures** | | | | | | | |
| Central Air Conditioner 16 SEER | N/A | 300 | 300 | 587 | N/A | 100% | 587 |
| Filter Whistle | N/A | 9,248 | 4,624 | 3,929 | N/A | 100% | 3,929 |
| Pipe Wrap, per home (Electric) | N/A | 10,964 | 10,964 | 7,347 | N/A | 100% | 7,347 |
| Smart Thermostat (Dual Fuel) | N/A | 140,508 | 140,508 | 159,588 | N/A | 100% | 159,588 |
| Smart Thermostat (Electric) | N/A | 1,889 | 1,889 | 7,901 | N/A | 100% | 7,901 |
| Water Heater Temperature Setback (Electric) | N/A | 1,037 | 1,037 | 978 | N/A | 100% | 978 |
| **Appliance and Plug Load Reduction** | | | | | | | |
| Refrigerator Replacement | 11,481 | 11,481 | 9,356 | 81% | N/A | 9,356 | 11,481 |
| Smart Power Strips | N/A | 25,047 | 24,018 | 26,975 | N/A | 100% | 26,975 |
| **Weatherization Measures** | | | | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 3,086 | 3,086 | 3,746 | N/A | 100% | 3,746 |
| Air Sealing 10% Infil. Reduction (Electric) | N/A | 4,688 | 4,688 | 1,132 | N/A | 100% | 1,132 |
| Attic Insulation (Dual Fuel) | N/A | 7,348 | 7,348 | 22,996 | N/A | 100% | 22,996 |
| Attic Insulation (Electric) | N/A | 828 | 828 | 3,917 | N/A | 100% | 3,917 |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 2,515 | 2,515 | 1,861 | N/A | 100% | 1,861 |
| Wall Insulation (Dual fuel)[1] | N/A | 1,231 | 1,231 | 1,282 | N/A | 100% | 1,282 |
| **Total** | **856,620[1]** | **856,867[1]** | **824,312** | **931,314** | **109%** | **100%** | **931,314** |

[1] Total reported and audited savings included interactive savings from the gas program. Cadmus did not evaluate savings for these measures in 2018, instead providing these inputs to Vectren for its cost-effectiveness analysis.

**Table 63. 2018 IQW Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| **Audit Education** | | | | | | | |
| Audit Fee (Dual Fuel) | N/A | 15.34 | 15.34 | 7.00 | N/A | 100% | 7.00 |
| Audit Fee (Electric) | N/A | 0.45 | 0.45 | 0.21 | N/A | 100% | 0.21 |
| **Lighting** | | | | | | | |
| Exterior LED Lamps | N/A | 0.00 | 0.00 | 0.00 | N/A | 100% | 0.00 |
| LED 5W Globe | N/A | 1.76 | 1.65 | 2.86 | N/A | 100% | 2.86 |
| LED 9W Bulb (Multifamily [MF]) | N/A | 1.44 | 1.35 | 2.23 | N/A | 100% | 2.23 |
| LED 9W Bulb (Manufactured home [MH]) | N/A | 0.71 | 0.66 | 1.08 | N/A | 100% | 1.08 |
| LED 9W Bulb (Single-family [SF]) | N/A | 38.99 | 36.37 | 36.60 | N/A | 100% | 36.60 |
| LED R30 Dimmable | N/A | 4.23 | 3.95 | 2.24 | N/A | 100% | 2.24 |
| LED Nightlight | N/A | 0.00 | 0.00 | 0.00 | N/A | 100% | N/A |
| **Water-Saving Devices** | | | | | | | |
| Bathroom Aerator 1.0 gpm – Electric DHW | N/A | 0.20 | 0.19 | 0.41 | N/A | 100% | 0.41 |
| Kitchen Flip Aerator 1.5 gpm – Electric DHW | N/A | 1.04 | 0.98 | 0.98 | N/A | 100% | 0.98 |
| Low Flow Showerhead 1.5 gpm – Electric DHW | N/A | 1.86 | 1.70 | 1.70 | N/A | 100% | 1.70 |
| **HVAC and Water Heating Measures** | | | | | | | |
| Central Air Conditioner 16 SEER | N/A | 0.39 | 0.39 | 1.05 | N/A | 100% | 1.05 |
| Filter Whistle | N/A | 0.00 | 0.00 | 6.49 | N/A | 100% | 6.49 |
| Pipe Wrap, per home (Electric) | N/A | 1.40 | 1.40 | 0.84 | N/A | 100% | 0.84 |
| Smart Thermostat (Dual Fuel) | N/A | 0.00 | 0.00 | 0.00 | N/A | 100% | N/A |
| Smart Thermostat (Electric) | N/A | 0.00 | 0.00 | 0.00 | N/A | 100% | N/A |
| Water Heater Temperature Setback (Electric) | N/A | 0.12 | 0.12 | 0.11 | N/A | 100% | 0.11 |
| **Appliance and Plug Load Reduction** | | | | | | | |
| Refrigerator Replacement | N/A | 1.70 | 1.70 | 1.38 | N/A | 100% | 1.38 |
| Smart Power Strips | N/A | 2.18 | 2.09 | 1.93 | N/A | 100% | 1.93 |

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net |
|---|---|---|---|---|---|---|---|
| **Weatherization Measures** | | | | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 8.56 | 8.56 | 4.87 | N/A | 100% | 4.87 |
| Air Sealing 10% Infil. Reduction (Electric) | N/A | 0.92 | 0.92 | 0.00 | N/A | 100% | N/A |
| Attic Insulation (Dual Fuel) | N/A | 7.41 | 7.41 | 22.66 | N/A | 100% | 22.66 |
| Attic Insulation (Electric) | N/A | 0.03 | 0.03 | 0.76 | N/A | 100% | 0.76 |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | N/A | 4.41 | 4.41 | 3.23 | N/A | 100% | 3.23 |
| Wall Insulation (Dual fuel)[1] | N/A | 0.81 | 0.81 | 0.92 | N/A | 100% | 0.92 |
| **Total** | **451.05**[1] | **93.96**[1] | **90.48** | **99.52** | **22%**[2] | **100%** | **99.52** |

[1] Total reported and audited savings included interactive savings from the gas program. Cadmus did not evaluate savings for these measures in 2018, instead providing these inputs to Vectren for its cost-effectiveness analysis.
[2] Realization rates are based on reported values in the 2018 DSM Scorecard. If compared to audited savings from the 2018 program tracking data, the demand realization rate would be 106%.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the IQW Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# INCOME QUALIFIED WEATHERIZATION PROGRAM

| Market Actor | Market Barriers | Intervention Strategies / Activities | Outcomes | Key Indicators |
|---|---|---|---|---|
| **End-Use Customer**<br>Income-Qualified Customers | • Lack of program awareness<br>• Lack of disposable income to make home improvements<br>• Lack of energy efficiency awareness<br>• Health and safety issues that prevent efficient product installation<br>• Skepticism of true energy savings<br>• Lack of time available for assessments and installation process | • Program marketing (direct mail, bill inserts, email, events, door-to-door canvassing)<br>• Information on Vectren website<br>• Direct installation of products at no cost to the customer<br>• Energy education provided during in-home assessment<br>• Budget for health and safety improvements<br>• Turnkey installation services<br>• Easy-to-use online scheduling tool<br>• Customer appointment reminders | • Increased awareness<br>• Increased participation<br>• Increased customer satisfaction<br>• Improved customer perception of energy efficiency<br>• Increased energy savings<br>• Increased adoption of energy efficiency measures<br>• Increased adoption of energy-saving behaviors<br>• Increased health and safety of the home<br>• Increased savings per home<br>• Fewer appointment cancellations | • Achievement of program participation and savings goals<br>• Number of participating homes<br>• Number of measures installed<br>• Persistence of measures<br>• Measure satisfaction ratings<br>• Program satisfaction ratings<br>• Percent of participant-adopted energy-saving behaviors<br>• Ease of participation rating<br>• Average kWh per household |
| **Program Implementer**<br>Assessors | • Participant concerns about assessors entering home<br>• Inability to reach eligible customers<br>• Health and safety issues that prevent product installation | • RFPs to attract qualified program implementer<br>• Direct contact with participant customers<br>• Open communication with participants to address concerns<br>• Budget for health and safety improvements<br>• Increased income eligibility requirements | • Increased program awareness<br>• Increased participation<br>• Assurance of quality work<br>• Increased customer satisfaction<br>• Increased savings per home | • Achievement of program participation and savings goals<br>• Number of participating homes<br>• Program satisfaction ratings<br>• Average kWh per household |
| **Trade Allies**<br>Installers | • Installer qualifications<br>• Participant concerns about installation staff entering home | • Interviews to hire qualified pool of installers<br>• Open communication with participants to address concerns | • Assurance of quality work<br>• Increased customer satisfaction | • Program satisfaction ratings |

## Program Performance

Cadmus measured 2012 to 2018 program performance against the KPIs listed in Table 64.

**Table 64. Income Qualified Weatherization KPI and 2012-2018 Performance**

| Key Performance Indicator | Performance[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | 100% | 101% | 107% | 123% | 153% | 156% | 226% |
| Achievement of gross kWh savings goals | 100% | 101% | 87% | 62% | 88% | 87% | 134% |
| Number of Participating Households | 1,010 | 1,246 | 1,355 | 692 | 485 | 719 | 2,138 |
| Number of Measures Installed[2] | 12,423 | 21,177 | 23,266 | 13,179 | 4,400 | 11,682 | 22,464 |
| Participant Program Satisfaction (*very satisfied* or *somewhat satisfied*) | 85% (n=151) | 88% (n=110) | 78% (n=200) | 97% (n=77) | 98% (n=69) | 90% (n=69) | 93% (n=85) |
| Percent of Participant-Adopted Energy-Saving Behaviors | 55% (n=151) | N/A | 31% (n=200) | 31% (n=77) | 52% (n=61) | 48% (n=56) | 61% (n=75) |
| Ease of Program Participation Rating (*very easy* or *somewhat easy*) | N/A | N/A | N/A | N/A | N/A | N/A | 98% (n=84) |
| Average kWh per household | 1,304 | 1,304 | 1,203 | 1,022 | 1,308 | 637 | 401 |
| Persistence of measures[3] | N/A | N/A | N/A | N/A | N/A | 98% | 94% |
| **Participant Measure Satisfaction[4]** | | | | | | | |
| Light Bulbs | N/A | N/A | N/A | CFLs: 93% | CFLs: 95% | LEDs: 92% | LED: 99% |
| Night Light | N/A | N/A | N/A | N/A | 94% | 97% | 91% |
| Smart Strip | N/A | N/A | N/A | N/A | 97% | 98% | 85% |
| Showerhead | N/A | N/A | N/A | 86% | 94% | 90% | 93% |
| Aerators | N/A | N/A | N/A | 94% | 94% | 90% | 88% |
| Filter Whistle | N/A | N/A | N/A | 85% | N/A | N/A | N/A |
| Pipe Wrap | N/A | N/A | N/A | 98% | 96% | N/A | N/A |
| Attic Insulation | N/A | N/A | N/A | 100% | N/A | N/A | N/A |
| Exterior LED Light Bulbs | N/A | N/A | N/A | N/A | N/A | N/A | 100% |

[1] 2012, 2013, and 2014 data are statewide rather than Vectren-specific data.
[2] Includes both electric and gas measures.
[3] There was no program-level persistence calculated in 2012-2016.
[4] For racking measures where n > 20. Combined *very satisfied* and *somewhat satisfied* responses.

In interviews with trade allies (n=3), Cadmus also asked about program market effects. All trade allies have been working with the program for two to four years, although the amount of work varied from year to year. For example, one insulation-only trade ally completed multiple projects a week, while another who installs additional measures to insulation completed a few projects every month. Trade allies said they most often receive insulation, air sealing, repair, and replacement work through the IQW Program. One said the program had increased the number of energy efficiency projects the firm completed, while two others said the program has not had any impact. All said they promote energy efficiency projects to their customers outside of the work they receive through the IQW Program.

# Online Home Energy Audit Program

The Online Home Energy Audit Program is a customer engagement tool and behavioral savings measure that offers energy education to all Vectren's residential customers. Vectren launched the program in May 2017. Customers access the tool by logging in to an online web portal, accessible from Vectren's website, then navigating to a "Ways to Save" page. The web portal offers energy saving tips, a link to the online home energy audit, and information on customers' energy usage.

Vectren markets the online home energy audit when customers sign in to the web portal, explaining that customers will receive more customized energy-saving tips via the portal if they complete the online audit by answering questions about their home. The online audit is also promoted through home energy reports sent through the Residential Behavioral Savings Program and high bill alerts sent by Oracle, the program implementer. The program implementer explained that high bill alerts were a major driver for online audit participation.

Customers who complete the online audit are immediately presented with a pie chart that displays the percentage of their home's energy use for end uses such as heating, cooling, water heating, and lighting. The pie chart highlights the end use that is estimated to use the most energy, and customers are provided a link to explore energy-saving tips related to that end use. Customers can still access tips for all energy-use categories on the tips page of the web portal—once the customer completes the online audit, the portal will display the most relevant tips first.

Vectren also uses the online energy audit data in the Residential Behavioral Savings Program, which offers customized home energy reports to a treatment group of customers. Treatment customers who also complete the online audit receive more tailored tips in their future home energy reports. The program implementer also uses the energy audit data to validate neighbor comparisons for the home energy reports.[38]

## Accomplishments

Vectren did not claim savings or set participation goals for the Online Home Energy Audit Program in 2018, because it was the first full year of implementation. Table 65 shows the program's participation and expenditures in 2018. A total of 11,260 Vectren residential customers completed the online audit (approximately 2% of Vectren's residential customer base); of these, 3,190 received electric service from Vectren (approximately 2% of Vectren's electric and dual-fuel residential customer base).

[38] Although the online audit is offered to all residential customers, the program was initially designed to keep treatment group customers' in the Residential Behavioral Savings Program engaged with the home energy reports. Tailored tips that stem from the online audit increases the relevance of the information contained in the reports and aims to increase treatment customers' trust in the accuracy of home energy reports.

**Table 65. 2018 Online Home Energy Audit Program Goals and Achievements**[1]

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | N/A | N/A | N/A |
| Gross kW Savings | N/A | N/A | N/A |
| Participants | N/A | N/A | N/A |
| Program Expenditures | $36,444 | $36,444 | 100% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

The evaluated program impacts, shown in Table 66, shows the evaluated *ex post* savings (pre-uplift) and net savings (post-uplift). The program's evaluated *ex post* savings is 2,233,959 kWh and 626 kW. To avoid double-counting savings from participation in Vectren's other residential programs, Cadmus conducted an uplift analysis then removed double-counted savings to produce evaluated net savings. For customers also enrolled in Vectren's Residential Behavioral Savings Program or High Bill Alert Program,[39] double-counted savings were accounted for within the research design and regression analysis.

In 2018, the Online Home Energy Audit Program achieved an evaluated net savings of 2,022,364 kWh and 567 kW.[40] Per customer, this resulted in an average daily savings (post-uplift adjusted) of 1.52 kWh, or 3.8%, compared to baseline average daily consumption. Program savings in 2018 included both the savings associated with 3,190 customers who completed an online audit in 2018 and the 2,246 customers who first completed an audit since it was first offered in May 2017. These customers were included in the analysis because they achieved savings in 2018 as a result of taking the online audit in 2017.

**Table 66. 2018 Online Home Energy Audit Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings[1] | Realization Rates | NTG Ratio | Evaluated Net Savings[2] |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | N/A | N/A | N/A | 2,233,959 | N/A | N/A | 2,022,364 |
| Total kW | N/A | N/A | N/A | 626 | N/A | N/A | 567 |

[1] Due to the experimental design approach of comparison group analysis, the regression analysis produces only net savings estimates (no gross estimates). These values do not include uplift.
[2] Evaluated net savings for the Online Home Energy Audit Program include uplift.

[39] The High Bill Alert Program is a behavioral program implemented by Oracle, the program implementer. Participants received alerts when their usage exceeded a predetermined threshold.

[40] The evaluated net savings incorporates uplift savings.

# Conclusions and Recommendations

## Program Promotion

**A nominal percentage of customers complete the online audit after logging in to the web portal.** Just 17% of all Vectren customers who logged in to the portal in 2018 completed the online audit.

**Recommendation:** Market the online audit on the home page of the web portal, instead of requiring customers to first click on the "Ways to Save" section before finding any information about the online audit. For customers who do not complete the online audit after they start it, send a reminder email one day later to prompt them to finish it.

**Cold weather and high bill alerts appear to have the greatest impact on program participation.** Customer participation was highest in January, February, November, and December, with a sharp spike in participation in November, because the program implementer sent high bill alerts during cold weather months. All Vectren customers are able to receive high bill alerts. The high bill alerts direct customers to the online web portal and the online audit. The program implementer also attributed the slight bump in June and July participation to promotion of the online audit in the home energy reports sent to treatment customers in June and July. Note, however, that the treatment group in the Residential Behavioral Savings Program makes up only approximately one-third of Vectren's total residential customer base.

**Recommendation:** Promote the online audit program to Vectren's entire customer base during summer months so customers can take energy-saving actions during warm weather as well as during the winter. In addition to promoting the program via home energy reports and the high bill alerts, promote the program via bill inserts, emails, and web banners.

## Program Savings Attribution

**The Online Home Energy Audit produces energy savings.** Customers who complete an audit saved 4.2% compared to baseline electricity consumption (before adjusting for uplift).[41] The online audit may produce electricity savings by encouraging customers to participate in Vectren's programs, to make other energy efficiency improvements, or to change their energy consumption behaviors. Although savings of approximately 4% may seem large, it should be remembered that savings are attributable to customers who completed an audit and were highly motivated to save.

**Only a small percentage of Online Home Energy Audit savings are from participation in Vectren's electric efficiency programs.** Cadmus estimated that participation in other electric efficiency programs can account for only 9.5% percent of the Online Home Energy Audit savings. These savings are counted

41 Similar ComEd program evaluation and research design in Northern Illinois found savings of 4.4% in the first program year. Harding, Matthew & Hsiaw, Alice. 2014. "Goal setting and energy conservation," http://web.holycross.edu/RePEc/hcx/HC1403-Harding-Hsiaw_EnergyConservation.pdf

by Vectren's other residential programs and should be subtracted from the Online Home Energy Audit savings or the portfolio savings to avoid double-counting. After accounting for double-counted savings due to program uplift, customers who complete an audit saved 3.8% compared to baseline electricity consumption.

Since only a small percentage of Online Home Audit savings are from participation in Vectren's electric efficiency programs, Vectren will have to continue to evaluate the online audit savings in future years to claim a majority of Online Home Energy Audit Program savings. If Vectren does not measure the Online Home Energy Audit savings, it will be able to claim only 9.5% of the savings through its other programs.

**Recommendation:** Vectren should claim savings from customers who completed an Online Home Energy Audit. Only 9.5% of Online Home Energy Audit savings are from customers participating in Vectren rebate programs, therefore, most of the program's savings are not claimed through Vectren rebate programs.

**Recommendation:** Because evaluated savings are associated with self-selecting and highly motivated customers, results may not represent the average Vectren residential customer. To better understand program impacts, Vectren can also measure savings for customers who start the online audit but do not finish it.

**Recommendation:** By conducting post-audit surveys and an analysis of online audit responses, Vectren can better determine exactly how participation in the Online Home Energy Audit leads to energy savings.

**Availability of advanced metering infrastructure (AMI) data may tighten the accuracy of the demand savings estimation in future program years.** Vectren was planning to fully deploy AMI by the end of 2018. If enough Online Home Energy Audit Program customers have AMI by the summer of 2019, Vectren should consider using AMI data to estimate demand savings. This will provide more granular consumption data for Vectren customers during the actual peak period.

## Process Evaluation

# ONLINE HOME ENERGY AUDIT PROGRAM

### 2018 Process Analysis Activities

1 VECTREN staff interview

1 ORACLE staff interview

### Program Overview

The program launched in May 2017.

All customers who logged into the web portal could access the online audit.

The online home energy audit gathers home characteristic data to better customize tips on home energy reports.

The online web portal shows data on customer usage over time, as well as energy saving tips.

### Key Process Evaluation Findings

11,260 customers completed the online audit in 2018

64,714 customers logged into the online web portal in 2018

17% of customers who logged into the online portal in 2018 completed the online audit

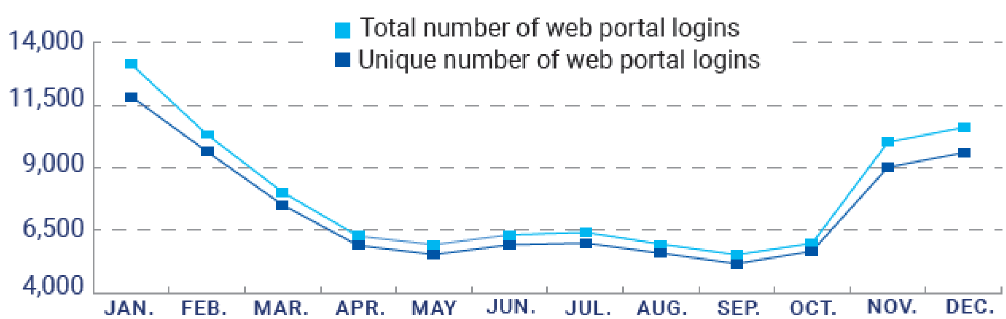
82% of participants had single family homes

18% were from a multifamily home

Marketing the online audit in home energy reports in June and July yielded a small increase in web portal log-ins compared to May

Vectren advertising of the web portal in January yielded high web portal logins

Number of web portal logins month to month for all Vectren customers, January 2018 through December 2018



# Impact Evaluation

## Impact Evaluation Methods and Findings

The Online Home Energy Audit Program impact evaluation included multiple data collection efforts and analysis tasks:

- Data collection, review, and preparation
- Customer weather data collection
- Calendarization of customer bills from billing periods to calendar months
- Panel regression analysis
- Uplift analysis
- Demand reduction calculation

Since customers opted in to the program and were already highly motivated to save energy, the challenge for estimating savings is to find an unbiased comparison group of customers with the same characteristics that led to participation in the program. Customers who complete an audit are observably different than customers who do not choose to do so.

To account for both the opt-in bias and the estimate of savings against a group of similar customers, Cadmus estimated program savings using variation in the timing of adoption within a difference-in-differences (D-in-D) panel regression approach. This experimental design compares the energy usage of customers who completed an energy audit (defined as treated) against the energy usage of customers who had not yet completed but completed one at a future date (defined as the baseline). This method limits the self-selection bias when measuring program impacts, because customers who completed an online audit were compared only to other Vectren customers who also, eventually, completed an audit.

Because customers joined the program at different points in time, it is possible to use future participants as controls for current participants. Following the start of the program, there are a relatively small number of customers who complete audits, and as time passes, the number in the treated group grows while the number in the comparison group diminishes.

To maintain a large enough sample size for analysis, Cadmus did not measure the impacts of completing an online energy audit separately for dual fuel versus all electric customers. Savings estimated represent the average savings across all customers receiving electric service in the analysis sample.

The methods Cadmus used to complete each analysis task and model specification are detailed in Appendix A. Impact Evaluation Methodology.

## Savings Review

Before accounting for uplift, Table 67 shows the 2018 evaluated program savings for the Online Home Energy Audit Program. The program achieved savings of 2,233,959 kWh and had a confidence interval of 1,599,212 kWh to 2,868,705 kWh. Because the experimental design uses a comparison group as the savings baseline, the regression analysis produces only net savings estimates (no gross estimates).

Savings estimates are significant at 90% level of confidence. The values in Table 67 do not include uplift analysis findings.

**Table 67. 2018 Online Energy Audit Program Savings**

| Customer Segment | Evaluated Annual Electricity Savings (kWh/yr) | 90% Confidence Interval | | Relative Precision |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 2,233,959 | 1,599,212 | 2,868,705 | 28% |

Table 68 lists program per-home savings for electric customers. Annual evaluated net electricity savings per home were 411 kWh. Percent daily savings are presented as the average program impact relative to comparison group average consumption. Before accounting for uplift, these savings were 4.2% compared to baseline usage.

**Table 68. 2018 Online Energy Audit Electricity Savings per Home**

| Customer Segment | Evaluated Electricity Savings per Home (kWh/yr) | 90% Confidence Interval | | Percent Daily Savings |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 411 | 294 | 528 | 4.2% |

## Participation Uplift

The Online Home Energy Audit could help increase participation in Vectren efficiency programs in the following ways:

- Educate customers specifically about Vectren's efficiency programs and encourage them to take advantage of program offerings and incentives
- Raise customers' general awareness and knowledge of energy efficiency, which may independently encourage some customers to participate in Vectren's programs

The impact of participating in the Online Home Energy Audit Program on participation in Vectren's other efficiency programs, as well as any savings resulting from this additional participation, is known as participation uplift. To avoid double-counted savings, Cadmus determined the average daily savings attributable to other voluntary residential programs tracked at the customer level. These are the other Vectren programs:

- Appliance Recycling Program
- Income Qualified Weatherization
- Home Energy Assessment 2.0
- Residential Prescriptive Program

Savings from these programs were estimated and removed from the Online Home Energy Audit Program evaluated *ex post* savings estimate for 1,112 electric service customers who also participated in other programs. Average daily program uplift estimates are provided in Table 69. Double-counted uplift savings represent only 9.5% of Online Home Energy Audit evaluated net electricity savings per home.

**Table 69. 2018 Online Home Energy Audit Electricity Savings from Program Uplift**

| Customer Segment | Evaluated Program Uplift per Home (kWh/yr) | 90% Confidence Interval | | Percent of Online Home Energy Audit Impact |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 38 | 33 | 45 | 9.5% |

Additionally, Cadmus avoided double-counting savings for the 1,432 treatment participants in the Residential Behavioral Savings Program and five customers who were also enrolled in the program implementer's High Bill Alert Program because of the research design. Because these customers were enrolled in either program before participating in the Online Home Energy Audit Program and because their consumption is used as both baseline and participant data, regression estimates are net of these impacts. These impacts are already removed from Online Home Energy Audit savings estimates because they are within the variation in timing of adopting the research design.

## Evaluated Net Energy Savings Adjustments

Table 70 lists the evaluated net savings for the Online Home Energy Audit Program, which resulted in 2,022,364 kWh after accounting for program uplift. There is no realization rate because Vectren did not claim savings for this program in 2018. After accounting for uplift, electricity savings were found to be 3.8% of daily savings. Percentage savings are generally consistent to those estimated in a similar ComEd program in Northern Illinois.[42]

**Table 70. 2018 Online Home Energy Audit Electric Savings (kWh)**

| | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Electric Total | N/A | N/A | N/A | 2,233,959 | N/A | N/A | 2,233,959 |
| Uplift | N/A | N/A | N/A | 211,595 | N/A | N/A | 211,595 |
| **Total Adjusted for Uplift** | **N/A** | **N/A** | **N/A** | **2,022,364** | **N/A** | **N/A** | **2,022,364** |

## Evaluated Net Demand Savings Adjustments

Cadmus applied the ratio of peak coincident demand savings and energy from the Residential Behavioral Savings Program to determine demand savings for Online Home Energy Audit participants. Both programs target behavioral change and provide customer education and promote participation in other residential programs. Confidence intervals around these estimates were also scaled by the same ratio to obtain demand savings.

Participation in the Online Home Energy Audit Program resulted in 626 kW *ex post* net demand savings, as shown in Table 71.

[42] Harding, Matthew & Hsiaw, Alice, 2014. "Goal setting and energy conservation." http://web.holycross.edu/RePEc/hcx/HC1403-Harding-Hsiaw_EnergyConservation.pdf

**Table 71. 2018 Online Home Energy Audit Evaluated Demand Savings for all Homes**

| Customer Segment | Evaluated Program Demand Savings (kW/yr) | 90% Confidence Interval | | Relative Precision |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 626 | 448 | 804 | 28% |

Cadmus estimated 0.115 kW of peak coincident demand savings per electric customer, based on a weighted average of dual fuel and electric only households who participated in the program. This value does not include demand savings also attributed to program uplift.

**Table 72. 2018 Online Home Energy Audit Demand Savings per Home**

| Customer Segment | Evaluated Net Demand Savings per Home (kW/yr) | 90% Confidence Interval | | Relative Precision |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 0.115 | 0.082 | 0.148 | 28% |

Demand savings attributable to uplift were also calculated by applying the demand savings ratio. Table 73 shows the resulting uplift demand savings of 0.011 kW per home. This equates to 59 kW program evaluated net savings attributable to uplift.

**Table 73. 2018 Online Home Energy Audit Uplift Demand Savings per Home**

| Customer Segment | Uplift Demand Savings per Home (kW/yr) | 90% Confidence Interval | | Relative Precision |
|---|---|---|---|---|
| | | Lower Bound | Upper Bound | |
| Electric | 0.011 | 0.009 | 0.012 | 28% |

Table 74 shows the program's combined evaluated *ex post* and net demand savings for 2018 and the total adjusted for uplift. The total *ex post* net adjusted for uplift savings is 567 kW.

**Table 74. 2018 Online Home Energy Audit Program Year Demand Savings**

| | *Ex Ante* Savings (kW) | | | Evaluated *Ex Post* Savings (kW) | Realization Rate | NTG Ratio | Evaluated Net Savings (kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Electric Total | N/A | N/A | N/A | 626 | N/A | N/A | 626 |
| Uplift | N/A | N/A | N/A | 59 | N/A | N/A | 59 |
| **Total Adjusted for Uplift** | **N/A** | **N/A** | **N/A** | **567** | **N/A** | **N/A** | **567** |

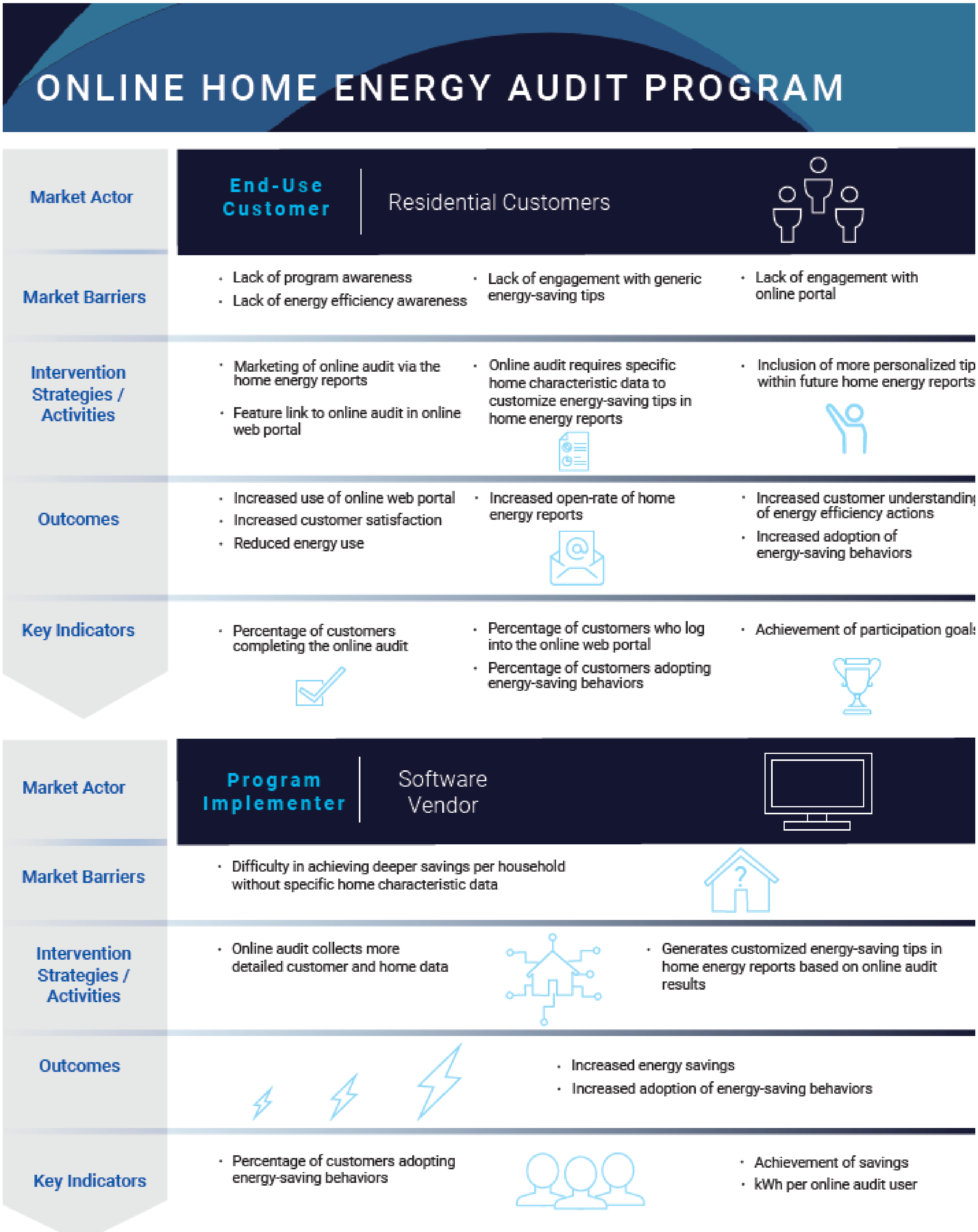
## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus developed a logic model and KPIs for the Online Home Energy Audit Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities

- Expected outcomes from implementing current intervention strategies

## Logic Model



## Program Performance

Cadmus measured 2018 program performance against the KPIs listed in Table 75.

**Table 75. 2018 Online Home Energy Audit KPI Performance**

| KPI | Performance 2018 |
|---|---|
| Percentage of total Vectren residential customers completing the online audit[1] | 2% |
| Percentage of customers who log into the online web portal[1] | 9% |
| Percentage of customers adopting energy-saving behaviors | Track in future years |
| Achievement of participation goals | Track in future years |
| Achievement of savings[2] | 2,233,959 |
| kWh savings per online audit user[2] | 411 |

[1]The customer percentages in this table include all Vectren customers who completed the audit (electric, dual fuel, and gas only customers)
[2] *Ex post* gross values

# Energy Efficient Schools Program

Through the Energy Efficient Schools (EES) Program, Vectren encourages students and their families to focus on conservation and the efficient use of electricity and gas. The EES Program is designed to help students and their families identify opportunities to manage their energy consumption by providing zero-cost improvements and tips in energy-savings kits for students to take home. The EES Program solicits fifth-grade teachers at schools in Vectren's territory to distribute energy-savings kits to their students. These kits contain energy-efficient measures that students can install at home along with other educational materials and activities. The kit also includes a survey, the Home Energy Worksheet (HEW), which students and their guardians fill out to indicate which kit measures they installed at home.

Table 76 shows the kit measures evaluated by Cadmus. This chapter evaluates only the measures applicable to electric savings.

**Table 76. Kit Measures Evaluated by Cadmus**

| Electric Measures | Electric and Natural Gas Measures |
|---|---|
| • One 15-watt LED<br>• Two 11-watt LEDs<br>• LED night light | • Kitchen faucet aerator (1.5 gpm)<br>• Two bathroom faucet aerators (1.0 gpm)<br>• Energy-efficient showerhead (1.5 gpm)<br>• Furnace filter whistle |

In 2018, Vectren worked directly with the National Energy Foundation (NEF) to implement the EES Program. NEF is responsible for day-to-day management, program outreach, and teacher enrollment.

## Accomplishments

The EES Program met its gross energy-savings and participation goals, distributing a total of 2,401 kits in 2018. Program expenditures were 4% under the planning goal. Vectren attributed this success to strong relationships with teachers and schools. Table 77 lists the 2018 program's goals and achievements.

**Table 77. 2018 Energy Efficient Schools Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 1,059,801 | 1,059,360 | 100% |
| Gross kW Savings | 106.04 | 106.00 | 100% |
| Participants (Kits) | 2,401 | 2,400 | 100% |
| Program Expenditures | $121,609 | $127,030 | 96% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 78 lists the evaluated savings summary for the EES Program, a total net savings of 712,638 kWh and 76 kW across the 2,401 kits distributed. Evaluated savings include all adjustments for in-service rates (ISRs) which Cadmus updated for 2018. The ISR update resulted in a savings decrease for all measures. Additionally, for the two 11W LEDs and the two bathroom faucet aerators in each kit, Vectren reported unit energy savings using per-kit savings rather than per-unit savings from the 2016 evaluation. This means their savings were effectively doubled. These reasons along with a decline in domestic hot water fuel saturation in 2018 from 2016 (Vectren based its 2018 reported *ex ante* savings on evaluated savings from 2016) were the main drivers for this 67% realization rate. In 2018, 40% of homes had electric water heaters compared to 46% in 2016.

**Table 78. 2018 Energy Efficient Schools Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 1,059,801 | 844,504 | 683,972 | 712,638 | 67% | 100% | 712,638 |
| Total kW | 106 | 106 | 77 | 76 | 72% | 100% | 76 |

# *Conclusions and Recommendations*

## Program Administration and Delivery

**Collecting student household contact data through the HEWs will increase the accuracy of the impact evaluation.** The program implementer combined the parent comment cards with the HEWs for the first time in 2018. This change increased the percentage of parent contact data collected by the program from 1.4% in 2017 to 59% in 2018. The increase in parent data collected enables future evaluations to capture more data for calculating ISRs, water heater fuel saturation, and spillover. Cadmus did not conduct a parent survey in 2018 and instead relied on benchmarking data to estimate ISRs for the program measures. Cadmus intends to conduct a parent survey for the 2019 program evaluation and anticipates that the program will collect a similar percentage of parent contact data in 2019.

## Teacher Engagement

**Strong teacher engagement is encouraging greater program goals for 2019.** Vectren intends to deliver 2,500 kits in 2019, compared to 2,400 in 2018. The implementer said keeping repeat teachers engaged is important to meeting the increased participation goal for 2019. In 2018, the implementer made efforts to keep teachers engaged by making it easier for them to coordinate the program's curriculum with their lesson plans. It revised the content in the lesson plans to tie in with social studies, art, and STEM activities. In 2018, 70% of teachers were repeat participants from previous program years. The implementer said teacher attrition typically occurs more from teachers switching grade levels (no longer teaching 5$^{th}$ grade) than from choosing not to participate in the program. The implementer reported that it had a waitlist for teachers to join the program in 2019.

**Recommendation:** If the program remains cost-effective at higher participation levels, consider increasing the kit distribution goal in future program years.

## Program Planning

**Reported savings are high for 11W LEDs and bathroom faucet aerators.** In 2018, Vectren reported unit energy savings for 11W LEDs and bathroom faucet aerators using the per-<u>kit</u> savings rather than the per-<u>unit</u> savings from the 2016 evaluation report, thus doubling the savings for these measures. *Ex ante* per-kit demand reduction was not affected. Vectren updated the *ex ante* savings to match per-<u>unit</u> value for the 2019 program year.

## *Process Evaluation*

# ENERGY EFFICIENT SCHOOLS PROGRAM

### 2018 Process Analysis Activities

1 VECTREN staff interview

1 National Energy Foundation staff interview

### 2018 Program Changes

Vectren combined HEW with the parent comment card to increase response rate & changed student incentive from a wristband to a glow-in-the-dark eraser head

Vectren exchanged the filter whistle with a filter tone alarm to increase installation rate

NEF condensed teacher guide to 10 lessons, simplified content and layout

NEF included more social studies, art, and STEM activities in lessons

NEF created more engaging content:

- added game page to website
- upgraded video content
- added educational and extracurricular activities for students to complete with their families

### 2019 Planned Program Changes

Vectren will increase number of kits distributed by 100, up to 2,500 & add a question to the HEW about water heater setback (pre- and post- temperature)

NEF will further streamline teacher curriculum and change activities to keep repeat teachers engaged & redesign poster with new activities and an interactive game that can be accessed online

### Key Process Evaluation Findings

70% of teachers are repeat participants from prior years (n=96)

Historical HEW and Parent Contact Data return rates:

| | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|
| HEW return rate | 69% | 65% | 66% | 65% |
| Parent Contact Data return rate | <1% | 2.6% | 1.4% | 59% |

# Impact Evaluation

## Impact Evaluation Methods and Findings

The EES Program impact evaluation included multiple data collection efforts and analysis tasks:

- Engineering analysis of energy savings for all kit measures
- Database review of the number of kits distributed
- Benchmarking of in-service rates
- Review of data collected from the HEWs (n=1,550)

## Gross Savings Review

Table 79 provides the per-unit annual gross savings for each program measure contained in the kit. Note that each kit contains two 11W LEDs and two bathroom aerators, but the table shows savings for one unit only. For the EES Program, Vectren includes ISRs in reported savings so evaluated savings also include all adjustments for ISRs as well as saturation rates for water heater fuel type. Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

**Table 79. 2018 Energy Efficient Schools Program Per-Unit Gross Savings[1]**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| 11W LED (one unit only)[2] | 68.1 | 31.2 | 0.004 | 0.003 |
| 15W LED | 47.6 | 42.3 | 0.005 | 0.005 |
| Energy-Efficient Bathroom Aerator (one unit only)[2] | 21.6 | 8.9 | 0.001 | 0.000 |
| Energy-Efficient Kitchen Aerator | 56.4 | 45.4 | 0.002 | 0.001 |
| Energy-Efficient Showerhead | 130.6 | 109.9 | 0.004 | 0.003 |
| LED Night Light | 7.0 | 6.6 | 0.000 | 0.000 |
| Furnace Filter Whistle | 20.4 | 12.3 | 0.025 | 0.015 |

[1] Reported and evaluated savings include ISRs.
[2] There are two 11W LEDs and two bathroom aerators in each kit; however, these savings are for one unit only.

Table 80 lists the 2018 EES Program's per-kit annual gross energy and demand savings. For the two 11W LEDs and the two bathroom faucet aerators in each kit, Vectren reported unit energy savings using per-kit savings rather than per-unit savings from the 2016 evaluation. This means their savings were effectively doubled, resulting in realization rates of 46% for 11W LEDs and 41% for bathroom faucet aerators. Comparing 2018 to 2016 evaluated per-unit savings would instead have yielded realization rates of 92% and 80%, respectively.

Cadmus used the program's HEW data to determine that electric domestic hot water fuel saturation was 40% in 2018 compared to 46% from 2016. This resulted in less electric energy savings for water measures (showerheads and aerators) and, along with decreased ISRs from updated benchmarking make up the majority of the difference between reported and evaluated savings for these measures.

**Table 80. 2018 Energy Efficient Schools Program Per-Kit Gross Savings[1]**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| 11W LED[2] | 136.14 | 62.4 | 0.007 | 0.007 |
| 15W LED | 47.64 | 42.3 | 0.005 | 0.005 |
| Energy-Efficient Bathroom Aerator[2] | 43.2 | 17.9 | 0.001 | 0.001 |
| Energy-Efficient Kitchen Aerator | 56.41 | 45.4 | 0.002 | 0.001 |
| Energy-Efficient Showerhead | 130.61 | 109.9 | 0.004 | 0.003 |
| LED Night Light | 7.02 | 6.6 | 0.000 | 0.000 |
| Furnace Filter Whistle | 20.38 | 12.3 | 0.025 | 0.015 |
| **Total per Kit[2]** | **441.4** | **296.8** | **0.044** | **0.032** |

[1] Reported and evaluated savings include ISRs.
[2] These savings account for two 11W LEDs and two bathroom aerators in each kit.

Table 79 lists evaluated gross per-unit energy savings for each program measure by year. These savings have not changed dramatically over the last six years, and 2018 savings are very comparable to 2017. To provide a normalized comparison of per-unit gross savings over time, Cadmus removed the per-unit savings adjustments for water heater fuel type saturation rates and ISRs (per-unit savings with these adjustments are shown in Table 81).

**Table 81. Energy Efficient Schools Program Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| 11W LED (one unit only)[1] | N/A | N/A | N/A | N/A | N/A | 46.0 | 46.0 |
| 15W LED | N/A | N/A | N/A | N/A | N/A | 62.5 | 62.5 |
| Energy-Efficient Bathroom Aerator (one unit only)[1] | N/A | N/A | N/A | 49.0 | 49.4 | 53.6 | 52.2 |
| Energy-Efficient Kitchen Aerator | 256.8 | 614.8 | 530.6 | 272.8 | 258.2 | 280.1 | 272.5 |
| Energy-Efficient Showerhead | 633.8 | 424.4 | 266.1 | 539.3 | 538.6 | 584.3 | 568.3 |
| LED Night Light | 17.3 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 |
| Furnace Filter Whistle | 45.4 | 45.4 | 45.4 | N/A | 47.0 | 44.0 | 44.0 |

[1] There are two 11W LEDs and two bathroom aerators in each kit; however, these savings are for one unit only.

## Measure Verification

For the impact evaluation, Cadmus first reviewed the program database to confirm the number of kits distributed and to verify tracking and accurate reporting of program savings. Cadmus updated these two inputs during the verification analysis:

- People per household
- Water heater fuel type saturation

### *Quantity of Kits Shipped*

Cadmus verified kit quantity by comparing reported quantities from the Vectren 2018 DSM Scorecard with year-end shipment data from the program implementer. Both sources confirmed shipment of 2,401 kits.

### *Measure-Level ISR Benchmarking*

Installation rates from HEWs are typically lower than ISRs from follow-up household surveys, which are completed months after student participation to give families more time to install the kit measures. The program implementer combined the parent comment cards with the home energy worksheets for the first time in 2018. This change increased the percentage of parent contact data collected by the program and will allow future evaluations to collect and analyze more accurate data for ISRs through follow-up household surveys.

Cadmus did not conduct a student household survey in 2018. Therefore, to determine a reliable ISR for the 2018 EES Program evaluation, Cadmus benchmarked ISRs from similar school kits programs. Table 82 shows the benchmarked measure-level ISRs. Cadmus intends to conduct a student household survey to collect ISR data for the 2019 program evaluation.

**Table 82. Energy Efficient Schools Program ISR Comparisons**

| Measure | Energizing Indiana (2014) | Midwest Utility A (2017) | Midwest Utility B (2017) | Northeast Utility (2018) | South Utility (2018) | Vectren 2018 HEW | 2017-2018 Follow-Up Survey Average |
|---|---|---|---|---|---|---|---|
| LED | N/A | 61%[1] | 87%[1] | 66%[1] | 57%[1] | 55% | **68%** |
| Energy-Efficient Bathroom Aerator | 47% | 30% | 56% | 48% | 38% | 28% | **43%** |
| Energy-Efficient Kitchen Aerator | 47% | 31% | 53% | 44% | 39% | 33% | **42%** |
| Energy-Efficient Showerhead | 52% | 28% | 57% | 58% | 51% | 35% | **49%** |
| LED Night Light | 86% | -- | -- | -- | -- | **81%** | **--** |
| Furnace Filter Whistle | 43% | -- | 45% | -- | -- | **28%** | 45% |
| ISR Data Source | Average of HEW and follow-up survey | Follow-up survey | Follow-up survey | Follow-up survey | Follow-up survey | HEW | Average |

[1] 9-watt LEDs

For the previous three evaluation years (2015-2017), Cadmus relied on the 2014 Energizing Indiana Statewide Core EES Program ISRs for non-lighting measures. The 2014 ISRs remain in the range of the benchmarked values for more recent evaluations (2017 and 2018 program years); however, they are at the higher end of the range and also relied on HEW data combined with follow-up surveys. Cadmus calculated an average of four benchmarked ISRs for LEDs, showerheads, and aerators for the comparison school kits programs shown in Table 82. Since most school kit programs did not include an LED night light or a furnace filter whistle, Cadmus defaulted to the average ISR from Vectren's 2018 HEWs.

Cadmus applied the new 2018 ISR adjustments to *ex ante* savings to generate verified savings for each measure in the kit. The verified ISRs Cadmus used to adjust *ex ante* savings are shown in Table 83.

**Table 83. Energy Efficient Schools Program Measure Verification Results – Installation Rate**

| Measure | Kits Shipped | | | Installation Rate | |
|---|---|---|---|---|---|
| | Reported | Audited | Verified | Reported | Verified |
| 11W LED | 2,401 | 2,401 | 2,401 | N/A | 68% |
| 15W LED | | | | N/A | 68% |
| Energy-Efficient Bathroom Aerator | | | | N/A | 43% |
| Energy-Efficient Kitchen Aerator | | | | N/A | 42% |
| Energy-Efficient Showerhead | | | | N/A | 49% |
| LED Night Light | | | | N/A | 81% |
| Furnace Filter Whistle | | | | N/A | 28% |
| **Total** | **2,401** | **2,401** | **2,401** | **N/A** | **N/A** |

Table 84 shows historical installation rates for each program measure.

**Table 84. Energy Efficient Schools Program Historical Installation Rates**

| Measure | Installation Rate | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012[1] | 2013[1] | 2014[1] | 2015 | 2016 | 2017 | 2018 |
| 11/13W LED[2] | N/A | N/A | N/A | N/A | 78% | 76% | 68% |
| 15/16W LED[2] | N/A | N/A | N/A | N/A | 78% | 76% | 68% |
| Energy-Efficient Bathroom Aerator | 60% | 48% | 48% | 47% | 47% | 47% | 43% |
| Energy-Efficient Kitchen Aerator | 60% | 48% | 48% | 47% | 47% | 47% | 42% |
| Energy-Efficient Showerhead | 60% | 50% | 50% | 52% | 52% | 52% | 49% |
| LED Night Light | 80% | 88% | 88% | 86% | 86% | 86% | 81% |
| Furnace Filter Whistle | 45% | 43% | 43% | N/A | 43% | 43% | 28% |

[1] ISRs based on statewide assumptions for utilities including Duke, I&M, IPL, NIPSCO, and Vectren.
[2] Vectren distributed 13W and 16W LEDs in 2016 and switched to 11W and 15W in 2017.

### *Water Heating Fuel Saturation*

Cadmus also adjusted the *ex ante* electric water heater fuel saturation rates for water-saving measures by analyzing data from the 2018 HEW results. There was a notable decrease in verified water heater fuel saturation rates between 2017 and 2018 after a three-year upward trend dating back to 2015 (Table 85).

**Table 85. Energy Efficient Schools Program Historical Electric Water Heater Saturation Rates**

| Program Year | Electric Saturation Rate |
|---|---|
| 2018 | 40% |
| 2017 | 50% |
| 2016 | 46% |
| 2015 | 43% |
| 2014 | 45% |
| 2013 | 52% |
| 2012 | 48% |

## Net-to-Gross Analysis

School kit programs tend to induce minimal freeridership because the kits are free to students and contain some items that are not typically found in the average home. Cadmus did not conduct student household surveys in 2018 and, therefore, did not estimate or apply any NTG adjustments to the *ex post* gross savings for this program. NTG ratios for school education programs tend to be close to 100%, and this is consistent with previous years' evaluations.

## Evaluated Net Savings Adjustments

Table 86 and Table 87 list evaluated net savings for the EES Program. The program achieved net savings of 712,638 kWh and 76 coincident kW demand reduction.

**Table 86. 2018 Energy Efficient Schools Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| 11W LED | 326,872 | 163,436 | 142,695 | 149,814 | 46% | 100% | 149,814 |
| 15W LED | 114,384 | 114,384 | 99,868 | 101,660 | 89% | 100% | 101,660 |
| Energy-Efficient Bathroom Aerator | 103,723 | 51,862 | 40,698 | 42,939 | 41% | 100% | 42,939 |
| Energy-Efficient Kitchen Aerator | 135,440 | 135,440 | 103,195 | 108,888 | 80% | 100% | 108,888 |
| Energy-Efficient Showerhead | 313,595 | 313,595 | 250,020 | 263,829 | 84% | 100% | 263,829 |
| LED Night Light | 16,855 | 16,855 | 15,893 | 15,888 | 94% | 100% | 15,888 |
| Furnace Filter Whistle | 48,932 | 48,932 | 31,602 | 29,620 | 61% | 100% | 29,620 |
| **Total** | **1,059,801** | **844,504** | **683,972** | **712,638** | **67%** | **100%** | **712,638** |

**Table 87. 2018 Energy Efficient Schools Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| 11W LED | 16.8 | 16.8 | 14.7 | 16.4 | 98% | 100% | 16.4 |
| 15W LED | 12.0 | 12.0 | 10.5 | 11.1 | 93% | 100% | 11.1 |
| Energy-Efficient Bathroom Aerator | 2.4 | 2.4 | 1.9 | 2.2 | 90% | 100% | 2.2 |
| Energy-Efficient Kitchen Aerator | 4.8 | 4.8 | 3.7 | 2.8 | 58% | 100% | 2.8 |
| Energy-Efficient Showerhead | 9.6 | 9.6 | 7.7 | 6.9 | 71% | 100% | 6.9 |
| LED Night Light | 0.0 | 0.0 | 0.0 | 0.0 | N/A | 100% | 0.0 |
| Furnace Filter Whistle | 60.0 | 60.0 | 38.8 | 36.8 | 61% | 100% | 36.8 |
| **Total** | **106** | **106** | **77** | **76** | **72%** | **100%** | **76** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the EES Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# ENERGY EFFICIENT SCHOOLS PROGRAM

**Market Actor:** End-Use Customer | 5th Grade Student Households

**Market Barriers**
- Students not sharing materials and measures with parents
- Upfront cost of energy efficiency upgrades
- Low installation rates
- Lack of knowledge about energy efficiency
- Lack of understanding about how energy-efficient behaviors and measures affect energy use
- Skepticism of true energy savings
- Lack of understanding about how to install kit measures

**Intervention Strategies / Activities**
- Free energy-saving kit
- Educational materials included in kit
- Students receive incentive for returning completed home energy worksheet
- Detailed installation instructions
- In-class activities/curriculum designed to engage students

**Outcomes**
- Increased awareness about benefits of energy efficiency
- Increased energy savings
- Student education about energy-savings kit, reducing high energy costs, and energy-savings behaviors
- Changes in household behavior
- Increased installation rates
- Evidence of program spillover

**Key Indicators**
- Percentage of home energy worksheets returned
- Program spillover
- Kit measure installation rates
- Persistence of measure installations
- Percentage of households adopting energy-saving behaviors
- Achievement of savings goals

**Market Actor:** Trade Allies | 4th and 5th Grade Teachers

**Market Barriers**
- Low response rate for home energy worksheet
- Low response rate for parent comment card
- Lack of time/resources for new curriculum

**Intervention Strategies / Activities**
- $50 gift card incentive for teachers who return 80% of the home energy worksheets distributed in their class
- Combined home energy worksheet and parent comment card into one document
- Curriculum designed to align with the Indiana Academic Standards
- Classroom activities and educational materials provided to teachers

**Outcomes**
- Increased home energy worksheet response rate
- Increased parent contact information response
- Necessary information obtained from home energy worksheets to inform savings calculations
- Increased teacher satisfaction
- Increased teacher participation
- Increased number of kits distributed

**Key Indicators**
- Number of schools participating in program
- Percentage of home energy worksheets returned
- Percentage of parent contacts collected
- Number of teachers participating in program
- Achievement of kit distribution goal

## Program Performance

Cadmus measured 2012 to 2018 program performance against the KPIs listed in Table 88.

**Table 88. Energy Efficient Schools Program KPI and 2012-2018 Performance**

| KPI | Performance | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Achievement of Program Participation Goals | N/A | N/A | N/A | 100% | 100% | 101% | 100% |
| Achievement of Gross kWh Savings Goals | 73% | 153% | 126% | 100% | 100% | 101% | 100% |
| Achievement of Gross kW Savings Goals | N/A | N/A | N/A | N/A | N/A | 100% | 100% |
| Kits Distributed | 4,279 | 3,039 | 2,562 | 2,600 | 2,400 | 2,422 | 2,401 |
| Number of Teachers Participating in Program | 119 | 101 | 90 | 103 | 85 | 71 | 96 |
| Number of Schools Participating in Program | 56 | 51 | 39 | 40 | 35 | 29 | 39 |
| Percentage of Home Energy Worksheets Returned | 50%[1] | 41%[1] | 51%[1] | 69% | 65% | 66% | 65% |
| Percentage of Parent Contacts Collected | N/A | N/A | N/A | <1% | 2.6% | 1.4% | 59% |
| Participant Spillover Measured through Student Household Surveys | 21.5%[1] | 17.6% | 20% | Spillover not assessed | Spillover not assessed | 0% | N/A[2] |
| Kit measure Installation Rates (Average across all Measures) | 61% | 60% | 61% | 61% | 62% | 61% | 60% |
| Persistence of Measure Installations | N/A | N/A | N/A | 27.3% | 41.7% | 33.6% | N/A |
| Percentage of Households Adopting Energy-Saving Behaviors | N/A | N/A | N/A | N/A | N/A | N/A | Track in future years |

[1] Energizing Indiana Statewide Core Program Evaluation estimate (statewide value, not Vectren-specific)
[2] Cadmus did not conduct a participant student household survey in 2018.

# Residential Behavioral Savings Program

Since 2012, the Residential Behavioral Savings (RBS) Program has been informing customers about their home energy consumption and encouraging the adoption of energy-saving home improvements and behaviors through home energy reports that contain the household's energy use data, a comparison to neighbor use, and energy-saving action steps.

The program uses an experimental design called a randomized control trial wherein customers are randomly assigned to either a treatment group (recipients of home energy reports) or a control group (nonrecipients). Treatment group customers are mailed home energy reports, and those with valid email addresses also receive the reports via email. All of Vectren's residential customers can access the program-affiliated web portal to obtain information on saving energy and details about their home energy use. Only treatment group customers can see on the web portal how their energy usage compares to their neighbors. Enrollment in the treatment group is automatic, but customers can opt not to receive the reports.

The program implementer, Oracle, researched and selected the customers eligible for the program and was responsible for forecasting and tracking savings, producing the content of the home energy reports, and distributing the reports to customers. During 2018, all treatment group customers were sent four mailed home energy reports. Customers for whom Vectren had email addresses also received 12 (monthly) electronic home energy reports (eHERs).

## Accomplishments

Table 89 shows the program's achievements against goals in 2018. According to the 2018 DSM Scorecard, the RBS Program did not meet its 2018 electric energy savings target by 4%. The program implementer explained that attrition, mostly because of customers moving homes over time, hindered the program's ability to meet its 2018 energy savings goals. Cadmus review of customer participation data confirmed that participation at the start of 2018 (41,334) decreased by 11% from the start of 2017 (46,588), almost entirely from customers who closed their Vectren account rather than those requested to no longer receive reports.

**Table 89. 2018 Residential Behavioral Savings Program Goals and Achievements**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 7,212,935 | 7,526,777 | 96% |
| Gross kW Savings | 1,481 | 1,481 | 100% |
| Participants | 41,800 | 41,800 | 100% |
| Program Expenditures | $295,324 | $300,054 | 98% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

At the start of 2018, the program population contained 41,334 treatment group customers and 6,205 control group customers, as shown in Table 90.[43] The 2018 program design did not expand its customer population nor perform a refill of the program customer population. The Wave 1 treatment group customers have been receiving reports since 2012.

**Table 90. 2018 Residential Behavioral Savings Program Participation**

| Group and Wave | Delivery Frequency | 2018 Customers |
|---|---|---|
| **Treatment Group** | | |
| Wave 1 – Electric only | 4 paper home energy reports; 12 eHERs; web portal access | 12,128 |
| Wave 1 – Dual fuel | 4 paper home energy reports; 12 eHERs; web portal access | 29,206 |
| **Total Treatment Group** | | **41,334** |
| **Control Group** | | |
| Wave 1 – Electric only | Web portal access | 2,935 |
| Wave 1 – Dual fuel | Web portal access | 3,270 |
| **Total Control Group** | | **6,205** |

Table 91 shows the total energy and demand savings for the RBS Program in 2018. The program's evaluated *ex post* savings is 7,063,475 kWh (98% realization rate) and 1,839 kW (124% realization rate).

**Table 91. 2018 Residential Behavioral Savings Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 7,212,935 | 7,212,935 | 7,212,935 | 7,063,475 | 98% | N/A | 7,063,475 |
| Total kW | 1,481 | 1,481 | 1,481 | 1,839 | 124% | N/A | 1,839 |

[43] The treatment group count value does not include customers who became inactive or opted out of the program prior to 2018. This methodology for determining participant count is consistent with the 2017 evaluation methodology.

# Conclusions and Recommendations

## Online Engagement

**Participants are increasingly engaged with the online portions of the RBS Program.** An average of 573 web portal logins per month were documented in 2018 for the treatment group, a 41% increase from 2017 when a new version of the web portal was launched. Additionally, the open rate of emailed home energy reports increased from 39.4% in 2017 to 41.4% in 2018. The program implementer added some variety to the reports by changing the content of its marketing module throughout 2018 to promote the Online Audit, Appliance Recycling, and Smart Cycle Bring Your Own Thermostat programs.[44] The program implementer used customer responses from the Online Home Energy Audit (a separate DSM program accessible through the online web portal) to tailor tips for future home energy reports to the individual characteristics of customer homes. For example, customers who reported that their homes have pools can now receive pool-related energy efficiency tips in their home energy reports. The program implementer did not make any other changes to the report contents in 2018.

## Cross-Program Participation

**For the second year in a row, control customers are saving more electricity through Vectren's other DSM programs than treatment customers.** In 2017 and 2018, Cadmus calculated negative electricity uplift. The RBS Program's impact on participation in Vectren's other efficiency programs, as well as any savings resulting from this additional participation, is known as participation uplift. Total uplift for 2018 is -241,531 kWh, -112.5 kW, and -1,289.7 therms. This means that, in 2018, control customers saved more, on average, than did treatment customers from participating in other energy efficiency programs.

**Recommendation:** If it becomes a priority to better understand historical uplift and how treatment group participation in Vectren's other DSM programs have changed over time, build a tracking database prior to the 2019 RBS Program savings analysis to track every customer's previous cross-program participation (since the beginning of the program in 2012) and incorporate Vectren's updated effective useful life values for each measure. This tracking database will allow Vectren to include customers' installed measures from previous years that still are deemed to be saving energy, hence better comparing cumulative uplift over the lifetime of the program. Most measures have an effective useful life of more than one year.

## Demand Savings Estimates

**Availability of advanced metering infrastructure (AMI) data may tighten the accuracy of the demand savings estimation in future program years.** Vectren was planning to fully deploy AMI by the end of 2018. If enough RBS Program customers have AMI by the summer of 2019, Vectren should consider using AMI data to estimate demand savings This will provide more granular consumption data for Vectren customers during the actual peak period.

44 The Smart Cycle Bring Your Own Thermostat Program is a residential demand response program.

## Program Attrition

**The number of home energy report recipients continues to decline because of attrition.** Specifically, participation at the start of 2018 decreased by 11% from the start of 2017, almost entirely from customers who closed their Vectren account rather than opted out, which is typical for this program. Note that the precision for estimating each wave's overall savings diminishes with attrition.

**Recommendation:** Consider refilling the population with a new wave of customers to help achieve the energy savings goals in future program years and improve the overall relative precision of evaluated net savings. Refilling the treatment group can offset customers who leave the program because of moving homes or who shut down electric service for vacant homes. The instances of customers actively opting out of the program (i.e., requesting to no longer receive reports) is not widespread.

*Process Evaluation*

# RESIDENTIAL BEHAVIORAL SAVINGS PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 ORACLE staff interview

## 2018 Program Changes

Vectren cross-promoted a greater variety of its programs in 2018 home energy reports:

- Smart Cycle Bring Your Own Thermostat
- Appliance Recycling
- Online Audit

In 2017, Vectren only cross-promoted smart thermostat rebates.

## 2019 Planned Program Changes

Vectren's AMI installation plan will be fully in place in 2019

They will use AMI data in place of monthly data to more frequently populate the consumption charts and graphs in the online web portal.

Vectren does not plan to add new participants in 2019, but the program implementer recommends a refill in 2019 to **mitigate program attrition.**

41,334 participants at the start of 2018, which was a 11% decrease from the start of 2017 (46,588 customers)

Most program attrition occurs when customer accounts go inactive, not due to program opt-outs

## Key Process Evaluation Findings

Participants are increasingly engaged with online portions of the program.

Open rate of eHERs increased from 39.4% in 2017 to 41.4% in 2018

Average of:

573 online web portal logins per month by eHERs recipients in 2018

41% increase from 2017 when a new version of the online web portal was launched

# Impact Evaluation

## Impact Evaluation Methods and Findings

The RBS Program impact evaluation included multiple data collection efforts and analysis tasks:

- Data collection, review, and preparation
- Equivalency checks on treatment and control groups
- Billing analysis
- Energy-savings estimations
- Energy efficiency program channeling analysis (i.e., uplift)
- Demand savings analysis

Cadmus used a panel regression analysis of customer monthly bills to estimate the program's electricity savings in electric only and dual fuel homes. Cadmus used Integral Analytics' DSMore software and typical load shapes for residential customers to estimate the program demand savings. Cadmus analyzed program participation and measure savings data to determine participation uplift in other efficiency programs as well as the RBS Program savings counted in other efficiency programs. The methods Cadmus used to complete each task are detailed in the Appendix A. Impact Evaluation Methodology.

## Savings Review

Table 92 shows the 2018 reported and evaluated program net savings and the realization rates for the RBS Program.[45] Because the experimental design uses a control group as the savings baseline, the regression analysis produces only net savings estimates (no gross estimates). The values in this table do not include the uplift findings.

**Table 92. 2018 Residential Behavioral Savings Program Savings**

| Deployment Wave | Customer Segment | Annual Net Electricity Savings (MWh/yr) | | 90% Confidence Interval | | Relative Precision | Realization Rate |
|---|---|---|---|---|---|---|---|
| | | Reported | Evaluated | Lower Bound | Upper Bound | | |
| Wave 1 | Electric only | N/A | 3,666 | 1,959 | 5,373 | ± 47% | N/A |
| | Dual fuel | N/A | 3,398 | 387 | 6,409 | ± 89% | N/A |
| **Total** | | **7,213** | **7,063** | **3,602** | **10,666** | **± 49%** | **98%** |

45 Cadmus' estimate of program net savings has a 90% confidence interval of 3,602 MWh to 10,666 MWh and relative precision of ± 49%. The 90% confidence interval for the evaluated savings does not contain zero, which indicates that the savings are statistically significant. Additionally, the confidence interval contains the reported program savings, so the program implementer's savings estimate of 7,213 MWh cannot be rejected.

Electric savings differed statistically from zero with 90**%** confidence, but estimated confidence intervals remained fairly wide. The relative precision on savings estimates continues to diminish year over year because of increasingly smaller sample sizes. Over time, as customers close accounts, fewer observations are available to estimate program savings, which leads to lower precision around savings estimates. When precision is combined across estimates, it is often lower than any one estimate. Adding new waves of customers to the program can improve the precision of overall program savings estimate. Nonetheless, the evaluated net savings estimates reject the null hypothesis that savings were equal to zero.

Table 93 shows the average daily energy savings per home for each customer segment (electric only and dual fuel). The savings are represented by the coefficient on the interaction variable between $PART_{it}$ x $POST_{it.}$. This isolates the effect of being a treated customer in post year *i.* In 2018, on average, electric only homes saved 0.80 kWh per day, and dual fuel homes saved 0.31 kWh per day (savings are indicated when the sign is negative). The savings estimates for both customer segments are statistically significant at the 90% confidence level. If a customer was active at the start of the program, then their data are included in the regression analysis, which is why the number of homes in the regression analysis is larger than the number of 2018 active homes.

**Table 93. Residential Behavioral Savings Program Regression Summaries**[1]

| Item | Electric Only 2018 | Dual Fuel 2018 |
|---|---|---|
| Dependent variable | kWh/day | kWh/day |
| $PART_{it}$ x $POST_{it}$ – Year 1 (2012 savings per day per home) | **-0.35** | **-0.18** |
| | (0.08) | (0.07) |
| $PART_{it}$ x $POST_{it}$ – Year 2 (2013 savings per day per home) | **-0.57** | **-0.28** |
| | (0.12) | (0.09) |
| $PART_{it}$ x $POST_{it}$ – Year 3 (2014 savings per day per home) | **-0.59** | **-0.38** |
| | (0.15) | (0.11) |
| $PART_{it}$ x $POST_{it}$ – Year 4 (2015 savings per day per home) | **-0.61** | **-0.42** |
| | (0.16) | (0.12) |
| $PART_{it}$ x $POST_{it}$ – Year 5 (2016 savings per day per home) | **-0.62** | **-0.43** |
| | (0.18) | (0.14) |
| $PART_{it}$ x $POST_{it}$ – Year 6 (2017 savings per day per home) | **-0.73** | **-0.40** |
| | (0.19) | (0.15) |
| $PART_{it}$ x $POST_{it}$ – Year 7 (2018 savings per day per home) | **-0.80** | **-0.31** |
| | (0.23) | (0.17) |
| Customer fixed effects | Yes | Yes |
| Month-by-year fixed effects | Yes | Yes |
| Weather polynomials | Yes | Yes |
| N (homes) | 28,960 | 54,609 |

[1] Estimates based on post-only regressions of average daily consumption in months between January 2011 and December 2018. Estimated standard errors in parentheses are clustered on homes.

Table 94 lists program per-home savings for each customer segment, which Cadmus estimated by multiplying the estimate of average daily savings from the regression analysis by the average number of program days for homes in the customer segment. For Wave 1 in 2018, electric only homes saved an average of 284 kWh (or 1.9%) and dual fuel homes saved an average of 110 kWh (or 1.0%).

**Table 94. Residential Behavioral Savings Program Electricity Savings per Home in 2018[1]**

| Deployment Wave | Customer Segment | Evaluated Net Electricity Savings per Home (kWh/yr) | 90% Confidence Interval | | Percent Daily Savings |
|---|---|---|---|---|---|
| | | | Lower Bound | Upper Bound | |
| Wave 1 | Electric only | 284 | 152 | 416 | 1.9% |
| | Dual fuel | 110 | 13 | 207 | 1.0% |

[1] These values are not net of uplift.

Table 95 shows the average daily electricity savings as a percentage of consumption for every year the program has existed. Electric only savings remained steady in 2018 at 1.9%. Dual fuel savings decreased from 1.4% in 2017 of consumption to 1.0% in 2018. These values differ slightly from last year's since Cadmus changed the regression model used to estimate savings. Previous estimates' confidence intervals include the reported values below, so the new model does not differ statistically from previous estimates. The new regression model is further explained in Appendix A. Impact Evaluation Methodology.

**Table 95. Annual Residential Behavioral Savings Program Percent Daily Electricity Savings per Home**

| Fuel Type | Average Daily Savings | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Wave 1 – Electric | 0.9% | 1.4% | 1.4% | 1.5% | 1.5% | 1.9% | 1.9% |
| Wave 1 – Dual Fuel | 0.6% | 0.9% | 1.2% | 1.4% | 1.4% | 1.4% | 1.0% |

## Participation Uplift

The RBS Program's home energy reports could help increase participation in Vectren efficiency programs in the following ways:

- Educate customers specifically about Vectren's efficiency programs and encourage them to take advantage of program offerings and incentives
- Raise customers' general awareness and knowledge of energy efficiency, which may independently encourage some customers to participate in Vectren's programs

The RBS Program's impact on participation in Vectren's other efficiency programs, as well as any savings resulting from this additional participation, is known as participation uplift. Uplift savings appear in the RBS Program regression-based savings estimate and the savings of other programs experiencing uplift. The RBS Program savings from treatment customers counted in other efficiency programs must be subtracted from the RBS Program or from Vectren's portfolio savings to avoid double-counting.

Table 96 shows uplift estimates for each program in the analysis and the estimated percentage of uplift for dual fuel, electric only, and all RBS Program homes in Wave 1 for 2018. The All Program Homes column estimates participation uplift and the percentage participation uplift across all homes.

**Table 96. 2018 Wave 1 Residential Behavioral Savings Program Participation Uplift for Efficiency Programs[1]**

| Program | Dual Fuel | | Electric Only | | All Program Homes | |
|---|---|---|---|---|---|---|
| | Participation Uplift | Percentage Participation Uplift | Participation Uplift | Percentage Participation Uplift | Participation Uplift | Percentage Participation Uplift |
| Appliance Recycling | -0.17% | -10.31% | 0.36% | 45.54% | **-0.02%** | **-1.40%** |
| Home Energy Assessment 2.0 | -0.32% | -14.55% | 0.03% | 8.92% | **-0.22%** | **-16.71%** |
| Income Qualified Weatherization | -0.09% | -31.02% | -0.17% | -54.84% | **-0.11%** | **-37.82%** |
| Residential Prescriptive | -0.11% | -2.85% | 0.33% | 15.13% | **0.02%** | **0.56%** |
| Online Energy Audit | -0.34% | -10.37% | -0.72% | -20.07% | **-0.26%** | **-5.31%** |

[1]Participation uplift derives from the estimate of change in the rate of program participation attributable to the RBS Program. The percentage of participation uplift is the change in the participation rate relative to the program participation rate of control homes in 2018.

As shown in Table 96, Wave 1 of the RBS Program increased participation only in the Residential Prescriptive Program. This is probably because treatment customers have participated more in other programs in past years but are now less likely to do so compared to control customers. Treatment group customers in the electric only wave increased participation in all programs except for the Income Qualified Weatherization Program.

Table 97 shows Wave 1 electricity savings from uplift from participation in the Appliance Recycling, Home Energy Assessment 2.0, Income Qualified Weatherization, Residential Prescriptive, and Online Energy Audit programs in 2018. These savings reflect the effects of the RBS Program on participation rates and on the numbers of and/or kinds of measures installed and should be subtracted from the total 2018 residential portfolio savings. Note that for every program, the negative uplift means that the average control customer saved more than the average treatment customer from program measures. The Online Energy Audit Program generated the largest negative uplift. Overall, control customers saved 241,531 kWh more than treatment customers.

**Table 97. 2018 Wave 1 Residential Behavioral Savings Program Electricity Savings from Program Uplift**

| Program | Wave 1 | |
|---|---|---|
| | kWh Savings per Home per Year | Total kWh Savings |
| Appliance Recycling | -0.55 | -22,842 |
| Home Energy Assessment 2.0 | -1.02 | -42,760 |
| Income Qualified Weatherization | -0.17 | -7,111 |
| Residential Prescriptive | -1.26 | -52,732 |
| Online Energy Audit | -2.78 | -116,085 |
| **Total** | **-5.78** | **-241,531** |

Table 98 shows demand savings for the same programs. Similar to energy savings, control customers generated more demand savings on average for every program compared to treatment customers. The difference in average demand savings between control and treatment customers was largest in the Residential Prescriptive Program, at 0.0022 kW on average per home, which amounted to 90.2 kW. Overall, control customers saved 112.5 kW more than treatment customers.

**Table 98. 2018 Wave 1 Residential Behavioral Savings Program Demand Savings from Program Uplift**

| Program | Wave 1 | |
|---|---|---|
| | kW Savings per Home per Year | Total kW Savings |
| Appliance Recycling | -0.0001 | -5.9 |
| Home Energy Assessment | 0.0000 | 0.4 |
| Income Qualified Weatherization | -0.0001 | -4.1 |
| Residential Prescriptive | -0.0022 | -90.2 |
| Online Energy Audit | -0.0003 | -12.8 |
| **Total** | **-0.0027** | **-112.5** |

## Evaluated Net Energy Savings Adjustments

The 2018 RBS Program resulted in 7,063,475 kWh *ex post* energy savings, as shown in Table 99. In remaining consistent with 2017, negative uplift savings should not be added to the *ex post* net savings, because there is not double counting of savings.

**Table 99. 2018 Residential Behavioral Savings Program Year Electric Savings**

| | Reported *Ex Ante* Savings (kWh) | Audited *Ex Ante* Savings (kWh) | Verified *Ex Ante* Savings (kWh) | Evaluated *Ex Post* Savings (kWh) | Realization Rate (kWh) | NTG | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| Total | 7,212,935 | 7,212,935 | 7,212,935 | 7,063,475 | 98% | N/A | 7,063,475 |
| Uplift | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Total Adjusted for Uplift** | **7,212,935** | **7,212,935** | **7,212,935** | **7,063,475** | **98%** | **N/A** | **7,063,475** |

## Evaluated Net Demand Savings Adjustments

Table 100 reports the 2018 RBS Program peak-coincident demand savings for Wave 1 electric only and dual fuel homes with 90% confidence intervals. Cadmus estimated 0.092 kW of peak coincident demand savings per Wave 1 dual fuel home and 0.024 kW per Wave 1 electric only home. Savings estimates for both segments are significant at 90%.

**Table 100. Residential Behavioral Savings Program Evaluated Demand Savings per Home in 2018**

| Deployment Wave | Customer Segment | Evaluated Net Demand Savings per Home (kW/yr) | 90% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Wave 1 | Electric only | 0.092 | 0.049 | 0.135 |
| | Dual fuel | 0.024 | 0.003 | 0.045 |

The RBS Program resulted in 1,839 kW *ex post* net demand savings, with a 90% confidence interval of 604 kW to 1,658 kW, while the relative precision is ±45%, as shown in Table 101. Vectren's reported net demand savings estimate is within the confidence interval, so that estimate cannot be rejected.

**Table 101. Residential Behavioral Savings Program Evaluated Demand Savings for all Homes**

| Deployment Wave | Customer Segment | Annual Net Electricity Savings (MWh/yr) | | 90% Confidence Interval | | Relative Precision | Realization Rate |
|---|---|---|---|---|---|---|---|
| | | Reported | Evaluated | Lower Bound | Upper Bound | | |
| Wave 1 | Electric only | N/A | 1,131 | 604 | 1,658 | ±47% | N/A |
| | Dual fuel | N/A | 708 | 81 | 1,336 | ±89% | N/A |
| **Total** | | **1,481** | **1,839** | **1,020** | **2,658** | **±45%** | **124%** |

Table 102 shows the combined evaluated *ex post* and net demand savings for the RBS program for 2018 and the total adjusted for uplift. In remaining consistent with 2017, negative uplift savings should not be added to the *ex post* net savings, because there is not double counting of savings. The total *ex post* net adjusted for uplift savings remains 1,839.

**Table 102. 2018 Residential Behavioral Savings Program Year Demand Savings**

| Deployment Wave | Reported *Ex Ante* Savings (kW) | Audited *Ex Ante* Savings (kW) | Verified *Ex Ante* Savings (kW) | Evaluated *Ex Post* Savings (kW) | Realization Rate (kW) | NTG | Evaluated Net Savings (kW) |
|---|---|---|---|---|---|---|---|
| Wave 1 | 1,481 | 1,481 | 1,481 | 1,839 | 124% | N/A | 1,839 |
| Uplift | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Total Adjusted for Uplift** | **1,481** | **1,481** | **1,481** | **1,839** | **124%** | **N/A** | **1,839** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus developed a logic model and KPIs for the RBS Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

### RESIDENTIAL BEHAVIORAL SAVINGS PROGRAM

| | | | |
|---|---|---|---|
| **Market Actor** | **End-Use Customer** | Residential Treatment Group Customers | |
| **Market Barriers** | • Lack of engagement with home energy reports<br>• Lack of engagement with online web portal | • Lack of understanding of how home uses energy<br>• Lack of home energy use benchmark | • Lack of awareness of energy efficiency options |
| **Intervention Strategies / Activities** | • Mailed reports sent 4 times per year and online reports emailed monthly<br>• Home energy use comparison to a group of similar homes included in home energy report | • Link to online web portal included in online reports<br>• Historical energy use data shown in the mailed home energy reports and available in online web portal | • Energy-saving tips included in home energy reports and online web portal<br>• Cross-promotion of other Vectren DSM programs |
| **Outcomes** | • Reduced energy use<br>• Reduced per-customer energy use and demand | • Increased use of online web portal<br>• Increased open-rate of eHERs<br>• Increased customer understanding of energy efficiency actions | • Increased adoption of energy-saving behaviors<br>• Increased participation in other Vectren DSM programs |
| **Key Indicators** | • Percentage of customers who recall receiving the reports<br>• Average monthly open-rate of eHERs<br>• Annual logins to the online web portal | • Per participant average energy savings<br>• Achievement of program participation and savings goals | • Annual number of unique web-users<br>• Percentage of customers adopting energy-saving behaviors<br>• Program uplift |

| | | | |
|---|---|---|---|
| **Market Actor** | **Program Implementor** | Home Energy Reports Distributor | |
| **Market Barriers** | • Difficulty estimating impact of behavior savings | | |
| **Intervention Strategies / Activities** | • RFP process to select qualified program implementer | • Experimental design with treatment and control groups to compare energy use impacts | • Robust, proven report design methodology |
| **Outcomes** | • Reliable energy savings estimates | | |
| **Key Indicators** | • Realization rate | | |

## Program Performance

Cadmus measured 2012 to 2018 program performance against the KPIs listed in Table 103.

**Table 103. Residential Behavioral Savings Program KPI and 2018 Performance**

| KPI | Performance | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Achievement of Program Participation Goals | N/A | N/A | N/A | N/A | 100% | 100% | 100% |
| Achievement of kWh Savings Goals | N/A | N/A | 132% | 158% | 115% | 120% | 96% |
| Achievement of kW Savings Goals | N/A | N/A | N/A | N/A | N/A | N/A | 100% |
| Percentage of Customers who Recall Receiving the Reports | N/A | N/A | 77% | 77% | N/A | N/A | Track in future years |
| Average Monthly Open-Rate of eHERs | 50% | 41% | 45% | 45% | 41% | 39% | 41% |
| Annual Total HERs Customer Logins to the Online Web Portal | 1,208 | 688 | 148 | 199 | 1,050 | 4,866 | 6,881 |
| Annual Number of Unique Web Portal Users | 872 | 385 | 106 | 93 | 696 | 2,955 | 4,188 |
| Per Participant Average Energy Savings[46] | 0.7% | 1.0% | 1.3% | 1.4% | 1.4% | 1.5% | 1.2% |
| Percentage of Customers Adopting Energy-Saving Behaviors | N/A | N/A | N/A | N/A | N/A | N/A | Track in future years |
| Program Uplift | N/A | N/A | 2.48% | 0.12% | 0.51%- | 0.77% | -1.78% |
| Realization Rate | N/A | N/A | 104% | 91% | 92% | 93% | 98% |

[46] These values are weighted by 2018 participant counts for electric and for dual fuel. They are also based on 2018 savings modeling and, therefore, values for 2012-2018 may change next year based on 2019 savings modeling. Cadmus believes this approach provides the most accurate estimates.

# Residential Lighting Program

The Residential Lighting Program targeted residential customers in Vectren's service territory and worked with retailers and manufacturers to offer reduced prices for standard and specialty ENERGY STAR-certified LED bulbs and fixtures across a range of wattages.

The program implementer, CLEAResult, worked with nine retailers across 14 storefronts to market and deliver the program. Participating retailers included big box stores, hardware stores, club stores, and general retailers. The program's marketing and promotional activities involved in-store point-of-purchase materials, store events, and television advertising.

## Accomplishments

Table 104 shows the program's achievements against goals in 2018. The program achieved 100% of its participation target and 99% of its gross energy savings goal. To meet the energy-savings goal, Vectren began offering additional fixture measures in 2018 and increased the incentives being offered, beginning in October, while only utilizing 72% of the program expenditure budget.

**Table 104. 2018 Residential Lighting Program Goals and Achievements[1]**

| Unit | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 8,302,409 | 8,366,513 | 99% |
| Gross kW Savings | 1,018.52 | 1,018.70 | 100% |
| Participants (measures) | 252,973 | 253,018 | 100% |
| Program Expenditures | $827,778 | $1,149,500 | 72% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 105 lists the evaluated savings summary for the Residential Lighting Program. Overall, the program achieved a 98% realization rate for energy and a 110% realization rate for demand savings. These realization rates are driven by differences between per-unit evaluated savings and *ex ante* deemed savings for each lamp category.

**Table 105. 2018 Residential Lighting Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 8,302,409 | 8,270,806 | 7,758,400 | 8,136,654 | 98% | 58% | 4,706,664 |
| Total kW | 1,018.52 | 991.91 | 933.05 | 1,121.49 | 110% | 58% | 648.84 |

# Conclusions and Recommendations

## *Ex Ante* Savings Assumptions

***Ex Ante* savings did not exactly match *ex post* savings assumptions.** While realization rates were very close to 100% for *ex ante* savings in 2018, the application of fixed per-unit deemed savings values to all lamps is not an ideal approach to estimating program savings. As the program measure mix changes, and as LEDs improve in efficiency, this approach may return unreliable results.

**Recommendation:** Use the UMP recommended lumens binning approach, combined with Indiana TRM values for HOU, WHF and CF, to generate *ex ante* savings for each lamp in the program, ensuring that the program gets fuller credit for higher wattage, specialty, and reflector LEDs and realization rates are closer to 100%.

## EISA 2020 Backstop

**There is high uncertainty related to how EISA 2020 baselines will be applied.** The Department of Energy has not made a decision on (but is obligated to decide) whether to amend standards for general service and specialty lamps; therefore, the elimination of the backstop energy conservation standard has not yet been determined. For this reason, current rulemaking and litigation make forecasting eligibility requirements for the Residential Lighting Program difficult. However, in most scenarios, general service A-shape lamps are most likely to end the options for halogen and CFL bulbs, with LEDs becoming the baseline lamps.

**Recommendation:** Refocus program incentives away from general service lamps, which are unlikely to qualify as eligible for the program once EISA 2020 is in effect and increase the per-unit incentives on LED reflectors and specialty lamps, which are not anticipated to be affected by the updated EISA baselines at this time.

*Process Evaluation*

# RESIDENTIAL LIGHTING PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

## 2018 Program Changes

VECTREN added ENERGY STAR fixtures to the list of program-eligible measures

## 2019 Planned Program Changes

Vectren may engage smaller stores like DOLLAR TREE & goodwill to further expand the program reach to low- and moderate-income customers.

& may expand the variety of program-eligible features.

## EISA 2020 Backstop Update

**There is uncertainty whether legislation will go into effect; makes planning for EISA 2020 difficult:**

On February 6, 2019, the U.S. Department of Energy proposed to withdraw the expansion of energy efficiency standards for light bulbs.
If this proposal is accepted, specialty bulbs will operate under current efficiency standards for the foreseeable future.

The proposal does not affect the law that requires standard A-lamps to meet efficiency standards by

2020

## Key Process Evaluation Findings

The Home Depot Truckload Event boosted participation.

During the event, Home Depot displayed lighting products in non-lighting areas of the store to promote efficient lighting products during daylight saving time.

CLEAResult visited each retailer once monthly.
They held at least one event each month at a participating retailer.

According to implementation staff, participating retailers have varied product knowledge; some have knowledgeable staff and others only use the provided information.

Light box demonstrations are effectively engaging people at events. The light box allows customers to test different bulbs for color and lumen output before they leave the store and to see a meter demonstration that shows energy consumption differences between LED and incandescent light bulbs.

Vectren may target lower income customers with email blasts or other outreach methods to increase awareness and participation among this segment.

# Impact Evaluation

## Impact Evaluation Methods and Findings

The impact evaluation of the Residential Lighting Program included these data collection and analysis tasks:

- Analysis of the program tracking database
- Engineering analysis of tracked savings, including a delta watts analysis based on the ENERGY STAR lumens equivalence approach as described in the most recent version of the UMP and deemed savings inputs established in the 2015 Indiana TRM
- Application of an in-service rate (ISR), established in the UMP to account for delayed installation of lamps after purchase
- Application of a net-of-freeridership rate, established through demand elasticity modeling

## Gross Savings Review

Cadmus reviewed the 2018 Residential Lighting Program tracking database to check savings estimates and calculations against agreed-upon *ex ante* values from the 2018 DSM Scorecard and to confirm the accurate application of the savings assumptions. Cadmus was unable to exactly match the total number of program lamps to the program scorecard, but the difference in total was less than one half percent.[47]

Cadmus determined the program's *ex ante* claimed savings by applying fixed kWh and kW per lamp to the total number of bulbs sold through the program in each lamp type. Table 106 provides per-unit annual gross savings for each program lighting measure. Comparably lower per-unit *ex ante* savings assumptions for specialty lamps in deemed kW savings, compared to kWh savings, resulted in the higher realization rate of 110% for demand savings Table 105 above).

**Table 106. 2018 Residential Lighting Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| LED Fixture | 57.5 | 48.5 | 0.006 | 0.007 |
| LED General Service | 27.8 | 30.0 | 0.003 | 0.004 |
| LED Reflector | 44.0 | 49.1 | 0.006 | 0.007 |
| LED Specialty | 44.0 | 34.1 | 0.006 | 0.005 |

[1] The 2018 DSM Scorecard did not include per-unit demand savings. These are the audited per-unit demand savings from the 2018 program tracking data.

Because LEDs have become even more efficient over time, using fewer watts to generate the same amount of light, the UMP method of calculating delta watts, which is based on regularly updated

[47] After consulting with Vectren, the minor difference was determined to be nonconsequential.

ENERGY STAR lumens bins, is preferred to using a fixed delta watts multiplier. Cadmus used the UMP-specified delta watts approach and the deemed values from the 2015 Indiana TRM to determine the *ex post* savings for each lamp's stock keeping unit (SKU) in Vectren's tracking database.[48] Cadmus then totaled the savings by each specific lamp type.

General service bulbs had, in aggregate, a per-unit evaluated savings that exceeded *ex ante* savings assumptions by 2.2 kWh. Reported and evaluated per-unit savings for specialty and reflector lamp types were varied, which is a function of measure mix and natural variation year to year. Table 107 lists the evaluated gross per-unit energy savings for each program measure by year.

**Table 107. Residential Lighting Program Historical Per-Unit Savings[1]**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| LED Fixture | 46.6 | 46.2 | 47.9 | 48.5 |
| LED General Service | 21.4 | 19.7 | 30.7 | 30.0 |
| LED Reflector | 46.6 | 46.2 | 49.2 | 49.1 |
| LED Specialty | 46.6 | 46.2 | 40.7 | 34.1 |

[1] LEDs represented less than 7% of program lamps prior to 2015.

Between 2014 and 2018, the proportion of LEDs has grown from 7% to 100% of program lamps. The mix of lamp types (or measures) has shifted as well, as more reflector, specialty, and higher wattage lamps have entered the program over time. The shift to higher wattages is most clearly reflected in the increased per-unit savings from general service lamps. Annual gross savings has also increased during this period for all but one measure. In 2018, substantially more low-watt equivalent candelabra lamps were sold, which lowered the average per-unit savings in the specialty channel.

Additional details for measure-level savings can be found Appendix A. Impact Evaluation Methodology.

## Measure Verification

Cadmus calculated verified savings by applying an installation rate to program-sponsored bulbs by lamp type. Table 108 lists the installation rates for each program measure.

Retailers participating in upstream lighting programs do not track customers' eventual installation of program-sponsored bulbs, so Cadmus could not determine how many bulbs customers installed during

[48] Stock keeping unit (SKU) is the standard retail categorization that identifies each individual product a particular retailer sells. Cadmus used SKU as a unique identifier for each lamp for which the Residential Lighting Program provided incentives through each participating retailer.

the previous year. Therefore, Cadmus used ISRs that were based on the discounted future savings [49] approach from the UMP to account for lifetime installation rates and savings and for anticipated baseline savings in 2020 when the next round of EISA regulations are applied. In addition, LED fixtures were given an ISR of 100%, which is in line with most other evaluations of this measure category and outlined in the 2018 Mid-Atlantic TRM.[50]

**Table 108. 2018 Residential Lighting Program Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate[2] |
|---|---|---|---|---|
| | Reported[1] | Audited | Verified | |
| LED Fixture | N/A | 8,266 | 8,266 | 100% |
| LED General Service | N/A | 180,702 | 166,246 | 92% |
| LED Reflector | N/A | 47,590 | 45,686 | 96% |
| LED Specialty | N/A | 15,619 | 14,994 | 96% |
| **Total** | **252,973** | **252,177** | **235,192** | **93%** |

[1] The total number of reported lamps was 252,973 in the program scorecard. Detailed values in this column are omitted as bulb type detail is not reported at that level in that document.
[2] ISRs are adjusted to include savings for lamps installed in future years.

Table 109 shows historical installation rates for each program measure. ISRs have fallen as LED lighting has become more common, though the vast majority of bulbs are still installed in the first two years after purchase. In years before 2016, the Indiana TRM recommended an LED ISR of 1.0. That value cannot be considered current, and updated values have been used since 2017.

**Table 109. Residential Lighting Program Historical Installation Rates**

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| LED Fixture | 100% | 100% | 97% | 100% |
| LED General Service | 100% | 100% | 97% | 92% |
| LED Reflector | 100% | 100% | 97% | 96% |
| LED Specialty | 100% | 100% | 97% | 96% |

In 2018, ISRs were updated to account for the delayed installation of lamps and upcoming changes to baseline lamp definitions. In Indiana, 86% of LED lamps are expected to be installed in the first year after

[49] U.S. Department of Energy. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* p. 22. http://www.energy.gov/eere/about-us/ump-protocols

[50] Northeast Energy Efficiency Partnerships. May 2018 *Mid-Atlantic Technical Reference Manual Version 8.* https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V8_0.pdf

purchase.[51] In subsequent years, additional lamps are installed. The UMP states that approximately 24% of stored lamps are installed in the first year following purchase, and 24% of stored lamps are installed in the second year after purchase, and so on. Cadmus used the program savings discounting method and, after accounting for the assumption that general service LEDs will not get savings credit following the application of updated EISA baselines in 2021, applied ISRs of 92% of general service LEDs and 96% of specialty and reflector LEDs to 2018 lamps.

## Net-to-Gross Analysis

Lighting products that incur price changes and promotion over the program period provide valuable information regarding the correlation between sales and prices. Cadmus developed a demand elasticity model to estimate freeridership for the upstream markdown channel in 2018. Table 110 presents the NTG results for the program. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

**Table 110. 2018 Residential Lighting Program Net-to-Gross Ratio**

| Measure | Percent of Savings | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|---|
| LED Fixture | 5% | 93% | 0% | 7% |
| LED General Service | 61% | 26% | 0% | 74% |
| LED Reflector | 28% | 61% | 0% | 39% |
| LED Specialty | 6% | 77% | 0% | 23% |
| **Total Program** | **100%** | **42%** | **0%** | **58%** |

Table 111 lists historical program-level NTG ratios by year. Cadmus found that the overall, savings weighted 58% NTG for LEDs (down from 72% in 2017) was reasonable. LEDs are seeing increases in freeridership year over year, which Cadmus expects to continue as customers become more familiar with LEDs as an option. As markets mature there are several factors that contribute to increases in freeridership. Some of these factors and their implications are discussed in the following Freeridership and Spillover Findings section.

51 Cadmus applied first-year installation rates, derived through the *2014 Market Effects Study* from Opinion Dynamics (2015), the most current research available from Indiana. More recent studies in Maryland (86%, 2016) and New Hampshire (87%, 2016) have similar first year LED ISRs. ISRs for LEDs typically range between 74% (Wyoming, 2016) and 97% (New Hampshire, 2016).

**Table 111. Historical Residential Lighting Program Net-to-Gross Ratios**

| Program Year | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| 2015 | 33% | 0% | 67% |
| 2016 | 21% | 0% | 79% |
| 2017 | 28% | 0% | 72% |
| 2018 | 42% | 0% | 58% |

### *Freeridership and Spillover Findings*

In 2018, freeridership remained relatively low for general service bulbs but was higher for reflector bulbs (61% compared to 28% in 2017) and specialty bulbs (77% compared to 35% in 2017). Table 112 shows historical freeridership for the Residential Lighting Program by measure.

**Table 112. Historical Residential Lighting Program Freeridership by Measure**

| Measure | 2017 | 2018 |
|---|---|---|
| LED General Service | 27% | 26% |
| LED Reflector | 28% | 61% |
| LED Specialty | 35% | 77% |
| **Total Program** | **28%** | **42%** |

In recent years, the LED market has matured quickly as prices have dropped and non-program LEDs (not ENERGY STAR-qualified or value line) have become increasingly common. Large national brands such as Philips, GE, and Feit are releasing lower-priced options for general service, specialty, and reflector bulbs. But competition from these comparably priced non-program LEDs means demand becomes less elastic for program LEDs. Without the discounts provided by the program, consumers in the market for LEDs have many other competitively priced options for LEDs.

Demand also tends to become less elastic when consumers come to expect lower prices in the long term. Consumers no longer have to jump at price discounts on LEDs because such discounts, even without program support, are now common and relatively low compared to the price when LEDs were first introduced to the market.

As saturations of LEDs increase, overall sales are expected to decrease given the 10- to 15-year lifespan of mid-tier LED products. In addition, LEDs are often sold in multipacks, which means consumers can purchase and store more LEDs. Once installed, LEDs need replacing much less frequently than do incandescent, halogen, or CFL bulbs. Program discounts lead to smaller increases in sales when overall demand decreases. This could account for the higher freeridership for reflector and specialty bulbs observed in 2018 since the number of non-general service sockets in an average home is typically lower than sockets for general service bulbs. Consumers are less likely to continue stocking up on bulbs that can only fill a small number of specialty sockets rather than bulbs that could fill a larger number of general sockets.

### *Benchmarking*

Freeridership for Residential Lighting Program LEDs typically ranged from 30% to 40% for the different bulb types, comparable to percentages observed in other recent evaluation results with one exception (Table 113). A recent evaluation for a Mid-Atlantic utility showed that the program focused heavily on merchandising and provided very detailed data on merchandising. Promotional events tied to the program and merchandising events created substantial lift for program LEDs. Having such detailed information on marketing and promotional events ensures that the evaluation team can identify all sources of program influence and give the program full credit for sales impacts resulting from marketing effects.

**Table 113. Benchmarking LED Freeridership (DEM Analyses)**

| Evaluation | Freeridership |
|---|---|
| **Vectren Indiana (2018)** | **42%** |
| Focus on Energy Wisconsin (2016) | 38% |
| Connecticut (2016) | 39% |
| Mid-Atlantic Utility (2016–2017) | 17% |

Sources: Wisconsin Focus on Energy: https://focusonenergy.com/sites/default/files/Evaluation%20Report%20-%202016%20Volume%20II.pdf

Connecticut: https://www.energizect.com/sites/default/files/R1615_CT%20LED%20Net-To-Gross%20Evaluation%20Report_Final_8.5.17.pdf

## Evaluated Net Savings Adjustments

Table 114 and Table 115 list evaluated net savings for the Residential Lighting Program. The program achieved net savings of 4,706,664 kWh and 649 coincident kW demand reduction.

**Table 114. 2018 Residential Lighting Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported[1] | Audited | Verified | | | | |
| LED Fixture | N/A | 475,130 | 475,130 | 400,796 | 84% | 7% | 28,056 |
| LED General Service | N/A | 5,014,481 | 4,613,322 | 4,981,372 | 99% | 74% | 3,686,215 |
| LED Reflector | N/A | 2,093,960 | 2,010,202 | 2,242,880 | 107% | 39% | 874,723 |
| LED Specialty | N/A | 687,236 | 659,747 | 511,606 | 74% | 23% | 117,669 |
| **Total** | **8,302,409** | **8,270,806** | **7,758,400** | **8,136,654** | **98%** | **58%** | **4,706,664** |

[1] The 2018 DSM Scorecard did not report kWh savings at the measure level.

**Table 115. 2018 Residential Lighting Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| LED Fixture | N/A | 53.12 | 53.12 | 55.04 | 104% | 7% | 3.85 |
| LED General Service | N/A | 532.56 | 489.95 | 686.72 | 129% | 74% | 508.17 |
| LED Reflector | N/A | 305.85 | 293.61 | 309.20 | 101% | 39% | 120.59 |
| LED Specialty | N/A | 100.38 | 96.36 | 70.53 | 70% | 23% | 16.22 |
| **Total** | **1,018.52** | **991.91** | **933.05** | **1,121.49** | **110%** | **58%** | **648.84** |

[1] The 2018 DSM Scorecard did not report kW savings at the measure level.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the Residential Lighting Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# RESIDENTIAL LIGHTING PROGRAM

**Market Actor:** End-Use Customer | Lighting Products Purchasers

**Market Barriers**

- Higher cost of efficient lighting products
- Customer preference for the familiar
- Skepticism of true energy savings
- Lack of program awareness
- Lack of energy efficiency awareness
- Negative associations with energy-efficient lighting
- Lighting products do not match customer's aesthetic preferences (shape, color)

**Intervention Strategies / Activities**

- Lighting products discounts at point of purchase
- In-store program signage and events
- Lighting products discounts for multiple bulb types, including specialty bulbs, fixtures, and ceiling fans
- Digital and broadcast media promotion of the program
- Information on Vectren website

**Outcomes**

- Increased awareness
- Increased participation
- Increased customer satisfaction
- Increased penetration of efficient lighting technologies
- Improved customer perception of efficient lighting
- Increased energy savings

**Key Indicators**

- Achievement of program participation and savings ls
- Efficient lighting saturation/ penetration in Vectren's territory
- Measure satisfaction ratings

**Market Actor:** Trade Allies | Retail Store Staff

**Market Barriers**

- Lack of program awareness
- Lack of understanding of efficient lighting benefits

**Intervention Strategies / Activities**

- Retail staff training on the program and efficient lighting
- In-store signage

**Outcomes**

- Increased awareness
- Increased participation
- Increased energy savings

**Key Indicators**

- Efficient lighting saturation/penetration in Vectren's territory
- Achievement of program participation and savings goals

## Program Performance

Cadmus measured 2015 to 2018 program performance against the KPIs listed in Table 116.

**Table 116. Residential Lighting KPI and 2015-2018 Performance**

| KPI | Performance | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Achievement of program kWh savings goals | Met goal; 101% | Met goal; 104% | Met goal; 105% | Did not meet goal; 99% |
| Achievement of program participation goals | Met goal; 101% | Did not meet goal; 86% | Met goal; 111% | Met goal; 100% |
| Efficient lighting saturation/penetration[1] | N/A | N/A | N/A | Track in future years |
| Customer satisfaction with bulbs purchased | N/A | N/A | N/A | Track in future years |

[1] These data may be available from the potential study currently being conducted.

# Appliance Recycling Program

The Appliance Recycling Program (ARP) is designed to reduce electricity use through the removal and environmentally sound recycling of inefficient secondary refrigerators and freezers and older primary refrigerators in Vectren's service territory.[52]

The program implementer, ARCA Recycling Inc., worked directly with Vectren to deliver the program. ARCA maintains a recycling facility that follows U.S. Environmental Protection Agency (EPA) best practices and recycles nearly 100% of each unit. Participants can recycle up to two working secondary refrigerators or freezers, sized 10 to 30 cubic feet, by scheduling a pick-up of the units through ARCA. Vectren provides a $50 incentive to customers for each qualifying unit picked up.

## Accomplishments

Table 117 shows the program's achievements against goals in 2018. The program achieved 108% of its participation target and, as a result, achieved 109% of its gross energy savings goal. Continued outreach through bill inserts, billboards, and radio and TV advertisements as well as cross-marketing in the home energy reports helped ensure Vectren met their energy savings goal for this program.

**Table 117. 2018 Appliance Recycling Program Goals and Achievements[1]**

| Unit | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 1,239,491 | 1,138,179 | 109% |
| Gross kW Savings | 158.17 | 146.00 | 108% |
| Participants (unit) | 1,300 | 1,200 | 108% |
| Program Expenditures | $242,799 | $252,260 | 96% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 118 lists the evaluated savings summary for the ARP. Overall, the program achieved a 107% realization rate for energy and a 107% realization for demand savings primarily because *ex post* per-unit refrigerator savings was higher than *ex ante* per-unit refrigerator savings. From 2016 to 2018, evaluated *ex post* gross energy savings for refrigerators increased mainly due to a 12% increase of refrigerators used as a primary and a 6% increase in the percentage of units with a side-by-side door configuration, which consume more energy than other configurations, compared to *ex ante* savings that are based on 2016 evaluation results.

[52] Environmentally sound disposal of this equipment includes proper disposal of oils, PCBs, mercury, and CFC-11 foam and recycling of CFC-12, HFC-134a, plastic, glass, steel, and aluminum.

**Table 118. 2018 Appliance Recycling Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 1,239,491 | 1,239,491 | 1,239,491 | 1,326,520 | 107% | 67% | 891,359 |
| Total kW | 158 | 158 | 158 | 169 | 107% | 67% | 114 |

## *Conclusions and Recommendations*

### Customer Satisfaction

**The ARP has very high customer satisfaction.** All (100%) survey respondents were satisfied with the program and also likely to recommend it to family, friends, or neighbors. Additionally, all participants were satisfied with the service and professionalism of the appliance pick-up staff.

### Gross Savings Review

**Freezer savings have decreased because newer units are being recycled and used less.** Vectren's 2018 *ex ante* per-unit savings for recycling refrigerators and freezers were based on the 2016 evaluation. Refrigerator *ex ante* per-unit estimates of 985 kWh are very close to the 2018 *ex post* per-unit savings of 1,096 kWh. However, freezer *ex ante* per-unit savings of 821 kWh are 16% higher than the freezer *ex post* per-unit savings of 706 kWh. The main reasons were that in 2018 the average freezer age decreased by three years and the proportion of the year that the units were being used (part-use) also decreased by 6% compared to the 2016 evaluation results.

### Net-to-Gross

**Freeridership decreased in 2018 compared to 2017.** An increase in the percentage of participants who said they would have kept their refrigerator in absence of the program was the main contributor to the higher program-level NTG ratio in 2018 (0.67) compared to 2017 (0.53).

## *Process Evaluation*

# APPLIANCE RECYCLING PROGRAM

### *2018 Process Analysis Activities*

1 VECTREN staff interview

1 ARCA INCORPORATED staff interview

113 participant customer phone surveys

70 refrigerator participants

43 freezer participants

### *2018 Program Changes*

VECTREN increased savings goal by 13% compared to 2017

Expanded marketing with: billboards in the summer, radio spots, TV commercials

as well as cross-promotion with the Residential Behavioral Savings Program's home energy report

### *2019 Planned Program Changes*

VECTREN further increasing the program savings goal by 31% and will increase program budget by 18%

### *Key Process Evaluation Findings*

100% of respondants are:

- satisfied with the program (n=112) consistant with 2017 results
- likely to recommend ARP to a friend, family member, or neighbor (n=112) consistant with 2017 results
- satisfied with the service they received from the appliance pick-up staff (n=110)
- satisfied with the professionalism of the appliance pick-up staff (n=109)

**85%** (n=105) considered Vectren's suggestions on ways to reduce energy usage and lower their monthly bills as useful
Consistant with 2017 results

**87%** (n=100) were satisfied with Vectren's efforts to help them manage their monthly energy usage
Refrigerator respondents (92%) had statistically higher satisfaction than freezer respondents (78%)

**97%** (n=111) were satisfied with the length of time between their scheduled appointment and their appliance pick-up date
The implementer reported an average wait time of 7 days

**98%** (n=91) were satisfied with the variety of energy efficiency programs offered by Vectren
This was statistically higher than in 2017 (93%; n=111)

# Impact Evaluation

## Impact Evaluation Methods and Findings

Cadmus' methodology for estimating ARP savings is consistent with the U.S. Department of Energy's UMP evaluation protocol for refrigerator recycling.[53] The impact evaluation of ARP included these data collection and analysis tasks:

- Verify quantities and types of measures recycled through the program recorded in the program tracking database
- Determine gross unit energy consumption (UEC) of retired refrigerators and freezers for 2018 using a multivariate regression model on an aggregated *in situ* metering dataset of 591 appliances metered for evaluations conducted in California, Wisconsin, and Michigan
- Conduct phone surveys with 113 program participants (stratified by measure type) to estimate the partial use of recycled appliances during the previous year of use and to estimate NTG

## Gross Savings Review

Table 119 lists the 2018 ARP's per-unit annual gross savings for each measure. Vectren's 2018 reported per-unit annual gross savings estimates are based on the evaluated estimates from the 2016 ARP evaluation. Refer to Appendix A. Impact Evaluation Methodology for detailed information on the 2018 evaluated gross savings methodology used for refrigerators and freezers.

**Table 119. 2018 Appliance Recycling Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| Refrigerator | 985 | 1,096 | 0.12 | 0.14 |
| Freezer | 821 | 706 | 0.12 | 0.08 |

Cadmus determined that evaluated per-unit gross energy savings was 1,096 kWh/year for refrigerators, 11% higher than the *ex ante* gross energy savings estimate of 985 kWh/year. From 2016 to 2018, evaluated *ex post* gross energy savings for refrigerators increased primarily due to a 12% increase of refrigerators used as a primary and a 6% increase in the percentage of units with a side-by-side door configuration compared to *ex ante* savings that are based on 2016 evaluation results.

Primary units typically have more door openings than secondary units and are used full-time in conditioned spaces (which contributes to higher part-use and gross savings). Secondary units tend to have fewer door openings and are more likely to be used part-time in unconditioned spaces compared to primary units. The part-use factor accounts for units that are not in use for the entire year.

[53] U.S. Department of Energy. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* October 2017. Available online: https://www.energy.gov/eere/about-us/ump-protocols

Refrigerators with side-by-side door configuration often have water and ice dispensing features through one door, which typically makes them less well-insulated than a refrigerator with a solid door configuration. The UMP savings model states that a side-by-side refrigerator uses 1.12 kWh more per unit than a refrigerator that does not have a side-by-side configuration.

For freezers, *ex ante* per-unit savings of 821 kWh/year savings were 16% higher than *ex post* per-unit savings of 706 kWh/year. Three main reasons contributed to the 115 kWh difference. Average freezer age decreased 11%. The percentage of units manufactured before 1990 decreased 16% compared to 2016. Part-use decreased from 0.86 in 2016 to 0.80 in 2018 in the evaluated *ex post* gross savings calculation.

Table 120 lists the evaluated gross per-unit energy savings for ARP measures since 2012.

**Table 120. Appliance Recycling Program Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Refrigerator | 1,260 | 1,092 | 1,090 | 1,000 | 986 | 1,044 | 1,096 |
| Freezer | 1,115 | 990 | 924 | 809 | 820 | 797 | 706 |

## Measure Verification

Cadmus verified quantities and measures recycled by conducting surveys with ARP participants and by reviewing the program tracking database. The installation rate is a comparison of appliance removal dates in the program tracking data to reported participation. Cadmus determined an installation rate of 100% for both refrigerators and freezers (Table 121).

**Table 121. 2018 Appliance Recycling Program Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported | Audited | Verified | |
| Refrigerator | 1,048 | 1,048 | 1,048 | 100% |
| Freezer | 252 | 252 | 252 | 100% |
| **Total** | **1,300** | **1,300** | **1,300** | **100%** |

Table 122 shows that the 2018 installation rate of 100% is identical to the aggregated installation rate for the last six program years.

**Table 122. Appliance Recycling Program Historical Installation Rates**

| Measure | Installation Rate | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Refrigerator | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Freezer | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

## Net-to-Gross Analysis

Cadmus calculated NTG for the 2018 ARP using findings from a survey of 113 program participants. Cadmus stratified the survey by measure type—refrigerators and freezers eligible for program recycling. Table 123 presents the NTG results for the program. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

**Table 123. 2018 Appliance Recycling Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Refrigerator | 32% | 0% | 68% |
| Freezer | 38% | 0% | 62% |
| **Total Program[1]** | **33%** | **0%** | **67%** |

[1]Program level estimates are weighted by each measure's *ex post* gross evaluated population energy savings.

Table 124 lists historical program-level NTG ratios by year. The 2018 ARP NTG Ratio is second highest when compared to NTG ratios from prior program years.

**Table 124. Appliance Recycling Program Historical Net-to-Gross Ratios**

| Measure | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| Refrigerator | 59% | 52% | 55% | 54% | 70% | 50% | 68% |
| Freezer | 72% | 55% | 57% | 57% | 73% | 72% | 62% |
| **Total Program[1]** | **61%** | **54%** | **55%** | **54%** | **71%** | **53%** | **67%** |

[1]Program level estimates are weighted by each measure's *ex post* gross evaluated population energy savings.

### *Freeridership and Spillover Findings*

In general, independent of program intervention, participant refrigerators and freezers are subject to one of three scenarios that inform freeridership:

- **Scenario 1:** The participant would have kept the refrigerator.
- **Scenario 2:** The participant would have discarded the refrigerator by a method that transfers it to another customer for continued use.
- **Scenario 3:** The participant would have discarded the refrigerator by a method that removes the unit from service.

Cadmus applies freeridership only under Scenario 3 because the unit would have been removed from the grid and destroyed, even if it was not recycled through the ARP. Therefore, Vectren cannot claim energy savings generated by recycling Scenario 3 appliances.

Table 125 lists the components used to calculate freeridership. Cadmus divided the freeridership and secondary market impacts kWh savings by the part-use adjusted gross per-unit kWh savings to obtain the freeridership estimate for each measure.[54] Refer to Appendix B. Net-to-Gross Detailed Findings for freeridership and secondary market impacts methodology and results.

**Table 125. 2018 Appliance Recycling Program NTG by Measure Type**

| Measure | Gross Per-Unit Savings (kWh/Year) | Freeridership and Secondary Market Impacts (kWh) | Freeridership |
|---|---|---|---|
| Refrigerator | 1,096 | 352 | 32% |
| Freezer | 706 | 265 | 38% |

As recommended in the UMP, the team did not include spillover in program net savings estimates for 2018. The UMP suggests that although appliance recycling programs promote enrollment in other energy efficiency programs, spillover of unrelated measures is unlikely to occur because appliance recycling programs do not provide comprehensive energy education like other programs. Spillover excluded in the 2018 analysis will be reported as 0% in relevant calculations and figures for Vectren's ARP.

## Evaluated Net Savings Adjustments

Table 126 and Table 127 list evaluated net savings for the ARP. The program achieved net savings of 891,359 kWh and 113.95 coincident kW demand reduction.

**Table 126. 2018 Appliance Recycling Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Refrigerator | 1,032,532 | 1,032,532 | 1,032,532 | 1,148,608 | 111% | 68% | 781,053 |
| Freezer | 206,959 | 206,959 | 206,959 | 177,912 | 86% | 62% | 110,305 |
| **Total** | **1,239,491** | **1,239,491** | **1,239,491** | **1,326,520** | **107%** | **67%** | **891,359** |

**Table 127. 2018 Appliance Recycling Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Refrigerator | 127.51 | 127.51 | 127.51 | 148.32 | 116% | 68% | 100.86 |
| Freezer | 30.66 | 30.66 | 30.66 | 21.11 | 69% | 62% | 13.09 |
| **Total** | **158.17** | **158.17** | **158.17** | **169.43** | **107%** | **67%** | **113.95** |

[54] Secondary market impacts accounts for the purchasing decisions that are made by would-be acquirers of Vectren participating units now that the units are unavailable on the used marketplace.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus developed a logic model and KPIs for the ARP. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# APPLIANCE RECYCLING PROGRAM

### Market Actor

**End-Use Customer** | Residential Customers

### Market Barriers

- Lack of program awareness
- Skepticism of true energy savings
- Customer perception of scheduling process as a hassle
- Lack of awareness of monetary and environmental benefits of removing an inefficient appliance

### Intervention Strategies / Activities

- Digital and broadcast program marketing
- Cross-promotion through other Vectren DSM programs
- Program information and eligibility requirements available on Vectren website
- Incentives for removal of working refrigerator or freezer
- Scheduling for removal available online and toll-free telephone
- On-time pick-up of appliances within two to three weeks of initial customer contact
- Removal staff deliver appliances to recycling center

### Outcomes

- Increased program awareness
- Increased program participation
- Increased customer satisfaction with program
- Increased customer understanding of energy efficiency benefits
- Fewer inefficient appliances available on the secondary market
- Environmentally responsible disposal of waste materials from recycled appliances
- Reduced energy use

### Key Indicators

- Achievement of program participation and savings goals
- Likelihood to recommend ratings
- Saturation of used appliances on the secondary market
- Program satisfaction ratings

### Market Actor

**Program Impelementer** | Removal Staff

### Market Barriers

- Insufficient removal staff qualifications
- Participant concerns about removal staff entering home

### Intervention Strategies / Activities

- RFPs to attract qualified program implementer
- Direct contact with participant customers
- Open communication with participants to address concerns
- Checklist followed by removal staff upon arrival at every home

### Outcomes

- Assurance of quality work
- Increased program participation
- Increased customer satisfaction with removal experience
- Fewer inefficient appliances in operation

### Key Indicators

- Achievement of program participation and savings goals
- Removal experience satisfaction ratings

## Program Performance

Cadmus measured 2014 to 2018 program performance against the KPIs listed in Table 128.

**Table 128. ARP KPI and 2014-2018 Performance**

| KPI | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Achievement of program participation goals | Did not meet; 94% | Met goal; 120% | Met goal; 105% | Met goal; 122% | Met goal; 108% |
| Achievement of kWh savings goals | Did not meet; 93% | Met goal; 120% | Met goal; 105% | Met goal; 122% | Met goal; 109% |
| Likelihood to recommend ratings | N/A | N/A | 98% | 98% | 100% |
| Saturation of used appliances on the secondary market | N/A | N/A | N/A | N/A | Track in future program years |
| Program satisfaction ratings | N/A | 96% | 99% | 98% | 100% |
| Satisfaction with pick-up staff service | N/A | N/A | N/A | N/A | 100% |
| Satisfaction with pick-up staff professionalism | N/A | N/A | N/A | N/A | 100% |
| Satisfaction with the time between appointment and pickup | N/A | N/A | N/A | N/A | 97% |

# Food Bank LED Distribution Program

In its Food Bank LED Distribution Program, Vectren partners with 17 food banks in its territory to distribute one 4-pack of general purpose, 9-watt LED bulbs at no cost to qualifying food bank patrons. By targeting these patrons, Vectren aims to increase the market share of LED bulbs among its customers with limited incomes. CLEAResult, as program implementer, ensures that food bank staff receive the program bulbs and distribute them to customers.

The Food Bank LED Distribution Program last ran in 2016. This program year, all distributions took place in June of 2018.

With each box of bulbs, Vectren included a brief postcard survey to assess installation rates and customer satisfaction. Customers were to complete the postcards and return them to a box stationed in each partnering food bank. To encourage the return of the postcards, Vectren offered customers the chance to win an Amazon Echo Dot.

## Accomplishments

Table 129 shows the program's achievements against goals in 2018. The program met its planned participation goal, distributing more than 50,000 9-watt LED bulbs, while spending 96% of planned expenditures.

**Table 129. 2018 Food Bank LED Distribution Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 1,495,959 | 1,495,959 | 100% |
| Gross kW Savings | 206 | 206 | 100% |
| Participants (Bulbs) | 50,496 | 50,496 | 100% |
| Program Expenditures | $167,513 | $174,609 | 96% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 130 lists the program's evaluated savings. In 2018, the difference between verified and audited savings was because of the 88% in-service rate (ISR). The difference between verified and *ex post* savings was because of leakage, the percentage of bulbs installed outside of Vectren's electric territory, which was 29% in 2018. Overall, the 2018 realization rate was 62% for both energy and demand savings. Cadmus calculated ISR and leakage using 2018 self-report participant survey data.

**Table 130. 2018 Food Bank LED Distribution Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 1,495,959 | 1,495,959 | 926,257 | 921,588 | 62% | 100% | 921,588 |
| Total kW | 206 | 206 | 128 | 127 | 62% | 100% | 127 |

# Conclusions and Recommendations

## Customer Satisfaction

**Customers are highly satisfied with the bulbs.** The program design successfully incorporated the food banks as a trusted partner in helping Vectren target the hard-to-reach low-income segment, as evidenced by high customer satisfaction and program participation achievements (100% of program participation goal achieved). All surveyed bulb recipients (100%, n=70) indicated they were satisfied with their bulbs.

## Marketing and Outreach

**The Food Bank LED Distribution Program successfully cross-promoted Vectren's Income Qualified Weatherization Program.** According to the 2018 participant survey, 9% of bulb recipients (n=70) participated in another Vectren program as a result of their participation in the Food Bank LED Distribution Program. Most often, this was the Income Qualified Weatherization Program, which is advertised on the box the LED bulbs come in. No respondent said they participated in the Residential Lighting Program. It is possible that bulb recipients have more than four non-LED bulbs to replace in their home, because more than half of the respondents (57%, n=68) reported never having had an LED bulb installed in their home prior to participating in the Food Bank LED Distribution Program. According to LED penetration rates from studies in other states, ranging from 75% to 85%,[55,56] there is opportunity to promote the purchase of program-supported LEDs in this population.

**Recommendation:** Provide information (such as a small flyer in the box of bulbs or on the packaging) that promotes Vectren-discounted lighting products at nearby participating retailers, while continuing to cross-promote the Income Qualified Weatherization Program.

## Leakage

**Most leakage likely came from two food banks located outside of Vectren's electric service territory.** Two partner food banks were in towns outside of Vectren's service territory, Petersburg and Princeton,[57] and distributed 18% of program bulbs. Leakage was 29%, which indicates customers may also be traveling from other service territories to food banks in Vectren's electric territory.

---

[55] NMR Group, Inc. March 28, 2018. *RLPNC Study 17-9 2017-18 Residential Lighting Market Assessment Study.* http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_179_LtgMarketAssessment_28March2018_FINAL-1.pdf.

[56] NMR Group, Inc. February 12, 2019. *2018 Pennsylvania Statewide Act 129 Residential Baseline Study*. http://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf.

[57] One food bank is in Petersburg, north of Interstate 69 and east of Highway 57, in Pike County, and appears to be about 10 miles northwest of Vectren's electric territory. Another food bank is in Princeton, just north of Highway 64 and east of North Main Street. It appears to be about three miles outside of Vectren's territory.

**Recommendation:** To reduce leakage, partner only with food banks in Vectren's electric territory. Ensure that partner food banks are giving LEDs to Vectren's electric customers by restricting distribution sites to addresses within a 15- or 20-minute drive from the service territory border.

*Process Evaluation*

# FOOD BANK LED DISTRIBUTION PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

70 phone surveys with bulb recipients

## Program Overview

12,624 customers recieved LEDs

17 partnering food banks

VECTREN increased its bulb giveaway goal by 108% compared to 2016

## 2019 Planned Program Changes

VECTREN is considering expanding giveaway measures to include:

- smart strips
- faucet aerators
- showerheads

## Key Process Evaluation Findings

9% (n=70) of bulb recipients participated in another Vectren program after the giveaway

Typically, the Income Qualified Weatherization Program

30% (n=69) of bulb recipients were aware that Vectren sponsored the program

55% (n=66) of bulb recipients are renters

57% (n=68) of bulb recipients had never installed LED bulbs in their home prior to the program

100% (n=70) of bulb recipients are satisfied with the LEDs

**Bulb Recipient Housing (n=67)**

| Single-Family Home | Multifamily Home | Mobile Home |
|---|---|---|
| 55% | 22% | 19% |

**Bulb Recipient Age (n=67)**

| 18 - 35 | 36 - 59 | 60 + |
|---|---|---|
| 7% | 48% | 43% |

94% (n=62) of bulb recipients are satisfied with Vectren's efforts to help them manage their monthly usage

95% (n=66) of bulb recipients found Vectren's suggestions to reduce energy usage useful

100% (n=62) of bulb recipients are satisfied with the variety of programs offered by Vectren

# Impact Evaluation

## Impact Evaluation Methods and Findings

Cadmus' impact evaluation of the LED Food Bank Distribution Program's involved the following data collection efforts and analysis tasks:

- Analysis of tracking database to review the number of LED bulbs distributed
- Telephone survey of 70 program participants to verify the number of measures installed and leakage rate
- Engineering analysis to determine energy and demand savings
- Spillover analysis[58]

## Gross Savings Review

Cadmus applied the savings algorithm in the Residential ENERGY STAR Lighting (CFL and LED) section of the Indiana TRM (V2.2).[59] It also applied two additions as recommended in Chapter 6: Residential Lighting Evaluation Protocol of the UMP.[60,61] Cadmus used the lumen equivalence method to determine the baseline bulb wattage and accounted for the leakage of program bulbs. Table 131 provides per-unit annual gross savings for the program LEDs—note that the values here do not account for leakage and ISR.

**Table 131. 2018 Food Bank LED Distribution Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| 9W LED | 29.63 | 29.48 | 0.0041 | 0.0041 |

The difference between the reported and evaluated per-unit gross savings was because Cadmus used weighted average waste heat factors (WHFs) by city, based on 2018 survey data. The reported per-unit savings assumed that all bulbs had WHFs in Evansville with the weighted average heating types, as in the

58 Cadmus assumes an NTG ratio of 100% for income-qualified programs. Cadmus conducted a spillover analysis for Vectren's program for planning purposes but did not apply a spillover adjustment to the program's evaluated savings.

59 Cadmus, Opinion Dynamics, Integral Analytics, and Building Metrics. July 28, 2015. *Indiana Technical Reference Manual, Version 2.2.* Prepared for Indiana Demand Side Management Coordination Committee and EM&V Subcommittee.

60 U.S. Department of Energy. October 2017. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.energy.gov/eere/about-us/ump-protocols

61 The UMP also recommends that evaluators determine if any LEDs were installed in nonresidential locations (which increases the savings as the hours of use are higher). Cadmus asked about this in the survey, but no respondents indicated they had installed any bulbs in nonresidential applications.

2016 evaluation. In 2018, Cadmus used the location from survey respondents and the weighted average heating and cooling system types from the Indiana TRM (V2.2).[62] All other inputs between reported and evaluated savings were the same. Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

Table 132 lists the evaluated gross per-unit energy savings for each program measure by year. Because the reported savings from 2018 used the 2016 evaluated savings, the difference between the 2016 and 2018 evaluated savings is the same as above—2018 used weighted average WHFs by city and 2016 did not.

**Table 132. Food Bank LED Distribution Program Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | |
|---|---|---|---|
| | 2016 | 2017[1] | 2018 |
| 9W LED | 29.63 | N/A | 29.48 |

[1] Vectren did not offer the program in 2017.

## Measure Verification

In 2018, Cadmus verified measures by estimating the ISR and leakage, using data from a telephone survey of 70 program participants for both analyses. Table 133 shows the overall measure verification of the LED Food Bank Program. The ISR and the leakage adjustments comprise the number of bulbs currently installed, and the number of bulbs currently installed in Vectren's service territory. In other words, Cadmus multiplied the per-unit gross savings by the ISR and the leakage—see the algorithm in section 5.5.8 of 2018 Illinois TRM (V6) as an example of how leakage is used in lighting savings.[63]

**Table 133. 2018 Measure Verification of Food Bank LED Distribution Program—ISR and Leakage**

| Measure | Installations[1] | | | | Total Adjustment (ISR and Leakage) |
|---|---|---|---|---|---|
| | Reported | Audited | Verified (ISR)[2] | Verified (ISR and Leakage)[3] | |
| 9W LED | 50,496 | 50,496 | 44,189 | 31,266 | 62% |
| **Total** | **50,496** | **50,496** | **44,189** | **31,266** | **62%** |

[1] When applying ISR and leakage, total installations may not sum due to rounding.
[2] The ISR is 88%.
[3] The leakage is 29%. The percentage of bulbs that stayed in the service territory is 71%.

[62] Cadmus' survey did not have enough responses to determine the weighted average heating and cooling system type; therefore, Cadmus used the Indiana TRM (V2.2) defaults.

[63] Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual—Volume 3: Residential Measures.* http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_3_Res_020817_Final.pdf.

### *In-Service Rate*

To estimate the ISR, Cadmus followed the approach recommended in Chapter 6: Residential Lighting Evaluation Protocol of the UMP,[64] which accounts for installation of program bulbs initially put into storage and assumes that of these 24% of bulbs get installed each year, for three years.

As Table 134 shows, 84% of bulbs are installed in the first year (2018) and 7% of bulbs are put into storage (according to 2018 survey data).[65] In the second year (2019), 24% of the bulbs initially put in storage will get installed—bringing the 2019 ISR up (to 86%) and the 2019 cumulative storage rate down (to 5%). In the final year, the ISR rises to 88%, and the storage rate down to 4%. The UMP recommends reporting the final year ISR, which Cadmus did.

**Table 134. First-Year, Second-Year, and Final Year ISR**

| Year | ISR | Cumulative Storage Rate |
|---|---|---|
| 2018 (First Year) | 84% | 7% |
| 2019 (Second Year) | 86% | 5% |
| 2020 (Final Year) | 88% | 4% |

Table 135 shows the 2016 and 2018 ISR for Food Bank LED Distribution Program LED bulbs. In 2016, using postcard surveys,[66] Cadmus had only enough data to estimate the installation rate, the percentage of bulbs initially installed, but not the in-service rate, which accounts for bulbs getting uninstalled and bulbs in storage eventually getting installed. For 2018, Cadmus could use the returned postcards to collect participants' contact information to field a more detailed phone survey. The methodology in 2018 was an improvement, and, despite the change in methodology, the "ISR" remained consistent across program years.

**Table 135. Food Bank LED Distribution Historical In-Service Rate**

| Measure | In-Service Rate | | |
|---|---|---|---|
| | 2016[1] | 2017[2] | 2018[3] |
| 9W LED | 86% | N/A | 88% |

[1] For simplicity and to compare 2016 to 2018, Cadmus presents the installation rate in 2016 and the in-service rate in 2018. In 2016, Cadmus could only collect the installation rate because data were limited.
[2] Vectren did not offer the program in 2017.
[3] This value does not include leakage.

64 U.S. Department of Energy. October 2017. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.energy.gov/eere/about-us/ump-protocols

65 Survey results also showed that participants gave away or did not know what happened to the remaining 9% of bulbs.

66 In 2016, participants mailed back postcard surveys that Vectren provided. The postcard asked participants only four questions: how many bulbs were installed, what was their satisfaction with the program, if they would like to see this program continue, and if they were interested in having their home weatherized.

### *Leakage*

To estimate leakage—that is bulbs distributed to non-Vectren customers—Cadmus asked survey respondents who installed at least one program bulb if Vectren provides their electricity service. Table 136 lists the electric utility, number of program bulbs installed, and number of survey respondents (included for context). Note that leakage is calculated from the number of bulbs installed, not the number of participants. Of 70 bulb recipients in Cadmus' survey, 62 knew their electric utility provider *and* how many bulbs they did or did not install, a total of 212 bulbs.

**Table 136. 2018 Food Bank LED Distribution Leakage Summary**

| Utility | Bulbs Installed | Participants |
|---|---:|---:|
| Vectren Indiana | 150 | 45 |
| Duke Energy | 58 | 16 |
| NIPSCO | - | - |
| Other | 4 | 1 |
| **Total** | **212** | **62** |
| Don't know[1] | 11 | 4 |
| **Percentage Outside of Vectren** | **29%** | **27%** |

[1] Participants who did not know their utility (and how many bulbs they installed) were excluded from the totals.

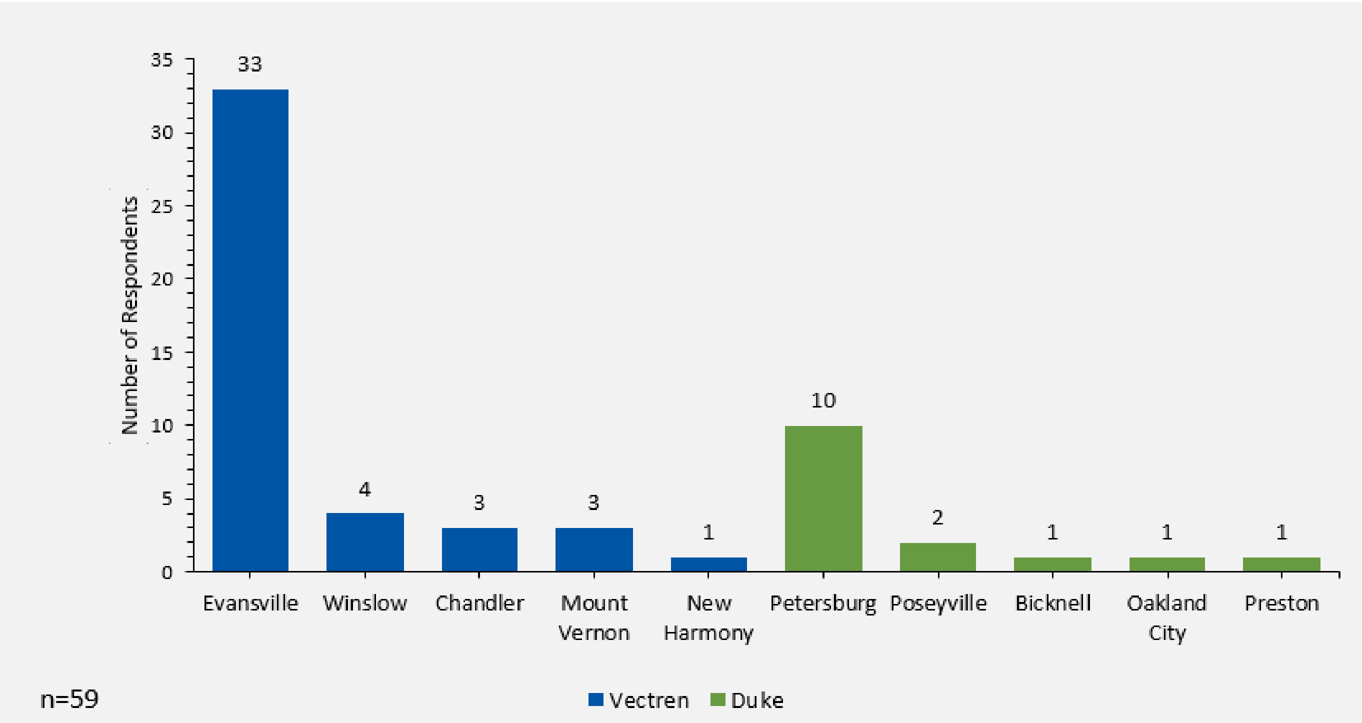
As an extra level of verification, Cadmus cross-referenced participants' stated addresses in the survey with their claimed electric utility. The vast majority of the time, the two aligned, that is, someone with an address in Evansville, Indiana, said his or her electric utility was Vectren. The same holds true for participants who said Duke was their electric utility provider and had an address in a city Duke services (such as Petersburg).

In four cases, Cadmus corrected the results and changed the electric utility of the respondent. Cadmus does not take this lightly and took participants at their word. Cadmus believes the changes were reasonable, and, though small, yielded the most accurate representation of where the bulbs were actually installed. For transparency, these are the four cases for which Cadmus made changes (note that Table 136 reflects these changes):

- One respondent listed the utility as "Veterans." The address was in Evansville. **Cadmus moved this participant from Other to Vectren Indiana**.
- One respondent listed the utility as "Light Switch." The address was in Evansville. **Cadmus moved this participant from Other to Vectren Indiana**.
- One respondent listed the utility as NIPSCO. The address was in Evansville. **Cadmus moved this participant from NIPSCO to Vectren Indiana**.
- One respondent listed the utility as "Winn Energy." The address was in the city of "Vincens," which probably refers to Vincennes, Indiana. Western Indiana Energy REMC (WIN) Energy does not service Vincennes, and this person's address clearly appeared to be in Duke Energy's territory. **Cadmus moved this participant from Other to Duke Energy**.

Figure 13 shows the residing cities of program participants (post adjustment, see above) who installed at least one bulb and stated they were either Vectren or Duke Energy customers. Most Vectren respondents (75%) said they live in Evansville, and most Duke participants (67%) said they live in Petersburg.

**Figure 13. Cities Program Participants Reside in—Vectren and Duke Customers**




To better understand what might be driving leakage, Cadmus also assessed the number of food banks in non-Vectren electric service areas (Table 137). Since each food bank can be assumed to draw patrons from its surrounding area, food banks located outside Vectren's territory are more likely to draw patrons from outside Vectren's territory.

Using program tracking data, Cadmus determined that about 18% of program bulbs were distributed from two food banks in Duke Electric's electric territory. Cadmus cannot conclude that all of these bulbs were leaked nor that only these two locations accounted for all program leakage. In fact, bulbs from these locations could have leaked back into Vectren's territory. It is, however, likely these locations had higher than average leakage.

**Table 137. Participating Food Bank Locations and their Likely Electric Utility (Based on City)**

| Food Bank Name | City | Likely Electric Utility[1] | Number of Bulbs Distributed | Percentage of Bulbs |
|---|---|---|---|---|
| **By Food Bank, City, and Likely Electric Utility** | | | | |
| Chandler CP Church | Chandler | Vectren | 288 | 1% |
| Evansville Emergency FP Consortium[2] | Evansville | Vectren | 27,936 | 55% |
| Family Matters of Posey County | Mount Vernon | Vectren | 672 | 1% |
| Gibson County CAPE | Princeton | Duke | 2,112 | 4% |
| Grace Baptist Church | Evansville | Vectren | 1,824 | 4% |
| New Harmony Food Pantry | New Harmony | Vectren | 960 | 2% |
| Potter's Wheel | Evansville | Vectren | 480 | 1% |
| Salvation Army | Evansville | Vectren | 8,640 | 17% |
| Somebody's Place | Petersburg | Duke | 7,008 | 14% |
| St Johns United Methodist Church | Evansville | Vectren | 576 | 1% |
| **By Utility** | | | | |
| Vectren | | | 41,376 | 82% |
| Duke | | | 9,120 | 18% |
| **Total** | | | **50,496** | **100%** |

[1] Cadmus assumed the electric utility of each food bank based on its address and cross-referenced to service territory maps.
[2] Evansville Emergency FP Consortium comprises eight food bank locations, all in Evansville.

## Net-to-Gross Analysis

Evaluations generally assume that most income-qualified customers would not have the discretionary income to install measures on their own outside of the financial support of the program. Consequently, the NTG ratio is assumed to be 100%.

To give Vectren information about the level of energy efficiency action its income-qualified population takes as a result of program participation, Cadmus asked spillover questions in its participant telephone survey. Cadmus did not quantitatively assess freeridership, so it did not apply the spillover results to the evaluated net savings. Instead, Cadmus reported spillover for program planning purposes only.

### *Spillover Findings*

No participants said their experience with the Food Bank LED Distribution Program was very important to their purchasing decision of additional energy efficiency measures that were not supported by Vectren. The resulting participant spillover estimate is 0%.

## Evaluated Net Savings Adjustments

Table 138 and Table 139 list evaluated net savings for the Food Bank LED Distribution Program. The program achieved net savings of 921,588 kWh and 127 coincident kW demand reduction.

**Table 138. 2018 Food Bank LED Distribution Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| 9W LED | 1,495,959 | 1,495,959 | 926,257 | 921,588 | 62% | 100% | 921,588 |
| **Total** | **1,495,959** | **1,495,959** | **926,257** | **921,588** | **62%** | **100%** | **921,588** |

**Table 139. 2018 Food Bank LED Distribution Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| 9W LED | 206 | 206 | 128 | 127 | 62% | 100% | 127 |
| **Total** | **206** | **206** | **128** | **127** | **62%** | **100%** | **127** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus developed a logic model and KPIs for the Food Bank LED Distribution Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies

## Logic Model

# FOOD BANK LED DISTRIBUTION PROGRAM

| Market Actor | End-Use Customer | Food bank Patrons | |
|---|---|---|---|
| Market Barriers | • Lack of program awareness<br>• Higher cost of efficient light bulbs | • Lack of energy efficiency education | • Skepticism of true energy savings<br>• Negative associations with energy-efficient lighting |
| Intervention Strategies / Activities | • LED bulbs offered to customers at no cost<br>• Program signage prominent in food banks | • Income Qualified Weatherization Program information on bulb box | • ENERGY STAR-certified bulbs to ensure quality |
| Outcomes | • Increased participation<br>• Increased customer satisfaction | • Increased energy savings<br>• Improved customer perception of efficient lighting technologies<br>• Increased awareness | • Increased saturation of efficient lighting technologies<br>• Increased awareness of Vectren energy efficiency programs |
| Key Indicators | • Achievement of program participation and savings goals<br>• Installation rate<br>• Persistence of measures | • Bulb satisfaction ratings | • Efficient lighting saturation in Vectren's territory<br>• Awareness of other Vectren energy efficiency programs |

| Market Actor | Trade Allies | Food bank Staff | |
|---|---|---|---|
| Market Barriers | • Lack of program understanding | • Inability to encourage postcard return | • Lack of understanding of benefits of efficient lighting |
| Intervention Strategies / Activities | • Program implementer trains food bank staff how to deliver program | • Provide incentive for returned postcards | • Program signage prominent in food banks |
| Outcomes | • Bulbs effectively distributed to food bank patrons<br>• Ability to contact bulb recipients to confirm installation of products | • Increased saturation of energy efficient lighting | • Increased program understanding |
| Key Indicators | • Achievement of program participation and savings goals | • Efficient lighting saturation in Vectren's territory<br>• Postcard response rate | • Number of bulbs distributed |

## Program Performance

Cadmus measured 2016 and 2018 program performance against the KPIs listed in Table 140. Vectren did not deliver the Food Bank LED Distribution Program in 2017.

**Table 140. Food Bank LED Distribution Program KPI and 2016 and 2018 Performance**

| KPI | Performance | |
|---|---|---|
| | 2016 | 2018 |
| Achievement of Program Participation Goals | 100% | 100% |
| Achievement of Gross kWh Savings Goals | 100% | 100% |
| Achievement of Gross kW savings goals | 100% | 100% |
| Number of Bulbs Distributed | 24,288 | 50,496 |
| Installation Rate (after Initial Receipt of Bulbs) | 86% | 94% |
| In-Service Rate (Persistence of LED Bulbs) | N/A | 84% |
| Bulb Satisfaction Ratings | 88%[1] | 100% |
| Efficient Lighting Saturation in Vectren's Territory | N/A | 43%[2] |
| Conversion to other Vectren Energy Efficiency Programs | N/A | 9% |
| Postcard Response Rate[3] | 3% | 6% |

[1] The 2016 results are derived from the postcard survey using a different scale than used in the 2018 participant survey to measure bulb satisfaction. In 2016, Cadmus calculated satisfaction on a scale of 1 to 5, where 1 means *extremely dissatisfied* and 5 means *extremely satisfied*. The mean satisfaction score in 2016 was 4.4. All 2018 Vectren surveys use a 4-point Likert scale of *very satisfied, somewhat satisfied, not too satisfied*, or *not at all satisfied* rather than a number scale to measure participant satisfaction.
[2] This percentage refers to market penetration. Track efficient lighting saturation in future program years.
[3] These are the evaluated response rate, after de-duplication has occurred.

# Commercial and Industrial Prescriptive Program

The Commercial and Industrial (C&I) Prescriptive Program promotes the installation of high-efficiency equipment to nonresidential customers, including government and nonprofit. Vectren offers financial incentives to offset the higher purchase costs of upgrades such as energy-efficient lighting, refrigeration, and HVAC equipment. The program implementer, Nexant, processes program paperwork and, with the help of trade allies, promotes the program to Vectren customers.

## Accomplishments

The C&I Prescriptive Program achieved 243% of its energy savings and 124% of its demand reduction goal. The implementer reported that the vast majority of the C&I activity during 2018 was in the C&I Prescriptive Program (the Custom Program achieved only 40% and 55% of its savings and demand reduction goals, respectively). Like last year, lighting measures contributed 81% of the C&I Prescriptive Program's gross kWh, followed by variable frequency drives (VFDs) and motors (8%) and chillers (5%).[67] Table 141 shows the program's achievements against goals in 2018.

**Table 141. 2018 C&I Prescriptive Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 19,401,442 | 8,000,000 | 243% |
| Gross kW Savings | 2,731.99 | 2,206.00 | 124% |
| Participants (Measures) | 37,200 | 21,869 | 170% |
| Program Expenditures | $1,619,433 | $1,052,341 | 154% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 142 shows the evaluated savings for the C&I Prescriptive Program. The program realization rates were close to 100%. Reported and *ex post* savings differed due to four reasons: the incorporation of early replacement savings increased savings, updating baseline standards, the incorporation of survey results, and miscellaneous minor calculation differences slightly lowered savings.

**Table 142. 2018 C&I Prescriptive Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 19,401,443[1] | 19,401,443 | 19,401,443 | 18,605,544 | 96% | 84% | 15,628,657 |
| Total kW | 2,731.99 | 2,731.99 | 2,731.99 | 2,713.37 | 99% | 84% | 2,279.23 |

[1] Total reported kWh does not sum to 2018 DSM Scorecard value due to rounding.

[67] In 2017, lighting measures contributed to 83% of gross kWh savings, chillers contributed 5%, and VFD/motors contributed 1%. Lighting measures continued to drive the program's savings, and the rest of the measures vary slightly based on several factors (equipment size, number of projects, etc.).

## Conclusions and Recommendations

### Customer Satisfaction

**C&I Prescriptive Program participants are highly satisfied with the program.** Nearly all surveyed participants were satisfied with the program overall (96%, n=70) and are likely to recommend the program to another business (90%, n=70).

### Marketing and Outreach

**Contractors remain the driving force of program awareness.** Although attending events about the program can contribute to improving participation over time, the implementer's emphasis on events as a way to raise awareness did not result in much mention by survey respondents in 2018. Only 2% said they learned of the program through an event (n=70), compared to 6% in 2017 (n=64). Participants continue to learn of the program primarily through their trade allies. In 2018, 53% of respondents (n=70) reported learning of the program through contractors, compared to 44% in 2017 (n=64).

### *Ex Ante* Savings

**C&I Prescriptive Program measures are outdated in the 2015 Indiana TRM.** The baseline efficiencies in the 2015 Indiana TRM for air conditioners, heat pumps, refrigerator cases, and ice machines do not meet current federal standards. In addition, the TRM has a limited range of chiller full load cooling hours by building type. For example, for one chiller project that made up 80% of total chiller savings, the implementer had to use a custom analysis to derive full load cooling hours because the TRM was insufficient.

The implementer plans to use the Iowa TRM as the basis for *ex ante* savings for more measures next year. To properly plan for savings, Vectren should consider using other secondary sources such as the UMP,[68] Illinois TRM V7,[69] Iowa TRM V3[70]) for *ex ante* energy savings methodologies.

**Recommendation:** Update the baseline efficiencies (and ENERGY STAR requirements, if applicable) for commercial air conditioners, heat pumps, refrigerated cases, and ice machines to match the current federal standards. To accurately estimate savings, in the absence of an updated Indiana TRM, Vectren

---

68 U.S. Department of Energy. October 2017. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* http://www.energy.gov/eere/about-us/ump-protocols

69 Illinois Energy Efficiency Stakeholder Advisory Group. September 28, 2018. *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 7.0—Volume 2: Commercial and Industrial Measures*. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf.

70 Iowa Utilities Board. September 14, 2018. *Iowa Energy Efficiency Statewide Technical Reference Manual—Volume 3: Nonresidential Measures.* https://efs.iowa.gov/cs/groups/external/documents/docket/mdax/oda0/~edisp/1804813.pdf.

and its implementer should consider using the UMP, Illinois TRM V7, or Iowa TRM V3 for planning purposes in future program years. Because Vectren plans to use 2017 *ex post* savings as the 2019 *ex ante* savings, these problems will persist. That is, the federal standards used in the 2017 *ex post* savings, though current at the time, will be out of date in 2019 and the realization rates for HVAC and kitchen equipment will continue to be lower than planned.

**Linear fluorescents had an updated federal standard in 2018; because of existing product stocks, this update will likely not affect the program in 2019 but may in 2020.**[71] The federal standard update did not impact C&I programs this year because of product stock (retailers are/were still allowed to sell products manufactured before January 26, 2018) and exemption rules. This update will lower the savings to the measures, "T12s or T8s to LEDs," whenever retailers' existing T12 product stock is sold[72]. However, likely in 2020, the baseline assumption will need to be updated, since only high performance T8s can be manufactured.

In 2018, T12s or T8s to LEDs made up 15% of total program savings. Of the 57 projects that had rebates for T12s or T8s to LEDs, 25 had a T12 baseline, 31 had a T8 baseline, and one had a high performance T8 baseline.

**ECM fans for residential-sized furnaces (furnaces with input capacities less than or equal to 225 kBtuh) will become the standard after July 3, 2019.**[73] All 114 furnaces in the program were residential-sized furnaces, and, of the 114 furnaces, nine were installed with ECM fans. Overall program impacts will be small (ECM furnace fans made up 0.03% of total program savings), but this measure will have no electric savings post 2020.

**Recommendation:** Be prepared for the reduction in savings for T12s and T8s to LEDs and furnace fans on residential-sized furnaces in 2019 and 2020, respectively. For T12s and T8s to LEDs, there was no effect this year, but next year, savings may be lowered. For furnace fans on residential-sized furnaces, savings will be impacted in 2020. Because retailers can sell existing product stocks, both federal standard updates will likely have partial year effects.

## Data Tracking

**Additional data fields in the program tracking database will increase accuracy of savings estimates.** In calculating the *ex post* savings, Cadmus found that new fields in the tracking data would allow better

---

71 Code of Federal Regulations. General Service Fluorescent Lamps: 10 CFR §430.23(r). "Energy conservation standards and their effective dates." https://www.ecfr.gov/cgi-bin/text-idx?SID=7cc7e61cad1f0a474009880d24a8d553&mc=true&node=se10.3.431_187&rgn=div8.

72 As of May 2019, several retailers still offer T12s.

73 Code of Federal Regulations. Residential Furnace Fans: 10 CFR §430.32(y). "Energy conservation standards and their effective dates." https://www.ecfr.gov/cgi-bin/text-idx?SID=0423028877ce42bb0c3e0e2529ac80ba&mc=true&node=se10.3.430_132&rgn=div8.

estimates of energy savings. In this evaluation, to find missing information, Cadmus had to either file an additional request or use manual techniques (such as looking up model numbers) or, if these options did not work, assume a value that may or may not have been tracked at one point.[74] For air conditioners and heat pumps, efficiency data for both the baseline and efficient units were reported inconsistently.

**Recommendation:** Several measures require more information in the tracking database to accurately calculate *ex post* savings:

- Air conditioner or air source heat pump (all size ranges):
    - Indicate if the installed equipment is an air conditioner or air source heat pump (as opposed to grouping them together as the measure name does). The difference between heat pumps and air conditioners is critical because each has different efficiency requirements.
    - Indicate if the equipment is a split system or single-package system.
    - Indicate the baseline efficiency information used in the *ex ante* analysis. This allows the evaluation team to identify discrepancies between *ex ante* and *ex post* estimates.
- Electric chiller tune-up:
    - Indicate the equipment type; see page 218 of the 2015 Indiana TRM
- Electrically commutated motor (ECM) (all types):
    - Track the horsepower of the motor. In the current tracking database, the reference for *ex ante* savings was from the Illinois TRM V5. Savings for ECMs have been updated in the next two versions (V6 and V7) and now require only the horsepower of the motor.

## Thermostat Savings

**The program may be overestimating *ex ante* thermostat savings.** Cadmus interviewed 15 participants who installed a new thermostat and five claimed that the building's HVAC setpoints did not change with the new thermostat. The implementer's model bases thermostat energy savings on a difference in setback scheduling between pre- and post-installation, so savings could be overstated for sites that programmed existing thermostats with the same setpoints.

Cadmus did not reduce *ex post* savings in these cases because of a lack of precision, but there still may be some evidence that thermostat savings are overstated.

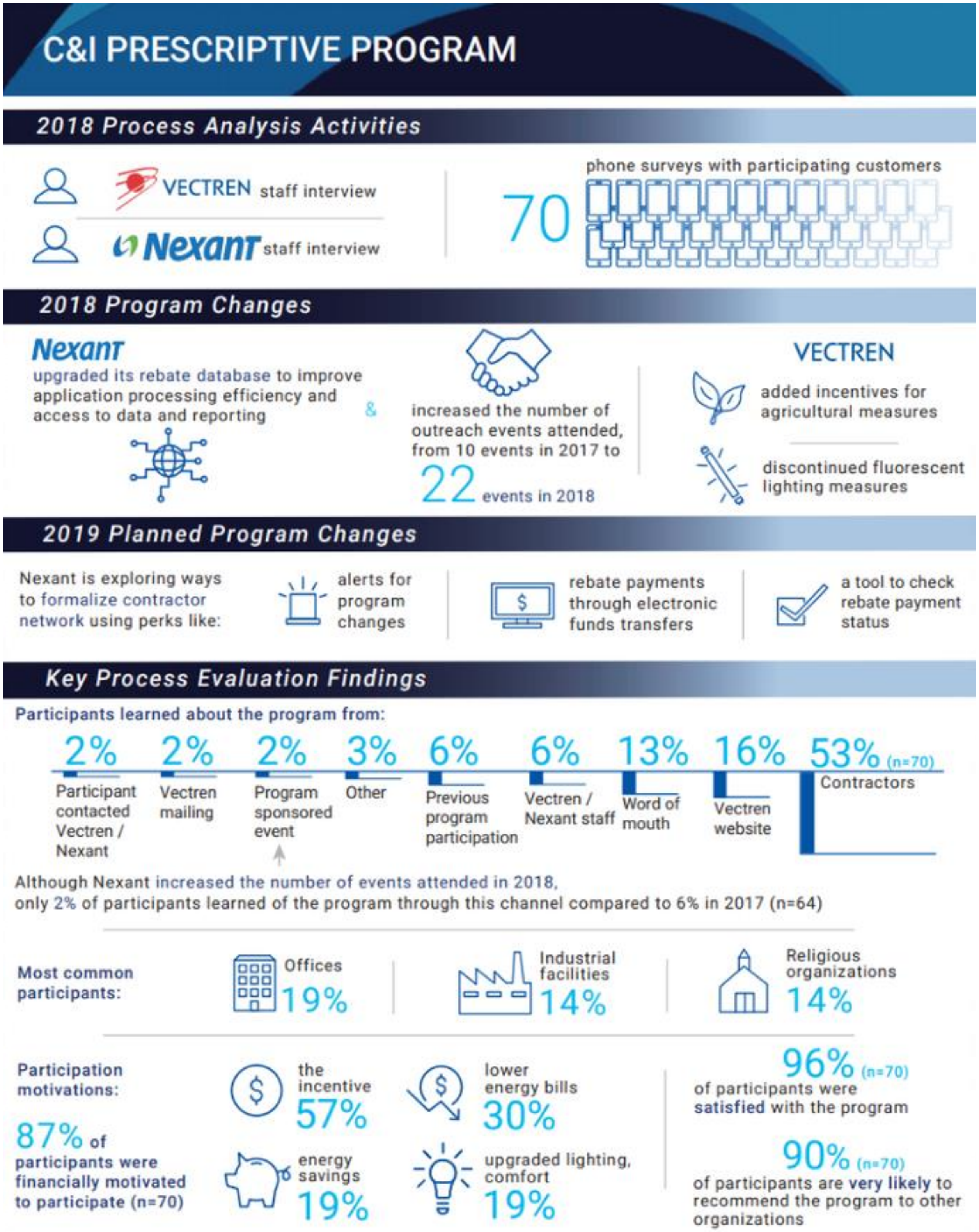
**Recommendation:** Collect and track the following baseline conditions of sites receiving thermostats:

- Type of existing thermostat (manual, programmable, smart)
- Current building HVAC schedule or temperature setpoints (heating and cooling)

---

[74] Specifically, additional information was needed for chillers and air conditioner equipment. Cadmus was able to follow up for most of its questions but sometimes Cadmus had to assume a value; generally, this was the most conservative value.

## *Process Evaluation*



# *Impact Evaluation*

## Impact Evaluation Methods and Findings

The impact evaluation of the C&I Prescriptive Program involved these data collection efforts and analysis tasks:

- Audit program tracking database for alignment with 2018 DSM Scorecard
- Review *ex ante* savings methodologies and algorithms for the census of program measures
- Develop evaluated (*ex post* gross) savings using the 2015 Indiana TRM.[75] For measures not present in the 2015 Indiana TRM, Cadmus used to the 2018 Illinois TRM[76] or the 2018 Wisconsin TRM.[77] Cadmus used TRMs in other jurisdictions effective during the 2018 C&I Prescriptive Program year.
- Incorporate site-specific findings, including installation rate, into evaluated savings via telephone surveys (n=70)
- Incorporate early replacement savings for air conditioning measures identified as retrofit projects

## Gross Savings Review

Figure 14 shows the total *ex post* savings for all measure categories and for a subset of higher impact measures, where applicable (e.g., lighting, chillers). Lighting upgrades, VFDs, and chiller upgrades and tune-ups comprised 95% of the total *ex post* electric impacts. Thermostats, HVAC equipment, kitchen equipment, refrigeration measures, and compressed air systems made up the remaining 5% of total *ex post* electric savings.

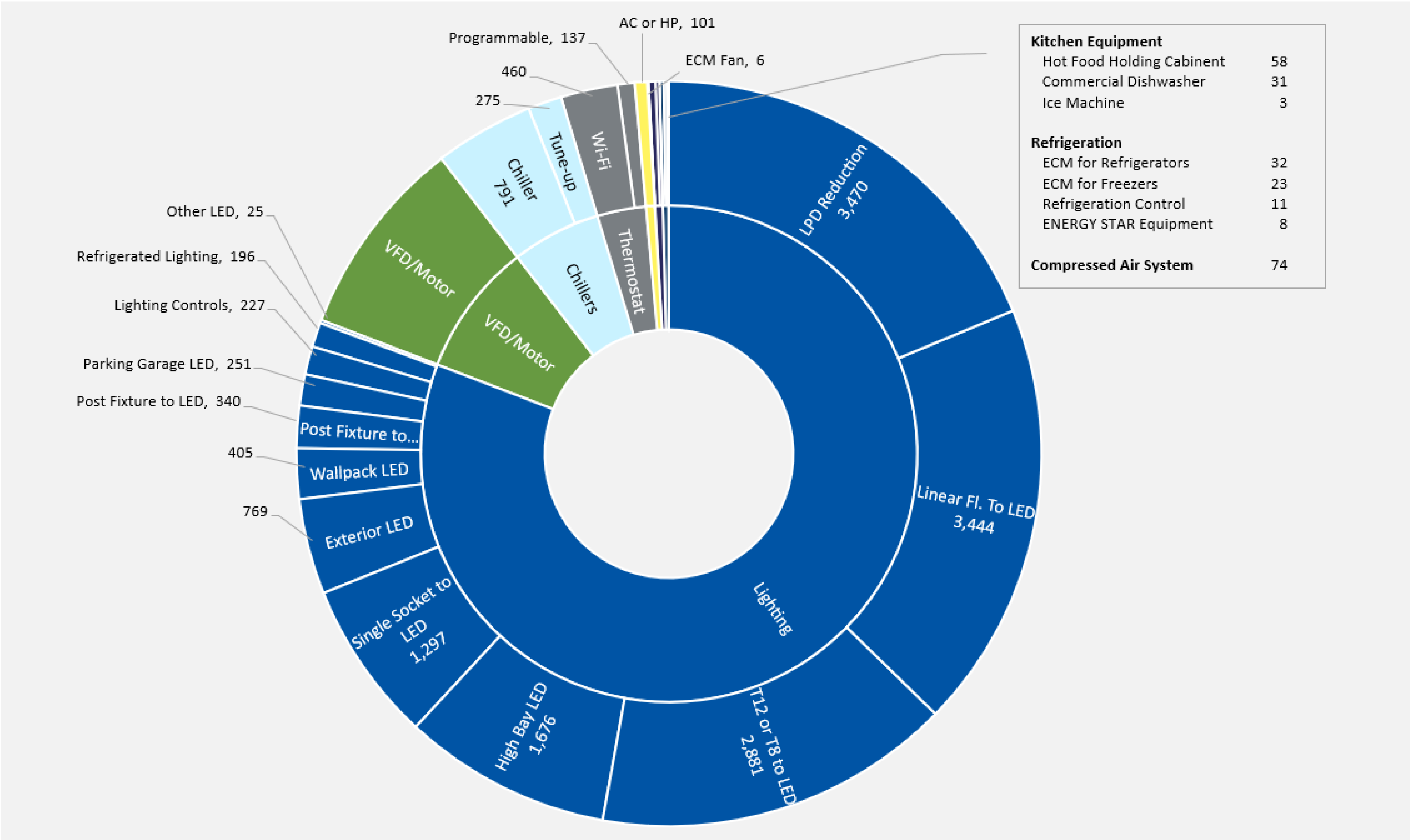
---

[75] 2015 Indiana Technical Reference Manual, V2.2.

[76] Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0—Volume 2: Commercial and Industrial Measures*. February 8, 2017. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_2_C_and_I_020817_Final.pdf.

[77] Focus on Energy. December 2017. *Wisconsin Focus on Energy 2018 Technical Reference Manual.* https://www.focusonenergy.com/sites/default/files/TRM%202018%20Final%20Version%20Dec%202017_1.pdf.

**Figure 14. 2018 C&I Prescriptive Program Total *Ex Post* Electric Impacts (MWh) by Measure Category and Measure Sub-Category**



To make the presentation of this program more digestible, Cadmus will only report savings by measure category and not measure-sub category (i.e., the inside portion of Figure 14).[78] Cadmus starts with Table 143—or, the per-unit annual gross savings (total savings divided by installed units) for each program measure category.

For most measure categories, Cadmus received documentation for *ex ante* savings and methodologies that clearly referenced the 2015 Indiana TRM or, when appropriate, the 2018 Illinois TRM (V6), the 2018 Iowa TRM (V2), or the 2018 Wisconsin TRM. The implementer also provided additional documentation about issues that remained unclear following Cadmus' initial review of the program data.

**Table 143. 2018 C&I Prescriptive Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| Compressed Air Systems | 73,448 | 73,533 | 4.71 | 4.71 |
| Chillers | 86,714 | 88,781 | 13.80 | 15.66 |
| HVAC | 1,306[2] | 1,094 | 0.70 | 0.69 |
| Kitchen Equipment | 4,196[2] | 3,397 | 0.54 | 0.69 |
| Lighting | 429 | 408 | 0.06 | 0.06 |
| Refrigeration | 498 | 427 | 0.04 | 0.04 |
| Thermostat | 5,075[2] | 5,062 | 0.00 | 0.00 |
| VFD/Motor | 23,744 | 23,744 | 3.48 | 3.48 |

[1] The 2018 DSM Scorecard did not distill demand savings by measure, so per-unit demand values come from the 2018 program tracking database.
[2] Reported per-unit savings are calculated by the total savings on the 2018 DSM Scorecard divided by the audited quantities rather than by the quantities on the scorecard. For HVAC, thermostat, and kitchen measures, the electric scorecard does not differentiate between gas only and electric only measures—that is, the total number of HVAC, thermostat, and kitchen measures are reported regardless of fuel type, which skews the per-unit savings. It is important to note that this difference in reporting quantities does not influence the program-level realization rate because the total measure savings between the tracking database and scorecard aligned exactly.

The reported per-unit savings generally match or are within a couple of percentage points of the evaluated per-unit savings. The discrepancies are attributed to the update of baseline standards, incorporation of early replacement savings,[79] or miscellaneous minor calculation errors. Table 144 lists the differences that apply to each measure.

[78] For some extra context on the scope of this program, the tracking database had 98 unique measure names.

[79] Vectren does not currently account for early replacement savings, and the evaluation team began to incorporate them into the *ex post* analysis in 2017.

**Table 144. Reasons for Differences between Reported and Evaluated Per-Unit Gross Savings**

| Measure | Update in Baseline Standards | Early Replacement Savings | Minor/Misc. Calculation Differences |
|---|---|---|---|
| Compressed Air Systems | | | ✓ |
| Chillers | | ✓ | ✓ |
| HVAC | ✓ | ✓ | ✓ |
| Kitchen Equipment | | | ✓ |
| Lighting | | | ✓ |
| Refrigeration | ✓ | | ✓ |
| Thermostat | | | ✓ |

The following describes the discrepancies for each measure category:

- For **compressed air systems**, the difference was minor and likely due to rounding.
- For **chillers**, there were early replacement savings for one project.[80] There were minor calculations differences for all projects (likely due to rounding).
- For **HVAC**,[81] there were several, simultaneous factors driving the difference in reported and evaluated savings:
  - Baseline update. The 2015 Indiana TRM uses ASHRAE 90.1-2007 standards as the baseline; new federal standards for commercial air conditioners and heat pumps went into effect January 1, 2018.[82] This update lowered the savings.
  - Early replacement savings. For three projects flagged in the tracking database as retrofit existing equipment, Cadmus assumed the baseline was the same as listed in IECC 2006.[83] This increased the savings.
  - Miscellaneous calculation differences. Cadmus used self-reported hours of use for several measures based on survey results. This slightly increased the savings.
- For **kitchen equipment,** there were minor calculation differences for three ice machine projects.[84] For ENERGY STAR hot food holding cabinets, Cadmus adjusted hours of use because

---

80 For this measure, Cadmus assumed the baseline was the IECC 2006 standard. See International Energy Conservation Code. Table 503.2.3(7). 2006. https://ia800302.us.archive.org/17/items/gov.law.icc.iecc.2006/icc.iecc.2006.pdf.

81 These include air conditioner, heat pump, and furnace ECM fan savings.

82 For the seven projects completed before January 1, 2018, Cadmus gave savings using the baseline in the 2015 Indiana TRM.

83 International Code Council. 2006. *International Energy Conservation Code.* Table 503.2.3(1). 2006. Available online: https://ia800302.us.archive.org/17/items/gov.law.icc.iecc.2006/icc.iecc.2006.pdf.

the eight projects had equipment installed in schools and not restaurants.[85] In both cases, the calculation differences lowered savings.

- For **lighting**, the primary driver of the difference between reported and verified per-unit savings were differences in survey results (Cadmus used the building type and building heating and cooling equipment from the survey and matched hours of use and waste heat factors accordingly) and other, minor calculation differences.
- For **refrigeration**, the updated federal standards that went into effect March 27, 2017, lowered the savings for refrigeration/freezer cases; however, the majority of this measure category's savings come from ECMs for refrigerators/freezers. This measure's realization rate was 100%.
- For **thermostats**, the calculations were slightly different.
- For **VFD/motors**, there were no difference between the reported and verified savings.

Table 145 lists evaluated gross per-unit energy savings for each program measure category by year. The main driver of differences in evaluated per-unit savings over the years is the combination of measures installed and number of units installed within each category. For example, chillers in 2015 and 2018 consisted mostly of equipment upgrades. In 2016 and 2017, these measures were mostly tune-ups, which produce lower per-installation savings.

**Table 145. C&I Prescriptive Program Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Savings (kWh) | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Compressed Air Systems | N/A | N/A | 81,021 | 73,533 |
| Chillers | 54,296 | 11,111 | 18,420 | 88,781 |
| HVAC | 440 | 5,745 | 1,107 | 1,094 |
| Kitchen Equipment | 8,503 | 1,487 | 6,747 | 3,397 |
| Lighting | 332 | 453 | 372 | 408 |
| Refrigeration | 843 | 955 | 851 | 427 |
| Thermostat | N/A | N/A | 5,281 | 5,062 |
| VFD/Motor | 69,053 | 35,192 | 67,785 | 23,744 |

Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

[84] An updated federal standard for ice makers went into effect January 28, 2018. However, the three projects with icemakers all participated before that date.

[85] The 2015 Indiana TRM only gives hours of use for restaurants, which are assumed to operate 15 hours a day for 365 days a year. Cadmus used the 2017 Wisconsin TRM hours of use for schools, which assumes operation of 10.5 hours a day for 282.5 days a year.

## Measure Verification

Table 146 lists the installation rates for each program measure category. The survey found that the installation rates were 100% for all measures.

**Table 146. 2018 C&I Prescriptive Program Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported | Audited | Verified | |
| Compressed Air Systems | 1 | 1 | 1 | 100% |
| Chillers | 12 | 12 | 12 | 100% |
| HVAC[1] | 98 | 98 | 98 | 100% |
| Kitchen Equipment[1] | 27 | 27 | 27 | 100% |
| Lighting | 36,702 | 36,702 | 36,702 | 100% |
| Refrigeration | 174 | 174 | 174 | 100% |
| Thermostat[1] | 118 | 118 | 118 | 100% |
| VFD/Motor | 68 | 68 | 68 | 100% |
| **Total** | **37,200** | **37,200** | **37,200** | **100%** |

Table 147 shows historical installation rates for each program measure. Since 2015, the installation rates have been 100% for all measures.

**Table 147. C&I Prescriptive Program Historical Installation Rates**

| Measure | Installation Rate | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Compressed Air Systems | N/A | N/A | 100% | 100% |
| Chillers | 100% | 100% | 100% | 100% |
| HVAC | 100% | 100% | 100% | 100% |
| Kitchen Equipment | 100% | 100% | 100% | 100% |
| Lighting | 100% | 100% | 100% | 100% |
| Refrigeration | 100% | 100% | 100% | 100% |
| Thermostat | N/A | N/A | 100% | 100% |
| VFD/Motor | 100% | 100% | 100% | 100% |
| **Total** | **100%** | **100%** | **100%** | **100%** |

## Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the C&I Prescriptive Program using findings from a survey conducted with 70 program participants.[86] The program resulted in an 84% NTG ratio. Table 148 presents the NTG results for the program. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

**Table 148. 2018 C&I Prescriptive Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 16% | 0% | 84%[1] |

[1] Absolute precision at 90% confidence interval is ± 5%.

Table 149 lists historical program-level NTG ratios by year.[87]

**Table 149. C&I Prescriptive Program Historical Net-to-Gross Ratios**

| Program Year | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| 2015 | 15% | 2% | 87% |
| 2016 | 20% | 2% | 82% |
| 2017 | 26% | 1% | 75% |
| 2018 | 16% | 0% | 84% |

The NTG ratios have been consistent over the years, and any differences are within error bounds of the estimates.

### *Freeridership and Spillover Findings*

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[88]

Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate the final program freeridership of 16%, as shown in Table 150.

---

86 NTG values are not separately calculated by fuel type. Electric and gas savings are combined and standardized using MMBtus and the overall NTG ratio is applied to both fuel types.

87 Evaluations in 2015, 2016 and 2017 used two different freeridership methods: the standard self-report intention freeridership method and the Intention/Influence freeridership method. The 2018 analysis is using a new method: the intention questions from the standard self-report intention freeridership method for an intention freeridership score and the influence questions from the Intention/Influence method for an influence freeridership score.

88 *Intention* and *influence* freeridership scores both have a maximum of 100%.

**Table 150. 2018 C&I Prescriptive Program Freeridership Estimate**

| Freeridership Metric | Estimate |
|---|---|
| Intention Score | 20%[1] |
| Influence Score | 12%[1] |
| **Final Freeridership Score** | **16%** |

[1] Weighted by *ex post* gross program savings

None of the interviewed participants reported that, after participating in the program, they had installed additional high-efficiency equipment for which they did not receive an incentive and that participation in the program was very important in their decision. Therefore, no spillover is attributed to the program.

## Evaluated Net Savings Adjustments

Table 151 and Table 152 list evaluated net savings for the C&I Prescriptive Program. The program achieved net savings of 15,628,657 kWh and 2,279 coincident kW demand reduction.

**Table 151. 2018 C&I Prescriptive Program Electric Savings (kWh)**

| Measure | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Compressed Air Systems | 73,448 | 73,448 | 73,448 | 73,533 | 100% | 84% | 61,768 |
| Chillers | 1,040,567 | 1,040,567 | 1,040,567 | 1,065,371 | 102% | 84% | 894,911 |
| HVAC | 127,977 | 127,977 | 127,977 | 107,209 | 84% | 84% | 90,056 |
| Kitchen Equipment | 113,285 | 113,285 | 113,285 | 91,718 | 81% | 84% | 77,043 |
| Lighting | 15,745,997 | 15,745,997 | 15,745,997 | 14,981,580 | 95% | 84% | 12,584,527 |
| Refrigeration | 86,708 | 86,708 | 86,708 | 74,213 | 86% | 84% | 62,339 |
| Thermostat | 598,876 | 598,876 | 598,876 | 597,335 | 100% | 84% | 501,761 |
| VFD/Motor | 1,614,585 | 1,614,585 | 1,614,585 | 1,614,585 | 100% | 84% | 1,356,251 |
| **Total** | **19,401,443**[1] | **19,401,443** | **19,401,443** | **18,605,544** | **96%** | **84%** | **15,628,657** |

[1] Total reported kWh does not sum to 2018 DSM Scorecard value due to rounding.

**Table 152. 2018 C&I Prescriptive Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Compressed Air Systems | 4.71 | 4.71 | 4.71 | 4.71 | 100% | 84% | 3.96 |
| Chillers | 165.63 | 165.63 | 165.63 | 187.94 | 113% | 84% | 157.87 |
| HVAC | 69.05 | 69.05 | 69.05 | 67.95 | 98% | 84% | 57.08 |
| Kitchen Equipment | 14.45 | 14.45 | 14.45 | 18.61 | 129% | 84% | 15.64 |
| Lighting | 2,233.97 | 2,233.97 | 2,233.97 | 2,191.25 | 98% | 84% | 1,840.65 |
| Refrigeration | 7.43 | 7.43 | 7.43 | 6.15 | 83% | 84% | 5.16 |
| Thermostat | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 84% | 0.00 |
| VFD/Motor | 236.75 | 236.75 | 236.75 | 236.75 | 100% | 84% | 198.87 |
| **Total** | **2,731.99** | **2,731.99** | **2,731.99** | **2,713.37** | **99%** | **84%** | **2,279.23** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the C&I Prescriptive Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies

## Logic Model

# C&I PRESCRIPTIVE PROGRAM

### Market Actor

**End-Use Customer** | C&I Customers

### Market Barriers

- Lack of program awareness or knowledge of energy conservation benefits
- Large out-of-pocket expenses
- Time commitment
- Perception that project is not cost-effective for business or that business does not need improvements

### Intervention Strategies / Activities

- Participation in industry associations and events, program handouts, and ongoing communication with customers
- Word-of-mouth and one-on-one marketing
- Participating trade ally base to make installation timely and convenient
- Program incentives for efficient technologies to offset initial upfront cost

### Outcomes

- Increased program awareness and participation
- Increased market saturation of energy-efficient measures
- Increased energy savings
- Improved customer perception of energy efficiency programs

### Key Indicators

- Achievement of program participation and savings goals
- Likelihood to recommend ratings
- Participant satisfaction with the program

### Market Actor

**Trade Allies** | Installation Contractors

### Market Barriers

- Lack of program awareness
- Administrative burden (e.g., paperwork)

### Intervention Strategies / Activities

- Program outreach staff train and communicate with trade allies about program offerings
- Program outreach staff cross-promote prescriptive and custom programs to deliver project assistance through a single procedure
- Program provides project-level assistance to promote the program

### Outcomes

- Increased contractor awareness of program and program offerings
- Increased and sustained contractor participation with program
- Streamlined program participation for customers
- Increased number of participating contractors
- Increased number of contractors promoting multiple C&I programs
- Increased number of projects per contractor

### Key Indicators

- Contractor satisfaction with the program
- Number of contractors participating in multiple C&I programs
- Number of contractors participating in multiple years
- Number of actively participating contractors
- Average number of projects per contractor
- Achievement of program participation and savings goals

## Program Performance

Cadmus measured 2014 to 2018 program performance against the KPIs listed in Table 153.

**Table 153. C&I Prescriptive Program KPI and 2014-2018 Performance[1]**

| KPI | Performance | | | |
|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | 267% | 133% | 357% | 170% |
| Achievement of gross kWh savings goals | 100% | 129% | 197% | 243% |
| Number of contractors that participated in multiple C&I programs | N/A | N/A | 16 of 195 (8%) | 11 of 157 (7%) |
| Number of contractors participating in multiple years | N/A | N/A | N/A | 66 of 157 (42%) |
| Number of actively participating contractors (completed one or more projects) | N/A | N/A | 195 | 157 |
| Average number of projects per contractor | N/A | N/A | N/A | 4 |
| Participant satisfaction with the program (very satisfied) | 74% | 86% | 84% | 84% |
| Participant likelihood to recommend the program (very likely) | N/A | N/A | 94% | 90% |
| Contractor satisfaction with the program (very satisfied) | 93% | N/A | N/A | N/A |

[1] N/A indicates that the metric was not tracked in the year noted.

# Commercial and Industrial Custom Program

The Commercial and Industrial (C&I) Custom Program focuses on energy-savings opportunities for C&I customers in Vectren's service territory. With the program, Vectren enables customers to install energy-efficient projects or technologies that are not available through its other DSM programs. These measures are unique to the participant's application or process and require individual engineering analyses to determine savings.

Vectren calculates program incentive levels on a basis of first-year, amount-of-energy saved ($0.10 per kWh saved and $1.00 per therm saved) that cannot exceed 50% of total project costs, with a maximum of up to $100,000 for qualified electric and natural gas projects. Projects achieving a simple payback of one year or less do not qualify for the program.

Vectren administers the program. Nexant, as program implementer, is responsible for program operations, managing day-to-day tasks, and confirming that all *ex ante* engineering calculations accurately represent installed measures for each project. Trade allies promote the program to customers and execute the custom energy efficiency measures.

## Accomplishments

The C&I Custom Program achieved 40% of its energy savings and 55% of its demand reduction goal, while utilizing 49% of its budget. The program implementer reported that the reason the C&I Custom Program did not achieve its goal was that the C&I Prescriptive Program captured most of the pipelined C&I projects.[89] The implementer also introduced building tune-up and new construction offerings into the C&I Custom Program but was not able to capture a substantial increase in activity from these offerings.

Table 154 shows the program's achievements against goals in 2018.

**Table 154. 2018 C&I Custom Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 2,735,821 | 6,900,000 | 40% |
| Gross kW Savings | 365.14 | 667.00 | 55% |
| Measures/Participants | 40 | 83 | 48% |
| Program Expenditures | $630,036 | $1,273,150 | 49% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 155 lists the 2018 C&I Custom Program's evaluated program savings. For 2018, the C&I Custom Program had a 92% kWh realization rate and an NTG ratio of 85%. The main factor affecting the

[89] The C&I Prescriptive Program achieved 243% and 124% of the savings and demand reduction goals, respectively, primarily through lighting and variable frequency drive (VFD) measures.

program's aggregate realization rates was a single measure, Custom Project 3, which was a new construction land-based casino with several HVAC sub-measures. This was also the largest program project in terms of kWh and kW savings. The project had a 71% kWh realization rate after Cadmus adjusted the *ex post* calculations based on on-site evaluation inspection findings which resulted in a gross reduction in the program savings. Aside from this single project, the 2018 C&I Custom Program *ex ante* and *ex post* savings matched closely.

**Table 155. 2018 C&I Custom Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rate | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 2,735,821 | 2,735,821 | 2,735,821 | 2,512,038 | 92% | 85% | 2,135,232 |
| Total kW | 365.14 | 364.7 | 364.7 | 324.2 | 89% | 85% | 275.6 |

## *Conclusions and Recommendations*

### Project Documentation

**Clear and adequate project documentation increased reliability of estimated savings for the program measures.** The documentation provided for almost all evaluated measures was clear, concise, and easy to verify and was a noticeable improvement over previous years. Nearly all major assumptions were supported by well-organized measurement and verification (M&V) inspection notes and photos. In all cases where Cadmus had to update the estimated savings, the changes resulted from observations made during the evaluation site visits performed by Cadmus engineers. Cadmus found that certain project parameters had shifted from what was observed during the initial project verification inspection (e.g., equipment speed setpoints) and were not from unclear or inaccurate documentation.

### Customer Satisfaction

**Participants were satisfied with the C&I Custom Program.** All 10 survey respondents reported being satisfied with the program and were very likely to recommend participation to another business.

### Program Delivery

**The C&I Custom Program expanded its offering to include new construction and building tune-up projects; however, the program did not reach its goals.** No building tune-up measures were completed in 2018, but the program implementer expected to make strides in 2019 with several projects in the pipeline. In 2018, new construction participation increased to six unique projects from one in 2017. However, the implementer said it continued to struggle with alleviating the concerns of design teams that participation in the program could delay their projects. In 2019, the implementer will subcontract with Weidt Group to help design teams incorporate program offerings into their new construction building designs. To encourage additional savings through the C&I Custom Program, the implementer also plans to launch a strategic energy management subcomponent in 2020.

The average savings per project decreased from 2016 to 2018, which is attributable to several large projects that occurred in 2016 and 2017. Most survey respondents expressed interest in pursuing additional projects beyond those installed in 2018, so the program could benefit from reaching out to past participants.

**Recommendation:** Consider reaching out directly to C&I Prescriptive and C&I Custom program participants who installed projects in the past several years. Document these outreach efforts and determine the necessary frequency of the outreach by the level of customer interest in future projects. Previous customers may wish to hear about the new building tune-up and the upcoming strategic energy management offerings.

## Data Management

**The program tracking data does not distinguish new construction from retrofit projects.** Cadmus found that during the transition of incorporating the C&I New Construction Program as a subcomponent of the C&I Custom Program, the program data identified several projects as new construction, but once the transition of pipelined new construction projects were paid, no other new construction projects were tracked in the program dataset. According to the program implementer, for the 2019 program year and beyond, Vectren will identify projects as either new construction or retrofit in the program data.

## *Process Evaluation*

# C&I CUSTOM PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 Nexant staff interview

10 phone surveys with participating customers

## 2018 Program Changes

The Commercial New Construction Program is now a **subcomponent of the C&I Custom Program**. This change allowed Nexant to better manage the project pipeline and budget across the new construction and retrofit market segments.

VECTREN introduced a **building tune-up offering** as a program subcomponent. Although no participation was reported in 2018, Nexant said several customers initiated projects in 2018 that are expected to be completed in 2019.

& reduced the incentive from $0.12 to $0.10 **per kWh** to align program spending with savings achievement.

Nexant **upgraded its rebate database** to improve application processing efficiency and access to data and reporting.

& increased the number of outreach events attended, from 10 events in 2017 to 22 in 2018

## 2019 Planned Program Changes

**Nexant** will subcontract with THE WEIDT GROUP® to encourage new construction energy design teams to incorporate program offerings into their building designs and sales practice.

They are also exploring ways to **formalize contractor network** using perks like:

- alerts for program changes
- rebate payments through electronic funds transfers
- a tool to check rebate payment status

**Vectren** will begin planning for a **Strategic Energy Management subcomponent** of the C&I Custom Program, expected to officially launch in 2020

## Key Process Evaluation Findings

8/10 surveyed participants are **very likely** to install efficient equipment in the future as a result of their 2018 program participation

5/10 surveyed participants learned about rebates **from contractors**
3/10 past participation, 1/10 Vectren website, 1/10 other website (dsireusa.org)

10/10 of participants were **satisfied** with the program & are **very likely** to recommend the program to other organizations

Of the 8 who used a contractor for their 2018 project, **all were very satisfied with the contractor's work**

# *Impact Evaluation*

## Impact Evaluation Methods and Findings

The C&I Custom Program impact evaluation included multiple data collection efforts and analysis tasks:

- Verify that all *ex ante* tracked savings are in alignment with the provided project documentation and calculations
- Review and verify that project savings calculations and assumptions are supported by the project documentation
- Perform on-site M&V on selected projects
- Adjust the *ex post* savings estimations based on the desk review and on-site inspection findings, where applicable.

## Gross Savings Review

In 2018, 22 unique customers completed 40 electric energy-saving projects in the C&I Custom Program:[90]

- 16 lighting or lighting control upgrades
- 9 HVAC equipment-related installations or upgrades
- 4 building envelope upgrades
- 10 HVAC control-related installations or upgrades
- 1 industrial equipment upgrade

Overall, the aggregated C&I Custom Program evaluation results closely aligned with reported kWh and demand savings. Cadmus made *ex post* adjustments for only nine of the 40 electric projects in the program. The reported savings come directly from the program tracking database. Approximately 50% of the program's total reported *ex ante* kWh savings come from the top three projects. Table 156 lists the evaluation results for each electric project in the program.

Most projects exhibited reasonable savings estimates and calculation methodologies. Nine projects required *ex post* adjustment, but only two of these resulted in *ex post* savings greater than 10% less from *ex ante* values. An adjustment for one large project had the greatest effect on aggregate *ex post* program savings.

Custom project 3, a new construction project on a new land-based casino, represented 30% of the reported program-level *ex ante* savings and required an adjustment that resulted in a project realization rate of 71% and an electrical energy savings reduction of 241,915 kWh. One of the projects measure's, the installation of VFDs on several large HVAC fans, resulted in most of the project's electrical energy savings. The *ex ante* saving estimates assumed that the fans would always run at 85% speed, based on post-implementation verification inspection findings collected by the implementer immediately after

[90] 2018 natural gas energy saving projects are evaluated in a separate report.

the project's completion. However, during an on-site evaluation inspection several months later, Cadmus found that several fans were running at speeds higher than 85%. Therefore, Cadmus adjusted the *ex post* savings calculation assumptions to match the inspection findings. According to the program implementer, the customer likely changed the settings sometime after its initial verification inspection.

**Table 156. 2018 C&I Custom Program Per-Unit Gross Savings**

| Project | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| Custom Project 3 | 831,365 | 589,450 | 156.1 | 118.8 |
| Custom Project 15 | 225,874 | 216,973 | 3.2 | 0.0 |
| Custom Project 16 | 313,543 | 313,543 | 16.4 | 16.4 |
| Custom Project 17 | 121,127 | 121,127 | 0.0 | 0.0 |
| Custom Project 18 | 217,782 | 237,342 | 47.2 | 47.2 |
| Custom Project 21 | 133,390 | 133,390 | 1.8 | 1.8 |
| Custom Project 23 | 62,809 | 62,809 | 3.4 | 3.4 |
| Custom Project 24 | 41,474 | 44,840 | 0.0 | 0.0 |
| Custom Project 25 | 109,452 | 109,452 | 14.6 | 14.6 |
| Custom Project 26 | 104,648 | 104,648 | 20.2 | 20.2 |
| Custom Project 27 | 74,172 | 74,172 | 0.0 | 0.0 |
| Custom Project 28 | 59,161 | 63,666 | 0.0 | 0.0 |
| Custom Project 29 | 27,739 | 27,739 | 4.6 | 4.6 |
| Custom Project 30 | 54,887 | 54,887 | 7.5 | 7.5 |
| Custom Project 31 | 46,422 | 46,422 | 0.0 | 0.0 |
| Custom Project 32 | 45,214 | 45,214 | 0.0 | 0.0 |
| Custom Project 33 | 44,096 | 44,096 | 10.6 | 10.6 |
| Custom Project 34 | 40,057 | 40,057 | 0.0 | 0.0 |
| Custom Project 35 | 27,923 | 27,923 | 0.0 | 0.0 |
| Custom Project 36 | 26,753 | 28,714 | 5.3 | 5.3 |
| Custom Project 37 | 2,492 | 2,492 | 0.0 | 0.0 |
| Custom Project 40 | 17,282 | 17,282 | 6.7 | 6.7 |
| Custom Project 41 | 9,772 | 9,772 | 21.7 | 21.7 |
| Custom Project 42 | 15,493 | 15,493 | 6.1 | 6.1 |
| Custom Project 43 | 8,493 | 8,493 | 20.6 | 20.6 |
| Custom Project 44 | 4,938 | 4,938 | 12.0 | 12.0 |
| Custom Project 45 | 10,807 | 9,047 | 0.0 | 0.0 |
| Custom Project 46 | 10,807 | 10,209 | 0.0 | 0.0 |
| Custom Project 47 | 9,346 | 9,346 | 0.3 | 0.3 |
| Custom Project 48 | 8,513 | 8,513 | 0.0 | 0.0 |
| Custom Project 49 | 8,288 | 8,288 | 1.1 | 1.1 |
| Custom Project 50 | 4,620 | 4,620 | 0.6 | 0.6 |
| Custom Project 51 | 4,481 | 4,481 | 1.3 | 1.3 |
| Custom Project 52 | 3,560 | 3,560 | 0.0 | 0.0 |
| Custom Project 53 | 3,311 | 3,311 | 0.0 | 0.0 |
| Custom Project 54 | 291 | 291 | 1.1 | 1.1 |
| Custom Project 55 | 280 | 280 | 1.1 | 1.1 |
| Custom Project 56 | 1,932 | 1,932 | 1.1 | 1.1 |
| Custom Project 57 | 1,932 | 1,932 | 0.0 | 0.0 |
| Custom Project 58 | 1,294 | 1,294 | 0.3 | 0.3 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.

In its review of all 40 projects, Cadmus focused on the largest energy savers that made up 95% of the ex-ante energy savings. For the remaining 5% of projects, Cadmus made sure the underlying methodology was consistent with the rest of the projects in the program and found no clerical issues for nonqualifying products and no double-counting of savings. Additional details for project-level savings can be found in Appendix A. Impact Evaluation Methodology.

As shown in Table 157, the 2018 C&I Custom Program had a notable reduction in total program kWh savings compared to previous program years. Additionally, the realization rate for 2018 is slightly lower than in previous years, 92% vs 100% in 2017. Again, the main contributor to this year's lower realization rate was the required adjustments to Custom Project 3. In 2016, gross evaluated savings achieved realization rates of 98% for kWh savings compared to 101% in 2015.

**Table 157. C&I Custom Program Historical Per-Unit Savings**

| Project | Annual Gross Savings (kWh) | | |
|---|---|---|---|
| | Reported | Evaluated | Realization Rate |
| 2012 | 8,233,939 | 8,318,213 | 101% |
| 2013 | 10,965,984 | 11,658,971 | 106% |
| 2014 | 9,209,254 | 9,118,480 | 99% |
| 2015 | 3,706,998 | 3,746,614 | 101% |
| 2016 | 7,639,112 | 7,474,553 | 98% |
| 2017 | 5,391,816 | 5,384,126 | 100% |
| 2018 | 2,735,821 | 2,512,038 | 92% |

Program year 2018 resulted in roughly half of the total kWh savings from the previous year (2,512,038 kWh vs. 5,384,126 kWh in 2017), with about twice as many individual projects (40 in 2018 vs. 21 in 2017). This is because the size of the projects in 2018, in terms of kWh saved, was significantly lower than in 2017. The average per project electrical energy savings in 2018 was 62,801 kWh vs 256,387 kWh in 2017. However, if the program savings are averaged over the number of unique customers as opposed to the individual projects the average per participant energy savings raises to 114,184 kWh; resulting in a much smaller difference from the most recent years. The main factor in the remaining discrepancy was that in 2017 there was a single project with over 2,700,000 kWh savings, which was over 50% of that program year's total custom electrical energy savings.

## Project Verification

During the audit phase for the electric projects, Cadmus determined that the sum of the database's reported savings and installations correctly matched the electric scorecard. Cadmus asked interviewed participants if they had removed or added additional measures to their projects and if the equipment still worked properly. All ten respondents said equipment installed through their measures remained operational and had not been removed.

Because Cadmus found that 100% of the surveyed customers confirmed installation, it assumed 100% verification for the remaining projects. Due to the nature, scope, and capital investment involved with

C&I custom projects, it is typically unlikely that they be removed. These results are consistent with findings from previous years for the C&I Custom Program.

## Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the C&I Custom Program as a whole using findings from interviews conducted with ten program participants. As shown in Table 158, the C&I Custom Program respondents exhibited an overall savings-weighted freeridership average of 15%, and the resulting NTG ratio for the program including spillover is 85%. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

**Table 158. 2018 C&I Custom Program Net-to-Gross Ratio**

| Project | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 15% | 0% | 85%[1] |

[1] Absolute precision at 90% confidence interval is ± 9%.

Table 159 lists historical program-level NTG ratios by year.[91]

**Table 159. C&I Custom Program Historical Net-to-Gross Ratios[1]**

| Program Year | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| 2012 | 31% | 0% | 69% |
| 2013 | 1% | 0% | 99% |
| 2014 | 24% | 1% | 77% |
| 2015 | 0% | 0% | 100% |
| 2016 | 25% | 0% | 75% |
| 2017 | 4% | 0% | 96% |
| 2018 | 15% | 0% | 85% |

[1] Program years 2013 to 2017 used the standard self-report intention freeridership method. In 2018, the evaluation combined the intention questions from the standard self-report intention freeridership method for an intention freeridership score and the influence questions from the Intention/Influence method for an influence freeridership score.

NTG results rely completely on self-reported responses and therefore can change considerably from one year to the next, especially when sample sizes are small and there is the potential for large variations in respondents' program energy savings. This has been the case throughout the C&I Custom Program.

[91] 2013 to 2017 used the standard self-report intention freeridership method. The 2018 analysis is using a new method: the intention questions from the standard self-report intention freeridership method for an intention freeridership score and the influence questions from the Intention/Influence method for an influence freeridership score.

In 2018, the three respondents with the highest program savings accounted for 60% of the program energy savings in the analysis sample, and their weighted freeridership estimate was 11%. The weighted freeridership of the program as a whole was therefore higher than in 2017.

In 2017, only one respondent was estimated as having freeridership associated with program activity, representing 7% of the analysis sample program energy savings. This respondent was estimated as a non-freerider, accounting for 57% of the program energy savings in the analysis sample.

### *Freeridership and Spillover Findings*

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[92]

Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate the final program freeridership of 15%, as shown in Table 160.

**Table 160. 2018 C&I Custom Program Freeridership Estimate**

| Freeridership Metric | Estimate |
|---|---|
| Intention Score | 27%[1] |
| Influence Score | 2%[1] |
| **Final Freeridership Score** | **15%** |

[1] Weighted by *ex post* gross program savings

None of the interviewed participants reported that, after participating in the program, they had installed additional high-efficiency equipment for which they did not receive an incentive and that participation in the program was very important in their decision. Therefore, no spillover is attributed to the program.

## Evaluated Net Savings Adjustments

Table 161 and Table 162 list reported *ex ante* savings, evaluated *ex post* savings, realization rates, and evaluated net savings for each project in the C&I Custom Program. The program achieved net savings of 2,135,232 kWh and 275.6 coincident kW demand reduction.

92 *Intention* and *influence* freeridership scores both have a maximum of 100%.

### Table 161. 2018 C&I Custom Program Electric Savings (kWh)

| Energy Savings Unit | *Ex ante* Savings (kWh) | | | Evaluated *Ex post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Custom Project 3 | 831,365 | 831,365 | 831,365 | 589,450 | 71% | 85% | 501,032 |
| Custom Project 15 | 225,874 | 225,874 | 225,874 | 216,973 | 96% | 85% | 184,427 |
| Custom Project 16 | 313,543 | 313,543 | 313,543 | 313,543 | 100% | 85% | 266,511 |
| Custom Project 17 | 121,127 | 121,127 | 121,127 | 121,127 | 100% | 85% | 102,958 |
| Custom Project 18 | 217,782 | 217,782 | 217,782 | 237,342 | 109% | 85% | 201,741 |
| Custom Project 21 | 133,390 | 133,390 | 133,390 | 133,390 | 100% | 85% | 113,382 |
| Custom Project 23 | 62,809 | 62,809 | 62,809 | 62,809 | 100% | 85% | 53,388 |
| Custom Project 24 | 41,474 | 41,474 | 41,474 | 44,840 | 108% | 85% | 38,114 |
| Custom Project 25 | 109,452 | 109,452 | 109,452 | 109,452 | 100% | 85% | 93,034 |
| Custom Project 26 | 104,648 | 104,648 | 104,648 | 104,648 | 100% | 85% | 88,951 |
| Custom Project 27 | 74,172 | 74,172 | 74,172 | 74,172 | 100% | 85% | 63,046 |
| Custom Project 28 | 59,161 | 59,161 | 59,161 | 63,666 | 108% | 85% | 54,116 |
| Custom Project 29 | 27,739 | 27,739 | 27,739 | 27,739 | 100% | 85% | 23,578 |
| Custom Project 30 | 54,887 | 54,887 | 54,887 | 54,887 | 100% | 85% | 46,654 |
| Custom Project 31 | 46,422 | 46,422 | 46,422 | 46,422 | 100% | 85% | 39,459 |
| Custom Project 32 | 45,214 | 45,214 | 45,214 | 45,214 | 100% | 85% | 38,432 |
| Custom Project 33 | 44,096 | 44,096 | 44,096 | 44,096 | 100% | 85% | 37,482 |
| Custom Project 34 | 40,057 | 40,057 | 40,057 | 40,057 | 100% | 85% | 34,049 |
| Custom Project 35 | 27,923 | 27,923 | 27,923 | 27,923 | 100% | 85% | 23,735 |
| Custom Project 36 | 26,753 | 26,753 | 26,753 | 28,714 | 107% | 85% | 24,407 |
| Custom Project 37 | 2,492 | 2,492 | 2,492 | 2,492 | 100% | 85% | 2,118 |
| Custom Project 40 | 17,282 | 17,282 | 17,282 | 17,282 | 100% | 85% | 14,690 |
| Custom Project 41 | 9,772 | 9,772 | 9,772 | 9,772 | 100% | 85% | 8,306 |
| Custom Project 42 | 15,493 | 15,493 | 15,493 | 15,493 | 100% | 85% | 13,169 |
| Custom Project 43 | 8,493 | 8,493 | 8,493 | 8,493 | 100% | 85% | 7,219 |
| Custom Project 44 | 4,938 | 4,938 | 4,938 | 4,938 | 100% | 85% | 4,197 |
| Custom Project 45 | 10,807 | 10,807 | 10,807 | 9,047 | 84% | 85% | 7,690 |
| Custom Project 46 | 10,807 | 10,807 | 10,807 | 10,209 | 94% | 85% | 8,678 |
| Custom Project 47 | 9,346 | 9,346 | 9,346 | 9,346 | 100% | 85% | 7,944 |
| Custom Project 48 | 8,513 | 8,513 | 8,513 | 8,513 | 100% | 85% | 7,236 |
| Custom Project 49 | 8,288 | 8,288 | 8,288 | 8,288 | 100% | 85% | 7,045 |
| Custom Project 50 | 4,620 | 4,620 | 4,620 | 4,620 | 100% | 85% | 3,927 |
| Custom Project 51 | 4,481 | 4,481 | 4,481 | 4,481 | 100% | 85% | 3,809 |
| Custom Project 52 | 3,560 | 3,560 | 3,560 | 3,560 | 100% | 85% | 3,026 |
| Custom Project 53 | 3,311 | 3,311 | 3,311 | 3,311 | 100% | 85% | 2,814 |
| Custom Project 54 | 291 | 291 | 291 | 291 | 100% | 85% | 247 |
| Custom Project 55 | 280 | 280 | 280 | 280 | 100% | 85% | 238 |
| Custom Project 56 | 1,932 | 1,932 | 1,932 | 1,932 | 100% | 85% | 1,643 |
| Custom Project 57 | 1,932 | 1,932 | 1,932 | 1,932 | 100% | 85% | 1,642 |
| Custom Project 58 | 1,294 | 1,294 | 1,294 | 1,294 | 100% | 85% | 1,100 |
| **Total** | **2,735,821** | **2,735,821** | **2,735,821** | **2,512,038** | **92%** | **85%** | **2,135,232** |

**Table 162. 2018 C&I Custom Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex ante* Savings (Coincident Peak kW) | | | Evaluated *Ex post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported[1] | Audited | Verified | | | | |
| Custom Project 3 | N/A | 156.1 | 156.1 | 118.8 | N/A | 85% | 101.0 |
| Custom Project 15 | N/A | 3.2 | 3.2 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 16 | N/A | 16.4 | 16.4 | 16.4 | N/A | 85% | 13.9 |
| Custom Project 17 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 18 | N/A | 47.2 | 47.2 | 47.2 | N/A | 85% | 40.1 |
| Custom Project 21 | N/A | 1.8 | 1.8 | 1.8 | N/A | 85% | 1.5 |
| Custom Project 23 | N/A | 3.4 | 3.4 | 3.4 | N/A | 85% | 2.9 |
| Custom Project 24 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 25 | N/A | 14.6 | 14.6 | 14.6 | N/A | 85% | 12.4 |
| Custom Project 26 | N/A | 20.2 | 20.2 | 20.2 | N/A | 85% | 17.2 |
| Custom Project 27 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 28 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 29 | N/A | 4.6 | 4.6 | 4.6 | N/A | 85% | 3.9 |
| Custom Project 30 | N/A | 7.5 | 7.5 | 7.5 | N/A | 85% | 6.4 |
| Custom Project 31 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 32 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 33 | N/A | 10.6 | 10.6 | 10.6 | N/A | 85% | 9.0 |
| Custom Project 34 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 35 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 36 | N/A | 5.3 | 5.3 | 5.3 | N/A | 85% | 4.5 |
| Custom Project 37 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 40 | N/A | 6.7 | 6.7 | 6.7 | N/A | 85% | 5.7 |
| Custom Project 41 | N/A | 21.7 | 21.7 | 21.7 | N/A | 85% | 18.4 |
| Custom Project 42 | N/A | 6.1 | 6.1 | 6.1 | N/A | 85% | 5.2 |
| Custom Project 43 | N/A | 20.6 | 20.6 | 20.6 | N/A | 85% | 17.5 |
| Custom Project 44 | N/A | 12.0 | 12.0 | 12.0 | N/A | 85% | 10.2 |
| Custom Project 45 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 46 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 47 | N/A | 0.3 | 0.3 | 0.3 | N/A | 85% | 0.3 |
| Custom Project 48 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 49 | N/A | 1.1 | 1.1 | 1.1 | N/A | 85% | 1.0 |
| Custom Project 50 | N/A | 0.6 | 0.6 | 0.6 | N/A | 85% | 0.5 |
| Custom Project 51 | N/A | 1.3 | 1.3 | 1.3 | N/A | 85% | 1.1 |
| Custom Project 52 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 53 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 54 | N/A | 1.1 | 1.1 | 1.1 | N/A | 85% | 1.0 |
| Custom Project 55 | N/A | 1.1 | 1.1 | 1.1 | N/A | 85% | 0.9 |
| Custom Project 56 | N/A | 1.1 | 1.1 | 1.1 | N/A | 85% | 0.9 |
| Custom Project 57 | N/A | 0.0 | 0.0 | 0.0 | N/A | 85% | 0.0 |
| Custom Project 58 | N/A | 0.3 | 0.3 | 0.3 | N/A | 85% | 0.2 |
| **Total** | **365.1** | **364.7** | **364.7** | **324.2** | **89%** | **85%** | **275.6** |

[1] The 2018 DSM Scorecard did not report kW savings at the measure level.

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the C&I Custom Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies.

## Logic Model

# C&I CUSTOM PROGRAM

| Market Actor | End-Use Customer | C&I Customers | |
|---|---|---|---|
| Market Barriers | • Lack of program awareness<br>• Lack of knowledge of energy conservation benefits<br>• Lack of knowledge of energy audit benefits | • Large out-of-pocket expenses<br>• Perception that project is not cost-effective for business or that business does not need improvements | • Lack of knowledge about project eligibility<br>• Concern with the complexity of project and time taken from business operations |
| Intervention Strategies / Activities | • Participation in industry associations and events, program handouts, and ongoing communication with customers | • Incentives of up to $100,000 for qualified projects<br>• Explanation of total amount customer responsible for and calculation of payback period | • Participating trade ally base to make installation timely and convenient<br>• Provide savings values, sample applications, and rebate process charts |
| Outcomes | • Increased program awareness<br>• Increased participation<br>• Incentive contribution allows energy efficiency customization to be viable option to C&I customers | • Increased market saturation of energy-efficient measures<br>• Increased energy savings | • Improved customer perception of energy efficiency programs<br>• Increased customer referrals |
| Key Indicators | • Achievement of participation and savings goals<br>• Average kWh per project | • Program satisfaction ratings<br>• Likelihood to recommend ratings | • Number of customers hearing about the program through word of mouth |

| Market Actor | Trade Allies | Installation Contractors | |
|---|---|---|---|
| Market Barriers | • Lack of program awareness<br>• Inability to communicate directly with decision-maker | • Lack of customer awareness | • Perception that time spent helping customer with application is burdensome |
| Intervention Strategies / Activities | • Advertisement through trade associations and events<br>• Marketing and communication through account managers to direct trade allies to decision-maker | • Group and individual training sessions detailing program operations and requirements, application forms, and invoicing requirements | • Provision of marketing materials to trade allies to deliver to customers |
| Outcomes | • Increased program awareness<br>• Increased energy savings | • Streamlined project communication and implementation<br>• Faster application processing times due to reduced errors | • Trade allies exposed to greater number of potential customers, thus increasing overall revenue and customer relationship |
| Key Indicators | • Number of contractors participating in multiple years<br>• Number of actively participating contractors | • Application processing time<br>• Contractor satisfaction ratings | • Contractor likelihood to recommend ratings |

## Program Performance

Cadmus measured 2012 to 2018 program performance against the KPIs listed in Table 163. Per-project savings notably decreased, from 256,387 kWh in 2017 to 62,801 kWh in 2018, as shown in the table. In the previous two years, there were one or more very large projects (greater than 1,500,000 kWh gross savings), which increased the program averages, but in 2018 the largest two projects only saved 831,365 kWh and 313,542 kWh.

Additionally, Cadmus observed that many of the multi-measure projects were generally administered as itemized projects (i.e., there is a dedicated line item in the tracked program savings for individual measures with a common application ID). Whereas in previous years more of the multi-measure projects were combined into a single "project" with a single line item in the tracked savings. In 2018, there were still several multi-measure projects, particularly large new construction, that were administered under a single line in the tracked program savings. However, there seemed to be a general shift toward more granular tracking of projects. This also had a significant effect on the per project average savings as the total program savings was spread over more line item projects.

**Table 163. C&I Custom Program KPI and 2012-2018 Performance[1]**

| KPI | Performance | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | Achieved | Not achieved | 103% | 118% | 80% | 42% | 48% |
| Achievement of gross kWh savings goals | 300% | 246% | 76% | 167% | 178% | 108% | 40% |
| Average kWh per project/measure | 124,763 | 163,938 | 94,844 | 142,577 | 381,956 | 256,753 | 62,801 |
| Participant satisfaction with the program (very satisfied) [2] | 92% | 100% | 93% | 80% | 87% | 88% | 90% |
| Participant likelihood to recommend the program (very likely) [2] | N/A | N/A | N/A | N/A | 100% | 88% | 100% |
| Participants hearing about the program through word of mouth[2] | N/A | N/A | N/A | N/A | 0% | 0% | 0% |
| Number of contractors participating in multiple years | N/A | N/A | N/A | N/A | N/A | 3 | 8 |
| Number of actively participating contractors | 26 | 34 | 39 | 20 | 19 | 23 | 28 |
| Application processing time (average number of days between application received date and check mailed date) | N/A | N/A | N/A | N/A | N/A | N/A | 54 days |
| Contractor satisfaction with the program (very satisfied) [2] | 83% | 72% | 64% | N/A | 40% | 78% | N/A |
| Contractor likelihood to recommend the program (very likely) [2] | N/A | N/A | N/A | N/A | N/A | 100% | N/A |

[1] N/A indicates that the metric was not tracked in the year noted.
[2] Small sample sizes have a greater influence on results from year to year.

# Commercial and Industrial Small Business Direct Install Program

The Small Business Direct Install (SBDI) Program, branded as Small Business Energy Solutions, helps qualifying businesses identify energy-saving opportunities. To participate, the customer's business must be in Vectren's service territory and have a peak electric demand of 400 kW or less over the past 12 months. In 2018, Vectren expanded program eligibility to common areas of multifamily buildings. The program offers participants these services and discounts:

- No-cost on-site energy assessment
- No-cost installation of direct install energy-efficient measures
- Energy assessment report detailing recommended site-specific energy-efficient upgrades
- Low-cost pricing for recommended energy-efficient measures

Vectren oversees the program. Nexant, the program implementer, is responsible for day-to-day operations, trade ally outreach, application processing, and technical review. Participating trade allies are responsible for customer outreach, conducting on-site energy assessments, and installing no-cost and low-cost direct install measures.

The no-cost direct install measures include interior and exterior lighting, vending machine sensors, smart Wi-Fi enabled or programmable thermostats, pre-rinse sprayers, and faucet aerators, which may be installed by the trade ally during the on-site energy assessment. Later, trade allies can install additional measures based on the outcome of the on-site energy assessment.

Vectren offers instant rebates, which reduce the out-of-pocket equipment cost for customers for the following measures (referred to as low-cost measures):

- Direct install and low-cost interior and exterior energy-efficient lighting
- LED refrigerated case lighting
- LED exit signs
- Lighting occupancy sensors
- Refrigerator/freezer efficiency measures
- Electronically commutated motors (ECMs) for refrigerated cases

## Accomplishments

The SBDI Program far exceeded its 2018 savings and participation goals while only slightly exceeding the budget, as shown in Table 164.

**Table 164. 2018 Small Business Direct Install Program Goals and Achievements[1]**

| Program | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Gross kWh Savings | 3,817,158 | 1,100,000 | 347% |
| Gross kW Savings | 597 | 94 | 635% |
| Participants | 146 | 60 | 243% |
| Program Expenditures | $328,578 | $316,479 | 104% |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Two top-performing trade allies generated 65% of the program's gross kWh savings, with each doubling or tripling the savings they contributed in 2018 compared to 2017. Ten trade allies delivered projects for the program in 2018, compared to eight in 2017. The average number of customers per trade ally increased from 9.5 in 2017 to 11.6 in 2018.

Vectren reduced its goals and budget in 2018 after not reaching its 2017 goals. Had Vectren maintained the same 2017 gross kWh savings goal in 2018, the program would have achieved 98% of its gross kWh savings goal.

Table 165 lists the evaluated savings summary for the SBDI Program. Overall, the program achieved a 100% realization rate for energy and a 104% realization rate for demand savings. There were no significant (greater than 5%) deviations between *ex ante* and *ex post* gross kWh savings for any of the program measure categories.

**Table 165. 2018 Small Business Direct Install Program Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings | | | Evaluated *Ex Post* Savings | Realization Rates | NTG Ratio | Evaluated Net Savings |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | 3,817,158 | 3,817,158 | 3,817,158 | 3,813,515 | 100% | 101% | 3,837,960 |
| Total kW | 597.20 | 597.20 | 597.20 | 619.42 | 104% | 101% | 623.39 |

## *Conclusions and Recommendations*

### Customer Satisfaction

**Vectren delivered an SBDI program that met or exceeded business customers' expectations.** Participating customers remain highly satisfied with and likely to recommend the program.

### Program Administration and Delivery

**Trade allies increased activity but refrained from installing no-cost measures until they secured low-cost projects with customers.** The implementer's decision to require participating contractors to deliver at least six assessments in 2018 proved successful. Ten trade allies contributed savings to the 2018 program, compared to eight in 2017, and the program achieved 347% of the 2018 energy savings goal. However, similar to previous years, the implementer said that it struggled to collect site assessment reports from contractors that did not result in a project and that contractors did not install no-cost measures unless customers committed to low-cost energy-saving projects. The implementer believes this is because trade allies have different staff conducting the site assessments than performing the installation, and the trade allies hold out on installing no-cost items as part of a paying project.

**Recommendation:** Encourage trade ally staff to keep an inventory of no-cost measures with them when conducting site assessments. Although site assessors may not have adequate storage space or the experience needed to install all of the no-cost measures, most should be able to maintain an adequate supply of and feel comfortable with installing LEDs, aerators, and pre-rinse sprayers. In return for performing these installations and managing the paperwork involved, consider offering trade allies a small incentive for projects that never advance to a paying project.

## Data Management

***Ex Ante* savings for some lighting measures could not be replicated.** In a few instances at four participating locations, Cadmus was unable to replicate *ex ante* savings for interior lighting measures, including LED exit signs. Cadmus determined that the most likely reason that *ex ante* and *ex post* savings differed was that the waste heat factors and coincidence factors related to space type were missing in the tracking database. Stating these values in the tracking data will allow for a more precise estimate of *ex ante* savings and confirmation of *ex post* savings.

**Recommendation:** Add the waste heat factors and coincidence factors for energy and demand to the program tracking data.

## *Process Evaluation*

# SMALL BUSINESS DIRECT INSTALL PROGRAM

## 2018 Process Analysis Activities

1 VECTREN staff interview

1 Nexant staff interview

27 participating customer phone surveys

## 2018 Program Changes

VECTREN **expanded program eligibility to multifamily** common areas

To increase program activity and maintain program standing, participating contractors are required to complete **at least** 6 **assessments annually**

## 2019 Planned Program Changes

Nexant planning **geotargeted marketing campaigns** to boost participation with small businesses in zip codes with limited project activity

## Key Process Evaluation Findings

70% (n=27) of participants learned about rebates from **contractors** *consistent with 2017 results

89% (n=27) were **very likely** to recommend the program to another business

91% (n=23) of participants were **very satisfied** with the assessment report

100% (n=26) of participants were **very satisfied with the contractor** who preformed the assessment and installation

100% (n=26) of participants were **satisfied with the program** overall

**Survey respondants recommended a few program improvements:**

- **2 responses** - Allow self-installation
- **1 response** - Provide more information / increase awareness
- **1 response** - Offer more products or measures

**10 trade allies delivered projects for the program in 2018**, compared to 8 in 2017. The **average number of customers per trade ally** increased from 9.5 in 2017 to **11.6 in 2018.** The two top-performing trade allies generated 65% of the program's gross kWh, **doubling or tripling their savings contributions in 2018** compared to 2017.

Although the new site assessment minimum improved program activity, Nexant had **difficulty collecting site assessment reports from contractors unless they were accompanied by a project.**

No participant received no-cost measures in 2018 **without also purchasing a low-cost measure.** According to Nexant, contractors refrained from installing no-cost measures **until securing low-cost projects with their customers.**

# Impact Evaluation

## Impact Evaluation Methods and Findings

The SBDI Program impact evaluation included multiple data collection efforts and analysis tasks:

- Tracking database review of the number of measures installed and their deemed savings assumptions
- Engineering analysis of *ex ante* energy savings and demand reductions for each measure
- Phone survey with 27 program participants to gather measure verification, freeridership, and spillover data

Cadmus compared its engineering calculations to Vectren's reported savings for each measure, with savings methodologies for each measure based on these sources:

- Vectren's program-tracking database
- 2015 Indiana TRM
- 2015 Vectren Small Business Direct Install TRM (for measures not in the 2015 Indiana TRM)

## Gross Savings Review

There were only very minor differences between reported and evaluated per-unit savings for measures in the SBDI Program. None of these differences resulted in aggregated measure-level realization rates larger than 1% of savings. The impact evaluation included only those measures that were installed or rebated in the 2018 program tracking data and for which savings were claimed. The impact evaluation did not include measures that the program offered but that were not installed by trade allies (e.g., faucet aerators, pre-rinse sprayers, and refrigerator/freezer efficiency measures).

Table 166 shows per-unit annual gross savings for each evaluated program measure.

**Table 166. 2018 Small Business Direct Install Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| ECMs | 397.5 | 397.5 | 0.05 | 0.05 |
| Exterior Lighting | 1,583.6 | 1,583.6 | 0.00 | 0.00 |
| Interior Lighting | 194.1 | 193.7 | 0.06 | 0.06 |
| LED Exit Signs | 82.5 | 83.3 | 0.01 | 0.01 |
| Occupancy Sensors | 136.1 | 136.3 | 0.03 | 0.03 |
| Smart Wi-Fi and Programmable Thermostats | 1,974.6 | 1,975.6 | 0.00 | 0.00 |
| Refrigerated Case Lighting | 230.4 | 230.4 | 0.03 | 0.03 |
| Vending Machine Occupancy Sensors | 1,611.8 | 1,611.8 | 0.00 | 0.00 |

There were only minor deviations between *ex ante* and *ex post* gross savings assumptions on a per-unit basis. Most of these were because of minor differences in room categorization for lighting measures, which led to differences in the applied *ex post* waste heat factor.

Table 167 lists the evaluated gross per-unit energy savings for each program measure by year. Savings vary between years primarily because of differences in measure quantity and mix, with some minor differences in installed space type and the number of controlled lamps (for occupancy sensors) and controlled equipment (for ECMs). Per-unit savings for smart Wi-Fi-enabled and programmable thermostats increased substantially following a revision in methodology in 2017 that more accurately incorporated location-specific values for conditioned space, setpoint, and runtime.

**Table 167. Small Business Direct Install Program Historical Per-Unit Savings**

| Measure | Evaluated Annual Gross Energy Savings[1] | | | | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| ECMs | - | 354.0 | 325.0 | 401.9 | - | 397.5 |
| Exterior Lighting | 635.3 | 827.5 | 756.6 | 1,008.3 | 1,164.6 | 1,583.6 |
| Interior Lighting | 217.6 | 288.0 | 240.6 | 229.6 | 218.6 | 193.7 |
| LED Exit Signs | 88.1 | 89.8 | 88.9 | 88.3 | 87.2 | 83.3 |
| Occupancy Sensors | 176.7 | 549.1 | 326.9 | 328.2 | 249.8 | 136.3 |
| Smart Wi-Fi and Programmable Thermostats | 50.4 | 290.0 | 92.0 | 136.7 | 2,591.9 | 1,975.6 |
| Refrigerated Case Lighting | - | 1638.4 | 280.0 | 611.0 | 234.5 | 230.4 |
| Vending Machine Occupancy Sensors | 1,611.8 | 1,611.8 | 1,611.8 | 1,611.8 | - | 1,611.8 |

[1] Cells with no values represent years where no measures were rebated or installed through the program.

Additional details for measure-level savings can be found in Appendix A. Impact Evaluation Methodology.

## Measure Verification

Through a telephone survey of 27 program participants, respondents reported that all measures installed through the program were still installed, resulting in a 100% installation rate for all measures. Cadmus was unable to complete telephone surveys with participants who installed refrigerated case lighting and vending machine occupancy sensors. Therefore, Cadmus assigned these measures a 100% installation rate, based on their historical installation rates and accounting for the difficulty and low probability of removing the measure after installation. Table 168 lists the installation rates for each program measure.

**Table 168. 2018 Small Business Direct Install Program Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported[1] | Audited | Verified | |
| ECMs | 8 | 8 | 8 | 100% |
| Exterior Lighting | 1,043 | 1,043 | 1,043 | 100% |
| Interior Lighting | 10,398 | 10,398 | 10,398 | 100% |
| LED Exit Signs | 101 | 101 | 101 | 100% |
| Occupancy Sensors | 188 | 188 | 188 | 100% |
| Smart Wi-Fi and Programmable Thermostats | 49 | 49 | 49 | 100% |
| Refrigerated Case Lighting | 45 | 45 | 45 | 100% |
| Vending Machine Occupancy Sensors | 2 | 2 | 2 | 100% |
| **Total** | **11,834** | **11,834** | **11,834** | **100%** |

[1] The 2018 DSM Scorecard tracked participation by number of small businesses served (n=146). These reported installations are representative of the 2018 program tracking database.

Table 169 shows historical installation rates for each program measure. The 2018 installation rate of 100% is nearly identical to the aggregated installation rate for the past four program years.

**Table 169. Small Business Direct Install Program Historical Installation Rates**

| Measure | Installation Rate | | | | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| ECMs | - | 100% | 100% | 100% | - | 100% |
| Exterior Lighting | 100% | 100% | 100% | 100% | 100% | 100% |
| Interior Lighting | 84% | 100% | 100% | 100% | 100% | 100% |
| LED Exit Signs | 100% | 100% | 100% | 100% | 100% | 100% |
| Occupancy Sensors | 100% | 100% | 100% | 100% | 100% | 100% |
| Smart Wi-Fi and Programmable Thermostats | 81% | 97% | 100% | 99% | 100% | 100% |
| Refrigerated Case Lighting | - | 100% | 100% | 100% | 100% | 100% |
| Vending Machine Occupancy Sensors | 100% | 100% | 100% | 100% | - | 100% |

## Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the SBDI Program as a whole using findings from a survey conducted with 27 program participants.[93] After including spillover, the program resulted in an NTG ratio of 101%.

Table 170 presents the NTG results for the program. These findings are described in greater detail in Appendix B. Net-to-Gross Detailed Findings.

[93] NTG values are not calculated separately by fuel type. Electric and gas savings are combined and standardized using MMBtus, and the overall NTG ratio is applied to both fuel types.

**Table 170. 2018 Small Business Direct Install Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| ECMs | 0% | 1% | 101% |
| Exterior Lighting | 0% | 1% | 101% |
| Interior Lighting | 0% | 1% | 101% |
| LED Exit Signs | 0% | 1% | 101% |
| Occupancy Sensors | 0% | 1% | 101% |
| Smart Wi-Fi and Programmable Thermostats | 0% | 1% | 101% |
| Refrigerated Case Lighting | 0% | 1% | 101% |
| Vending Machine Occupancy Sensors | 0% | 1% | 101% |
| **Total Program** | **0%** | **1%** | **101%** |

Table 171 lists historical program-level NTG ratios by year.[94] NTG results rely completely on self-reported responses and therefore can change considerably from one year to the next, especially when sample sizes are small and when there is the potential for large variations in the program energy savings of respondents, which has been the case throughout the C&I Custom Program. In 2018, the three respondents with the highest program savings accounted for 60% of the analysis sample program energy savings, their weighted freeridership estimate was 11%, and, as a result, the weighted freeridership of the program as a whole was higher than 2017. In 2017, only one respondent customer was estimated as having freeridership associated with program activity, representing 7% of the analysis sample program energy savings. The respondent with the highest savings from 2017 was estimated as a non-freerider, accounted for 57% of the analysis sample program energy savings and, as a result, the weighted freeridership of the program as a whole was lower in 2017.

**Table 171. Small Business Direct Install Program Historical Net-to-Gross Ratios**

| Program Year | Survey n | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|---|
| 2013 | 39 | 0% | 0% | 100% |
| 2014 | 38 | 4% | 0% | 96% |
| 2015 | 42 | 5% | 0% | 95% |
| 2016 | 43 | 23% | 0% | 77% |
| 2017 | 15 | 21% | 7% | 86% |
| 2018 | 27 | 0% | 1% | 101% |

94 2013 and 2014 used the standard self-report intention freeridership method. 2015, 2016 and 2017 used two different freeridership methods: the standard self-report intention freeridership method and the Intention/Influence freeridership method. The 2018 analysis is using a new method: the intention questions from the standard self-report intention freeridership method for an intention freeridership score and the influence questions from the Intention/Influence method for an influence freeridership score.

### *Freeridership and Spillover Findings*

Cadmus estimated freeridership by combining two methods use in prior evaluations—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with the *influence* methodology, Cadmus produced a program freeridership score.[95] Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate the final program freeridership of 0%, as shown in Table 172.

**Table 172. 2018 Small Business Direct Install Program Freeridership Estimate**

| Freeridership Metric | Estimate |
| --- | --- |
| Intention Score | 0% |
| Influence Score | 0% |
| **Final Freeridership Score[1]** | **0%** |

[1] Weighted by *ex post* gross program savings

After participating in the program, one respondent reported installing 30 LEDs and one energy-efficient central air conditioning unit for which the company did not receive an incentive. The respondent said participation in the program was very important in the company's decision to install the additional measures. Cadmus used two per-unit evaluated gross savings estimates—one for interior lighting (193.7kWh) from the SBDI Program and one for HVAC (1,094.0) from the 2018 C&I Prescriptive Program—to calculate spillover for the additional equipment attributed to the program. Cadmus then divided the total survey sample spillover savings (23.5 MMBtu) by the gross program savings from the survey sample (1,785 MMBtu) to obtain the 1% spillover estimate for the program, as shown in Table 173.

**Table 173. 2018 Small Business Direct Install Program Spillover Estimate**

| Survey Sample Spillover Savings (MMBtu) | Survey Sample Program Savings (MMBtu) | Spillover Percentage Estimate |
| --- | --- | --- |
| 23.5 | 1,785 | 1% |

## Evaluated Net Savings Adjustments

Table 174 and Table 175 list evaluated net savings for the SBDI Program. The program achieved net savings of 3,837,960 kWh and 623.39 coincident kW demand reduction.

95 *Intention* and *influence* freeridership scores both have a maximum of 100%.

**Table 174. 2018 Small Business Direct Install Program Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| ECMs | 3,180 | 3,180 | 3,180 | 3,180 | 100% | 101% | 3,200 |
| Exterior Lighting | 1,651,697 | 1,651,697 | 1,651,697 | 1,651,697 | 100% | 101% | 1,662,284 |
| Interior Lighting | 2,018,005 | 2,018,005 | 2,018,005 | 2,014,206 | 100% | 101% | 2,027,117 |
| LED Exit Signs | 8,336 | 8,336 | 8,336 | 8,415 | 101% | 101% | 8,469 |
| Occupancy Sensors | 25,593 | 25,593 | 25,593 | 25,622 | 100% | 101% | 25,787 |
| Programmable Thermostats | 96,756 | 96,756 | 96,756 | 96,803 | 100% | 101% | 97,424 |
| Refrigerated Case Lighting | 10,368 | 10,368 | 10,368 | 10,368 | 100% | 101% | 10,434 |
| Vending Machine Occupancy Sensors | 3,224 | 3,224 | 3,224 | 3,224 | 100% | 101% | 3,244 |
| **Total** | **3,817,158** | **3,817,158** | **3,817,158** | **3,813,515** | **100%** | **101%** | **3,837,960** |

**Table 175. 2018 Small Business Direct Install Program Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| ECMs | 0.40 | 0.40 | 0.40 | 0.40 | 100% | 101% | 0.41 |
| Exterior Lighting | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 101% | N/A |
| Interior Lighting | 588.02 | 588.02 | 588.02 | 610.18 | 104% | 101% | 614.09 |
| LED Exit Signs | 0.74 | 0.74 | 0.74 | 0.79 | 107% | 101% | 0.80 |
| Occupancy Sensors | 6.50 | 6.50 | 6.50 | 6.51 | 100% | 101% | 6.55 |
| Programmable Thermostats | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 101% | N/A |
| Refrigerated Case Lighting | 1.54 | 1.54 | 1.54 | 1.54 | 100% | 101% | 1.55 |
| Vending Machine Occupancy Sensors | 0.00 | 0.00 | 0.00 | 0.00 | N/A | 101% | N/A |
| **Total** | **597.20** | **597.20** | **597.20** | **619.42** | **104%** | **101%** | **623.39** |

## *Market Effects*

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the SBDI Program. The logic model reflects these key program components:

- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies

## Logic Model

# SMALL BUSINESS DIRECT INSTALL PROGRAM

### Market Actor

**End-Use Customer** | Small Business Customers

### Market Barriers

- Time constraints, difficulty dedicating time to an energy efficiency project
- Lack of program awareness
- Upfront costs affiliated with purchase and installation of efficient measures
- Lack of understanding and perceiving benefits of the energy assessment's recommended low-cost energy-efficient installations

### Intervention Strategies / Activities

- Lighting products discounts at point of purchase
- Lighting products discounts for multiple bulb types, including specialty bulbs, fixtures, and ceiling fans
- Digital and broadcast media promotion of the program
- Information on Vectren website
- In-store program signage and events

### Outcomes

- Increased awareness
- Increased participation
- Increased customer satisfaction
- Improved customer perception of efficient lighting
- Increased energy savings
- Increased penetration of efficient lighting technologies

### Key Indicators

- Achievement of program participation and savings goals
- Measure satisfaction ratings
- Number of participating small businesses

### Market Actor

**Trade Allies** | Installation Contractors

### Market Barriers

- Lack of program understanding
- Lack of contractor engagement
- Concern that the program is not profitable enough to offset the time involved in delivering it

### Intervention Strategies / Activities

- Group and individual training sessions detailing program operations and requirements, application forms, invoicing requirements, and sales strategies
- Trade allies required to complete a minimum number of assessments per year
- Referrals to potential customers who are interested in participating in the program
- Program incentives and detailed energy assessment reports that entice customers to install low-cost measures

### Outcomes

- Increased program awareness
- Increased participation
- Deeper savings per participant
- Increased energy savings
- Increased market penetration of energy-efficient measures
- Increased sales volume per trade ally
- Increased program satisfaction

### Key Indicators

- Achievement of program participation and savings goals
- Number of participating trade allies
- Average number of recruited participants per trade ally
- Average kWh per participant
- Program satisfaction ratings
- Trade ally reported impact of program on sales
- Conversion rate of energy assessments to low-cost measure installations

## Program Performance

Cadmus measured 2013 to 2018 program performance against the KPIs listed in Table 176.

**Table 176. Small Business Direct Install Program KPI and 2013-2018 Performance**

| KPI | Performance | | | | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Achievement of program participation goals | 47% | 18% | 13% | 41% | 36% | 243% |
| Achievement of gross kWh savings goals | 100% | 194% | 58% | 61% | 38% | 347% |
| Average kWh per participant | 12,710 | 25,360 | 24,257 | 33,487 | 19,763 | 32,907 |
| Number of participating small businesses[1] | 146 | 163 | 143 | 121 | 76 | 116 |
| Number of participating trade allies | 11 | 11 | 10 | 12 | 8 | 10 |
| Participant satisfaction with the program (*very satisfied* or *somewhat satisfied*) | 100% | 100% | 98% | 98% | 100% | 100% |
| Participant satisfaction with the measures installed (*very satisfied* or *somewhat satisfied*) | 100% | 100% | N/A | 100% | 100% | 100% |
| Average Number of Recruited Participants per Trade Ally | 13.2 | 14.9 | 10.3 | 10.2 | 9.5 | 11.6 |
| Trade Ally Satisfaction (*very satisfied* or *somewhat satisfied*) | 8 of 8 | 6 of 6 | N/A | 8 of 10 | 5 of 5 | N/A |
| Impact of Program on Trade Ally Sales (% increase) | 20% | 12% | N/A | 5% | 5% | N/A |
| Conversion Rate of energy assessments to low-cost measure installations[2] | N/A | N/A | N/A | N/A | 44% | 51% |

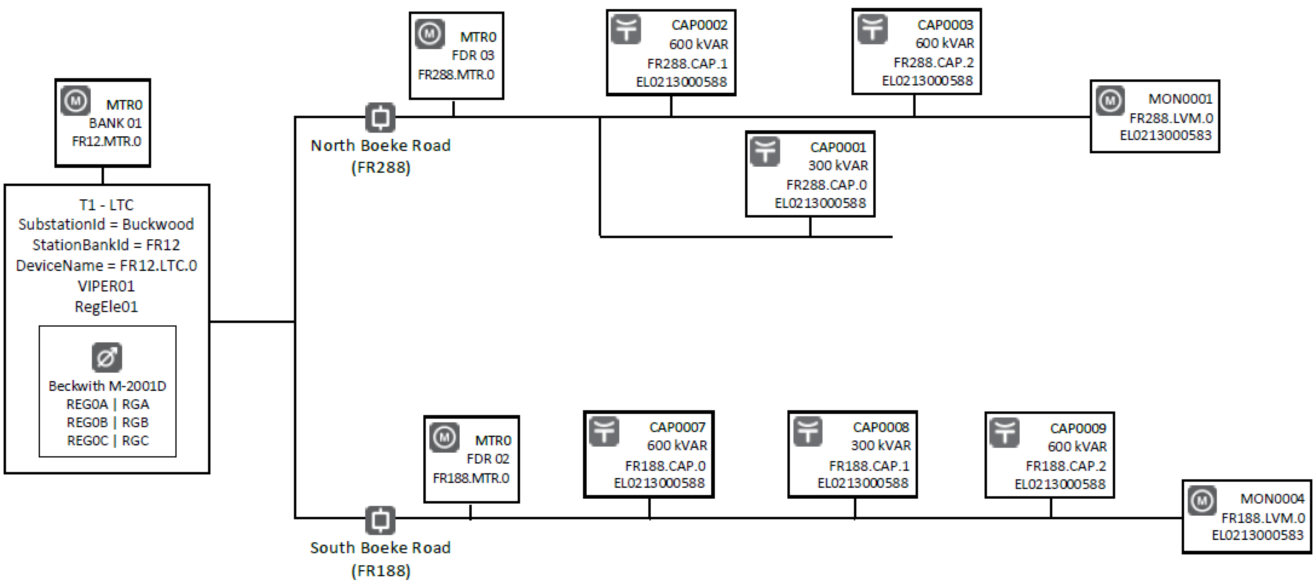
[1] Participants may have completed more than one project.
[2] Assessments completed in the fourth quarter of the previous year through the third quarter of evaluated program year, compared to measure installations completed January-December of evaluated program year

# Conservation Voltage Reduction Program

The Conservation Voltage Reduction (CVR) Program achieves residential and commercial end-user energy and demand savings by reducing the voltage on distribution feeders while ensuring that residential meters remain above the allowable minimum voltage of 114 V (allowable maximum is 126 V) set by the American National Standards Institute (ANSI). Through the CVR Program, the end user reduces energy consumption without having to alter behavior or equipment—that is, savings are generated without a noticeable impact on customers. Vectren implemented the CVR Program by installing voltage monitors and automated control systems on the electric distribution system connected to its Buckwood substation in Evansville, Indiana.

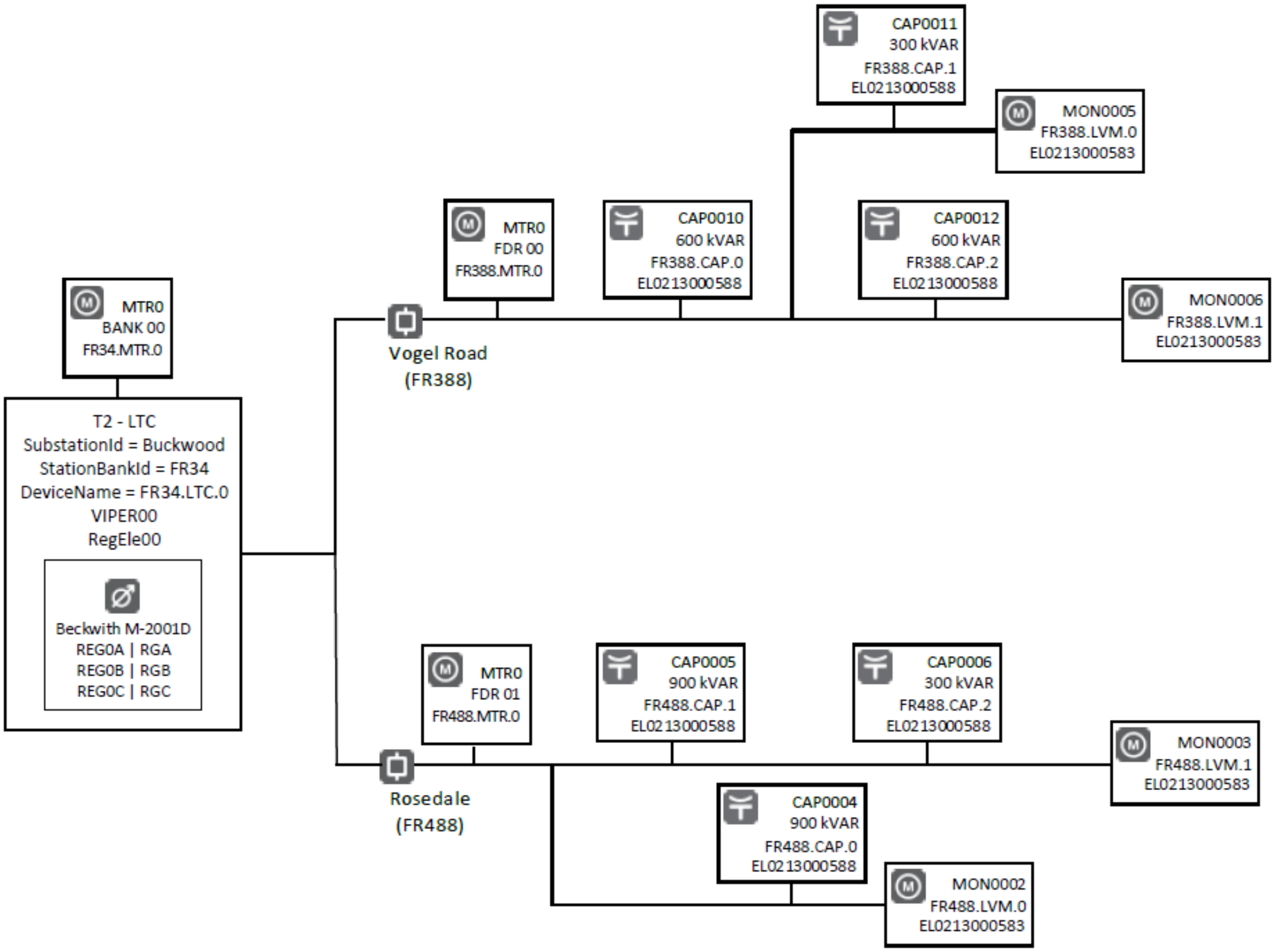
Vectren partnered with Utilidata to implement the CVR Program and provide analytic support to adjust voltage levels. Utilidata installed the CVR system on two load tap changers (LTCs) at the substation.[96] Each LTC controls voltage on two distribution feeders (total of four feeders) that serve a mix of residential and commercial electric customers. Figure 15 and Figure 16 show the configuration of these feeders and the devices installed on them.

**Figure 15. Feeders FR188 and FR288 at Buckwood Substation**




96 Load tap changers regulate voltage by discretely changing the “tap” position of a transformer.

**Figure 16. Feeders FR388 and FR488 at Buckwood Substation**




## Accomplishments

Vectren designed the CVR Program to claim first-year savings on its Buckwood substation in 2017, but it kept the CVR Program running throughout 2018. In 2018, Vectren switched its cycling protocol from one-day intervals to varying on/off cycling intervals for each feeder. Therefore, Vectren did not claim savings in 2018,[97] but it did incur costs, shown in Table 177. Vectren plans to expand its CVR activities in the future, installing monitors and controls on its East Side substation in 2020.

97 Because Vectren designed the CVR Program to claim savings only in 2017, the program did not have savings or participation goals in 2018.

**Table 177. 2018 CVR Goals and Achievements[1]**

| Unit | 2018 Actual | 2018 Planning Goal | Percentage of Goal |
|---|---|---|---|
| Residential Program Expenditures | $99,613 | $115,846 | 86% |
| Commercial and Industrial Program Expenditures | $99,613 | $105,894 | 94% |
| **Total** | **$199,226** | **$221,740** | **90%** |

[1] Goals and achievements from Vectren's 2018 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 178 lists the evaluation savings summary for the CVR Program. Because Vectren did not claim savings for the CVR Program in 2018, there is no realization rate for evaluated savings. The program achieved annual energy savings of 887,414 kWh, more than double the electric energy savings compared to 2017 (417,445 kWh in 2017), in part because of more hours of operation in 2018. However, CVR did not operate continuously during either year.

**Table 178. 2018 CVR Electric Savings**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Total kWh | N/A | N/A | N/A | 887,414 | N/A | 100% | 887,414 |
| Total kW | N/A | N/A | N/A | 13.53 | N/A | 100% | 13.53 |

## *Conclusions and Recommendations*

### Program Planning

**Vectren should claim annual savings for CVR for as long as it is implemented.** CVR's energy savings impact is quantified as a percentage of total annual energy usage, so this percentage could be applied to claim savings year over year as long as CVR is active.

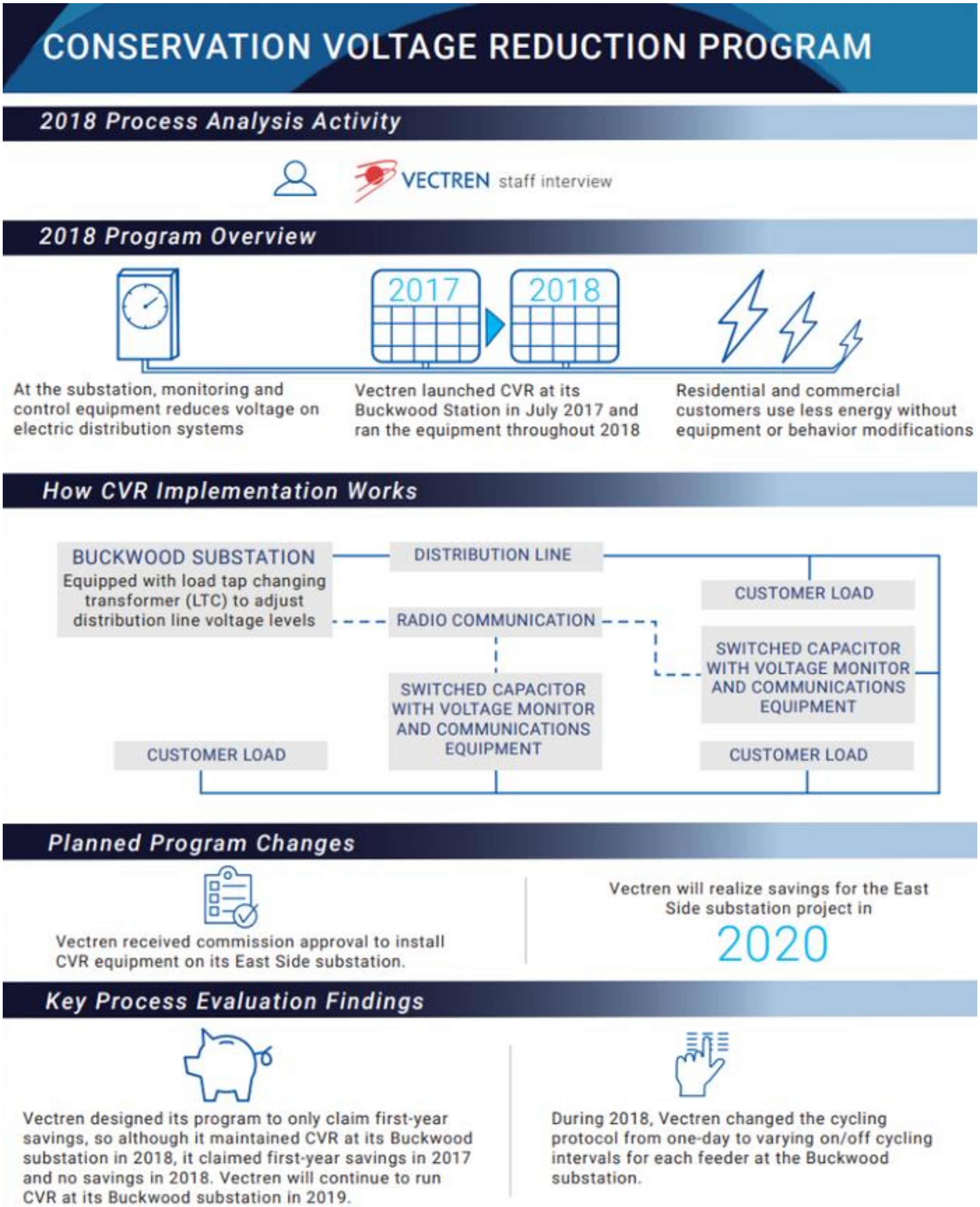
**Recommendation:** Although Vectren designed its program to claim only first-year savings, it should revise this approach to claim annual savings, assuming the utility maintains CVR at its Buckwood substation in future years. Not only can this multiyear approach be used for the Buckwood substation, it can also be used when Vectren implements CVR at its East Side substation in 2020.

### Peak Period Consumption

**Consumption during summer peak periods decreased drastically in 2018 compared to 2017.** When comparing average consumption of each feeder, overall usage during the 2018 summer peak period was much lower than in 2017. During 2018, Vectren changed the cycling protocol for CVR from one-day to varying on/off cycling intervals. Because Vectren cycled on an intermittent basis in 2018, Cadmus could not generate an accurate baseline using 2018 data, instead relying on its baseline model from 2017 to estimate savings. Although Cadmus' model controls for weather anomalies from year to year, Cadmus is not able to control for major changes in consumption. The decrease in consumption equated to a large decrease in program demand reduction.

**Recommendation**: To better isolate peak demand savings and minimize potential effects in savings estimates resulting from changes in consumption on each feeder, perform the alternating on/off cycling of the CVR system at three-day intervals for a complete summer peak period.

## Process Evaluation



# Impact Evaluation

## Impact Evaluation Methods and Findings

The CVR impact evaluation included multiple data collection efforts and analysis tasks:

- Compile dataset of grid-level voltages and power consumption, CVR operational state, and local weather data
- Model demand as a response to temporal and meteorological independent variables for cases when CVR is and is not operational
- Apply models to predict counterfactual power consumption when the CVR system was operational to estimate realized savings. Use models to predict power consumption for all of 2018 to estimate potential for savings if the CVR system was operated continuously.

## Gross Savings Review

Vectren did not claim savings for the CVR Program for 2018. Cadmus estimated savings of 887,414 kWh and peak coincident demand savings of 13.53 kW in 2018. Table 179 provides per-unit annual gross savings for the Buckwood substation. Program savings could be evaluated only as a whole because Cadmus did not receive site-specific data for residential or C&I customers, so unit-level savings are equal to program-level savings.

**Table 179. 2018 CVR Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| Buckwood Substation CVR | N/A | 887,414 | N/A | 13.53 |

CVR is operated separately for each of two pairs of feeders served by the Buckwood substation. During 2018, CVR was active 1,896 hours for two of these feeders (approximately 22% of the year) and active for 4,780 hours for the other two feeders (approximately 55% of the year). Energy and demand savings are only achieved during periods when CVR is active. During peak coincident hours, CVR was active for 191 hours (about 26% of the peak period) for two feeders and 684 hours (about 91%) for the other pair of feeders.

Table 180 lists the evaluated gross per-unit energy savings for the Buckwood substation by year. It is important to note that CVR did not operate continuously in either 2017 or 2018. Additionally, CVR did not operate the same number of hours in either year. CVR can only achieve energy and demand saving when the system is active; therefore, historical comparisons indicate a combination of program performance and hours of operation.

**Table 180. CVR Historical Per-Unit Savings**

| Measure | 2017 | | 2018 | |
|---|---|---|---|---|
| | Annual Hours of Operation | Evaluated Annual Gross Savings (kWh) | Annual Hours of Operation | Evaluated Annual Gross Savings (kWh) |
| Buckwood Substation CVR | 2,322 | 417,445 | 6,676 | 887,414 |

## Measure Verification

CVR was implemented at the Buckwood substation. This single installation had an installation rate of 100%. Table 181 lists the installation rate for the Buckwood substation. In 2017, the CVR Program also had an installation rate of 100%.

**Table 181. 2018 CVR Measure Verification Results – Installation Rates**

| Measure | Installations | | | Installation Rate |
|---|---|---|---|---|
| | Reported | Audited | Verified | |
| Buckwood Substation CVR | 1 | 1 | 1 | 100% |
| **Total** | **1** | **1** | **1** | **100%** |

## Net-to-Gross Analysis

CVR does not experience freeridership because program participants could not have reduced line voltage in the absence of the program. CVR also does not experience spillover because it does not exert a noticeable effect on participants that could influence their behavior. CVR has an assumed 100% NTG ratio.

## Evaluated Net Savings Adjustments

Table 182 and Table 183 list evaluated net savings for the CVR. The program achieved net savings of 887,414 kWh and 13.53 coincident kW demand reduction.

**Table 182. 2018 CVR Electric Savings (kWh)**

| Energy Savings Unit | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rates (kWh) | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Buckwood Substation CVR | N/A | N/A | N/A | 887,414 | N/A | 100% | 887,414 |
| **Total** | N/A | N/A | N/A | **887,414** | N/A | **100%** | **887,414** |

**Table 183. 2018 CVR Demand Reduction (Coincident Peak kW)**

| Energy Savings Unit | *Ex Ante* Savings (Coincident Peak kW) | | | Evaluated *Ex Post* Savings (Coincident Peak kW) | Realization Rates (Coincident Peak kW) | NTG Ratio | Evaluated Net Savings (Coincident Peak kW) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Buckwood Substation CVR | N/A | N/A | N/A | 13.53 | N/A | 100% | 13.53 |
| **Total** | N/A | N/A | N/A | 13.53 | N/A | 100% | 13.53 |

# Appendix A. Impact Evaluation Methodology

Appendix style uses Heading Level 7. Subsequent headings are level 8, level 9, and so on.

## *A.1 Residential Prescriptive Program*

Cadmus' impact evaluation of the Residential Prescriptive Program included measures with attributable electric savings, including these:

- HVAC measures:
  - Air source heat pumps
  - Central air conditioners
  - Ductless heat pumps
  - ECM HVAC motors
- Thermostats:
  - Programmable thermostats
  - Nest thermostats
  - Smart programmable thermostats
  - Wi-Fi thermostats
- Weatherization measures:
  - Attic and wall insulation
  - Duct sealing
- Other measures:
  - Air Purifiers
  - Heat pump water heaters
  - Pool heaters
  - Variable speed pool pumps

The following sections detail the calculations and assumptions used in Cadmus' estimation of gross savings for the Residential Prescriptive Program. For each measure, Cadmus calculated savings for each unit using tracking data then averaged savings across all installations. Table A-1 provides per-unit annual gross savings for each program measure.

**Table A-1. Residential Prescriptive Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| **HVAC** | | | | |
| Air Source HP 16 SEER | 791 | 881 | 0.374 | 0.463 |
| Air Source HP 18 SEER | 1,617 | 1,590 | 0.479 | 0.530 |
| CAC 16 SEER | 300 | 435 | 0.389 | 0.540 |
| CAC 18 SEER | 705 | 666 | 0.710 | 0.577 |
| Dual Fuel Air Source HP 16 SEER | 1,089 | 695 | 0.389 | 0.330 |
| Dual Fuel Air Source HP 18 SEER | 1,499 | 992 | 0.127 | 0.325 |
| Ductless HP 17 SEER 9.5 HSPF | 3,625 | 3,804 | 0.440 | 0.406 |
| Ductless HP 19 SEER 9.5 HSPF | 3,675 | 3,066 | 0.449 | 0.380 |
| Ductless HP 21 SEER 10 HSPF | 3,770 | 2,932 | 0.421 | 0.368 |
| Ductless HP 23 SEER 10 HSPF | 3,788 | 4,306 | 0.342 | 0.711 |
| ECM HVAC Motor | 298 | 301 | 0.115 | 0.051 |
| **Thermostats** | | | | |
| Programmable Thermostats (2017 Carry Over)[2] | 185 | 209 | 0.000 | 0.000 |
| Nest On-Line Store (Dual Fuel) | 378 | 301 | 0.900 | 0.000 |
| Nest On-Line Store (Electric) | 467 | 772 | 0.900 | 0.000 |
| Smart Programmable Thermostat (Dual) | 370 | 299 | 0.000 | 0.000 |
| Smart Programmable Thermostat (Electric) | | 740 | | 0.000 |
| Wi Fi Thermostat | 405 | 295 | 0.000 | 0.000 |
| **Weatherization** | | | | |
| Duct Sealing (Dual Fuel, 2017 Carry Over)[3] | 239 | 218 | 0.401 | 0.382 |
| Attic Insulation (Electric) | 2,625 | 3,019 | 0.327 | 0.103 |
| Attic Insulation (Dual Fuel) | 296 | 304 | 0.274 | 0.464 |
| Wall Insulation (Electric) | 889 | 801 | 0.090 | 0.019 |
| Wall Insulation (Dual Fuel) | 59 | 29 | 0.039 | 0.259 |
| **Other** | | | | |
| Air Purifier | 493 | 681 | 0.056 | 0.078 |
| Heat Pump Water Heater | 2,295 | 2,557 | 0.324 | 0.349 |
| Pool Heater | 971 | 1,266 | 0.000 | 0.000 |
| Variable Speed Pool Pump | 1,220 | 1,173 | 1.716 | 1.716 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.

841 Vectren discontinued programmable thermostats in 2018 due to a market shift to smart and Wi-Fi thermostats. This measure is the result of rebates filed in late 2017 that Vectren processed in early 2018.

841 Vectren discontinued this measure in 2018 to redesign it for reintroduction in 2019. This measure is the result of rebates filed in late 2017 that Vectren processed in early 2018.

## A.1.1 HVAC Measures

### *Air Source Heat Pump, Dual Fuel Heat Pump, and Central Air Conditioner*

Cadmus used these equations to calculate savings per heat pump and central air conditioner installed (excluding ISR):[98]

$$Annual\ kWh\ Savings = [((FLHcool \times BTUH \times (1/SEERbase - 1/SEERnew)))/1000 + ((FLHheat \times BTUH \times (1/HSPFbase - 1/HSPFnew)))/1000]$$

$$Demand\ kW\ Savings = [BTUH \times (1/EERbase - 1/EERnew))/1000 \times CF]$$

Cadmus calculated central air conditioner savings using the following equation:

$$Annual\ kWh\ Savings = [(FLHcool \times BTUH \times (1/SEERbase - 1/SEERnew))/1000]$$

$$Demand\ kW\ Savings = [BTUH \times (1/EERbase - 1/EERnew))/1000 \times CF]$$

Table A-2 shows the inputs Cadmus used to evaluate impacts for these measures.

**Table A-2. Residential Prescriptive Program**
**Heat Pump and Central Air Conditioner Inputs Variables**

| Variable | Value | Units | Source |
| --- | --- | --- | --- |
| $FLHcool$ | 600 | Hours | 2015 Indiana TRM; Evansville |
| $FLHheat$ | 982 | Hours | 2015 Indiana TRM; Evansville |
| $SEERbase$ | 14 ASHP, 13 CAC, 10 Early Replacement | Btu/Watt-hr | Federal standard for ASHPs and CACs. SEER 10 for both ASHP and CAC early replacement installations, as explained in this section. |
| $EERbase$ | 11 Replacement, 9.0 Early Replacement | Btu/Watt-hr | Federal standard for ASHPs and CACs. Early replacement baseline calculated based on 2018 Indiana TRM equation EER = SEER * 0.9 |
| $HSPFbase$ | 8.2 Replacement, 6.8 Early Replacement | Btu/Watt-hr | Federal standard for ASHPs. HSPF 6.8 for ASHP early replacement installations, as explained in this section. |
| CF | 0.88 | decimal | 2015 Indiana TRM |
| $FLHheat$ | 775 | hours | This was a corrected *FLHheat* value for heat pumps installed at a property with gas heating. The assumption was that gas heat will be used as a supplemental heat source; therefore, the heat pump can qualify only for a portion of heating savings. |

Cadmus used output capacity (BTUH), SEER (SEERnew), EER (EERnew), and HSPF (HSPFnew) values of installed equipment from the program data to calculate savings for each installation. For the remaining systems with missing data, Cadmus used average values by measure.

Cadmus assumed that dual fuel gas and electric heat pumps have gas furnaces that supply supplemental heat when outside temperatures fall below 38°F; therefore, all electric only heat pumps received heating and cooling savings while gas and electric heat pumps received all cooling savings and partial

98 These equations are referenced in the 2015 Indiana TRM.

heating savings. To calculate heating savings for dual fuel gas and electric heat pumps, Cadmus ran a bin analysis to adjust the full load hours (FLH) in the 2015 Indiana TRM from 982 to 775 to correct the heat pump run time hours where supplemental gas heat was available.

**Early Replacement Savings**

The program tracking data did distinguish early replacement units, but the field was not consistently populated.[99] Therefore, Cadmus used 2018 Residential Prescriptive Program participant survey data to determine the percentage of customers who had ASHPs or central air conditioners that qualified for early retirement (units were required to be in working order and less than 20 years old). According to these survey data, 26% of all units were early replacement and 74% were replaced on burnout.

The Indiana 2015 TRM does not have a default value for existing unit HSPF, so Cadmus relied on secondary sources to determine the baseline for early replacement units. Cadmus used a 6.8 HSPF and a 10 SEER to calculate early replacement savings. These values were based on ASHP and central air conditioner models and default, age-based values developed by the Residential Energy Services Network (RESNET) for the Mortgage Industry National Home Energy Rating Systems Standards, as shown in Table A-3. The Indiana 2015 TRM does have a default value for existing unit SEER, but Cadmus used the same method for existing unit SEER as for existing unit HSPF to maintain consistency.

**Table A-3. RESNET Default Values for Mechanical System Efficiency by Age**

| Mechanical Systems | Units | Pre-1960 | 1960-1969 | 1970-1974 | 1975-1983 | 1984-1987 | 1988-1991 | 1992 to present |
|---|---|---|---|---|---|---|---|---|
| Air Source Heat Pump | HSPF | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.8 | 6.8 |
| Air Source Heat Pump | SEER | 9 | 9 | 9 | 9 | 9 | 9.4 | 10 |
| Central Air Conditioner | SEER | | | | | | | |

Source: RESNET. Mortgage Industry National Home Energy Rating Systems Standards. Table 303.8.1(3): Default values for Mechanical System Efficiency (Age-Based).
http://www.resnet.us/standards/RESNET_Mortgage_Industry_National_HERS_Standards.pdf

## *Ductless Heat Pump*

DHP measures are broken into four efficiency bins in the Residential Prescriptive Program:

- Ductless heat pump 17 SEER 9.5 HSPF
- Ductless heat pump 19 SEER 9.5 HSPF
- Ductless heat pump 21 SEER 10.0 HSPF
- Ductless heat pump 23 SEER 10.0 HSPF

The 2015 Indiana TRM does not include ductless heat pumps (DHP). For the 2018 evaluation, Cadmus used the Illinois TRM Version 6.0 method for DHPs.

99 Although the field was inconsistently filled out in the program tracking data, preliminary analysis indicated results would be similar to the participant survey results for frequency of early replacement.

Cadmus calculated ductless heat pump savings for all four efficiency bins using these equations (excluding ISR):

$$Annual\ \mathrm{kWh\ Savings} = \Delta\mathrm{kWh}_{\mathrm{HEATING}} + \Delta\mathrm{kWh}_{\mathrm{COOLING}}$$

$$\Delta kW\mathrm{h}_{\mathrm{HEATING}} = \mathrm{Elec}_{\mathrm{Heat}} * \mathrm{Capacity}_{\mathrm{Heat}} * \mathrm{FLH}_{\mathrm{Heat}} * \mathrm{DHP}_{\mathrm{HeatFLH}_{\mathrm{Adjustment}}} * (1/(\mathrm{HSPF\_base}) - 1/(\mathrm{HSPF\_ee}))$$

$$\Delta kW\mathrm{h}_{\mathrm{Cooling}} = \mathrm{Capacity}_{\mathrm{cool}} * \mathrm{FLH}_{\mathrm{Cool}} * \mathrm{DHP}_{\mathrm{CoolFLH}_{\mathrm{Adjustment}}} * \left(\frac{1}{\mathrm{SEER}_{\mathrm{base}}} - \frac{1}{\mathrm{SEER}_{\mathrm{ee}}}\right)$$

$$Demand\ kW\ Savings = \mathrm{Capacity}_{\mathrm{Cool}} \times \frac{\left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right)}{1000} \times CF$$

Table A-4 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-4. Residential Prescriptive Program Ductless Heat Pump Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| $\mathrm{Elec}_{\mathrm{Heat}}$ | 1 | - | Illinois TRM V6.0 |
| $\mathrm{DHP}_{\mathrm{HeatFLH}_{\mathrm{Adjustment}}}$ | 0.73 | - | This adjustment is necessary to accurately calculate the savings for DHP measures using Indiana 2015 TRM FLHs. The Illinois TRM v6.0 has FLHs specific to DHP, which are lower than the FLHs for ASHPs. This adjustment factor is the DHP FLHs divided by the ASHP FLHs from the Illinois TRM. We apply this factor to the Indiana FLHs to get Indiana DHP FLHs. |
| $\mathrm{DHP}_{\mathrm{CoolFLH}_{\mathrm{Adjustment}}}$ | 0.61 | - | This adjustment is necessary to accurately calculate the savings for DHP measures using Indiana 2015 TRM FLHs. The Illinois TRM v6.0 has FLHs specific to DHP, which are lower than the FLHs for ASHPs. This adjustment factor is the DHP FLHs divided by the ASHP FLHs from the Illinois TRM. We apply this factor to the Indiana FLHs to get Indiana DHP FLHs. |
| Factor of 3.412 | 3.412 | kBtu/kWh | Illinois TRM V6.0 |
| FLHcool | 600 | Hours | 2015 Indiana TRM |
| FLHheat | 982 | Hours | 2015 Indiana TRM |
| HSPFbase | 3.412 | Btu/Watt-hr | Assume electric baseboard heat as baseline |
| SEERbase | 13 | Btu/Watt-hr | Illinois TRM V6.0 |
| EERbase | 11 | Btu/Watt-hr | Illinois TRM V6.0 |
| CF | 0.88 | - | 2015 Indiana TRM |

Cadmus used output capacity ($\mathrm{Capacity}_{\mathrm{cool}}$ and $\mathrm{Capacity}_{\mathrm{heat}}$), SEER (SEERee), EER (EERee), and HSPF (HSPFee) values of installed equipment from the program data on a per-installation basis.

### *Electronically Commutated Motor (ECM) HVAC Motor*

The ECM technology reduces energy use by lowering the fan power required to circulate air through a house. One portion of savings comes from reduced fan power during a call for heating and/or cooling, and another portion of savings comes from the reduced fan power required to continuously circulate air through a house with no call for heating or cooling. Cadmus compared the savings to the deemed value in the 2015 Indiana TRM and found that the TRM did not differentiate savings derived from heating/ cooling or continuous circulation.

Like past evaluation years, for 2018 Cadmus applied a methodology from its evaluation of Wisconsin Focus on Energy's deemed savings changes,[100] which used metering data and secondary assumptions to estimate energy savings for ECMs. The study, which directly metered ECMs in residential homes across Wisconsin, provided a detailed methodology to calculate ECM savings during cooling, heating, and circulation events.

Cadmus used these equations to calculate savings per ECM installed (excluding ISR):[101]

$$Annual\ kWh\ Savings = Cooling\ kWh + \ Heating\ kWh + \ Circulation\ kWh$$

$$Cooling\ kWh = FLHcool\ \times\ BTUH\ \times \left(\frac{1}{SEERbase} - \frac{1}{SEERnew}\right) \times \%AC$$

$$Heating\ kWh = HOURSheat\ \times\ \Delta kW_{heat}$$

$$Circulation\ kWh = HOURScirc\ \times\ \Delta kWcirc$$

$$Cooling\ kW\ = FLHcool\ \times\ BTUH\ \times \left(\frac{1}{EERbase} - \frac{1}{EERnew}\right) \times CF \times \%AC$$

Table A-5 shows the inputs Cadmus used to evaluate impacts for this measure. Cadmus used inputs from the 2015 Indiana TRM and Evansville-specific weather data to calculate savings for the ECMs installed, including updates to $FLHcool$, $HOURSheat$, and coincidence factor inputs. Cadmus again defaulted to using the metering inputs and secondary assumptions from the Wisconsin Focus on Energy study to inform the remaining inputs. The methods used to calculate ECM savings in that study accounted for the fact that ECM fan savings depend on the whole HVAC system in which they operate.

**Table A-5. Residential Prescriptive Program ECM Motor Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| $BTUH$ | 36,935 | BTUH | 2018 program tracking data |
| $FLHcool$ | 600 | Hours | 2015 Indiana TRM; Evansville |
| SEERbase | 12.0 | Btu/W-hr | Conservative CAC SEER baseline efficiency from the 2012 Indiana Residential Baseline Report |
| SEERnew | 13.0 | Btu/W-hr | Federal standard |
| EERbase | 10.8 | Btu/W-hr | Conservative CAC SEER baseline efficiency from the 2012 Indiana Residential Baseline Report (SEER = 12).[1] Used 2015 Indiana TRM calculation to determine EER from SEER (EER = SEER * 0.9) |
| EERnew | 11.0 | Btu/W-hr | Federal standard |
| CF | 88% | % | 2015 Indiana TRM |
| %AC | 93% | % | 2018 Residential Prescriptive Program participant survey |

100 Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 14, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

101 These equations are referenced in the 2015 Indiana TRM.

| Variable | Value | Units | Source |
|---|---|---|---|
| $HOURSheat$ | 713 | Hours | Focus on Energy Evaluated Deemed Savings Changes, Nov 2014. Adjusted using HDD ratio between Evansville, Indiana, and Wisconsin. |
| $\Delta kW_{\text{heat}}$ | 0.116 | kW | Focus on Energy Evaluated Deemed Savings Changes, Nov 2014. |
| $HOURScirc$ | 1020 | Hours | Focus on Energy Evaluated Deemed Savings Changes, Nov 2014. |
| $\Delta kWcirc$ | 0.207 | kW | Focus on Energy Evaluated Deemed Savings Changes, Nov 2014. |
| $Cooling\ kWh$ | 104 | kWh | Calculated |
| $Heating\ kWh$ | 83 | kWh | Calculated |
| $Circulation\ kWh$ | 211 | kWh | Calculated |

The 2018 evaluation of ECMs used these three scenarios to determine savings:

- **ECM without program central air conditioner or heat pump.** An ECM fan installed without a program-qualifying central air conditioner or heat pump obtains its savings through reduced fan power during calls for cooling, heating, and when continuously circulating air through a house (without a call for heating or cooling).
- **ECM with program central air conditioner.** An ECM fan installed with a program-qualifying central air conditioner obtains its savings through a reduced fan power during calls for heating as well as when called to continuously circulate air through a house (without a call for heating/cooling). It does not receive cooling savings because these savings have already been incorporated in the central air conditioner savings calculations.
- **ECM with program heat pump.** An ECM fan installed with a program-qualifying heat pump obtains its savings when called to continuously circulate air through a house (without a call for heating/cooling). It does not receive heating or cooling savings as these savings have already been incorporated in the heat pump savings calculation.

## A.1.2 Thermostat Measures

### *Programmable Thermostat*

Cadmus calculated programmable thermostat (non-learning) savings using the following equations (excluding ISR):[102]

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{HEAT} * \left(\frac{Saturation_{HP}}{\eta_{HEAT\ PUMP}} + \frac{Saturation_{ER}}{\eta_{ER}}\right) * Correct\ Use\ Factor\_Heat$$

$$\Delta kWh_{Cooling} = \Delta Cooling * Correct\ Use\ Factor\_Cool * \%AC$$

102 These equations modify savings reported in Vectren's *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program*. Cadmus prefers this method because the results of this study are more applicable to Vectren's customers than the 2015 Indiana TRM methodology.

$$Demand\ kW\ Savings = \Delta kWh_{COOLING}/FLH_{COOL} * CF$$

Table A-6 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-6. Residential Prescriptive Program Programmable Thermostat Input Variables**

| Variable | Value | Source |
|---|---|---|
| Δcooling | 332 kWh/unit | Vectren 2013–2014 Programmable and Smart Thermostat Program evaluation |
| FLH_COOL | 600 Hours | 2015 Indiana TRM |
| FLH_HEAT | 982 Hours | 2015 Indiana TRM |
| BTUH_HEAT | 33,700 BTUH | From 2018 Residential Prescriptive Program heat pump installation data |
| ESF_HEAT | 5% | Vectren 2013–2014 Programmable and Smart Thermostat Program evaluation |
| Correct Use Factor_Heat | 57% | 2018 Residential Prescriptive participant Survey |
| Correct Use Factor_Cool | 61% | 2018 Residential Prescriptive participant Survey |
| Saturation_HP | 6% | 2018 Residential Prescriptive participant survey |
| Saturation_GAS | 93% | 2018 Residential Prescriptive participant survey |
| Saturation_ER | 1% | 2018 Residential Prescriptive participant survey |
| CF | 0% | 2015 Indiana TRM |
| % AC | 93% | 2018 Residential Prescriptive participant survey |
| η_ER | 3.412 Btu/Watt-hr | 2015 Indiana TRM |
| η_(HEAT PUMP) | 8.2 Btu/Watt-hr | Federal standard |

Cadmus obtained the unit energy savings for the thermostat measure by calculating the savings for each installation in the tracking database and averaging the results. The tracking data included the HVAC equipment type for many installations. Installations with gas furnace equipment achieved no electric heating savings. Installations with no heating equipment information received electric savings based on equipment saturation (93% gas and 7% electric) derived from the 2018 Residential Prescriptive Program participant survey.

Cadmus used heat pump and electrical resistance saturations for the electric heating savings calculation and applied the heat pump and electrical resistance heat efficiencies from the 2015 Indiana TRM. Cadmus used the average heat pump capacity from the program tracking database for $BTUH_{HEAT}$ in the electric heating savings calculation.

Cadmus' analysis also used the results of the 2013–2014 evaluation of programmable and smart thermostats in Vectren's South Indiana territory,[103] which reports cooling electricity savings of 332 kWh for programmable thermostats. A bias inherent in this study is that participants were trained in the proper use of their thermostats.[104,105] In the 2018 Residential Prescriptive Program survey, Cadmus

[103] Cadmus. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* January 29, 2015.

[104] Cadmus assumed that a trained user will always program his/her thermostat in an energy-saving manner.

asked participants a series of questions to determine the correct usage rate for programmable thermostats and found 57% for heating and 61% for cooling. Table A-7 shows the survey questions, results, and sample size for the programmable thermostat correct use factors.

**Table A-7. Programmable Thermostat Correct Use Survey Results**

| Survey Question | Positive Response Rate | n |
|---|---|---|
| **Determining Energy Savings Usage** | | |
| During cold months, is the thermostat programmed to lower the temperature at night, while you are asleep? | 57% | 87 |
| During the summer, is the thermostat programmed to a higher temperature during the day, while you are away? | 61% | 87 |

## *Nest Online, Smart Programmable, and Wi-Fi Thermostats*

Vectren's Residential Prescriptive Program has three types of Wi-Fi-enabled thermostat measures:

- Nest Online Store (learning)[106]
- Smart programmable thermostats (mostly learning)
- Wi-Fi thermostats (mostly non-learning)

Cadmus calculated smart programmable, Nest, and Wi-Fi thermostat savings using the following equations (excluding ISR).

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{\%_{HEAT\ PUMP}}{\eta_{HEAT\ PUMP} * 3412} + \frac{\%_{ER}}{\eta_{ER} * 3412}\right) * TStat\_Type_{Adjustment}$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline} * TStat_{Type_{COOLING_{DiscountRate}}} * \%AC$$

105 The evaluation refers to two other studies that found that only 47% and 56% of programmable thermostats are programmed in an energy-saving manner. The 47% was taken from this study: Meier, A., et al. (Lawrence Berkeley National Laboratory and University of California Davis). "How People Actually Use Thermostats." Presented at American Council for an Energy Efficient Economy proceedings, Pacific Grove, California, August 15–20, 2010. The 56% was taken from this study: GDS Associates. *Programmable Thermostats.* Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness. 2002.

106 Examples of learning Wi-Fi-enabled thermostats are all Nest thermostats, Ecobee3, and Honeywell Lyric, which all have advanced features that can attribute to higher savings. These features include occupancy detection, heat pump lockout temperature control, upstaging and downstaging, optimal humidity/humidity control/air conditioner overcool, fan dissipation, behavioral features, and free cooling/economizer capability.

Cadmus used the same savings methodology for all three categories of thermostats, although the savings differ significantly because of differences in the proportion of learning and non-learning thermostats in each category.[107] Table A-8 shows the inputs Cadmus used to evaluate impacts for this measure.

Cadmus applied savings to installations with defined heating or cooling equipment for that equipment type. For installations with no defined equipment type, Cadmus applied partial electric and gas savings based on the equipment saturations of existing heating equipment reported in Table A-8. Cadmus used the average heat pump capacity from the tracking database for the BTUH capacity in the electric heating savings calculation. Cadmus used a heat pump efficiency of 2.40 based on the federal standard and an electric resistance efficiency of 1.0 from the 2015 Indiana TRM.

**Table A-8. Residential Prescriptive Program Smart Programmable Thermostats Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| $\eta_{HEAT\ PUMP}$ | 2.40 | - | Federal standard |
| $\eta_{ER}$ | 1.0 | - | 2015 Indiana TRM |
| $FLH_{HEAT}$ | 982 | Hours | 2015 Indiana TRM; Evansville, Indiana |
| $BTUH_{HEAT}$ | 33,700 | BTUH | Average of 2018 VEDI Evaluation heat pump tracking data capacities. |
| $\%_{HEAT\ PUMP}$ | 6% | % | 2018 Residential Prescriptive Program participant survey |
| $\%_{GAS}$ | 93% | % | 2018 Residential Prescriptive Program participant survey |
| $\%_{ER}$ | 1% | % | 2018 Residential Prescriptive Program participant survey |
| Manual thermostat saturation | 27% | % | 2018 Residential Prescriptive Program participant survey |
| Programmable thermostat saturation | 73% | % | 2018 Residential Prescriptive Program participant survey |
| $TStat\_Type_{\mathrm{DiscountRate}}$ | 31% non-learning 100% learning | % | The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. |
| $TStat\_Type_{COOLING\ Disco}$ | 100% | % | No cooling savings adjustment can be directly derived from the comparative of study smart Wi-Fi thermostats. Cadmus is not comfortable discounting products without direct supporting evidence. The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. |
| $ESF_{AdjustedBaseline_{HEAT}}$ | 10.42% | % | Calculated, example below |
| $\%AC$ | 93% | % | 2018 Residential Prescriptive Program participant survey |
| $\Delta Cooling_{AdjustedBaselin}$ | 263 | kWh | Calculated, example below |

107 Cadmus reviewed thermostat capabilities using model numbers to determine whether if the thermostat was learning or non-learning.

**2013–2014 Thermostat Evaluation and Adjusted Baseline**

Cadmus' analysis of smart programmable thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren's Indiana South territory.[108] This evaluation reports household cooling energy savings of 332 kWh and a household heating energy saving factor (ESF) of 5% for programmable thermostats. It reports household cooling energy savings of 429 kWh and a household heating ESF of 12.5% for Nest Wi-Fi thermostats.

This study used a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2018 Residential Prescriptive Program participant survey indicated that the saturation was 27% for manual thermostats and 73% for programmable thermostats.

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2014 Cadmus thermostat study and a weighted average to adjust the savings for Nest thermostats from a manual thermostat baseline to a mixed manual and programmable thermostat baseline.

Cadmus used these equations:[109]

$$\Delta Cooling_{AdjustedBaseline} = [27\% * 429 + 73\% * (429 - 201.6)] * 93\% = 263\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 27\% * 12.5\% + 73\% * (12.5\% - 2.86\%) = 10.42\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 201.6 represents the cooling savings (332 kWh multiplied by 61% correct use factor) for programmable thermostats. Cadmus did equivalent calculations to obtain adjusted baseline values for ESF-heat. The 2013–2014 thermostat evaluation investigated only homes with gas heating, so Cadmus assumed that the percentage of gas savings from that evaluation apply to electric heat as well.

**Learning and Non-Learning Wi-Fi Thermostats**

Although the 2014 thermostat evaluation concerned Nest Wi-Fi thermostats only, the Residential Prescriptive Program's tracking data recorded many more models of Wi-Fi thermostats. According to a Cadmus 2015 study,[110] there is a significant difference in savings between Nest Wi-Fi thermostats and other Wi-Fi thermostats; this study yielded a heating savings discount rate of 31% for non-Nest Wi-Fi thermostats. Cadmus' 2016 Vectren Smart Thermostat Pilot evaluation results supported this conclusion.[111] However, no cooling savings adjustment can be directly derived from this comparative study because the result was not statistically different than 0%.

---

[108] Cadmus. January 29, 2015. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.*

[109] Ibid.

[110] Cadmus conducted an evaluation of thermostats for a Midwest utility, but the report is not publicly available.

[111] Cadmus. August 8, 2017. *Vectren Residential Smart Thermostat Program 2016 Energy Savings Analysis.*

The Vectren 2013–2014 Programmable and Smart Thermostat Program Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. Heating savings are 5% for programmable thermostats and 12.5% for smart Wi-Fi thermostats, and cooling savings are 13.1% for programmable thermostats and 13.9% for smart Wi-Fi thermostats. Cadmus did not discount specific name brands without direct supporting evidence and instead took a features-based approach. Cadmus determined if each thermostat in the tracking data exhibited learning features. For the 2018 evaluation, Cadmus applied the 31% discount rate to the heating savings of all non-learning thermostat installations.

Vectren's thermostat offerings for 2018 aligned with this evaluation approach by segmenting Wi-Fi-enabled thermostats into three separate thermostat measures: Nest, smart programmable, and Wi-Fi thermostats. Nest thermostats are all learning thermostats, so Cadmus did not apply the 31% discount rate to the heating savings. Cadmus found that thermostats rebated through the smart programmable thermostats measure were overwhelmingly learning thermostats, which meant applying the 31% discount to only a handful of thermostats determined to be non-learning for this measure. Cadmus found that thermostats rebated through the Wi-Fi thermostats measure were overwhelmingly non-learning, which meant applying the 31% to all but a handful of thermostats for this measure. All differences in savings between these thermostat variants are because of the proportion of learning thermostats in each thermostat measure.

## A.1.3 Weatherization Measures

### *Attic and Wall Insulation*

This algorithm from the 2015 Indiana TRM served as the basis to calculate and verify energy saving (excluding ISR):

$$Annual\ (Energy\ or\ Demand)\ Savings\ =\ kSF\ x\ \frac{(Energy\ or\ Demand)\ Savings}{kSF}$$

Where:

kSF = Area of installed insulation (1,000 square feet)

= Actual installed

$\frac{(Energy\ or\ Demand)\ Savings}{kSF}$ = Unit energy or demand savings per 1,000 square feet of insulation. Dependent on recorded pre-and post R-value conditions. kWh/kSF or kW/kSF.

Energy and demand savings (kWh/kSF, kW/kSF) differed based on heating, cooling, and measure type using a series of look-up tables in the 2015 Indiana TRM. Table A-9 shows savings scenarios by measure and equipment type.

**Table A-9. Residential Prescriptive Program Equipment Scenarios by Measure**

| Equipment Scenarios | | | |
|---|---|---|---|
| Variable | Value | Units | Source |
| Heat pump | Heat pump | Gas furnace with A/C | Gas furnace with A/C |
| Electric heat with A/C | Electric heat with A/C | Gas furnace without A/C | Gas furnace without A/C |
| Electric heat without A/C | Electric heat without A/C | - | - |

Energy savings per installation depended on pre- and post-retrofit insulation R-values, which Cadmus calculated using a three-step process. For the few cases where these R-values were not recorded in the tracking database, Cadmus used the average pre- and post-retrofit value for calculating savings, following these steps:

1. Determine variables to use for insulation compression, $R_{ratio}$, and void factors.
2. Calculate adjusted pre- and post-retrofit R-values using the inputs from step one.
3. Interpolate the 2015 Indiana TRM tables to calculate savings using the adjusted R-values from step two.

**Variables to Use for Insulation Compression, $R_{ratio}$, and Void Factors.**

Cadmus adjusted R-values to account for compression, void factors, and surrounding building material. To calculate these adjusted pre- and post-retrofit R-values, Cadmus used this formula:

$$R\ value\ Adjusted\ = R_{nominal}\ x\ F_{compression}\ x\ F_{void}$$

Where:

$R_{nominal}$ = Actual pre- and post-retrofit R-values per manufacturing specifications.

$F_{compression}$ = Compression factor dependent on the percentage of insulation compression. Cadmus assumed a value of 1 at 0% compression for the evaluation.

$F_{void}$ = Void factor, which accounted for insulation coverage and was dependent on installation grade level, pre- and post-retrofit R-values and compression effects.

This equation determined $F_{void}$:

$$R_{ratio} = (R_{nominal}\ x\ F_{compression})x\ ((R_{nominal}\ x\ R_{framing\ and\ air\ space}))$$

Where:

$R_{nominal}$ = As stated above.

$F_{compression}$ = As stated above.

$R_{framing/airspace}$ = R-value for material, framing, and air space of the installed insulation's surrounding area. Cadmus used R-5 for this evaluation, as recommended in the 2015 Indiana TRM.

Table A-10 lists the void factor based on the calculated $R_{ratio}$. Cadmus used 2% as a conservative assumption since this information was unknown.

**Table A-10. Indiana TRM: Insulation Void Factors**

| $R_{ratio}$ | Void Factor | |
|---|---|---|
| | 2% Void (Grade II) | 5% Void (Grade III) |
| 0.5 | 0.96 | 0.9 |
| 0.55 | 0.96 | 0.9 |
| 0.6 | 0.95 | 0.88 |
| 0.65 | 0.94 | 0.87 |
| 0.7 | 0.94 | 0.85 |
| 0.75 | 0.92 | 0.83 |
| 0.8 | 0.91 | 0.79 |
| 0.85 | 0.88 | 0.74 |
| 0.9 | 0.83 | 0.66 |
| 0.95 | 0.71 | 0.49 |
| 0.99 | 0.33 | 0.16 |

**Adjusted R-values**

Applying the formula above ($R_{value}$ Adjusted), Cadmus used the inputs defined in step one to calculate R-adjusted values for pre- and post-installation and calculated adjusted R-values for every insulation installation in the database.

**Interpolate Indiana TRM Tables**

Cadmus used the pre- and post-installation adjusted R-values from step two to interpolate energy and demand for every 2018 insulation installation. Appendix C of the 2015 Indiana TRM v2.2 defines energy and demand savings for insulation measures by heating and cooling equipment.

Cadmus based its assumptions on data collected in the 2018 Residential Prescriptive Program participant survey, which found that the saturation of central cooling equipment was 93%, of heat pumps was 85%, of electric furnaces was 15%, and of electric baseboard was 0%.[112] Cadmus adjusted the ducted savings by a duct efficiency of 76%. Finally, Cadmus calculated demand savings using a 0.88 coincidence factor from the 2015 Indiana TRM for central air conditioners and cooling heat pumps.

### *Duct Sealing*

The Residential Prescriptive Program has a ‘gas heating with air conditioner’ duct sealing measure. Because a central air conditioner was not a requirement to obtain the rebate, Cadmus assumed 93% of the homes with gas heating had a central air conditioner based on results from the 2018 Residential Prescriptive Program participant survey.

[112] Cadmus normalized electric heating saturations to sum to 100% (excluding gas heating) for the all-electric insulation measures.

Cadmus calculated savings for the duct sealing measure using the following equations (excluding ISR):

$$Annual\ Cooling\ kWh\ Savings = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * EFLH_{COOL} * \frac{Btuh_{COOL}}{SEER * 1{,}000}$$

$$Annual\ Heating\ kWh\ Savings = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * EFLH_{HEAT} * \frac{Btuh_{HEAT}}{3{,}412\ *\ \eta_{HEAT}}$$

$$Demand\ kW\ Savings = \frac{DEPK_{AFTER} - DEPK_{BEFORE}}{DEPK_{AFTER}} * \frac{Btuh_{COOL}}{EER * 1{,}000} * CF$$

Because program-specific information was not available regarding pre-existing conditions, to determine $DE_{before}$ Cadmus used the average distribution efficiency for cases between no observable leaks and catastrophic leaks as a conservative assumption. Cadmus used the 2015 Indiana TRM to determine the $DEPK_{BEFORE}$ and $DEPK_{AFTER}$ values for the appropriate $DE_{before}$ and $DE_{after}$ values.

Cadmus used program data to determine average heating and cooling system capacities. Table A-11 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-11. Residential Prescriptive Program Duct Sealing Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| $DE_{AFTER}$ | Distribution efficiency of ductwork after dealing sealing | 87% | Used the following reference (listed in the 2015 Indiana TRM): http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf Percentage of ducts within conditioned space was unknown. Assumed the average of all potential values under “Connections Sealed with Mastic.” |
| $DE_{BEFORE}$ | Distribution efficiency of ductwork before dealing sealing | 76% | Used the following reference (listed in the 2015 Indiana TRM): http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf Percentage of ducts within conditioned space was unknown. Assumed the average of all potential values under “No Observational Leaks,” “Some Observed Leaks,” “Significant Leaks,” and “Catastrophic Leaks.” |
| $DEPK_{AFTER}$ | DE for use in peak demand savings | 85% | 2015 Indiana TRM |
| $DEPK_{BEFORE}$ | DE for use in peak demand savings | 73% | 2015 Indiana TRM |
| $EFLH_{HEAT}$ | Full-load heating hours | 1,341; 982 | 2015 Indiana TRM for Indianapolis and Evansville |
| $EFLH_{COOL}$ | Full-load cooling hours | 600 | 2015 Indiana TRM for Evansville |
| $Btuh_{COOL}$ | Cooling system capacity | 36,935 BTUH | 2018 program tracking data |
| SEER | Efficiency of cooling system | 12 | Conservative CAC SEER baseline efficiency from the 2012 Indiana Residential Baseline Report |
| EER | Efficiency of cooling system | 10.8 | Conservative CAC SEER baseline efficiency from the 2012 Indiana Residential Baseline Report* (SEER = 12). Used 2015 Indiana TRM calculation to determine EER from SEER (EER = SEER * 0.9) |

## A.1.4 Other Measures

### *Air Purifier*

Cadmus calculated air purifier savings using the following equations (excluding ISR): [113]

$$Annual\ kWh\ Savings = kWh_{BASE} - kWh_{ESTAR}$$

$$Demand\ kW\ Savings = \frac{Annual\ kWh\ Savings}{Hours} * CF$$

Table A-12 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-12. Residential Prescriptive Program Air Purifier Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| CF | 66.7% | - | 2018 Iowa TRM |
| Hours | 5,844 | Hours | 2018 Iowa TRM |

The Indiana 2015 TRM does not have an air purifier measure, so Cadmus used the 2018 Iowa TRM. This method uses the ENERGY STAR air purifier calculator to determine kWh_BASE and kWh_ESTAR for different clean air delivery rate (CADR), as shown in Table A-13. The tracking data did not include equipment CADR, so Cadmus used the ENERGY STAR-qualified products list to get a weighted average energy savings for air purifiers, also shown in this table.[114]

**Table A-13. Air Purifier Baseline and ESTAR Consumption**

| Clean Air Delivery Rate (CADR) | CADR used in calculation (midpoint) | $kWh_{BASE}$ (kWh/year) | $kWh_{ESTAR}$ (kWh/year) | ΔkWh | Weight (from QPL)[1] |
|---|---|---|---|---|---|
| CADR 51-100 | 75 | 441 | 148 | 293 | 13% |
| CADR 101-150 | 125 | 733 | 245 | 488 | 32% |
| CADR 151-200 | 175 | 1025 | 342 | 683 | 22% |
| CADR 201-250 | 225 | 1317 | 440 | 877 | 10% |
| CADR Over 250 | 300 | 1755 | 586 | 1169 | 22% |

[1] Weights do not sum to 100% due to small number of ENERGY STAR air purifiers from the qualified products list that have CADR <50.

113 These equations are referenced in the 2018 Iowa TRM.

114 ENERGY STAR. “Find and Compare Products: Room Air Cleaners.” Accessed online 2019. https://www.energystar.gov/productfinder/product/certified-room-air-cleaners/results

### Heat Pump Water Heater

Cadmus calculated heat pump water heater (HPWH) savings using the following equations (excluding ISR):[115]

$$Annual\ kWh\ Savings = kWh_{BASE} * \frac{COP_{NEW} - COP_{Base}}{COP_{New}} + (kWh_{COOLING} - kWh_{HEATING}) * \%\_Units\_In\_Conditioned\_Space$$

$$kWh_{HEATING} = kWh_{ER} * Saturation_{ER} + kWh_{HP} * Saturation_{HP} + kWh_{GAS} * Saturation_{GAS}$$

$$Demand\ kW\ Savings = \frac{Annual\ kWh\ Savings}{Hours} * CF$$

Table A-14 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-14. Residential Prescriptive Program Heat Pump Water Heater Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| kWh_BASE | 3,460 | kWh | 2015 Indiana TRM |
| COP_BASE | 0.945 | - | Federal standard |
| kWh_COOLING | 180 | kWh | 2015 Indiana TRM |
| CF | 34.6% | - | 2015 Indiana TRM |
| Hours | 2,533 | Hours | 2015 Indiana TRM |
| kWh_ER | 1,577 | kWh | 2015 Indiana TRM |
| kWh_HP | 779 | kWh | 2015 Indiana TRM |
| kWh_GAS | 0 | kWh | 2015 Indiana TRM |
| Saturation_HP | 6% | % | 2018 Residential Prescriptive participant survey |
| Saturation_GAS | 93% | % | 2018 Residential Prescriptive participant survey |
| Saturation_ER | 1% | % | 2018 Residential Prescriptive participant survey |
| %_Units_In_Conditioned_Space | 25% | % | 2018 Residential Prescriptive participant survey |
| kWh_HEATING | 66 | kWh | Weighted average calculation |

Cadmus obtained the unit energy savings for HPWHs by calculating the savings for each installation in the tracking database and averaging the results. Cadmus used assumptions from the 2015 Indiana TRM for all values except $\mathrm{COP_{NEW}}$ and $\mathrm{kWh_{HEATING}}$. Cadmus used actual HPWH model specifications for $\mathrm{COP_{NEW}}$ and a weighted average of heating equipment saturations and deemed kWh savings to determine $\mathrm{kWh_{HEATING}}$ using the 2015 Indiana TRM.

Cadmus used the federal standard coefficient of performance (COP) for <55 gallon electric storage water heaters because the storage capacity of HPWHs is larger for the same water heating load than for

[115] These equations are referenced in the 2015 Indiana TRM.

non-HPWHs. Cadmus assumed the baseline was a 50-gallon water heater to represent the typical electric storage water heater load, regardless of the HPWH tank size.

### *Variable Speed Pool Pump*

Cadmus used these equations to calculate savings per variable speed pool pump installed (excluding ISR):[116]

$$Annual\ kWh\ Savings = HP * LF * \frac{0.746}{\eta Pump} * \frac{Hrs}{day} * \frac{Days}{yr} * ESF$$

$$Annual\ kW\ Savings = HP * LF * \frac{0.746}{\eta Pump} * CF * DSF$$

Table A-15 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-15. Residential Prescriptive Program Variable Speed Pool Pump Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| HP – Horsepower | 1.5 | hp | Default baseline horsepower from the 2015 Indiana TRM |
| LF – Load factor | 0.66 | Decimal | 2015 Indiana TRM; First Energy, Residential Swimming Pool Pumps memo |
| ηPump | 0.325 | Decimal | 2015 Indiana TRM; First Energy; Residential Swimming Pool Pumps memo |
| Hrs/day | 6 | Hrs/day | 2015 Indiana TRM; Consortium for Energy Efficiency; Pool Pump Exploration Memo, June 2009 |
| Days/yr | 100 | Days/yr | 2015 Indiana TRM. Assumes pool operation from Memorial Day to Labor Day |
| ESF (energy savings factor) | 86% | % | 2015 Indiana TRM; First Energy; Residential Swimming Pool Pumps memo |
| CF | 83% | % | 2015 Indiana TRM; Efficiency Vermont, TRM August, 9, 2013. Coincidence factor based on market feedback about typical run pattern for pool pumps, which revealed that most people run pump during the day and set timer to turn pump off during the night. |
| DSF (demand savings factor) | 91% | % | 2015 Indiana TRM; First Energy, Residential Swimming Pool Pumps memo |

Additionally, a federal standard requiring pool pumps to be variable speed is expected to come into effect in 2021. Although this federal standard is still a few years off, Cadmus recommends Vectren continue to follow the upcoming change and be prepared to discontinue offering the variable speed pool pump starting in 2021.

[116] These equations are referenced in the 2015 Indiana TRM.

### Pool Heater

Cadmus used the following equations to calculate savings per pool heater installed (excluding ISR):

$$Annual\ kWh\ Savings = \left(kWh\ Consumption * \frac{COP_{Assumed}}{COP_{base}} - kWh\ Consumption * \frac{COP_{Assumed}}{COP_{ee}}\right) * \left(\frac{Hrs_{Evansville}}{Hrs_{Chicago}}\right)$$

$$kWh\ Consumption = \frac{Cost_{OPERATION}}{Year} * Price_{ELECTRICITY}$$

$$Annual\ kW\ Savings = There\ are\ no\ peak\ demand\ savings\ for\ this\ measure$$

Table A-16 shows the inputs Cadmus used to evaluate impacts for this measure.

**Table A-16. Residential Prescriptive Program Pool Heater Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| COP_Assumed | 5.0 | unitless | Energy.gov. "Heat Pump Swimming Pool Heaters." http://energy.gov/energysaver/heat-pump-swimming-pool-heaters |
| COP_base | 5.2 | unitless | engineering assumption, based on available models in Air Conditioning, Heating, & Refrigeration Institute (AHRI) catalogue |
| kWh Consumption | 12,176 | kWh/yr | Calculated from equation, above |
| Hrs_Chicago: Hrs June-Sep temp below 80F | 1,884 | Hours | Typical Meteorological Year 3 (TMY3) bin data |
| Hrs_Evansville/: Hrs June-Sep temp below 80F | 1,514 | Hours | Typical Meteorological Year 3 (TMY3) bin data |
| (Cost_OPERATION)/Year: Cost to operate a pool in Chicago per year | 1,035 | $/yr | Energy.gov. "Heat Pump Swimming Pool Heaters." http://energy.gov/energysaver/heat-pump-swimming-pool-heaters |
| Price_ELECTRICITY | 0.085 | $/kWh | Energy.gov. "Heat Pump Swimming Pool Heaters." http://energy.gov/energysaver/heat-pump-swimming-pool-heaters |

Cadmus used heat pump pool heater calculations from the U.S. Department of Energy to derive the average heating energy consumption for a residential pool in Chicago.[117] Cadmus adjusted this value for weather in Evansville, Indiana, using the ratio of the number of hours every June through September (assuming pools are operated for 100 days[118]) that the outside air temperature is below 80°F in Evansville compared to Chicago.[119] This ratio is 80% (1,514 hours divided by 1,884 hours). Cadmus' calculations assumed a $COP_{Assumed}$ of 5.0, a pool area of 1,000 square feet, a temperature setpoint of 80°F, and a cost of 0.085 $/kWh.

---

117 The U.S. Department of Energy provides values only for large cities and Chicago is the closest city to Vectren's Indiana territory. ENERGY STAR. "Heat Pump Swimming Pool Heaters." http://energy.gov/energysaver/heat-pump-swimming-pool-heaters.

118 The 2015 Indiana TRM assumes pool operation from Memorial Day to Labor Day.

119 TMY3 bin data for Chicago, Illinois, and Evansville, Indiana.

## A.2 Residential New Construction Program

Cadmus' impact evaluation of the RNC Program included homes with attributable electric savings, including the following:

- Gold Star Homes (dual fuel)
- Gold Star Electric Only Homes (electric heat)
- Platinum Star Homes (dual fuel)
- Platinum Star Electric Only Homes (electric heat)

Table A-17 provides per-unit annual gross savings for each program measure.

**Table A-17. Residential New Construction Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| Gold Star (Dual Fuel) | 2,020 | 1,033 | 1.2 | 0.4 |
| Gold Star (Electric Only) | 7,624 | 3,900 | 1.5 | 0.5 |
| Platinum Star (Dual Fuel) | 2,236 | 1,144 | 1.7 | 0.5 |
| Platinum Star (Electric Only) | 9,763 | 4,995 | 1.5 | 0.6 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.

### A.2.1 Gold and Platinum Star Homes

As in 2017, Cadmus evaluated gross savings for RNC Program homes by drawing a random sample of builder applications from 2018 participants and recording critical home data, such as square footage, insulation levels, and HVAC efficiencies from HERS certificates. Cadmus modeled program home savings for this sample using the REM/Rate data then applied the sample's realization rate to the overall deemed program savings to estimate *ex post* program per-unit and program-level savings.

Cadmus developed energy models using REM/Rate V15.7.1 to evaluate the electric savings of the homes built under program requirements and found that savings were lower than the *ex ante* savings (derived from evaluated savings from 2016).[120]

Program homes had an average HERS score of 60—three points better than the program requirement of 63—which builders achieved through high-efficiency lighting, tight building envelopes, sealed duct systems, and efficient windows.[121] Measures found in participant homes were very similar to 2015, 2016, and 2017. However, in 2017 and 2018 homes were smaller, averaging 2,300 square feet compared

[120] REM/Rate V15.7.1 was released in August 2018.

[121] The lower the HERS score, the higher the efficiency of the home.

to 3,200 square feet in 2016. Smaller homes generally achieve lower energy savings because the baseline and efficient consumption of a smaller home is less.

Cadmus reviewed 52 random REM/Rate and Ekotrope-generated HERS reports.[122] Based on these reports, Cadmus compiled the homes' characteristics, such as insulation levels and square footage, into a database for energy modeling. Characteristics for 2015 and 2016 were based on a sample of 30 homes. In 2018, Cadmus drew a sample of 52 homes. Table A-18 shows the sample of the 2018 homes.

**Table A-18. 2018 Residential New Construction Program Homes Sample**

| Measure | 2018 Participants | Sample |
|---|---|---|
| Gold Star (Dual Fuel) | 91 | 33 |
| Platinum Star (Dual Fuel) | 52 | 19 |

Table A-19 presents the average home characteristics from 2015 to 2018, as well as sample sizes and precision estimates. Since 2015, the typical characteristics of program homes have become more energy-efficient with noticeable improvements in home tightness and insulation. Heating and cooling equipment and lighting efficiencies, however, varied across program years. For example, 2015 homes had more efficient cooling systems than homes in 2016, with cooling system efficiency increasing again in 2017 and 2018. Homes in 2018 contained the most efficient lighting and the most efficient windows. For several home characteristics, such as insulation and duct tightness, program homes were slightly less efficient in 2018 than in 2017.

**Table A-19. 2015-2018 Residential New Construction Program Home Characteristics**

| Home Characteristic | Program Year[1] | | | | Changes in Program Home Characteristics from 2017 |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | |
| Sample Size | 30 | 30 | 46 | 52 | Slight increase in sample size |
| Participants | 124 | 128 | 171 | 145 | Slight decrease in participants |
| Precision at 90% Confidence[2] | 14% | 13% | 11% | 10% | Slight increase in precision |
| Home Size | 2,431 | 3,191 | 2,279 | 2,268 | Slight decrease in home size |
| Ceiling R Value | 38 | 40 | 39 | 38 | Slight decrease in insulation |
| Walls R Value | 15 | 15 | 15.3 | 14.8 | Slight decrease in insulation |
| Floors R Value | 32 | 37 | N/A | N/A | N/A |
| Basement Wall R Value | 10 | 11 | N/A | 10.2 | N/A |

[122] Home energy raters used either the Ekotrope and REM/Rate software to generate HERS scores. Cadmus requested 65 HERS certificates but 13 of these could not be reviewed because the certificates were not legible or were produced in a non-standard format that did not contain home characteristics information. Neither of HERS certificates for the electrically heated homes were legible so they could not be included in the modeling analysis.

| Home Characteristic | Program Year[1] | | | | Changes in Program Home Characteristics from 2017 |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | |
| Slab Edge R Value | 5 | 8 | 8 | N/A | N/A |
| Crawlspace Wall R Value | 11 | 11 | 12 | 11 | Sight decrease in insulation level |
| Windows U Value[3] | 0.302 | 0.302 | 0.302 | 0.295 | Slight increase in window efficiency |
| Home Tightness ACH50[3] | 3.92 | 3.42 | 3.13 | 3.04 | Slight increase in home tightness |
| Duct Tightness CFM25/100 sq. ft.[3] | 3.42 | 2.82 | 2.27 | 2.69 | Slight decrease in duct tightness |
| Furnace AFUE | 94 | 93 | 94 | 94 | None |
| Air Conditioner SEER | 14.3 | 13.5 | 14.4 | 14.4 | None |
| Percentage High-Efficiency Lighting | 69% | 81% | 76% | 86% | Higher percentage of high-efficiency bulbs |
| Gas Water Heat Energy Factor | 0.9 | 0.87 | 0.85 | 0.88 | Slight increase in gas water heater efficiency |
| Electric Water Heat Energy Factor | N/A | 0.95 | 0.95 | N/A[4] | N/A |

[1] All values rounded.

841 Cadmus calculated precision estimates based on each year's population and sample size, assuming standard variability. Cadmus expected most metrics to be estimated at 90% confidence. Note that Cadmus did not calculate confidence and precision for individual metrics.

841 Lower value represents higher efficiency.

[4] None of the homes in the 2018 sample had electric water heaters; therefore, Cadmus was unable to calculate the average for this metric.

To evaluate electric savings for the participating homes, Cadmus developed six prototype energy models,[123] shown in Table A-20, using the characteristics of the homes documented in the HERS certificates (Table A-19). The models represented typical characteristics of the sampled participants.

**Table A-20. Residential New Construction Program Prototype Model Iterations**

| Foundation Type | Water Heating[1] | Weather Location |
|---|---|---|
| Conditioned Basement | Gas Tank | Evansville |
| Conditioned Basement | Gas Tankless | Evansville |
| Conditioned Crawl Space | Gas Tank | Evansville |
| Conditioned Crawl Space | Gas Tankless | Evansville |
| Slab on Grade | Gas Tank | Evansville |
| Slab on Grade | Gas Tankless | Evansville |

[1] Used for modeling natural gas savings

[123] Prototype energy models represent simulated program homes. Because there were no homes with heat pumps in the sample, the prototypes did not include heating and cooling system iterations.

Cadmus calculated electric energy and demand savings as the savings between the baseline energy code model and the modeled home for each of the six prototypes. Cadmus established the characteristics of the baseline models based on 2011 Indiana Energy Code and current federal standards.

Cadmus calculated program realization rates as the evaluated savings divided by the reported savings of the modeled homes. The realization rate for energy savings was 51%, and the realization for demand reduction was 33%, as shown in Table A-21. Cadmus applied the realization rates to reported savings for Gold Star and Platinum Star homes.

**Table A-21. 2018 Residential New Construction Program Modeled Prototypes Realization Rates**

| Annual Gross Savings Type | Reported Sample (n=52) | Evaluated Sample (n=52) | Realization Rate |
|---|---|---|---|
| kWh | 109,145 | 55,833 | 51% |
| Coincident Peak kW | 67.8 | 22.3 | 33% |

## *A.3 Home Energy Assessment (HEA 2.0) Program*

Cadmus' impact evaluation of the Home Energy Assessment (HEA) 2.0 Program included measures with attributable electric savings, including these:

**Audit education**

- Audit

**Lighting**

- Exterior LED lamp
- LED 6W globe
- LED 9W bulb
- LED R30 dimmable
- LED downlight retrofit
- LED candelabra
- LED .5W night light

**Plug load reduction**

- Smart power strips

**HVAC and water heating measures**

- Filter whistle
- Pipe wrap
- Water heater temperature setback
- Smart thermostat

**Water-saving devices**

- Bathroom aerator
- Kitchen aerator
- Efficient showerhead
- Thermostatic shower valve

Table A-22 provides per-unit annual gross savings for each program measure.

**Table A-22. HEA 2.0 Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported *Ex Ante* | Evaluated *Ex Post* | Reported *Ex Ante* | Evaluated *Ex Post* |
| **Audit Education** | | | | |
| Audit Fee – Electric | 61 | 63 | 0.003 | 0.007 |
| **Lighting** | | | | |
| LED 9W Bulb (Exterior) | 92 | 84 | 0.000 | 0.000 |
| LED 9W Bulb | 32 | 32 | 0.003 | 0.004 |
| LED 6W Globe | 10 | 21 | 0.003 | 0.003 |
| LED 8W Bulb | 53 | 53 | 0.003 | 0.007 |
| LED Downlight Retrofit | 35 | 42 | 0.003 | 0.005 |
| LED Candelabra | 41 | 33 | 0.003 | 0.004 |
| LED Nightlight | 14 | 13 | 0.000 | 0.000 |
| **Plug Load Reduction** | | | | |
| Smart Strips | 103 | 26 | 0.003 | 0.002 |
| **HVAC and Water Heating Measures** | | | | |
| Filter Whistle – Electric | 61 | 239 | 0.003 | 0.050 |
| Filter Whistle – Gas | 0 | 63 | 0.003 | 0.002 |
| Pipe Wrap – Electric | 65 | 75 | 0.003 | 0.009 |
| Smart Thermostat – Electric | 370 | 1307 | 0.000 | 0.000 |
| Smart Thermostat – Gas | 0 | 323 | 0.000 | 0.000 |
| Water Heater Setback – Electric | 87 | 66 | 0.003 | 0.008 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator – Electric | 9 | 24 | 0.003 | 0.003 |
| Kitchen Aerator – Electric | 115 | 163 | 0.003 | 0.007 |
| Showerhead – Electric | 206 | 259 | 0.003 | 0.015 |
| Thermostatic Shower Valve – Electric | 85 | 46 | 0.003 | 0.003 |

## A.3.1 Audit Education

Energy auditors gave HEA 2.0 Program participants home audit reports that identified additional energy-efficient measures they could take to further reduce energy consumption.

The participant survey collected data from 74 Home Energy Assessment Program participants. Sixty-four percent of survey respondents said they implemented one or more recommendations from the home audit report. The reports had two types of recommended measures:

- Behavioral measures, which required homeowners to modify how they used energy in their homes
- Measures that required purchases and installations of equipment

Table A-23 shows household percentages for recommended measures that HEA 2.0 Program participants reportedly engaged in after receiving a program audit.

**Table A-23. 2018 HEA 2.0 Percentages per Recommended Action**

| Recommendation | Percentage of Households that Reportedly Took Action |
|---|---|
| **Behavioral Measures** | |
| Turn off lights when not in use | 56% |
| Take shorter showers | 34% |
| Program thermostat with efficient settings (excludes recipients of smart thermostats through program) | 52% |
| Unplug appliances when not in use | 31% |
| **Installation Measures** | |
| Air sealing/weather-stripping | 6% |

*Ex post* audit savings were specific to participants and based on survey responses. The majority of electric savings came from programming the thermostat with efficient settings.

## A.3.2 Lighting

Cadmus used the following equations from the 2015 Indiana TRM to calculate savings per bulb installed (excludes ISR):

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right) * (1 + WHF_E)$$

$$kW\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right) * (1 + WHF_D) * CF$$

Cadmus used baseline wattage values based on methodology from the Uniform Methods Project (UMP), which specifies baseline wattages based on lumen output and style of the installed bulbs. The baselines used to calculate savings are shown in Table A-24 based on bulb.

Cadmus used the 2015 Indiana TRM's assumption of 902 as the hours of use (HOU) per year for direct install measures. Cadmus also applied a waste heat factor (WHF), representing the portion of annual lighting energy that produces an interactive effect (lost or gained) with heating and cooling equipment. The heating and cooling factors were taken from the Indiana TRM for the city of Evansville, Indiana, and were dependent on the heating and cooling type at each home.

The Indiana TRM assumption of 902 hours of use applied only to lighting installed indoors; therefore, Cadmus used 2,475 hours from the Illinois TRM Version 6.0, which specifically applies to exterior bulbs. Exterior bulbs also did not have a WHF applied to them because there are not interactive effects on bulbs installed outdoors. Table A-24 shows the savings inputs Cadmus used for its *ex post* calculations.

**Table A-24. Lighting Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline wattage for equivalent incandescent bulb (6-watt LED globe) (WattsBase) | 29 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for EISA-exempt 525 lumen LED globe |
| Baseline wattage for equivaent halogen bulb (9-watt LED) (WattsBase) | 43 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 800 lumen A-line LED |
| Baseline wattage for equivalent halogen bulb (BR30 Dimmable LED) (WattsBase) | 65 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 900 lumen A-line LED |
| Baseline wattage for equivalent incandescent bulb (exterior bulb 9-watt LED) (WattsBase) | 43 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 1200 lumen A-line LED |
| Baseline wattage for equivalent candelabra fixture | 40 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 1200 lumen A-line LED |
| Hours of use per year (HOURS) | 902 (interior)<br>2,475 (exterior) | 2015 Indiana TRM (interior)<br>Illinois TRM V6.0 (exterior) |
| Summer peak coincidence factor (CF) | 0.11 | 2015 Indiana TRM |
| Waste heat factor for energy (WHFe) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each lighting participant |
| Waste heat factor for demand (WHFd) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each lighting participant |

### *LED Night Lights*

Cadmus used the following 2015 Indiana TRM equation to calculate savings per bulb installed (excluding ISR):

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right)$$

Cadmus used the 2015 Indiana TRM value of 2,902 as the hours of use per year assumption. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-25.

**Table A-25. LED Night Light Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline wattage for equivalent incandescent night light (WattsBase) | 5.00 | 2015 Indiana TRM |
| Wattage of LED night light (WattsEff) | 0.5 | Provided by Vectren |
| Hours of use per year (Hours) | 2,920 | 2015 Indiana TRM |

## A.3.3 Water-Saving Devices

### *Faucet Aerators*

Cadmus used the following 2015 Indiana TRM equations to calculate savings per faucet aerator installed (excluding ISR):

$$kWh\ Savings = (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{SH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = (GPM_{BASE} - \ GPM_{LOW}) * 60 * DR * \ 8.3 * \frac{(T_{MIX} - \ T_{IN})}{RE * 3{,}412} * \ CF$$

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-26.

**Table A-26. Faucet Aerator Savings Inputs**

| Input | Assumption | | Source |
|---|---|---|---|
| | Kitchen Faucet | Bathroom Faucet | |
| Faucet usage (minutes/day/person) (MPD) | 4.5 | 1.6 | 2015 Indiana TRM |
| Number of faucets per home (FH) | 1 | 2.51 | 2018 HEA Participant survey data for bathroom; 2015 Indiana TRM for kitchen |
| Average household size (PH) | 2.81 | 2.81 | 2018 HEA participant survey data |
| Input water temperature to house (°F) (°F, Tin) | 62.8 | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Temperature of water at faucet (°F) (°F, Tmix) | 93 | 86 | 2015 Indiana TRM |
| Percent of water flowing down drain (DR) | 0.5 | 0.7 | 2015 Indiana TRM |
| Gallons per minute of baseline faucet aerator (GPMbase) | 2.44 | 1.9 | 2015 Indiana TRM |
| Gallons per minute of low-flow faucet aerator (GPMlow) | 1.5 | 1.0 | Implementer tracking data |
| Electric water heater recovery efficiency (RE) | 0.98 | 0.98 | 2015 Indiana TRM |
| Summertime peak coincidence factor (CF) | 0.0033 | 0.0033 | 2015 Indiana TRM |

### *Efficient Showerhead*

Cadmus used the following 2015 Indiana TRM equations to calculate savings per efficient showerhead installed (excluding ISR):

$$kWh\ Savings = (GPM_{BASE} - \ GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - \ T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = (GPM_{BASE} - \ GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - \ T_{IN})}{RE * 3{,}412} * \ CF$$

Efficient showerheads provided through the program replaced participants' existing showerheads, reducing water flow rates. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-27.

**Table A-27. Efficient Showerhead Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Average shower length (MS) | 7.8 | 2015 Indiana TRM |
| Average household size (participants/household, PH) | 2.81 | 2018 HEA Participant survey data |
| Number of showerheads per home (SH) | 1.99 | 2018 HEA Participant survey data |
| Number of showers per day per person (SPD) | 0.6 | 2015 Indiana TRM |
| Input water temperature to house (°F, Tin) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Water temperature at showerhead (°F, Tmix) | 101 | 2015 Indiana TRM, average mixed temperature of water used for shower |
| Gallons per minute of baseline showerhead (GPMbase) | 2.63 | 2015 Indiana TRM |
| Gallons per minute of low-flow showerhead (GPMlow) | 1.50 | Implementer tracking data |
| Electric recovery efficiency of hot water heater (RE) | 0.98 | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 0.0023 | 2015 Indiana TRM |

## *Thermostatic Shower Valve*

Cadmus used the following Illinois TRM V6.0 equations (measure not available in 2015 Indiana TRM) to calculate savings for thermostatic shower valves (excluding ISR):

$$\Delta kWh = ((GPM\_base\_S * L\_showerdevice) * Household * SPCD * 365.25 / SPH) * EPG\_electric$$

$$\boldsymbol{\Delta kW = \Delta kWh / Hours * CF}$$

Thermostatic shower valves are directly installed alongside participants' showerheads, restricting shower water flow once a certain water temperature is reached. Savings for recipients of HEA 2.0 Program showerheads were calculated using the GPM of the installed efficient showerheads whenever an efficient showerhead was installed in conjunction with a thermostatic shower valve. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-28.

**Table A-28. HEA Thermostatic Shower Valve Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Average household size (participants/household, Household) | 2.81 | 2018 HEA participant survey data |
| Number of showers per day per person (SPD) | 0.6 | 2015 Indiana TRM |
| Number of showerheads per home (SH) | 1.99 | 2018 HEA participant survey data |
| Gallons per minute of baseline showerhead (GPMbase) | 1.5-2.63 | 2015 Indiana TRM and HEA participant tracking data |
| Hot water waste time avoided due to thermostatic restrictor valve (L_showerdevice) | 0.89 | IL TRM V6.0 |
| Energy per gallon of hot water supplied by electric (kWh/gal, EPG_electric) | 0.0952 | IL TRM V6.0 with the following inputs from the 2015 Indiana TRM |
| Electric water heater recovery efficiency (RE) | 0.98 | 2015 Indiana TRM |
| Water temperature at showerhead (°F, Tmix) | 101 | 2015 Indiana TRM, average mixed temperature of water used for shower |
| Input water temperature to house (°F, Tin) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Annual electric DHW recovery hours for wasted showerhead use prevented by device | 34.4 | IL TRM V6.0 single-family direct install default. |

## A.3.4 HVAC and Water Heating Measures

### *Furnace Filter Whistle*

Cadmus used the following analysis equations from a Quantec study to calculate savings per filter whistle,[124] in combination with 2015 Indiana TRM assumptions (excludes ISR):

$$kWh\ Savings_{CAC} = FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} * EF_{elec}$$

$$kWh\ Savings_{HP} = \left( FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} + FLH_{heat} * BtuH_{HP} * \frac{\frac{1}{HSPF}}{1000} \right) * EF_{elec}$$

$$kW\ Savings_{CAC} = BtuH_{CAC} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

$$kW\ Savings_{HP} = BtuH_{HP} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

Cadmus has previously used the Quantec study to estimate savings for the HEA 2.0 Program's furnace whistle measure in 2015 , 2016, and 2017. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-29.

---

124 Reichmuth, Howard. *Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm.* White paper prepared for Energy Technology Laboratories. Prepared by Quantec. n.d.

**Table A-29. Furnace Whistle Savings Inputs**

| Input | Assumption | Source |
| --- | --- | --- |
| Efficiency savings for gas furnace (Efgas) | 0.0185 | Quantec analysis: Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm |
| Efficiency savings for heat pump/air conditioner (Efelec) | 0.0350 | |
| Seasonal energy efficiency ratio (SEER) | Varies by customer | 2018 HEA participant tracking data |
| Energy efficiency ratio (EER) | Varies by customer | 2018 HEA participant tracking data, SEER * .9 |
| Size of central AC units (BtuHCAC) | Varies by customer | 2018 HEA participant tracking data |
| Heating season performance factor (HSPF) | Varies by customer | 2018 HEA participant tracking data |
| Size of heat pump (BtuHHP) | Varies by customer | 2018 HEA participant tracking data |
| Summer peak coincidence factor for heat pump/central AC (CF) | 0.88 | 2015 Indiana TRM: Summer peak coincidence factor is deemed at 0.88 per Duke Energy load shape |
| Full load cooling hours (FLHcool) | 600 | 2015 Indiana TRM: Evansville |
| Full load heating hours (FLHheat) | 982 | 2015 Indiana TRM: Evansville |

### *Pipe Wrap*

Cadmus used the following equation to calculate savings per water heater with temperature setback (excludes ISR):

$$kWh\ savings = ESF * GPD * 8.3 * 365 * (T_{set} - T_{in})/(3412 * RE_{electric})$$

$$kW\ Savings = kWh\ Savings/Hours *\ CF$$

Cadmus did not use the Indiana TRM methodology because the TRM assumed that the average temperature difference between water heater-supplied water and ambient air temperature was constant for every foot of pipe. However, hot water does not flow constantly in most domestic residential water heating systems, so this TRM approach likely overestimates energy savings from pipe wrap. Cadmus assumed insulating water heater pipes saved an average 3% of annual hot water energy consumption.[125]

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-30.

[125] American Council for an Energy-Efficient Economy. April 2009. ACEEE Report Number E093. *Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy in Pennsylvania.*

**Table A-30. Pipe Wrap Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Energy savings factor (ESF) | 3% | ACEEE Report Number E093, assumption used in CL&P and UI PSD 2013 |
| Gallons of water used per day (GPD) | 58.8 | Calculated using 2.81 average home size from 2018 HEA survey data to interpolate daily usage, based on the relationship between gallons of water per day, per household vs. the number of people. 2015 Indiana TRM |
| Water heater temperature setpoint (°F, Tsetpoint) | Varies by customer | 2018 HEA tracking data |
| Input water temperature to house (°F, Tin) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Conversion from Btu to kWh | 3412 | Conversion factor |
| Electric water heater recovery efficiency (Reelectric) | 98% | 2015 Indiana TRM |
| Hours in a year (Hours) | 8760 | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 1 | 2015 Indiana TRM |

### *Water Heater Temperature Setback*

Cadmus used the following Illinois TRM Version 6.0 equations (measure not available in the 2015 Indiana TRM) to calculate savings per water heater with temperature setback (excludes ISR):

$$kWh\ Savings = \left(U * A * (T_{pre} - T_{post}) * Hours\right)/(3412 * RE_{electric})$$

$$kW\ Savings = kWh\ Savings/Hours *\ CF$$

During the home audit, water heater temperatures were set back to a lower temperature to achieve energy savings. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-31.

**Table A-31. Water Heater Temperature Setback Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Heat transfer coefficient of tank (U) | 0.083 | Illinois TRM V6.0 default value |
| Surface area of tank (A) | 24.99 | Illinois TRM V6.0 default value |
| Water heater temperature before setback (Tpre) | Varies by customer | HEA tracking data |
| Water heater temperature before setback (Tpost) | Varies by customer | HEA tracking data |
| Hours in a year (Hours) | 8760 | 2015 Indiana TRM |
| Electric water heater recovery efficiency (Reelectric) | 98% | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 1 | Illinois TRM V6.0 default value |
| Conversion from Btu to kWh | 3412 | Conversion factor |

### *Smart Thermostats*

Cadmus calculated smart programmable, Nest, and Wi-Fi thermostat savings using the following equations (excluding ISR):

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{1}{\eta_{HEAT}\ * 3412}\right)$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline}$$

Cadmus applied savings to installations with defined heating or cooling equipment for that equipment type. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-32.

**Table A-32. Smart Thermostat Savings Inputs**

| Variable | Value | Units | Source |
|---|---|---|---|
| $FLH_{HEAT}$ | 982 | Hours | 2015 Indiana TRM; Evansville, Indiana |
| $BTUH_{HEAT}$ | 32,000 | BTUH | From Pennsylvania TRM |
| $\eta_{HEAT}$ | Varies | - | 2015 Indiana TRM – Varies by system type |
| $ESF_{Heat}$ | 12.5% | % | Evaluation of the 2013–2014 Programmable and Smart Thermostat Program |
| $\Delta kWh_{COOLING}$ | 429 | kWh | Evaluation of the 2013–2014 Programmable and Smart Thermostat Program |
| Manual thermostat saturation | 34% | % | 2018 HEA Tracking Data |
| Programmable thermostat saturation | 66% | % | 2018 HEA Tracking Data |
| $ESF_{AdjustedBaseline_{HEAT}}$ | 10.90% | % | Calculated, example below |
| $\Delta Cooling_{AdjustedBaseline}$ | 323 | kWh | Calculated, example below |

#### 2013–2014 Thermostat Evaluation and Adjusted Baseline

Cadmus' analysis of smart programmable thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren's Indiana South territory.[126] This evaluation reports household cooling energy savings of 332 kWh and a household heating energy saving factor (ESF) of 5% for programmable thermostats. It reports household cooling energy savings of 429 kWh and a household heating ESF of 12.5% for Nest Wi-Fi thermostats.

This study uses a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2018 HEA 2.0 tracking data indicated that the saturation was 34% for manual thermostats and 66% for programmable thermostats.

[126] Cadmus. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* January 29, 2015.

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2014 Cadmus thermostat study and a weighted average to adjust the savings for Nest thermostats from a manual thermostat baseline to a mixed manual and programmable thermostat baseline.

Cadmus used these equations:[127]

$$\Delta Cooling_{AdjustedBaseline} = [34\% * 429 + 66\% * (429 - 161)] = 323\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 34\% * 12.5\% + 66\% * (12.5\% - 2.40\%) = 10.90\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 161 represents the cooling savings (332 kWh multiplied by 48% correct use factor) for programmable thermostats. Cadmus did equivalent calculations to obtain adjusted baseline values for ESF-heat. The 2013–2014 thermostat evaluation investigated only the homes with gas heating, so Cadmus assumed that the percentage of gas savings from that evaluation apply to electric heat as well.

A proper usage factor was not applied to this evaluation because of the change in technology from programmable Wi-Fi to learning thermostats. The additional features these smart thermostats offer, such as optimizing heating and cooling schedules, make it much more likely that the thermostat is operating efficiently.

## A.3.5 Plug Load Reduction

### *Tier 1 Advanced Power Strips (Smart Strips)*

Cadmus used deemed savings from the 2015 Indiana TRM to evaluate savings for smart strips (excluding ISR):

$$Energy\ Savings = \sum^{Peripherals} W_{standby} * F_{homes} * F_{control} * H * \frac{1 + WHF_E}{1000}$$

$$Demand\ Savings = \sum^{Peripherals} W_{standby} * F_{homes} * F_{control} * CF * \frac{1 + WHF_D}{1000}$$

The end usage of the smart strip is unknown, so Cadmus used the default weighting from the 2015 Indiana TRM where 50% are installed with TV systems and 50% are installed with computer systems. The heating and cooling factors were taken from the Indiana TRM for the city of Evansville and were dependent on the heating and cooling type of each different site.

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-33**.**

[127] Cadmus. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.* January 29, 2015.

**Table A-33. HEA Smart Strip Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Power use in standby mode (Wstandby) | Varies from 0.3 to 18 watts depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Percentage of homes with peripherals (Fhomes) | Varies from 0.3% to 69% depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Percentage of peripherals controlled (Fcontrol) | Varies from 57% to 100% depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Number of hours per year peripherals are controlled (computers) (H) | 7,474 | 2015 Indiana TRM |
| Number of hours per year peripherals are controlled (televisions) (H) | 6,784 | 2015 Indiana TRM |
| Coincident factor (CF) | 0.50 | 2015 Indiana TRM |
| Waste heat factor for energy (WHFe) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each participant |
| Waste heat factor for demand (WHFd) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each participant |

## *A.4 Income Qualified Weatherization Program*

Cadmus' impact evaluation of the Income Qualified Weatherization (IQW) Program included measures with attributable electric savings, including these:

**Audit education**
- Audit (dual fuel)
- Audit (electric)

**Lighting**
- Exterior LED lamp
- LED 5W globe
- LED 9W bulb
- LED R30 dimmable
- LED night light

**Water-saving devices**
- Bathroom aerator
- Kitchen aerator
- Efficient showerhead

**Appliance and plug load reduction**
- Refrigerator replacement
- Smart power strips

**HVAC and water heating measures**
- Central Air Conditioner
- Filter whistle
- Pipe wrap (electric) (per home)
- Water heater temperature setback
- Smart thermostat (dual fuel)

**Weatherization measures**
- Air sealing (dual fuel)
- Air sealing (electric)
- Attic insulation (dual fuel)
- Attic insulation (electric)
- Duct sealing (dual fuel)
- Wall Insulation (dual fuel)
- Wall Insulation (gas)

Table A-34 provides per-unit annual gross savings for each program measure. The following sections provide details on Cadmus' equations and assumptions used to calculate evaluated gross savings by measure type.

**Table A-34. 2018 IQW Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| **Audit Education** | | | | |
| Audit Fee (Dual Fuel) | 68 | 83 | 0.008 | 0.003 |
| Audit Fee (Electric) | 68 | 102 | 0.008 | 0.000 |
| **Lighting** | | | | |
| Exterior LED Lamps | 92 | 99 | 0.000 | 0.000 |
| LED 5W Globe | 10 | 20 | 0.001 | 0.002 |
| LED 9W Bulb (Multifamily [MF]) | 19 | 33 | 0.003 | 0.004 |
| LED 9W Bulb (Manufactured home [MH]) | 19 | 24 | 0.003 | 0.004 |
| LED 9W Bulb (Single-family [SF]) | 32 | 33 | 0.004 | 0.004 |
| LED R30 Dimmable | 53 | 33 | 0.007 | 0.004 |
| LED Nightlight | 14 | 14 | 0.000 | 0.000 |
| **Water-Saving Devices** | | | | |
| Bathroom Aerator | 12 | 35 | 0.001 | 0.003 |
| Kitchen Flip Aerator | 120 | 146 | 0.007 | 0.007 |
| Efficient Showerhead | 300 | 343 | 0.015 | 0.015 |
| **HVAC and Water Heating Measures** | | | | |
| Central Air Conditioner 16 SEER | 300 | 587 | 0.389 | 1.047 |
| Filter Whistle | 54 | 46 | 0.000 | 0.076 |
| Pipe Wrap, per home (Electric) | 148 | 99 | 0.019 | 0.011 |
| Smart Thermostat (Dual Fuel) | 378 | 429 | 0.000 | 0.000 |
| Smart Thermostat (Electric) | 378 | 1,580 | 0.000 | 0.000 |
| Water Heater Temperature Setback (Electric) | 86 | 82 | 0.010 | 0.009 |
| **Appliance and Plug Load Reduction** | | | | |
| Refrigerator Replacement | 442 | 360 | 0.065 | 0.053 |
| Smart Power Strips | 23 | 26 | 0.002 | 0.002 |
| **Weatherization Measures** | | | | |
| Air Sealing 10% Infil. Reduction (Dual Fuel) | 103 | 125 | 0.285 | 0.162 |
| Air Sealing 10% Infil. Reduction (Electric) | 4,688 | 1,132 | 0.921 | 0.000 |
| Attic Insulation (Dual Fuel) | 122 | 383 | 0.123 | 0.378 |
| Attic Insulation (Electric) | 828 | 3,917 | 0.030 | 0.762 |
| Duct Sealing 10% Infil. Reduction (Dual Fuel) | 210 | 155 | 0.368 | 0.269 |
| Wall Insulation (Dual fuel)[2] | 56 | 58 | 0.037 | 0.042 |

[1] Vectren's 2018 DSM Scorecard did not have kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2018 program tracking data.
[2] The measure name indicated that wall insulation installations were gas only measures and not dual. These participants had claimed electric savings and were verified to have central air conditioning and were Vectren customers.

## A.4.1 Audit Education

Energy auditors gave IQW Program participants home audit reports that identified additional energy-efficient actions they could take to further reduce energy consumption. The ex *post* audit savings were specific to participants and based on survey response data from 92 IQW Program participants. More than half (61%) of the survey respondents said they had implemented one or more recommendations from the home audit report. Home audit reports had two types of recommended measures:

- Behavioral measures, which required homeowners to modify how they used energy in their homes. Cadmus evaluated behavioral savings for the following energy-savings actions:
  - Turning off lights when not in use
  - Unplugging unused appliances
  - Taking shorter showers
  - Programming your thermostat with efficient settings.
- Measures that required purchases and installations of equipment

Table A-35 shows household percentages for each recommended action that IQW Program participants reportedly engaged in after receiving a program audit. The majority of electric savings for the audit education measure category came from cooling savings from programming home thermostats with efficient settings (67%). This was the main reason evaluated savings were higher than reported savings.

**Table A-35. 2018 IQW Household Percentages and Average Savings per Recommended Measure**

| Recommendation | Percentage of Households that Reportedly Took Action | Average Evaluated Savings for Action (kWh) |
|---|---|---|
| **Behavioral Measures** | | |
| Turn off lights when not in use | 56% | 16 |
| Unplug appliances when not in use | 44% | 4 |
| Take shorter showers | 40% | 2 |
| Program thermostat with efficient settings (excludes recipients of smart thermostats through program) | 44% | 56 |
| **Installation Measures** | | |
| Air sealing/weather-stripping | 7% | 5 |

Table A-35 shows the assumptions that went into the evaluated savings for each component. For all energy-saving actions, savings were adjusted to account for any efficient equipment that was installed. For turning off the lights and showerheads, this meant adjusting the baseline usage to account for the installed efficient equipment. For unplugging appliances and programming thermostats correctly, this meant not evaluating savings for participants who received smart strips or smart thermostats, respectively.

**Table A-36. 2018 IQW Audit Education Savings Assumptions**

| Recommendation | Assumption | Source |
|---|---|---|
| **Behavioral Measures** | | |
| Turn off lights when not in use | 20% reduction in hours of use per day. | CPUC PY2006-2008 Indirect Impact Evaluation of the Statewide Marketing and Outreach Programs. Vol II. 2009. |
| Unplug appliances when not in use | 21.3 kWh | CPUC PY2006-2008 Indirect Impact Evaluation of the Statewide Marketing and Outreach Programs. Vol II. 2009. |
| Take shorter showers | 5% reduction in time spent in shower. Household showerhead usage was adjusted to account for efficient showerheads installed | Engineering judgement |
| Program thermostat with efficient settings (excludes recipients of smart thermostats through program) | Savings are equivalent to the savings from installing a new programmable thermostat (incorporating a proper usage factor) | Evaluation of the 2013–2014 Programmable and Smart Thermostat Program |
| **Installation Measures** | | |
| Air sealing/weather-stripping | Additional air sealing and weather-stripping will achieve 50% of evaluated air sealing savings. | Engineering judgement |

## A.4.2 Lighting

### *LED Bulbs*

Cadmus used the following equations from the 2015 Indiana TRM to calculate gross savings per LED bulb installed (excluding ISR):

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right) * (1 + WHF_E)$$

$$kW\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right) * (1 + WHF_D) * CF$$

Cadmus used baseline wattage values based on methodology from the U.S. Department of Energy Uniform Methods Project (UMP), which specifies baseline wattages based on lumen output and style of the installed bulbs.

Cadmus used the 2015 Indiana TRM's assumption of 902 as the hours of use (HOU) per year for direct install measures. Cadmus also applied a waste heat factor (WHF), representing the portion of annual lighting energy producing an interactive effect (lost or gained) with heating and cooling equipment. The heating and cooling factor were taken from the Indiana TRM for the city of Evansville, Indiana, and were dependent on the heating and cooling type of each different site.

The Indiana TRM assumption of 902 hours of use applied only to lighting installed indoors; therefore, Cadmus used the value of 2,475 hours from the Illinois TRM Version 6.0, which specifically applies to exterior bulbs. Exterior bulbs also did not have a WHF applied to them because there are no interactive effects on bulbs installed outdoors.

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-37.

**Table A-37. Lighting Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline wattage for equivalent incandescent bulb (5-watt LED globe) (WattsBase) | 25 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for EISA-exempt 525 lumen LED globe |
| Baseline wattage for equivalent halogen bulb (9-watt LED) (WattsBase) | 43 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 800 lumen A-line LED |
| Baseline wattage for equivalent halogen bulb (R30 Dimmable LED) (WattsBase) | 45 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 900 lumen A-line LED |
| Baseline wattage for equivalent incandescent bulb (exterior bulb 13-watt LED) (WattsBase) | 53 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 1200 lumen A-line LED |
| Hours of use per year (HOURS) | 902 (interior)<br>2,475 (exterior) | 2015 Indiana TRM (interior)<br>Illinois TRM V6.0 (exterior) |
| Summer peak coincidence factor (CF) | 0.11 | 2015 Indiana TRM |
| Waste heat factor for energy (WHFe) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each lighting participant |
| Waste heat factor for demand (WHFd) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2018 heating and cooling for each lighting participant |

### *LED Night Lights*

Cadmus used the following 2015 Indiana TRM equation to calculate gross savings per night light installed (excluding ISR):

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right)$$

Cadmus used the 2015 Indiana TRM value of 2,902 as the hours of use per year assumption. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-38.

**Table A-38. LED Night Light Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline wattage for equivalent incandescent night light (WattsBase) | 5.00 | 2015 Indiana TRM |
| Wattage of LED night light (WattsEff) | 0.33 | Provided by Vectren |
| Hours of use per year (Hours) | 2,920 | 2015 Indiana TRM |

## A.4.3 Water-Saving Devices

### *Faucet Aerators*

Cadmus used the following 2015 Indiana TRM equations to calculate savings per faucet aerator installed (excluding ISR):

$$kWh\ Savings = (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{SH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = (GPM_{BASE} - GPM_{LOW}) * 60 * DR * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-39.

**Table A-39. Faucet Aerator Savings Inputs**

| Input | Assumption | | Source |
|---|---|---|---|
| | Kitchen Faucet | Bathroom Faucet | |
| Faucet usage (minutes/day/person) (MPD) | 4.5 | 1.6 | 2015 Indiana TRM |
| Number of faucets per home (FH) | 1 | 1.54 | 2018 IQW Participant survey data for bathroom. 2015 Indiana TRM for kitchen |
| Average household size (participants/household, PH) | 2.52 | 2.52 | 2018 IQW participant survey data |
| Input water temperature to house (°F) (°F, Tin) | 62.8 | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Temperature of water at faucet (°F) (°F, Tmix) | 93 | 86 | 2015 Indiana TRM |
| Percent of water flowing down drain (DR) | 0.5 | 0.7 | 2015 Indiana TRM |
| Gallons per minute of baseline faucet aerator (GPMbase) | 2.44 | 1.9 | 2015 Indiana TRM |
| Gallons per minute of low-flow faucet aerator (GPMlow) | 1.5 | 1.0 | Implementer tracking data |
| Electric water heater recovery efficiency (RE) | 0.98 | 0.98 | 2015 Indiana TRM |
| Summertime peak coincidence factor (CF) | 0.0033 | 0.0033 | 2015 Indiana TRM |

### *Efficient Showerhead*

Cadmus used the following 2015 Indiana TRM equations to calculate savings per efficient showerhead installed (excluding ISR):

$$kWh\ Savings = (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = (GPM_{BASE} - GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

Efficient showerheads provided through the program replaced participants' existing showerheads, reducing water flow rates. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-40.

**Table A-40. Efficient Showerhead Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Average shower length in minutes (MS) | 7.8 | 2015 Indiana TRM |
| Average household size (participants/household, PH) | 2.52 | 2018 IQW Participant survey data |
| Number of showerheads per home (SH) | 1.34 | 2018 IQW Participant survey data |
| Number of showers per day per person (SPD) | 0.6 | 2015 Indiana TRM |
| Input water temperature to house (°F, Tin) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Water temperature at showerhead (°F, Tmix) | 101 | 2015 Indiana TRM, average mixed temperature of water used for shower |
| Gallons per minute of baseline showerhead (GPMbase) | 2.63 | 2015 Indiana TRM |
| Gallons per minute of low-flow showerhead (GPMlow) | 1.50 | Implementer tracking data |
| Electric recovery efficiency of hot water heater (RE) | 0.98 | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 0.0023 | 2015 Indiana TRM |

## A.4.4 HVAC and Water Heating Measures

### *Central Air Conditioner*

Cadmus used these equations to calculate savings per air conditioner replacement (excluding ISR):

$$Annual\ kWh\ Savings = FLH_{COOL} * Btuh * \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{Eff}}\right) * \frac{1}{1000}$$

$$Demand\ kW\ Savings = \ Btuh * \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{Eff}}\right) * \frac{1}{1000} * CF$$

Cadmus calculated savings for central air conditioners replacement implemented through the IQW Program using the savings inputs used for its *ex post* calculations are shown in Table A-41.

**Table A-41. IQW Program Central Air Conditioner Savings Inputs**

| Description | Assumption | Source |
|---|---|---|
| Efficient SEER | Varies | 2018 IQW Tracking |
| Efficient EER | Varies | 2018 IQW Tracking |
| Baseline SEER | 13 | Federal Standard SEER Rating, IN 2015 TRM |
| Baseline EER | 11 | Federal Standard EER Rating, IN 2015 TRM |
| CAC Btuh | 36,000 Btuh | 2018 IQW Tracking |
| FLHcool – Evansville | 600 | IN 2015 TRM |
| CF | 88% | IN 2015 TRM |

### *Furnace Filter Whistle*

Cadmus used the following analysis equations from a Quantec study to calculate savings per filter whistle,[128] as in 2015–2017, in combination with 2015 Indiana TRM assumptions (excluding ISR):

$$kWh\ Savings_{CAC} = FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} * EF_{elec}$$

$$kWh\ Savings_{HP} = \left( FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} + FLH_{heat} * BtuH_{HP} * \frac{\frac{1}{HSPF}}{1000} \right) * EF_{elec}$$

$$kW\ Savings_{CAC} = BtuH_{CAC} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

$$kW\ Savings_{HP} = BtuH_{HP} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-42.

**Table A-42. Furnace Whistle Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Efficiency savings for gas furnace (Efgas) | 0.0185 | Quantec analysis: Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm |
| Efficiency savings for heat pump/air conditioner (Efelec) | 0.0350 | |
| Seasonal energy efficiency ratio (SEER) | 13 | 2015 Indiana TRM: 13 SEER reflects new federal efficiency standard for baseline equipment |
| Energy efficiency ratio (EER) | 11 | 2015 Indiana TRM: 11 EER reflects new federal efficiency standard for baseline equipment |
| Size of central AC units (BtuHCAC) | 28,994 | 2015 Indiana TRM: CAC early replacement default for existing cooling capacity |
| Heating season performance factor (HSPF) | 8.2 | 2015 Indiana TRM: 8.2 HSPF reflects new federal efficiency standard for baseline equipment |
| Size of heat pump (BtuHHP) | 28,994 | 2015 Indiana TRM: CAC early replacement default for existing cooling capacity |
| Summer peak coincidence factor for heat pump/central AC (CF) | 0.88 | 2015 Indiana TRM: Summer peak coincidence factor is deemed at 0.88 per Duke Energy load shape |
| Full load cooling hours (FLHcool) | 600 | 2015 Indiana TRM: Evansville |
| Full load heating hours (FLHheat) | 982 | 2015 Indiana TRM: Evansville |

[128] Reichmuth, Howard. *Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm.* White paper prepared for Energy Technology Laboratories. Prepared by Quantec. n.d.

### *Pipe Wrap*

Cadmus used the following equation to calculate savings per water heater with pipe wrap:

$$kWh\ savings = ESF * GPD * 8.3 * 365 * (T_{set} - T_{in})/(3412 * RE_{electric})$$

$$kW\ Savings = kWh\ Savings/Hours * \ CF$$

Cadmus did not use the Indiana TRM methodology because the TRM assumed the average temperature difference between water supplied by the water heater and ambient air temperature were constant for every foot of pipe. However, hot water does not flow constantly in most domestic residential water heating systems, so the TRM probably overestimates energy savings from pipe wrap. Cadmus assumed insulating water heater pipes saved an average 3% of annual hot water energy consumption, based on ACEEE Report Number E093.[129]

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-43.

**Table A-43. Pipe Wrap Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Energy savings factor (ESF) | 3% | ACEEE Report Number E093, assumption used in CL&P and UI PSD 2013 |
| Gallons of water used per day (GPD) | 56.8 | Calculated using 2.51 average home size from 2018 IQW survey data to interpolate daily usage, based on the relationship between gallons of water per day, per household vs. the number of people. 2015 Indiana TRM |
| Water heater temperature setpoint (°F, Tsetpoint) | 130 | 2015 Indiana TRM |
| Input water temperature to house (°F, Tin) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DWH system |
| Conversion from Btu to kWh | 3412 | Conversion factor |
| Electric water heater recovery efficiency (Reelectric) | 98% | 2015 Indiana TRM |
| Hours in a year (Hours) | 8760 | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 1 | 2015 Indiana TRM |

### *Smart Thermostats*

Cadmus calculated smart thermostat savings using the following equation (excluding ISR).

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{Heat} * \left(\frac{1}{\eta_{HEAT} \ * 3412}\right)$$

[129] ACEEE Report Number E093. *Potential for Energy Efficiency, Demand Response, and Onsite Solar Energy in Pennsylvania.* April 2009.

In 2018, smart thermostats were installed in homes with gas heating and central air conditioning as well as homes with electric heating and central air conditioning. Electric heating savings were calculated for all thermostats installed in electrically heated homes.

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-44. These inputs were primarily derived from results of a 2013–2014 evaluation of programmable and smart thermostats in Vectren's South Indiana territory.[130] This evaluation reported a cooling electricity savings of 429 kWh for smart thermostats replacing a manual thermostat. Because smart thermostats have a learning function, it was assumed that 100% were auto-adjusting temperature appropriately. For the 2018 evaluation, Cadmus assumed smart thermostats replaced a manual thermostat for two reasons—the small incidence or thermostats installed was small (17% of program participants) and the IQW Program targets the low-income population. Additional data about thermostats should be collected during the on-site assessment if possible.

**Table A-44. Smart Thermostat Savings Inputs**

| Variable | Value | Units | Source |
|---|---|---|---|
| $FLH_{HEAT}$ | 982 | Hours | 2015 Indiana TRM; Evansville, Indiana |
| $BTUH_{HEAT}$ | 32,000 | BTUH | From Pennsylvania TRM |
| $\eta_{HEAT}$ | 1.0 | - | 2015 Indiana TRM – All heating systems were electric resistance heating systems |
| $ESF_{Heat}$ | 12.5% | % | Evaluation of the 2013–2014 Programmable and Smart Thermostat Program |
| $\Delta kWh_{COOLING}$ | 429 | kWh | Evaluation of the 2013–2014 Programmable and Smart Thermostat Program |

### *Water Heater Temperature Setback*

Cadmus used the following Illinois TRM Version 6.0 equations (measure not available in the 2015 Indiana TRM) to calculate savings per water heater with temperature setback (excluding ISR):

$$kWh\ Savings = \left(U * A * (T_{pre} - T_{post}) * Hours\right)/(3412 * RE_{electric})$$

$$kW\ Savings = kWh\ Savings/Hours *\ CF$$

During the home audit, water heater temperatures were set back to a lower temperature to achieve energy savings. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-45.

130 Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. January 29, 2015.

**Table A-45. Water Heater Temperature Setback Savings Inputs**

| Input | Assumption | Source |
| --- | --- | --- |
| Heat transfer coefficient of tank (U) | 0.083 | Illinois TRM V6.0 default value |
| Surface area of tank (A) | 24.99 | Illinois TRM V6.0 default value |
| Water heater temperature before setback (Tpre) | 135 | Illinois TRM V6.0 default value |
| Water heater temperature before setback (Tpost) | 120 | Illinois TRM V6.0 default value |
| Hours in a year (Hours) | 8760 | 2015 Indiana TRM |
| Electric water heater recovery efficiency (Reelectric) | 98% | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 1 | Illinois TRM V6.0 default value |
| Conversion from Btu to kWh | 3412 | Conversion factor |

## A.4.5 Appliance and Plug Load Reduction

### *Refrigerator Replacement*

Cadmus used the following equation from the 2015 Indiana TRM to calculate savings for replaced refrigerators (excludes ISR). The regression coefficients were updated with the coefficient findings for the 2018 Appliance Recycling Program.

$$kWh\ Savings = [(UEC_{RETIRED} * F_{RUNTIME}) - UEC_{NEW}] * \left(\frac{RUL_{RECYCLED}}{EUL_{NEW}}\right) + [(UEC_{STANDARD} - UEC_{NEW}) * (\frac{(EUL_{new} - RUL_{RECYCLED})}{EUL_{NEW}})]$$

$$UEC_{existing} = 365.25 * \left[0.81 + (0.02 * Age) + \left(1.04 * F_{before1990}\right) + (0.06 * Size) + \left(-1.75 * F_{singledoor}\right) + \left(1.12 * F_{side-by-side}\right) + \left(0.56 * F_{primary}\right) + (-0.04 * HDD * F_{outdoor}) + (0.03 * CDD * F_{outdoor})\right]$$

$$kW\ Savings = \frac{\Delta kWh}{8{,}760} * TAF * LSAF$$

Cadmus calculated savings for each refrigerator replaced using the following sources:

- 2015 Indiana TRM methodology for refrigerator recycling to establish the UEC of the retired refrigerators, using updated algorithm coefficients from the 2018 Appliance Recycling Program evaluation results
- ENERGY STAR database to determine the UEC of the new refrigerator units based on make and model numbers.
- 2018 IQW tracking data for recycled and new refrigerator characteristics for each participant

Cadmus determined a weighted average energy savings for two baseline scenarios over the life of the new refrigerator unit, obtaining remaining useful life and effective useful life values from the 2015 Indiana TRM:

- Recycled old refrigerator with a remaining useful life of eight years
- New standard refrigerator baseline for the remaining duration of the life of the new refrigerator (9 years = $EUL_{\text{new refrigerator}} - RUL_{\text{recycled unit}}$)

Savings inputs are shown in Table A-46.

**Table A-46. IQW Program Refrigerator Replacement Savings Inputs**

| Description | Assumption | Source |
|---|---|---|
| UEC_new (kWh) | 362 | Program data, ENERGY STAR database |
| UEC_retired (kWh) | 1193 | Program data, appliance recycling program coefficients |
| UEC_standard baseline (kWh) | 402 | 2015 Indiana TRM, averaged by program data configuration |
| F_run time | 1.000 | 2015 Indiana TRM |
| TAF | 1.21 | 2015 Indiana TRM |
| LSAF_old | 1.063 | 2015 Indiana TRM, refrigerator recycling |
| LSAF_new | 1.124 | 2015 Indiana TRM, time-of-sale refrigerator |
| Remaining useful life of old unit (years) | 8 | 2015 Indiana TRM |
| EUL of new refrigerator (years) | 17 | 2015 Indiana TRM |

### *Smart Strips*

Cadmus used deemed savings from the 2015 Indiana TRM to evaluate savings for smart strips (excludes ISR):

$$Energy\ Savings = \sum^{Peripherals} W_{standby} * F_{homes} * F_{control} * H * \frac{1 + WHF_E}{1000}$$

$$Demand\ Savings = \sum^{Peripherals} W_{standby} * F_{homes} * F_{control} * CF * \frac{1 + WHF_D}{1000}$$

The end usage of the smart strip is unknown, so Cadmus used the default weighting from the 2015 Indiana TRM where 50% are installed with TV systems and 50% are installed with computer systems. The heating and cooling factor were taken from the Indiana TRM for the city of Evansville and were dependent on the heating and cooling type of each different site.

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-47.

**Table A-47. IQW Smart Strip Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Power use in standby mode (Wstandby) | Varies from 0.3 to 18 watts depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Percentage of homes with peripherals (Fhomes) | Varies from 0.3% to 69% depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Percentage of peripherals controlled (Fcontrol) | Varies from 57% to 100% depending on home computer or TV system peripheral device, per tables in the 2015 Indiana TRM Smart Power Strip section | 2015 Indiana TRM |
| Number of hours per year peripherals are controlled (computers) (H) | 7,474 | 2015 Indiana TRM |
| Number of hours per year peripherals are controlled (televisions) (H) | 6,784 | 2015 Indiana TRM |
| Coincident factor (CF) | 0.50 | 2015 Indiana TRM |
| Waste heat factor for energy (WHFe) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2017 heating and cooling for each lighting participant |
| Waste heat factor for demand (WHFd) | Dependent on heating and cooling type | 2015 Indiana TRM appendix with 2017 heating and cooling for each lighting participant |

## A.4.6 Weatherization Measures

### *Air Sealing / Infiltration Reduction*

Cadmus used these equations from the 2015 Indiana TRM to calculate savings for each infiltration reduction retrofit (excludes ISR):

$$kWh\ Savings\ = \frac{CFM50_{EXIST} - CFM50_{NEW}}{N - factor} * \frac{kWh}{CFM}$$

$$kW\ Savings = \frac{CFM50_{EXIST} - CFM50_{NEW}}{N - factor} * \frac{\Delta kW}{CFM} * CF$$

Each site was calculated on an individual basis with different blower door measurements and heating and cooling types. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-48.

**Table A-48. IQW Program Air Sealing Savings Inputs**

| Description | Assumption | Source |
|---|---|---|
| Leakage rate before installation (CFM50_exist) | Actual | 2018 IQW Program Data |
| Leakage rate after installation (CFM50_new | Actual | 2018 IQW Program Data |
| N-Factor) | 16.3 | 2015 Indiana TRM |
| Summer peak coincidence factor (CF) | 0.88 | 2015 Indiana TRM |
| kWh/CFM – Electric, CAC (kWh/CFM) | 40.30 | 2015 Indiana TRM |
| kW/CFM – Electric, CAC (kW/CFM) | 0.01 | 2015 Indiana TRM |
| kWh/CFM – Heat Pump (kWh/CFM) | 20.50 | 2015 Indiana TRM |
| kW/CFM – Heat Pump (kW/CFM) | 0.01 | 2015 Indiana TRM |
| kWh/CFM – Electric, NO AC (kWh/CFM) | 36.90 | 2015 Indiana TRM |
| kW/CFM – Electric, NO AC (kW/CFM) | 0.00 | 2015 Indiana TRM |
| kWh/CFM – Gas Furnace, CAC (kWh/CFM) | 3.00 | 2015 Indiana TRM |
| kW/CFM – Gas Furnace, CAC (kW/CFM) | 0.01 | 2015 Indiana TRM |

### *Insulation (Attic and Wall)*

Cadmus applied this algorithm from the 2015 Indiana TRM to calculate and verify energy saving (excludes ISR):

$$Annual\ (Energy\ or\ Demand)\ Savings\ =\ kSF\ x\ \frac{(Energy\ or\ Demand)\ Savings}{kSF}$$

**Table A-49. IQW Program Attic Insultation Savings Inputs**

| Description | Assumption | Source |
|---|---|---|
| Area of installed insulation (kSF) | Actual | 2018 IQW Program data |
| Energy Savings | Dependent on recorded pre and post R-values | 2018 IQW Program data |

Energy savings (kWh/kSF) differed by heating type and measure and are in a series of look-up tables in the 2015 Indiana TRM. Energy savings by installation depended on pre- and post-retrofit insulation R-values, which Cadmus calculated using a three-step process:

1. Determine variables to use for insulation compression, $R_{ratio}$, and void factors
2. Calculate adjusted pre- and post-retrofit R-values using the inputs from step one
3. Interpolate the 2015 Indiana TRM tables to calculate savings using the adjusted R-values from step two

**Variables to Use for Insulation Compression, Rratio, and Void Factors**

Cadmus adjusted R-values to account for compression, void factors, and surrounding building material, using this formula:

$$R\ value\ Adjusted\ =\ R_{nominal}\ x\ F_{compression}\ x\ F_{void}$$

The following equation determined $F_{void}$:

$$R_{ratio} = (R_{nominal} \; x \; F_{compression}) x \; ((R_{nominal} \; x \; R_{framing\ and\ air\ space}))$$

The inputs used for these formulas are shown in Table A-50.

**Table A-50. Attic Insulation Compression, Rratio, and Void Factors**

| Description | Assumption | Source |
|---|---|---|
| Actual pre- and post-R-values per manufacturing specifications (Rnominal) | Actual | 2018 IQW Program data |
| Compression factor dependent on the percentage of insulation compression (Fcompression) | 1 | Cadmus assumed a value of 1 at 0% compression for the evaluation |
| Void Factor (Fvoid) | Varied | Void factors accounted for insulation coverage and were dependent on installation grade level, pre- and post-R-values and compression effects |
| R-value for material (Rfarming and air space) | 5 | 2015 Indiana TRM |
| Area of installed insulation in thousand square feet (kSF) | Varies by participant | 2018 IQW Program Tracking Data for heating/cooling combination for each participant |

Table A-51 lists the void factor based on the calculated $R_{ratio}$. Cadmus used a 2% void for the evaluation because this information was unknown, and 2% is common in most households.

**Table A-51. Indiana TRM: Insulation Void Factors**

| $R_{ratio}$ | Void Factor | |
|---|---|---|
| | 2% Void (Grade II) | 5% Void (Grade III) |
| 0.5 | 0.96 | 0.9 |
| 0.55 | 0.96 | 0.9 |
| 0.6 | 0.95 | 0.88 |
| 0.65 | 0.94 | 0.87 |
| 0.7 | 0.94 | 0.85 |
| 0.75 | 0.92 | 0.83 |
| 0.8 | 0.91 | 0.79 |
| 0.85 | 0.88 | 0.74 |
| 0.9 | 0.83 | 0.66 |
| 0.95 | 0.71 | 0.49 |
| 0.99 | 0.33 | 0.16 |

**Adjusted R-Values**

Applying the formula above ($R_{value}$ Adjusted), Cadmus used the inputs defined in step one to calculate adjusted R-values for pre- and post-installation and calculated adjusted R-values for every installation in the database.

**Interpolate Indiana TRM Tables**

Cadmus used the pre- and post-adjusted R-values from step two to interpolate energy and demand for every 2017 installation based on the reported heating and cooling types. Appendix C of the 2015 Indiana TRM defines energy and demand savings for insulation measures by heating and cooling equipment.

### *Duct Sealing*

Cadmus used these equations to calculate savings per duct sealing retrofit (excludes ISR):

$$Annual\ Cooling\ kWh\ Savings = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * EFLH_{COOL} * \frac{Btuh_{COOL}}{SEER * 1{,}000}$$

$$Annual\ Heating\ kWh\ Savings = \frac{DE_{AFTER} - DE_{BEFORE}}{DE_{AFTER}} * EFLH_{HEAT} * \frac{Btuh_{HEAT}}{3{,}412\ *\ \eta_{HEAT}}$$

$$Demand\ kW\ Savings = \frac{DEPK_{AFTER} -\ DEPK_{BEFORE}}{DEPK_{AFTER}} * \frac{Btuh_{COOL}}{EER * 1{,}000} * CF$$

Cadmus calculated savings for duct sealing jobs implemented through the IQW Program using the savings inputs used for its *ex post* calculations are shown in Table A-52.

**Table A-52. IQW Program Duct Sealing Savings Inputs**

| Description | Assumption | Source |
|---|---|---|
| Distribution efficiency of ductwork after dealing sealing ($DE_{AFTER}$) | 87% | Used the following reference (listed in the 2015 Indiana TRM): http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf Percentage of ducts within conditioned space was unknown. Assumed the average of all potential values under: "Connections Sealed with Mastic." |
| Distribution efficiency of ductwork before dealing sealing ($DE_{BEFORE}$) | 76% | Used the following reference (listed in the 2015 Indiana TRM): http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf Percentage of ducts within conditioned space was unknown. Assumed the average of all potential values under: "No Observational Leaks," "Some Observed Leaks," "Significant Leaks," and "Catastrophic Leaks." |
| DE for use in peak demand savings ($DEPK_{AFTER}$) | 85% | 2015 Indiana TRM |
| DE for use in peak demand savings ($DEPK_{BEFORE}$) | 73% | 2015 Indiana TRM |
| Full-load heating hours ($EFLH_{HEAT}$) | 1,341; 982 | 2015 Indiana TRM for Indianapolis and Evansville |
| Full-load cooling hours ($EFLH_{COOL}$) | 600 | 2015 Indiana TRM for Evansville |
| Heating system capacity – electric furnace ($Btuh_{HEAT}$) | 32,000 BTUH | From Pennsylvania TRM |
| Cooling system capacity ($Btuh_{COOL}$) | 28,994 BTUH | 2015 Indiana TRM |
| Efficiency of heating system – electric furnace ($\eta_{HEAT}$) | HSPF = 3.412 | 2015 Indiana TRM |

| Description | Assumption | Source |
|---|---|---|
| Efficiency of cooling system (SEER) | 13 | 2015 Indiana TRM: 13 SEER reflects new federal efficiency standard for baseline equipment |
| Efficiency of cooling system (EER) | 11 | 2015 Indiana TRM: 11 EER reflects new federal efficiency standard for baseline equipment |

## *A.5 Online Home Energy Audit Program*

Cadmus' impact evaluation of the Online Home Energy Audit Program included a billing analysis to evaluate the effect on customer behavior from completing the online energy audit. The evaluation of program associated savings involved the following:

- Data collection, review, and preparation
- Billing analysis
- Uplift analysis
- Energy savings estimation
- Demand savings estimation

### A.5.1 Data Collection, Review, and Preparation

Vectren provided electricity billing data for customers who had completed an online home energy audit since the program was launched in May 2017. Vectren provided billing data between January 2016 and March 2019 that included the following fields:

- Service territory (Vectren North, Vectren South, or Vectren Ohio)[131]
- Fuel type (gas or electric)
- Usage value (kWh or therms)
- Bill duration
- Opt-out date for customers choosing not to participate in the program
- Move-out date for customers who have moved
- Electric and gas account numbers for linking to billing data

Cadmus collected National Oceanic and Atmospheric Administration (NOAA) daily temperature data from the weather station at the Evansville Regional Airport.

In addition, Oracle, the program implementer, provided participant data that included the date customers had completed an online audit and if any of these customers had participated in other residential programs.

131 To capture economies of scale, Cadmus conducted the Indiana and Ohio evaluations of the Online Home Energy Audit Programs at the same time. This report includes the results of the Indiana analysis only.

### *Data Preparation*

Cadmus used daily average temperature and billing cycle information to estimate cooling degree days (CDDs) and heating degree days (HDDs) for each home during the billing cycle. This required using a base temperature of 65 degrees, for HDDs and CDDs and billing cycle end dates to calculate the HDDs and CDDs that exactly matched energy use in the customer's bill. To fit monthly designations for the billing analysis, Cadmus calendarized the billing data by creating an average daily consumption value for each billing cycle and assigning that value proportionally to the number of days of each month the cycle covers.

Using the number of days in the billing cycle, Cadmus expressed each month's energy use and weather in average daily terms then merged the billing, weather, and program information data.

Cadmus performed the billing analysis on the population of program homes, with a few exceptions. Cadmus tested for several possible issues with participant bills, including duplicate values, bills with missing durations, or bills that spanned greater than 65 days. Customer bills with bills spanning greater than 65 days or bills missing days were removed from the final analysis. Additionally, customer bills more than 12 months prior to a customers' completion of an online audit or in 2019 were removed. Cadmus tested savings estimates with and without these bills and found that the models were robust with and without including the billing data.

Table A-53 shows the data cleaning process and resulting analysis sample. The final analysis data frame included electric fuel Vectren customers, all from the Vectren South service territory. Due to data limitations, the final estimation sample was different than the total number of electric service participants in the program. Cadmus estimated savings using the final estimation sample but applied savings to the total number of program participants within program participation data.

**Table A-53. Online Energy Audit Tool Electric Analysis Sample**

| Data Processing Step | Total |
|---|---:|
| Included in billing Data | 5,932 |
| Merge to program participation data | 5,932 |
| Filtered billing data | 5,352 |
| **Final Estimation Sample** | **5,352** |

## A.5.2 Billing Analysis

To estimate the program electricity savings, Cadmus used a regression analysis of monthly billing data. By comparing the usage of participants who had completed an online audit against the usage of participants who had not yet completed an audit, but eventually did, Cadmus estimated program savings. The regression included time and customer fixed effects to control for temporal or individual variance in consumption. Indicators for participation in the Residential Behavioral Savings Program or for customers who received high bill alerts were also included to better account for changes in consumption unrelated to the impact of completing an online audit.[132]

### Regression Model

Cadmus specified the regression model assuming the average daily consumption ($ADC_{it}$) of electricity of home '$i$' in year '$t$' as given by the following equation:

$$ADC_{it} = \beta_1 PART_i * Yr_t + Yr_t + W'\gamma + \ \omega_t + \ \varepsilon_{it}$$

Where:

| | | |
|---|---|---|
| $\beta_1$ | = | Coefficient representing the conditional average treatment effect of the program on electricity use (kWh per customer per day). |
| $PART_i$ | = | Indicator variable for program participation (which equals 1 if customer '$i$' had completed an Online Home Energy Audit and 0 otherwise). |
| $Yr_t$ | = | Indicator variable for each program year (which equals 1 if the year '$t$' was in the program year and 0 otherwise). |
| $W$ | = | Vector using both HDD and CDD variables to control for weather impacts on energy use. |
| $\gamma$ | = | Vector of coefficients representing the average impact of weather variables on energy use. |
| $\omega_t$ | = | Indicator for a customer fixed effect (which equals 1 if customer '*I*' and 0 if otherwise). The inclusion of this variable in the model controls for differences across customers. |
| $\varepsilon_{it}$ | = | Error term for customer '$i$' in month '$t$.' |

## A.5.3 Uplift Analysis

To estimate program uplift, Cadmus used a regression analysis of monthly residential program savings data. By comparing the presence of other program savings of participants who had completed an online audit against the usage of those participants who had not yet completed an audit, but eventually did, Cadmus estimated uplift savings as a function of Online Home Energy Audit Program completion. The regression included time and customer fixed effects to control for temporal or individual variance in savings. The average daily savings estimated from uplift is used to adjust evaluated net program savings.

### Regression Model

Cadmus specified the regression model assuming the average daily savings ($ADS_{it}$) of electricity of home '$i$' in year '$t$' as given by the following equation:

---

[132] The High Bill Alert Program is a behavioral program implemented by Oracle, the program implementer. Participants received alerts when their usage exceeded a predetermined threshold.

$$ADS_{it} = \beta_1 PART_i * Yr_t + Yr_t + W'\gamma + \omega_t + \varepsilon_{it}$$

Where:

| | | |
|---|---|---|
| $\beta_1$ | = | Coefficient representing the conditional average treatment effect of the program on savings from other programs (kWh per customer per day). |
| $PART_i$ | = | Indicator variable for program participation (which equals 1 if customer '$i$' had completed an Online Home Energy Audit and 0 otherwise). |
| $Yr_t$ | = | Indicator variable for each program year (which equals 1 if the year '$t$' was in the program year and 0 otherwise). |
| $W$ | = | Vector using both HDD and CDD variables to control for weather impacts on energy use. |
| $\gamma$ | = | Vector of coefficients representing the average impact of weather variables on energy use. |
| $\omega_t$ | = | Indicator for a customer fixed effect (which equals 1 if customer '*I*' and 0 if otherwise). The inclusion of this variable in the model controls for differences across customers. |
| $\varepsilon_{it}$ | = | Error term for customer '$i$' in month '$t$.' |

## A.5.4 Energy Savings Estimation

Cadmus estimated Online Home Energy Audit Program energy savings in 2018. To illustrate the approach, let i=1, 2, …, N index the number of households who completed an online audit; and D(x) return the number of the days in 2018 from January 1 for a given date *x* (e.g., D[February 1]=32).

For a home and energy type, the net program savings then equaled the product of the average daily savings, $\beta_2$, and the total number of days in the program:

$$Net\ Savings = -\beta_2 * (\sum_{i=1}^{N} ProgramDays_i)$$

Where:

| | | |
|---|---|---|
| *i* | = | 1, 2, …, N indexes the number of homes in the customer segment. |
| $ProgramDays_i$ | = | number of days household i had bills in 2018. If the home i's billing account became inactive before December 31, 2018, then D(inactive $date_i$) – D(January 1, 2018). |

## A.5.5 Demand Savings Estimation

Cadmus estimated the peak-coincident demand savings by applying the coincident kW reduction factor determined in the Residential Behavioral Savings Program. Because savings in the Online Home Energy Audit Program were estimated as an average impact across dual fuel and electric only customers, this ratio was calculated using the weighted average of electric customer types.

Residential Behavioral Savings Program peak-coincident demand was estimated with Integral Analytics' DSMore software using a load shape for a typical Vectren home and the evaluated net program energy savings as inputs. This is the same software that Vectren uses to assess program cost-effectiveness, which helps maintain alignment. It was necessary for Cadmus to apply the Calibrated DSMore Load-Shape Differences (CLSD) approach because Vectren, like the other Indiana electric utilities, did not have enough homes with advanced metering infrastructure (AMI) to estimate the demand savings using electricity use measurements. Vectren's full AMI deployment was planned to be complete by the end of 2018.

The CLSD approach uses Vectren-specific residential load shapes built into DSMore and calibrates the load shapes to match the verified annual consumption of the treatment group to equal the annual kWh savings. It then identifies and reports the demand reductions during the coincident peak for the utility. Cadmus performed separate demand savings analyses for dual fuel and electric only customers using load shapes specific to these customer groups.

The CLSD approach follows six specific steps:

1. Conduct a pre-post D-in-D (experimental design with randomized control group) billing analysis to identify average participant and program-wide energy (kWh) savings achieved. (This is described in more detail above in the Billing Analysis section in this appendix.)
2. Calibrate Vectren-specific residential DSMore load shapes to match the kWh consumption levels of the treatment group.
3. Adjust the load shape so that the annual savings identified in the billing analysis are reflected on that load shape. Maintain the same shape, while reducing the amplification of that shape.[133]
4. Record the coincident load reduction on the calibrated DSMore load shape for the peak period defined by Vectren.
5. Report the number determined in step four as the coincident kW reduction.
6. Multiply the peak reduction determined in step five by the number of participants to report program kW impacts.

The CLSD approach provides a reasonable estimate of the per household and program-wide peak kW reduction given the available data. By adjusting the coincident kW reduction factor by a weighted average across dual fuel and electric only customer types, an estimate of kW reduction was obtained for all electric customers who completed an online audit.

[133] This load-shape adjustment accounted for the fact that delivery of the first home energy reports occurred in late January and early February of 2012.

## A.6 Energy Efficient Schools Program

Cadmus' impact evaluation of the Energy Efficient Schools (EES) Program included measures with attributable electric savings, including these:

- One 15-watt LED
- Two 11-watt LEDs
- Kitchen faucet aerator (1.5 gpm)
- Two bathroom faucet aerators (1.0 gpm)
- Energy-efficient showerhead (1.5 gpm)
- LED night light
- Furnace filter whistle

Table A-54 provides per-unit annual gross savings for each program measure. These savings include adjustments for in-service rate (ISR) and water heater fuel saturation.

**Table A-54. Energy Efficient Schools Program Per-Unit Gross Savings[1]**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| 11W LED (one unit only)[1] | 68.1 | 31.2 | 0.004 | 0.003 |
| 15W LED | 47.6 | 42.3 | 0.005 | 0.005 |
| Energy-Efficient Bathroom Aerator (one unit only)[1] | 21.6 | 8.9 | 0.001 | 0.000 |
| Energy-Efficient Kitchen Aerator | 56.4 | 45.4 | 0.002 | 0.001 |
| Energy-Efficient Showerhead | 130.6 | 109.9 | 0.004 | 0.003 |
| LED Night Light | 7.0 | 6.6 | 0.000 | 0.000 |
| Furnace Filter Whistle | 20.4 | 12.3 | 0.025 | 0.015 |

[1] Reported and evaluated savings include ISRs
[2] There are two 11W LEDs and two bathroom aerators in each kit; however, these savings are for one unit only.

### A.6.1 LED

Cadmus used these equations to calculate savings per LED bulb installed:

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * ISR * HOURS\right) * (1 + WHF_E)$$

$$kW\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * ISR * HOURS\right) * (1 + WHF_D) * CF$$

Cadmus used the 2015 Indiana TRM's assumption of 1,135 hours of use per year.[134] Cadmus also applied a waste heat factor (WHF), representing the portion of annual lighting energy producing an interactive effect (lost or gained) with heating and cooling equipment.

To account for net increases in heating loads (because of more efficient lighting), Cadmus applied a -0.034 WHF for electricity savings and a 0.092 WHF for demand as indicated in the 2015 Indiana TRM

[134] The 2015 Indiana TRM LED bulb assumptions do not account for bulb location.

for Evansville, Indiana. Cadmus verified that all participating schools were in or around Evansville by mapping their zip codes. Assumptions used in LED savings calculations are shown in Table A-55.

**Table A-55. 2018 Energy Efficient Schools Program LED Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline Wattage for Equivalent Incandescent Bulb (16-watt LED) | 72 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 1600 lumen LED (program data provided by Vectren)[1] |
| Baseline Wattage for Equivalent Incandescent Bulb (13-watt LED) | 53 | DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for post-EISA 1100 lumen LED (program data provided by Vectren) [1] |
| Hours of Use per Year | 1,135 | 2015 Indiana TRM v2.2 school kits value |
| Summer Peak Coincidence Factor | 0.11 | 2015 Indiana TRM v2.2 |
| Waste Heat Factor for Energy | -0.034 | 2015 Indiana TRM v2.2 Evansville value |
| Waste Heat Factor for Demand | 0.092 | 2015 Indiana TRM v2.2 Evansville value |
| ISR | 68% | Benchmarking |

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

## A.6.2 Energy-Efficient Showerhead

Cadmus used these equations to calculate savings per energy-efficient showerhead installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

Energy-efficient showerheads provided through the program replaced residents' existing showerheads, reducing water flow rates. To inform the energy-savings estimate, Cadmus used the 2015 Indiana TRM and data collected from the 2018 HEWs to determine average household size. Table A-56 shows these inputs.

**Table A-56. 2018 Energy Efficient Schools Program Showerhead Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Average Shower Length (Minutes) | 7.8 | 2015 Indiana TRM |
| Average Household Size (Number of People) | 4.7 | 2018 Indiana School Kit Home Energy Worksheet |
| Number of Showerheads per Home | 1.5 | Weighted average, based on 2015 Indiana TRM and EIA RECS 2009 for Indiana/Ohio[1] |
| Number of Showers per Day per Person | 0.6 | 2015 Indiana TRM |
| Input Water Temperature to House (°F) | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DHW system |
| Water Temperature at Showerhead (°F) | 101 | 2015 Indiana TRM, average mixed temperature of water used for shower |
| Gallons per Minute of Baseline Showerhead | 2.63 | 2015 Indiana TRM |
| Gallons per Minute of Energy-Efficient Showerhead | 1.50 | Provided by Vectren |
| Recovery Efficiency of Electric Hot Water Heater | 0.98 | 2015 Indiana TRM |
| Summer Peak Coincidence Factor | 0.0023 | 2015 Indiana TRM |
| ISR | 49% | Benchmarking |
| %Fuel | 40% | 2018 Indiana School Kit Home Energy Worksheet |

[1] U.S. Energy Information Administration. *2009 Residential Energy Consumption Survey.* https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf

## A.6.3 Energy-Efficient Faucet Aerator

Cadmus used these equations to calculate savings per faucet aerator installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{SH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * DR * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

Cadmus calculated savings for kitchen and bathroom faucet aerators installed through the EES Program using values from the 2015 Indiana TRM and HEW data, as shown in Table A-57.

**Table A-57. 2018 Energy Efficient Schools Program Faucet Aerator Savings Inputs**

| Input | Kitchen Faucet Assumption | Bathroom Faucet Assumption | Source |
|---|---|---|---|
| Faucet Usage (Minutes/Day/Person) | 4.5 | 1.6 | 2015 Indiana TRM |
| Number of Faucets per Home | 1 | 1.9 | Weighted average, based on 2015 Indiana TRM and EIA RECS 2009 for Indiana/Ohio[1] |
| Average Household Size (Number of People) | 4.7 | 4.7 | 2018 Indiana School Kit Home Energy Worksheet |
| Input Water Temperature to House (°F) | 62.8 | 62.8 | 2015 Indiana TRM for Evansville, IN, cold water temperature entering the DHW system |
| Temperature of Water at Faucet (°F) | 93 | 86 | 2015 Indiana TRM |
| Percent of Water Flowing Down Drain | 50% | 70% | 2015 Indiana TRM |
| Gallons per Minute of Baseline Faucet Aerator | 2.44 | 1.9 | 2015 Indiana TRM |
| Gallons per Minute of Energy-Efficient Faucet Aerator | 1.5 | 1.0 | Provided by Vectren |
| Recovery Efficiency of Electric Hot Water Heater | 0.98 | 0.98 | 2015 Indiana TRM |
| Summertime Peak Coincidence Factor | 0.0033 | 0.0012 | 2015 Indiana TRM |
| ISR | 42% | 43% | Benchmarking |
| %Fuel | 40% | 40% | 2018 Indiana School Kit Home Energy Worksheet |

[1] U.S. Energy Information Administration. *2009 Residential Energy Consumption Survey.* https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf

## A.6.4 LED Night Light

Cadmus used this equation to calculate savings per LED night light installed:

$$kWh\ Savings = \frac{watts_{BASE} - watts_{LED}}{1{,}000} * ISR * HOURS * IRF$$

Cadmus calculated savings for LED night lights using values from the 2015 Indiana TRM for hours of use and baseline wattages. The U.S. Department of Energy Uniform Methods Project was used for standard LEDs, but it does not provide guidance for night lights. For the incandescent replacement factor (IRF), or the percentage of LED night lights that replaced incandescent night lights, Cadmus used follow-up survey data from the 2013 Energizing Indiana Statewide Core Program (also used in Vectren's 2014–2016 evaluations).[135] The assumptions used in these savings calculations are shown in Table A-58. According to the 2015 Indiana TRM, no peak demand reduction is associated with night lights.

[135] *2013 Energizing Indiana Evaluation Report. May 2014*. Submitted by the Indiana Statewide Core Program Evaluation Team for the Indiana Demand Side Management Coordination Committee.

**Table A-58. 2018 Energy Efficient Schools Program LED Night Light Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Baseline Wattage for Incandescent Night Light | 5 | 2015 Indiana TRM |
| LED Night Light Wattage | 0.5 | Provided by program |
| Hours of Use per Year | 2,920 | 2015 Indiana TRM |
| Incandescent Replacement Factor | 0.62 | 2013 Energizing Indiana School Kit Follow-Up Survey data |
| ISR | 81% | Benchmarking |

## A.6.5 Furnace Filter Whistle

Cadmus used these equations to calculate savings per furnace filter whistle installed:

$$kWh_{central\ AC}\ Savings = ISR * \%CAC * FLH_{cool} *\ BtuH_{central\ AC} * \frac{\frac{1}{SEER}}{1000} * EF_{elec}$$

$$kWh_{heat\ pump}\ Savings = ISR * \%HP * (FLH_{cool} *\ BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} + FLH_{heat} * BtuH_{HP} * \frac{\frac{1}{HSPF}}{1000}) *\ EF_{elec}$$

$$kW_{central\ AC}\ Savings = ISR * \%CAC * BtuH_{central\ AC} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * CF$$

$$kW_{heat\ pump}\ Savings = ISR * \%HP * BtuH_{heat\ pump} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * CF$$

As shown in Table A-59, Cadmus calculated savings for the furnace filter whistles installed through the program using values from the 2015 Indiana TRM, prior evaluation results, the Indiana residential baseline study, and an engineering review conducted by Quantec detailing algorithms for the measure.[136]

**Table A-59. 2018 Energy Efficient Schools Program Furnace Filter Whistle Savings Inputs**

| Input | Assumption | Source |
|---|---|---|
| Efficiency Savings for Electric Furnace | 0.035 | Quantec analysis: Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm |
| Seasonal Energy Efficiency Ratio | 11.15 | 2015 Indiana TRM: when unknown use 11.15 (Minimum Federal Standard) |
| Energy Efficiency Ratio | 10.04 | 2015 Indiana TRM: EER=SEER*0.9 |
| Multiplier for Energy Efficiency Ratio | 0.90 | 2015 Indiana TRM: EER=SEER*0.9 |
| Heating Season Performance Factor | 6.8 | 2015 Indiana TRM: When unknown use HSPF 7.7 (Minimum Federal Standard after 2006) |
| Size of Central Air Conditioner and Heat Pump Units in BTUH | 28,994 | 2015 Indiana TRM: CAC early replacement default existing unit cooling capacity |

136 Reichmuth, Howard. n.d. *Engineering Review and Savings Estimates for the "Filtertone" Filter Restriction Alarm.* White paper prepared for Energy Technology Laboratories. Prepared by Quantec.

| Input | Assumption | Source |
| --- | --- | --- |
| Size of Gas Heating System in BTUH | 78,236 | 2012 Indiana Residential Baseline Study, average capacity of heat pump |
| Summer Peak Coincidence Factor | 0.88 | 2015 Indiana TRM |
| Full Load Cooling Hours | 600 | 2015 Indiana TRM for Evansville |
| Full Load Heating Hours (Gas and Electric) | 982 | 2015 Indiana TRM for Evansville |
| ISR | 28% | 2018 Indiana School Kit Home Energy Worksheet data |
| %CAC | 54% | RECS 2009 Indiana/Ohio values |
| %HP | 7% | RECS 2009 Indiana/Ohio values |

## A.7 Residential Behavioral Savings Program

Cadmus' impact evaluation of the RBS Program included a billing analysis to evaluate the effect of home energy reports on the behavior of treated customers. The evaluation of the RBS Program savings and efficiency program uplift consisted of these six tasks:

- Data collection, review, and preparation
- Equivalency checks on treatment and control groups
- Billing analysis
- Energy-savings estimations
- Energy efficiency program channeling analysis
- Demand savings analysis

### A.7.1 Data Collection, Review, and Preparation

Vectren provided data from monthly electricity bills for electric only and dual fuel homes for Wave 1 treatment and control group customers between January 2011 and January 2019 (approximately 13 months of bills prior to the beginning of the RBS Program in 2012 and 84 months of bills after the program began). Billing data included energy use during the monthly billing cycle, the last day of the billing cycle, and these fields:

- Customer segment (electric only or dual fuel)
- Assignment to treatment or control groups
- First report date[137]
- Opt-out date for customers choosing not to participate in the program

[137] The program implementer assigned a first-report date to control homes, with a "pseudo first report date" as the date the first home energy report would have been mailed to control homes.

- Move-out date for customers who have moved
- Electric and gas account numbers for linking to billing data

Cadmus collected National Oceanic and Atmospheric Administration (NOAA) daily temperature data from the municipal airport weather stations near Henderson, Kentucky, Lawrenceville, Illinois, and Evansville, Indiana, the three stations nearest to all RBS Program treatment and control homes.

Vectren provided participation and measure savings data for its 2018 DSM programs. For each program and measure, these data included the account number, the number and description of measures installed, measure installation dates, and verified savings. Cadmus used these data to estimate the RBS Program's participation and savings effects on other efficiency programs (uplift).

### *Data Preparation*

Cadmus used daily average temperature and billing cycle information to estimate cooling degree days (CDDs) and heating degree days (HDDs) for each home during the billing cycle. This required using a base temperature of 65 degrees for HDDs and CDDs and billing cycle end dates to calculate the HDDs and CDDs that exactly matched energy use in the customer's bill. To fit monthly designations for the billing analysis, Cadmus calendared the billing data by creating an average daily consumption value for each billing cycling and assigning that value proportionally to the number of days of each month the cycle covers.

Because all weather data derived from three closely located stations, temperatures did not vary significantly among homes. Most weather variation in the data occurred over time.

Using the number of days in the billing cycle, Cadmus expressed each month's energy use and weather in average daily terms then merged the billing, weather, and program information data, including information about the approximate delivery date of the first home energy report. Because there is only one wave in the program, every customer has the same first delivery date.

Cadmus performed the billing analysis on the population of program homes, with a few exceptions. Cadmus tested for several possible issues with program homes—such as missing randomized control trial start date and missing usage information. The only customers excluded from the estimation were those missing billing data, fewer than six pre-program monthly energy bills, or insufficient data to calculate summer and winter pre-period usage. Savings estimates did, however, include these customers because they were not inactive customers.

Table A-60 shows the effects of applying this filter. The final treatment group sample frame was 72,642—the sum of 23,426 electric only treatment group customers and 49,216 dual fuel treatment group customers—from an original treatment group population of 77,260 (25,750 electric only customers and 51,510 dual fuel customers). Even if a customer was not active at the start of 2018, the customer was included in the regression analysis if the filter criteria were met.

**Table A-60. Analysis Sample Selection**

| | Electric Only | | | Dual Fuel | | |
|---|---|---|---|---|---|---|
| | Treatment | Control | Total | Treatment | Control | Total |
| Original Randomly Assigned Homes | 25,750 | 6,098 | 31,848 | 51,510 | 5,595 | 57,105 |
| Missing Billing Data | 73 | 15 | 88 | 113 | 13 | 126 |
| Fewer than 6 Bills in Pre-Program Period | 2,251 | 549 | 49,216 | 2,181 | 224 | 2,405 |
| Total Filtered | 2,324 | 564 | 2,888 | 2,294 | 237 | 2,531 |
| **Final Estimation Sample** | **23,426** | **5,534** | **28,960** | **49,216** | **5,358** | **54,574** |

### *Equivalency Checks on Treatment and Control Groups*

Cadmus summarized average daily consumption in the pre-period (2011) and used a 2-sample *t*-test to test for statistical significance in the mean consumption of control and treatment group customers. No statistical difference in average daily electric consumption was found for either electric only or dual fuel customers. This shows that the consumption for treatment and control groups was balanced in the pre-period. If consumption had not been balanced in the pre-period, Cadmus would have needed to change its evaluation methodology to account for any differences.

### *Billing Analysis*

To estimate the program electricity savings, Cadmus used regression analyses of monthly billing data. In the past, Cadmus reported savings from a difference-in-differences (D-in-D) model and used a post-only model to test for the robustness of savings. This year (and in past years), both models' estimates were contained within the other model's 90% confidence interval, meaning their results did not statistically differ. Because the estimates for the post-only model provided higher precision, Cadmus reported only the results of the post-only model. The billing analysis conformed to the approach described in the UMP.[138,139]

The following sections provide additional details about each modeling approach.

138 Agnew, K., and M. Goldberg. *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol.* U.S. Department of Energy, National Renewable Energy Laboratory. April 2013. (NREL/SR-7A30-53827) Available online: http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

139 Stewart, J., and A. Todd. *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Residential Behavior Protocol.* U.S. Department of Energy, National Renewable Energy Laboratory. August 2014. (NREL/SR-7A40-62497) Available online: http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

**Post-Only Model**

Cadmus specified the post-only model assuming the average daily consumption ($ADC_{it}$) of electricity of home '$i$' in month '$t$' as given by the following equation:

$$ADC_{it} = \beta_1 PART_i * PY_t + \beta_2 Pre\text{–}Usage_i + \beta_3 Pre\text{–}Summer_i + \beta_4 Pre\text{–}Winter_i + \beta_5 Pre\text{–}Usage_i \times \tau_t + \beta_6 Pre\text{–}Summer_i \times \tau_t + \beta_7 Pre\text{–}Winter_i \times \tau_t + W'\gamma + \tau_t + \varepsilon_{it}$$

Where:

$\beta_1$ = Coefficient representing the conditional average treatment effect of the program on electricity use (kWh per customer per day).

$PART_i$ = Indicator variable for program participation (which equals 1 if customer '$i$' was in the treatment group and 0 otherwise).

$PY_t$ = Indicator variable for each program year (which equals 1 if the month '$t$' was in the program year and 0 otherwise).

$\beta_2$ = Coefficient representing the conditional average effect of pre-treatment electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{–}Usage_i$ = Mean household energy consumption of customer '$i$' across all pre-treatment months.

$\beta_3$ = Coefficient representing the conditional average effect of pre-treatment summer electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{–}Summer_i$ = Mean household energy consumption of customer '$i$' during June, July, August, and September of the pre-treatment period.

$\beta_4$ = Coefficient representing the conditional average effect of pre-treatment winter electricity use on post-treatment average daily consumption (kWh per customer per day).

$Pre\text{–}Winter_i$ = Mean household energy consumption of home '$i$' during December, January, February, and March of the pre-treatment period.

$W$ = Vector using both HDD and CDD variables to control for weather impacts on energy use.

$\gamma$ = Vector of coefficients representing the average impact of weather variables on energy use.

$\tau_t$ = Average energy use in month '$t$ reflecting unobservable factors specific to the month. The analysis controls for these effects with month-by-year fixed effects.

$\beta_5$ = Coefficient representing the conditional average effect of pre-treatment electricity use, given month '$t$', on post-treatment average daily consumption (kWh per customer per day).

| | | |
|---|---|---|
| $\beta_6$ | = | Coefficient representing the conditional average effect of pre-treatment summer electricity use, given month '$t$', on post-treatment average daily consumption (kWh per customer per day). |
| $\beta_7$ | = | Coefficient representing the conditional average effect of pre-treatment winter electricity use, given month '$t$', on post-treatment average daily consumption (kWh per customer per day). |
| $\varepsilon_{it}$ | = | Error term for customer '$i$' in month '$t$.' |

### *Difference-in-Differences Fixed Effects Model*

The D-in-D fixed effects model was specified, assuming average daily consumption ($ADC_{it}$) of electricity of customer '$i$' in month '$t$', as given by the following equation:

$$ADC_{it} = \alpha_i + \tau_t + W'\gamma + \beta_1 PART_i \times POST_t + \epsilon_{it}$$

Where:

| | | |
|---|---|---|
| $\beta_1$ | = | Coefficient representing the program's conditional average treatment effect on electricity use (kWh per customer per day). |
| $PART_i$ | = | Indicator variable for program participation (which equals 1 if customer '$i$' was in the treatment group and 0 otherwise). |
| $POST_t$ | = | Indicator variable for whether month '$t$' is pre- or post-treatment (which equals 1 if month '$t$' was in the treatment period and 0 otherwise). |
| $W$ | = | Vector using HDD and CDD variables to control for weather impacts on energy use. |
| $\gamma$ | = | Vector of coefficients representing the average impact of weather variables on energy use. |
| $\alpha_i$ | = | Average energy use in customer '$i$' reflecting unobservable, non-weather-sensitive, and time-invariant factors specific to the customer. The analysis controlled for these effects with customer fixed effects. |
| $\tau_t$ | = | Average energy use in month '$t$' reflecting unobservable factors specific to the month. The analysis controlled for these effects with month-by-year fixed effects. |
| $\epsilon_{it}$ | = | Error term for customer '$i$' in month '$t$' |

## A.7.2 Energy-Savings Estimation

Cadmus estimated RBS Program energy savings in 2018 for each customer segment (dual fuel and electric only). To illustrate the approach, let i=1, 2, …, N index the number of dual fuel or electric only homes receiving a home energy report; and D(x) return the number of the days in 2018 from January 1 for a given date *x* (e.g., D[February 1]=32).

For a home and energy type, the net program savings then equaled the product of the average daily savings, $\beta_2$, and the total number of home energy report days in the program:

$$Net\ Savings = -\beta_2 * (\sum_{i=1}^{N} ProgramDays_i)$$

Where:

| | | |
|---|---|---|
| $i$ | = | 1, 2, …, N indexes the number of homes in the customer segment. |
| $ProgramDays_i$ | = | 365 if home i was in Wave 1 and its billing account remained active on December 31, 2018. If the home i was in Wave 1 and its billing account became inactive before December 31, 2018, then D(inactive $date_i$) – D(January 1, 2018). |

## A.7.3 Energy Efficiency Program Channeling (Uplift) Analysis

Analysis of efficiency program uplift proved important for two reasons:

- Vectren sought to learn whether and to what extent the RBS Program caused participation in Vectren's other programs.
- To the extent the RBS Program caused participation in other efficiency programs, energy savings resulting from this participation would be counted twice—once in the regression estimate of RBS Program savings and once in the other programs' savings. (Thus, Vectren should subtract the double-counted savings from its portfolio savings.)

The uplift analysis yielded estimates of the percentage of the RBS Program's effect on other efficiency program participation and on the double-counted savings. Cadmus limited the analysis, however, to program measures that Vectren tracked at the customer level. Cadmus performed participation and savings uplift analyses for these residential efficiency programs:

- Appliance Recycling Program (ARP)
- Income Qualified Weatherization (IQW) Program
- Home Energy Assessment (HEA) 2.0 Program
- Residential Prescriptive Program
- Online Energy Audit (OEA) Program

Cadmus did not perform channeling analyses for these residential efficiency programs:

- The Energy Efficient Schools Program targeted school children and their families. Participation was not voluntary.
- For the Residential Lighting Program, although the RBS Program may have influenced LED and other high-efficiency lighting purchases, such purchases were tracked at the store level.
- The Residential New Construction Program targeted builders of new homes, which the RBS Program did not target.

- The Multifamily Direct Install Program targeted multifamily property managers, which the RBS Program did not target.[140]

As with the energy-savings analysis, the uplift analysis followed the logic of the program's experimental design. Cadmus collected efficiency program participation and savings data in 2018, matching the data to RBS Program treatment and control homes, and applied a simple differences analysis to each customer-energy segment and wave. Because customers in the treatment and control groups are expected to be identical, except for having participated in the RBS Program, the difference between these groups in other efficiency program participation would equal the RBS Program uplift. In homes matching the 2018 efficiency program data, Cadmus excluded measures installed after an account became inactive or measures installed before the first energy report date. When calculating energy uplift, Cadmus pro-rated a measure's savings based on the installation date, so that a measure installed halfway through the year was only credited half a year of savings. Additionally, Cadmus pro-rated a measure's savings based on weather sensitivity. For demand uplift, Cadmus included full demand savings for any measure installed prior to the end of September 2018.

Let $\rho_m$ be the participation rate (defined as the number of participants to the number of potential participants) in a program in 2018 for group m (as before, m=1, for treated homes, and m=0 for control homes) in period t (t in {0,1}), as illustrated in this equation:

$$\textit{Participation uplift} = \rho_1 - \rho_0$$

Cadmus used this method to express participation uplift relative to the participation rate of control homes in 2018, which yielded an estimate of the percentage uplift, as in this equation:

$$\textit{\%Participation Uplift} = \textit{Program Uplift}/\rho_0$$

Cadmus estimated RBS Program savings from participation in other efficiency programs the same way, by replacing the program participation rate with the program net savings per home, as illustrated in this equation:

$$\textit{Net savings per home from participation uplift} = \sigma_1 - \sigma_0$$[141]

Multiplying net savings per home by the number of program homes yielded an estimate for a customer segment and wave of total RBS net savings counted in Vectren's other efficiency programs.

[140] Cadmus did not conduct the uplift analysis for the Multifamily Direct Install Program because the RBS Program is a behavioral program targeting residents of single-family and multifamily housing units. The Multifamily Direct Install Program targets property managers who did not receive home energy reports and did not make decisions about electricity use in multifamily tenant units.

[141] Cadmus obtained net savings by multiplying measure-verified gross savings by the estimated measure NTG ratio.

## A.7.4 Demand Savings Analysis

Cadmus estimated the peak-coincident demand savings with Integral Analytics' DSMore software using a load shape for a typical Vectren home and the evaluated net program energy savings as inputs. This is the same software that Vectren uses to assess program cost-effectiveness, which helps maintain alignment. It was necessary for Cadmus to apply the Calibrated DSMore Load-Shape Differences (CLSD) approach because Vectren, like the other Indiana electric utilities, did not have enough homes with AMI to estimate the demand savings using electricity use measurements. Vectren's full AMI deployment was planned to be complete by the end of 2018.

The CLSD approach uses Vectren-specific residential load shapes built into DSMore and calibrates the load shapes to match the verified annual consumption of the treatment group to equal the annual kWh savings. It then identifies and reports the demand reductions during the coincident peak for the utility. Cadmus performed separate demand savings analyses for dual fuel and electric only customers using load shapes specific to these customer groups.

The CLSD approach follows six specific steps:

7. Conduct a pre-post D-in-D (experimental design with randomized control group) billing analysis to identify average participant and program-wide energy (kWh) savings achieved. (This is described in more detail above in the Billing Analysis section in this appendix.)
8. Calibrate Vectren-specific residential DSMore load shapes to match the kWh consumption levels of the treatment group.
9. Adjust the load shape so that the annual savings identified in the billing analysis are reflected on that load shape. Maintain the same shape, while reducing the amplification of that shape.[142]
10. Record the coincident load reduction on the calibrated DSMore load shape for the peak period defined by Vectren.
11. Report the number determined in step four as the coincident kW reduction.
12. Multiply the peak reduction determined in step five by the number of participants to report program kW impacts.

The CLSD approach provides a reasonable estimate of the per household and program-wide peak kW reduction given the available data.

[142] This load-shape adjustment accounted for the fact that delivery of the first Opower home energy reports occurred in late January and early February of 2012.

## A.8 Residential Lighting Program

Cadmus' impact evaluation of the Residential Lighting Program included measures with attributable electric savings, including LED fixtures, general service bulbs, reflectors, and specialty bulbs. Table A-61 provides per-unit annual gross savings for each program measure.

**Table A-61. 2018 Residential Lighting Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| LED Fixture | 57.5 | 48.5 | 0.006 | 0.007 |
| LED General Service | 27.8 | 30.0 | 0.003 | 0.004 |
| LED Reflector | 44.0 | 49.1 | 0.006 | 0.007 |
| LED Specialty | 44.0 | 34.1 | 0.006 | 0.005 |

### A.8.1 LED Lighting

To determine the program's *ex post* gross savings, Cadmus applied the deemed values in the 2015 Indiana TRM to each lamp in the program tracking database. The 2015 Indiana TRM uses the following equations for determining energy savings and demand reductions for residential lighting:

$$\Delta kWh = (\frac{watts_{BASE} - watts_{EFF}}{1000}) * HOURS * (1 + WHF_E)$$

$$\Delta kW = (\frac{watts_{BASE} - watts_{EFF}}{1000}) * CF * HOURS * (1 + WHF_D)$$

To determine baseline watts for all program bulbs, ($watts_{base}$), Cadmus used the ENERGY STAR lumens equivalence method specified in the most recent version of the Uniform Methods Project (UMP).[143] After carefully reviewing the delta watts multiplier approach recommended by the 2015 Indiana TRM, Cadmus determined that the specific values in this approach were out of date. The multiplier for LEDs generated for the 2015 TRM produced, on average, around 50 lumens per watt.

For 2018 data, the average LED produced closer to 85 lumens per watt.[144] The U.S. Energy Information Administration (EIA) expects that LEDs will continue to get more efficient for the next decade, eventually achieving an efficiency of greater than 150 lumens per watt.[145] This, in turn, means that as the

---

[143] U.S. Department of Energy. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* http://www.energy.gov/eere/about-us/ump-protocols

[144] Based on 2018 measure mix.

[145] U.S. Energy Information Administration. "LED bulb efficiency expected to continue improving as cost declines." March 19, 2014. Available online: https://www.eia.gov/todayinenergy/detail.php?id=15471

technology improves, the continued use of the current TRM multiplier will probably significantly understate the savings potential of LED bulbs.

Cadmus used 2015 Indiana TRM-specified values for hours of use, waste heat factor for energy and demand, and coincidence factor for demand, as shown in Table A-62.

**Table A-62. Residential Lighting Program Deemed Inputs Used to Determine *Ex Post* Gross Savings**

| Input | Deemed Input |
|---|---|
| Hours of Use[1] | 902 |
| Coincidence Factor[2] | 0.11 |
| Waste Heat Factor Energy[3] | -0.034 |
| Waste Heat Factor Demand[3] | 0.092 |
| Waste Heat Factor Gas[3] | -.0017 |

[1] TecMarket Works, et al. *Indiana Core Lighting Logger Hours of Use (HOU) Study*. July 29, 2013. Annual hours of use for specialty bulbs and multifamily common areas are from Illinois TRM, Version 4.0. 2015.

841 Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation.* January 20, 2009.

[3] Based on weighted average waste heat factor for Evansville Indiana. Indiana TRM, Version 2.2. 2015.

## A.9 Appliance Recycling Program

Cadmus' impact evaluation of the Appliance Recycling Program included measures with attributable electric savings, including refrigerator and freezer recycling. Table A-63 provides per-unit annual gross savings for each program measure.

**Table A-63. 2018 Appliance Recycling Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| Refrigerator | 985 | 1,060 | 0.12 | 0.14 |
| Freezer | 821 | 662 | 0.12 | 0.07 |

### A.9.1 Refrigerator and Freezer Models

Cadmus used a regression model specified in the U.S. Department of Energy's Uniform Methods Project (UMP) to estimate consumption for refrigerators.[146] Because the UMP does not have specifications for freezers, Cadmus created an analogous freezer model. The coefficient for each independent variable indicated the influence of that variable on daily consumption. Holding all other variables constant, a

[146] U.S. Department of Energy. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* October 2017. https://www.energy.gov/eere/about-us/ump-protocols

positive coefficient indicated an upward influence on consumption, and a negative coefficient indicated a downward effect on consumption.

Table A-64 shows the model specification Cadmus used to estimate a refrigerator's annual unit energy consumption (UEC) and its estimated parameters. The coefficient indicated the marginal impact on the UEC of a one-point increase in the independent variable. For example, an increase of one cubic foot in the size of a refrigerator will result in a 0.06 kWh increase in daily consumption. For dummy variables, the coefficient value represented the difference in consumption if the given condition proved true. For example, Cadmus' refrigerator model used a coefficient of 0.56 for the variable indicating whether a refrigerator was a primary unit; thus, with all else equal, a primary refrigerator consumed 0.56 kWh per day more than a secondary unit.

**Table A-64. Refrigerator UEC Regression Model Estimates**

(Dependent Variable = Average Daily kWh, R2 = 0.30)

| Independent Variables | Coefficient | Variance Inflation Factor (VIF) | p-Value |
|---|---|---|---|
| Intercept | 0.80 | 0.0 | 0.13 |
| Age (years) | 0.021 | 2.0 | 0.04 |
| Dummy: Unit manufactured pre 1990s | 1.04 | 1.7 | <.0001 |
| Size (cu. Ft.) | 0.06 | 1.8 | 0.02 |
| Dummy: Single Door | -1.75 | 1.2 | <.0001 |
| Dummy: Side-by-Side | 1.12 | 1.5 | <.0001 |
| Dummy: Primary | 0.56 | 1.6 | 0.003 |
| Interaction: Unconditioned Space x HDDs[1] | -0.04 | 1.3 | <.0001 |
| Interaction: Unconditioned Space x CDDs[2] | 0.03 | 1.5 | 0.19 |

[1] Heating degree day

[2] Cooling degree day

Table A-65 shows the final model specifications Cadmus used to estimate annual energy consumption of participating freezers and their estimated parameters. Because the UMP specifies only a refrigerator model, Cadmus created an analogous freezer model from an aggregated dataset of freezers metered by Cadmus in Wisconsin and Michigan.[147]

---

[147] U.S. Department of Energy. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Chapter 7: Refrigerator Recycling Evaluation Protocol. September 2017. Table 2. Available online: https://www.nrel.gov/docs/fy17osti/68563.pdf

**Table A-65. Freezer UEC Regression Model Estimates**
(Dependent Variable = Average Daily kWh, R2 = 0.45)

| Independent Variables | Coefficient | Variance Inflation Factor (VIF) | p-Value |
|---|---|---|---|
| Intercept | -0.96 | 0.0 | 0.54 |
| Age (years) | 0.045 | 2.2 | 0.12 |
| Dummy: Unit Manufactured Pre-1990 | 0.54 | 2.1 | 0.24 |
| Size (cu. Ft.) | 0.12 | 1.2 | 0.09 |
| Dummy: Chest Freezer | 0.30 | 1.1 | 0.07 |
| Interaction: Unconditioned Space x HDDs[1] | -0.03 | 1.1 | 0.54 |
| Interaction: Unconditioned Space x CDDs[1] | 0.08 | 0.1 | 0.07 |

[1] CDDs and HDDs derive from the weighted average CDDs and HDDs from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 is a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

Cadmus analyzed the corresponding characteristics (i.e., the independent variables) for the participating appliances (captured by ARCA in the 2018 program tracking database). Table A-66 lists program averages or proportions for each independent variable. Cooling degree days (CDDs) equal the weighted average CDDs from typical meteorological year 3 (TMY3) data for weather stations mapped to participating appliance ZIP codes.[148]

[148] TMY3 used median daily values for a variety of weather data collected from 1991 to 2005.

**Table A-66. 2018 Appliance Recycling Program Participant Mean Explanatory Variables and Model Coefficients**

| Appliance | Independent Variables | 2018 Mean Value | 2018 Model Coefficient |
|---|---|---|---|
| Refrigerator | Intercept | 1.00 | 0.80 |
| | Age (years) | 21.72 | 0.021 |
| | Dummy: Manufactured pre 1990s | 0.25 | 1.04 |
| | Size (cu. Ft.) | 20.33 | 0.06 |
| | Dummy: Single Door | 0.02 | -1.75 |
| | Dummy: Side-by-Side | 0.34 | 1.12 |
| | Dummy: Primary | 0.49 | 0.56 |
| | Interaction: Unconditioned Space x HDDs[1] | 4.53 | -0.04 |
| | Interaction: Unconditioned Space x CDDs[1] | 1.37 | 0.03 |
| Freezer | Intercept | 1.00 | -0.96 |
| | Age (years) | 25.03 | 0.045 |
| | Dummy: Unit Manufactured Pre-1990 | 0.40 | 0.54 |
| | Size (cu. Ft.) | 16.22 | 0.12 |
| | Dummy: Chest Freezer | 0.46 | 0.30 |
| | Interaction: Unconditioned Space x HDDs[1] | 9.00 | -0.03 |
| | Interaction: Unconditioned Space x CDDs[1] | 2.72 | 0.08 |

[1] CDDs and HDDs derive from the weighted average CDDs and HDDs from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 is a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

## *Unit Energy Consumption*

To determine annual and average daily per-unit energy consumption using UEC models and 2018 ARP tracking data, Cadmus applied average participant refrigerator and freezer characteristics to regression model coefficients. This approach ensured that the resulting UEC was based on specific units recycled through Vectren's program in 2018 rather than on a secondary data source.

Table A-67 shows the average per-unit UEC for refrigerators and freezers recycled during 2018 and 2017. In 2018, refrigerators had a higher UEC and freezers had a lower UEC than in 2017. Note that the average per-unit UEC shown in the table does not include the part-use adjustment factor.

**Table A-67. 2018 and 2017 Appliance Recycling Program Average UEC by Appliance Type**

| Appliance | 2017 Average Unit Energy Consumption (kWh/Year) | 2018 Average Unit Energy Consumption (kWh/Year) | 2018 Relative Precision (90% Confidence) |
|---|---|---|---|
| Refrigerator | 1,160 | 1,178 | 9% |
| Freezer | 927 | 882 | 21% |

For example, using values from Table A-66 above, Cadmus calculated the estimated annual UEC for 2017 freezers using the following equation:

$$\text{2018 Freezer UEC} = 365.25\ days * (-0.96 + 0.045 * [25.03\ years\ old] + 0.54 * [40\%\ units\ manufactured\ pre-1990] + 0.12 * [16.22\ ft.^3\ ] + 0.30 * [46\%\ units\ that\ are\ chest\ freezers] + 0.08 * [2.72\ Unconditioned\ CDDs] - 0.03 * [9.00\ Unconditioned\ HDDs]) = 882\ kWh/year$$

In 2018, the average UEC for refrigerators increased by 18 kWh and for freezers decreased by 45 kWh compared to 2017. The change in the refrigerator UEC is because of a 3% increase in the percentage of primary units, a 6% increase in the percentage of refrigerators that had a side-by-side door configuration, and 0.43-cubic-foot size increase from 2017 to 2018. The independent variables for primary unit, side-by-side door configuration, and unit size all have positive coefficients in the gross savings model, which means a unit with these characteristics uses more energy compared to a unit without these characteristics, holding all else equal.

The decrease in the freezer UEC is primarily because newer units were recycled in 2018 compared to 2017, specifically a 10% decrease in the number of units manufactured before 1990.[149] Table A-68 shows a direct comparison of average values for 2018 and 2017 for all model variables.

**Table A-68. Appliance Recycling Program**
**Participant Mean Explanatory Variables 2018 and 2017 Comparison**

| Appliance | Independent Variables | 2018 Mean Value | 2017 Mean Value |
|---|---|---|---|
| Refrigerator | Age (years) | 21.72 | 22.25 |
| | Dummy: Manufactured pre 1990s | 0.25 | 0.29 |
| | Size (cubic feet) | 20.33 | 19.90 |
| | Dummy: Single Door | 0.02 | 0.03 |
| | Dummy: Side-by-Side | 0.34 | 0.33 |
| | Dummy: Primary | 0.49 | 0.46 |
| | Interaction: Unconditioned Space x HDDs[1] | 4.53 | 5.57 |
| | Interaction: Unconditioned Space x CDDs[1] | 1.37 | 1.69 |
| Freezer | Age (years) | 25.03 | 27.12 |
| | Dummy: Unit Manufactured Pre-1990 | 0.40 | 0.50 |
| | Size (cubic feet) | 16.22 | 16.02 |
| | Dummy: Chest Freezer | 0.46 | 0.44 |
| | Interaction: Unconditioned Space x HDDs[1] | 9.00 | 7.74 |
| | Interaction: Unconditioned Space x CDDs[1] | 2.72 | 2.33 |

[1] CDDs and HDDs derive from the weighted average CDDs and HDDs from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 is a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

[149] The first set of national refrigerator and freezer efficiency standards took effect in 1987 as part of the National Appliance Energy Conservation Act. Refrigerator and freezers manufactured before 1990 used significantly more energy that units manufactured after the standard took effect.

### *Part-Use*

Part-use is an adjustment factor specific to appliance recycling that is used to convert the UEC into an average per-unit gross savings value. The UEC itself is not equal to the gross savings value, because the UEC model yields an estimate of annual consumption and not all recycled refrigerators would have operated year-round had they not been decommissioned through the program.

The part-use methodology relies on information from surveyed customers regarding their pre-program appliance use patterns. The final estimate of part-use reflects how appliances were likely to operate had they not been recycled (rather than how they previously operated). For example, a primary refrigerator, operated year-round, could have become a secondary appliance, operating part-time in a situation where the participant bought a new refrigerator for the kitchen.

The methodology accounts for these possible shifts in usage types. Specifically, Cadmus calculated part-use using a weighted average of these prospective part-use categories and factors:

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

Using information gathered through the 2018 participant survey, Cadmus used this multistep process to determine part-use:

- First, Cadmus determined whether a recycled refrigerator served as a primary or secondary unit (with all stand-alone freezers considered secondary units).
- If participants said they recycled a secondary refrigerator, Cadmus asked whether the refrigerator remained unplugged, operated year-round, or operated for a portion of the preceding year (assuming all primary units operated year-round). Cadmus asked the same question for all participants recycling a freezer.
- If participants said their secondary refrigerator or freezer operated for only a portion of the preceding year, Cadmus estimated the total number of months that the appliance was plugged in. (In 2018, responses from this participant subset resulted in secondary refrigerators operating an average of 6.2 months and secondary freezers operating an average of 5.2 months.)
- Cadmus divided each value by 12 to calculate the annual part-use factor for all secondary refrigerators and freezers operated for only a portion of the year. (In 2018, the average secondary refrigerator had a part-use factor of 0.52, and the average secondary freezer had a part-use factor of 0.43.)
- If participants said they would have kept their unit, Cadmus then asked if they would have moved the unit to a new location or would have kept the unit in the same location. If participants said they would have kept their refrigerators in the kitchen, Cadmus assumed these participants would have continued to use the refrigerator as a primary appliance and assigned them a part-use factor of 1. For all other responses, Cadmus assumed the appliance would have been used as a secondary appliance and applied the weighted average part-use factor for secondary appliances (0.88 for refrigerators and 0.80 for freezers).

- If participants said they would have discarded their appliance independent of ARP, Cadmus did not follow up about that appliance's future use because those actions would be determined by another customer. Therefore, because the future use of discarded refrigerators remains unknown, Cadmus applied the weighted part-use average (0.95) of all refrigerator units (primary and secondary) to this subset of refrigerators. Cadmus acknowledges that the discarded appliances might be used as either primary or secondary units in the would-be recipient's home.

Table A-69 lists the resulting part-use factor results by category.

**Table A-69. 2018 Appliance Recycling Program Part-Use Factor by Category**

| Usage Type and Part-Use Category | Refrigerators | | | Freezers | | |
|---|---|---|---|---|---|---|
| | Percentage of Recycled Units[1] | Part-Use Factor | Per-Unit Energy Savings (kWh/Yr) | Percentage of Recycled Units[1] | Part-Use Factor | Per-Unit Energy Savings (kWh/Yr) |
| **Secondary Units Only** | n = 29 | | | N/A | | |
| Not in Use | 3% | 0.00 | - | | | |
| Used Part Time | 17% | 0.52 | 609 | | | |
| Used Full Time | 79% | 1.00 | 1,178 | | | |
| **Weighted Average** | 100% | 0.88 | 1,039 | | | |
| **All Units (Primary and Secondary)** | n = 63 | | | n = 42 | | |
| Not in Use | 2% | 0.00 | - | 12% | 0.00 | - |
| Used Part Time | 8% | 0.52 | 304 | 14% | 0.43 | 380 |
| Used Full Time | 90% | 1.00 | 1,178 | 74% | 1.00 | 882 |
| **Weighted Average** | 100% | 0.95 | 1,114 | 100% | 0.80 | 705 |

[1] Percentages may not sum to 100% due to rounding of the individual percentages.
[2] All freezer units are considered to be secondary.

Combining the part-use factors in Table A-70 with participants' self-reported likely actions in the absence of the program resulted in the distribution of future-use scenarios and corresponding part-use estimates for refrigerators shown in Table A-71. This table shows that the weighted average of these future scenarios produces final part-use factor for refrigerators of 0.93 for the 2018 ARP. The final part-use estimate of 0.80 for freezers comes from Table A-70, as all freezer units are considered secondary units and no additional weighting is needed.

**Table A-70. 2018 Appliance Recycling Program Refrigerator Weighted Average Part-Use**

| Use Prior to Recycling | Likely Use Independent of Recycling | Refrigerators | |
|---|---|---|---|
| | | Gross Savings Factor | Percentage of Participants[1] |
| Secondary | Kept | 0.84 | 26% |
| | Discarded | 0.93 | 29% |
| Primary | Kept (as primary unit) | 1.00 | 6% |
| | Kept (as secondary unit) | 0.88 | 9% |
| | Discarded | 0.95 | 30% |
| **Overall** | | 0.93 | 100% |

[1] Percentages may not sum to 100% due to rounding of the individual percentages.

In 2018, the part-use factor for refrigerators increased from 0.90 in 2017 to 0.93 in 2018, while freezers decreased from 0.86 in 2017 to 0.80 in 2018. Table A-71 compares Vectren's part-use to previous evaluation years.

**Table A-71. Appliance Recycling Program Historical Part-Use**

| Program Year | Refrigerators | Freezers |
|---|---|---|
| 2012 | 0.97 | 0.92 |
| 2013 | 0.97 | 0.96 |
| 2014 | 0.93 | 0.90 |
| 2015 | 0.91 | 0.79 |
| 2016 | 0.88 | 0.79 |
| 2017 | 0.90 | 0.86 |
| **2018** | **0.93** | 0.80 |

## *A.10 Food Bank LED Distribution Program*

Cadmus' impact evaluation of the Food Bank LED Distribution Program was for one measure: a four-pack of 9W LED bulbs. Table A-72 provides per-unit annual gross savings for the 9W LED bulbs.

**Table A-72. 2018 Food Bank LED Distribution Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| 9W LED | 29.63 | 18.34 | 0.0041 | 0.0025 |

### A.10.1 9W LEDs

Cadmus used these equations to calculate savings per LED bulb installed:

$$kWh\ Savings = \left(\frac{Watts_{BASE} - Watts_{EFF}}{1{,}000}\right) * HOURS\ * (1 + WHF_E)$$

$$kW\ Savings = \left(\frac{Watts_{BASE} - Watts_{EFF}}{1{,}000}\right) * (1 + WHF_D) * CF$$

Cadmus applied the savings equation in the 2015 Indiana TRM and also accounted for leakage. Table A-73 shows the input values and the source for each value.

**Table A-73. 2018 9W LED Inputs**

| Cadmus Assumptions | Inputs | Source |
|---|---|---|
| HOURS – Hours of use per year | 902 | 2015 Indiana TRM (V2.2) |
| $Watts_{BASE}$ – Equivalent baseline wattage of program bulb | 43 | DOE Uniform Methods Project, Chapter 6 Residential Lighting |
| $Watts_{EFF}$ – Wattage of program bulbs | 9 | Spec sheets of program bulb |
| $WHF_E$ – Waste heat factor to account for cooling and heating savings | -0.039 | 2015 Indiana TRM—weighted average of weighted average heating types—cities comprised of Evansville (82%) and Indianapolis (18%), based on 2018 survey data |
| $WHF_D$ – waste heat factor for demand to account for cooling kW | 0.085 | |
| $WHF_G$ – Waste heat factor to account for gas impacts | -0.0017 | |
| CF – coincidence factor | 11% | 2015 Indiana TRM (V2.2) |

## *A.11 Smart Cycle (Smart Thermostats)*

In 2018, Vectren launched the Smart Cycle Program to enable control of selected residential central air conditioner (CAC) loads during summer hours of system peak demand via Nest smart thermostats. Vectren recruited participants from the 2016 Smart Thermostat Pilot and the long-running Summer Cycler Program.[150,151] Smart Thermostat Pilot participants with a Nest smart thermostat were automatically enrolled. Summer Cycler participants received complimentary removal of their load control switches and a Nest thermostat installed by a technician at no additional cost.

This section includes only those savings derived from normal use of a Nest thermostat installed in 2018 relative to the existing manual or programmable thermostat baseline. Cadmus evaluated demand response impacts, separately, in the *Smart Cycle Program 2018 Evaluation Report*.[152] Table A-77 shows the per-unit energy savings and total number of units for the Smart Cycle Nest thermostats.

---

[150] The 2016 Smart Thermostat Pilot tested peak load reductions, energy savings, and customer acceptance of Nest and Honeywell thermostats. Customers received an installation of a Wi-Fi-enabled thermostat at no additional cost and $25 in bill credits for participating in events.

[151] The Summer Cycler Program is another Vectren program designed to reduce residential and small commercial air-conditioning and water-heating electricity loads during summer peak hours. Through this program, customers receive bill credits for allowing Vectren to cycle off selected appliances during the summer.

[152] Cadmus. Smart Cycle Program 2018 Evaluation Report. April 11, 2019.

**Table A-74. Smart Cycle Thermostat Savings and Installations**

| Measure | Reported Per Unit Savings (kWh) | Evaluated Per Unit Savings (kWh) | Reported Installations (# of Thermostats) | Evaluated Installations (# of Thermostats)[1] |
|---|---|---|---|---|
| Smart Cycle Thermostat – Electric | 198 | 703 | 975 | 202 |
| Smart Cycle Thermostat – Dual Fuel | | 283 | | 841 |
| **Total** | **N/A** | **N/A** | **975** | **1,043** |

[1] Evaluated installations includes all smart thermostats installed during the 2018 program year. Only some of these thermostats were installed in time for summer load control events, therefore, the *Smart Cycle 2018 Evaluation Report* indicates 1,010 verified thermostats.

Cadmus assumed 20% of participants had electric heat pumps and 80% had central air conditioning with a gas furnace, per email correspondence with Vectren regarding equipment type saturations for Smart Cycle participants.[153] Notably, due to some homes having multiple thermostats, the percent of thermostats installed in homes with heat pumps is not exactly 20%. Using the same savings methodology used to calculate smart programmable thermostat savings in the Residential Prescriptive Program, Cadmus calculated Nest thermostat savings using the following equations (excluding ISR):

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{1}{\eta_{HEAT\ PUMP} * 3412}\right) * TStat\_Type_{Adjustment}$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline} * TStat_{Type_{COOLING_{DiscountRate}}} * \%AC$$

Table A-75 shows the inputs Cadmus used to evaluate impacts for the Smart Cycle. Cadmus used the average heat pump capacity from the Residential Prescriptive Program tracking database for the BTUH capacity in the electric heating savings calculation. Cadmus used a heat pump efficiency of 2.40 coefficient of performance (COP) based on the federal standard.

**Table A-75. Smart Cycle Smart Thermostat Input Variables**

| Variable | Value | Units | Source |
|---|---|---|---|
| $\eta_{HEAT\ PUMP}$ | 2.40 | - | Federal standard (COP) |
| $\eta_{ER}$ | 1.0 | - | 2015 Indiana TRM (COP) |
| $FLH_{HEAT}$ | 982 | Hours | 2015 Indiana TRM; Evansville, Indiana |
| $BTUH_{HEAT}$ | 33,700 | BTUH | Average of 2018 Vectren Indiana DSM Portfolio Evaluation heat pump tracking data capacities (Residential Prescriptive program). |
| $\%_{HEAT\ PUMP}$ | 20% | % | Used to determine the evaluated installations. Email correspondence with Vectren on May 5th, 2019 via Tonya Rine |
| $\%_{GAS}$ | 80% | % | Used to determine the evaluated installations. Email correspondence with Vectren on May 5th, 2019 via Tonya Rine |
| Manual thermostat saturation | 27% | % | 2018 Residential Prescriptive Program participant survey |
| Programmable | 73% | % | 2018 Residential Prescriptive Program participant survey |

[153] Email correspondence with Vectren on May 5th, 2019 via Tonya Rine.

| Variable | Value | Units | Source |
|---|---|---|---|
| thermostat saturation | | | |
| $TStat\_\mathrm{Type}_{\mathrm{DiscountRate}}$ | 31% non-learning 100% learning | % | The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. All Nest thermostats are learning thermostats, so this value is 100% for this program. |
| $TStat\_Type_{COOLING\,Disco}$ | 100% | % | No cooling savings adjustment can be directly derived from the comparative of study smart Wi-Fi thermostats. Cadmus is not comfortable discounting products without direct supporting evidence. The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. |
| $ESF_{AdjustedBaseline_{HEAT}}$ | 10.42% | % | Calculated, example below |
| $\%AC$ | 100% | % | Program design |
| $\Delta Cooling_{AdjustedBaselin}$ | 283 | kWh | Calculated, example below |

The 2015 Indiana TRM does not assign coincidence peak demand savings for smart thermostats, so Cadmus assigned 0 kW from normal use of the Nest smart thermostats.

### *2013–2014 Thermostat Evaluation and Adjusted Baseline*

Cadmus' analysis of the Smart Cycle smart thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren's Indiana South territory.[154] This evaluation reports household cooling energy savings of 332 kWh and a household heating energy saving factor (ESF) of 5% for programmable thermostats. It reports household cooling energy savings of 429 kWh and a household heating ESF of 12.5% for Nest Wi-Fi thermostats.

This study used a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2018 Smart Cycle Program did not exclude participants based on their existing thermostat type. Therefore, Cadmus assumed the baseline thermostat for the Smart Cycle Program aligned with the 2018 Residential Prescriptive Program participant survey results, which indicated that the saturation was 27% for manual thermostats and 73% for programmable thermostats.

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2014 Cadmus thermostat study and a weighted average to adjust the savings for Nest thermostats from a manual thermostat baseline to a mixed manual and programmable thermostat baseline.

Cadmus used these equations:[155]

$$\Delta Cooling_{AdjustedBaseline} = [27\% * 429 + 73\% * (429 - 201.6)] * 100\% = 283\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 27\% * 12.5\% + 73\% * (12.5\% - 2.86\%) = 10.42\%$$

154 Cadmus. January 29, 2015. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.*

155 Ibid.

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 201.6 represents the cooling savings (332 kWh multiplied by 61% correct use factor) for programmable thermostats. Cadmus did equivalent calculations to obtain adjusted baseline values for ESF-heat. The 2013–2014 thermostat evaluation investigated only homes with gas heating, so Cadmus assumed that the percentage of gas savings from that evaluation apply to electric heat as well.

### *Program Year Electric Savings*

Table A-76 shows the program year electric savings for the Smart Cycle smart thermostats.

**Table A-76. 2018 Program Year Electric Savings**

| Measure | *Ex Ante* Savings (kWh) | | | Evaluated *Ex Post* Savings (kWh) | Realization Rate | NTG Ratio | Evaluated Net Savings (kWh) |
|---|---|---|---|---|---|---|---|
| | Reported | Audited | Verified | | | | |
| Smart Cycle Thermostat - Electric | 193,050 | 39,996 | 39,996 | 142,058 | N/A | 100% | 142,058 |
| Smart Cycle Thermostat - Dual Fuel | | 166,518 | 166,518 | 237,721 | N/A | 100% | 237,721 |
| **Total** | **193,050** | **206,514** | **206,514** | **379,779** | **197%** | **100%** | **379,779** |

## *A.12 Commercial and Industrial Prescriptive Program*

Cadmus' impact evaluation of the C&I Prescriptive Program included measure categories with attributable electric savings, including these:

- Compressed air
- Chillers
- HVAC
- Kitchen equipment
- Lighting
- Refrigeration
- Programmable and Wi-Fi thermostats
- VFD/motors

Table A-77 provides per-unit annual gross savings for each program measure.

**Table A-77. 2018 C&I Prescriptive Program Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Audited[1] | Evaluated |
| Compressed Air Systems | 73,448 | 73,533 | 4.71 | 4.71 |
| Chillers | 86,714 | 88,781 | 13.80 | 15.66 |
| HVAC | 1,306[2] | 1,094 | 0.70 | 0.69 |
| Kitchen Equipment | 4,196[2] | 3,397 | 0.54 | 0.69 |
| Lighting | 429 | 408 | 0.06 | 0.06 |
| Refrigeration | 498 | 427 | 0.04 | 0.04 |
| Thermostat | 5,075[2] | 5,062 | 0.00 | 0.00 |
| VFD/Motor | 23,744 | 23,744 | 3.48 | 3.48 |

[1] The 2018 DSM Scorecard did not distill demand savings by measure, so per-unit demand values come from the 2018 program tracking database.
[2] Reported per-unit savings are calculated by the total savings on the 2018 DSM Scorecard divided by the audited quantities rather than by the quantities on the scorecard. For HVAC, thermostat, and kitchen measures, the electric scorecard does not differentiate between gas only and electric only measures—that is, the total number of HVAC, thermostat, and kitchen measures are reported regardless of fuel type, which skews the per-unit savings. It is important to note that this difference in reporting quantities does not influence the program-level realization rate because the total measure savings between the tracking database and scorecard aligned exactly.

The following sections provide the evaluation assumptions and calculations Cadmus used for each measure category.

## A.12.1 Compressed Air Systems

Cadmus used the 2015 Indiana TRM algorithms for the efficient air compressor project in 2018 (manufacturing process application):

$$\Delta kWh = Bhp * \frac{0.746}{\eta_{motor}} * HOURS * ESF$$

$$\Delta kWh = \frac{\Delta kWh}{HOURS} * CF$$

Where Bhp is the full load brake horsepower, $\eta_{motor}$ is the motor efficiency, and ESF is the energy savings factor based on the load control type.

## A.12.2 Chillers

Cadmus used the 2015 Indiana TRM algorithms for chiller replacements:

$$\Delta kWh = TONS \times \left(\frac{3.516}{IPLV_{BASE}} - \frac{3.516}{IPLV_{EE}}\right) \times EFLH$$

$$\Delta kW = TONS \times \left(\frac{3.516}{COP_{BASE}} - \frac{3.516}{COP_{EE}}\right) \times CF$$

In the first equation:

| | | |
|---|---|---|
| TONS | = | New chiller's size in tons |
| $IPLV_{EE}$ | = | New chiller's integrated part-load value |
| 3.516 | = | Conversion factor to IPLV in kW/ton |
| $IPLV_{BASE}$ | = | Assumed baseline IPLV that depends on the chiller type and size and is derived from the ASHRAE 90.1–2007 standard |
| EFLH | = | Estimated full-load hours selected based upon city, building type, and chiller type |

The second equation uses coefficient of precision (COP) instead of integrated part load value (IPLV) because COP is an instantaneous efficiency, rather than a seasonal average efficiency like IPLV. The coincidence factor, CF, is assumed to be 74%.

For the early replacement savings, Cadmus assumed that the $IPLV_{BASE}$ and $COP_{BASE}$ values came from IECC 2006 standards.

For chiller tune-ups, the chiller baseline values for IPLV and COP are used to calculate yearly energy use, and a savings factor of 8% is applied.

## A.12.3 HVAC

The predominant HVAC measure was upgrading unitary or split air conditioning units. Cadmus followed the algorithm in the 2015 Indiana TRM for time-of-sale measures and early replacement measures:

$$\Delta kWh = kBTU \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) \times EFLH$$

$$\Delta kW = kBTU \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times CF$$

Here, kBTU, $SEER_{ee}$, and $EER_{ee}$ are the capacity and efficiency specifications of the installed cooling equipment. Baseline efficiency terms are equal to the current federal baseline based on equipment size. The early replacement savings assume IECC 2006 standards as the baseline.

HVAC also includes furnace fan ECM savings. Cadmus used the equation in the 2015 Indiana TRM:

$$\Delta kWh = CAP \times EFLH_H \times \left(10 * \frac{n_{EE}}{n_{Base}} - 5\right)$$

Where:

| | | |
|---|---|---|
| CAP | = | Heating input capacity of installed equipment in MMBtu/hr |
| $EFLH_H$ | = | Equivalent full load heating hours selected based upon city and building type |
| 10 | = | Non-ECM kWh per MMBtu of heating fuel consumption |
| 5 | = | ECM kWh per MMBtu of heating fuel consumption |

$n_{EE}$ = Installed equipment efficiency

$n_{Base}$ = Baseline equipment efficiency

There are no demand savings with furnace ECMs.

## A.12.4 Kitchen Equipment

This measure category contains a heterogenous mix of different commercial kitchen appliances (dishwasher, ice machine, convection oven, steamcooker, hot food holding cabinet), some of which are not in the 2015 Indiana TRM. For these, Cadmus referred to the Illinois TRM (v6), which has a similar approach for kitchen equipment savings. Generally, the algorithms assign a single energy savings based on a number of production and building fuel assumptions. This deemed savings approach requires reference to look-up tables, which are available in the measure sections in the TRM.

## A.12.5 Lighting

Retrofits were the predominant type of lighting measure, and the basic algorithm is the same regardless of the replaced or efficient lighting technology (LED panels, high output T8 fixtures, refrigerated LEDs, etc.). Cadmus evaluated all retrofit lighting measures using this 2015 Indiana TRM algorithm:

$$\Delta kWh = (WATTS_{BASE} - WATTS_{EE}) \times Hours \times \frac{(1 + WHF_E)}{1000}$$

$$\Delta kW = (WATTS_{BASE} - WATTS_{EE}) \times CF \times \frac{(1 + WHF_D)}{1000}$$

In these equations:

$WATTS_{ee}$ = Wattage of the new lighting

$WATTS_{base}$ = Wattage being replaced

Hours = Hours the lights are on per year

CF = Peak demand coincidence factor

$WHF_E$ = Waste heat factors for energy

$WHF_D$ = Waste heat factor for demand

The program tracking database reported savings and new and replaced wattages for each project from this measure type. In accordance with the 2015 Indiana TRM, Cadmus used actual wattages (from the program tracking data) for $WATTS_{ee}$ and $WATTS_{base}$.

The program also offered a number of new construction lighting measures, which Cadmus evaluated using the lighting power density reduction method described in the 2015 Indiana TRM:

$$\Delta kWh = (LPD_{BASE} - LPD_{EE}) \times AREA \times Hours \times \frac{(1 + WHF_E)}{1000}$$

$$\Delta kW = (LPD_{BASE} - LPD_{EE}) \times AREA \times CF \times \frac{(1 + WHF_D)}{1000}$$

In these equations:

| | | |
|---|---|---|
| LPD | = | Lighting power density (lighting wattage per square foot) |
| AREA | = | Area (in square feet) that has its lighting power density reduced |
| $LPD_{BASE}$ | = | Minimum lighting power density required by the ASHRAE 90.1–2007 standard |
| $LPD_{ee}$ | = | Final lighting power density after fixture removal, efficient lighting installation, and/or other methods have been applied to the area |

The difference between $LPD_{BASE}$ and $LPD_{EE}$ multiplied by the area produces an overall wattage reduction.

Cadmus categorized occupancy sensors as a lighting measure for the purposes of the 2018 C&I Prescriptive Program evaluation and used the 2015 Indiana TRM to evaluate savings:

$$\Delta kWh = kW_{CONTROLLED} \times Hours \times (1 + WHF_E) \times ESF$$

$$\Delta kW = kW_{CONTROLLED} \times (1 + WHF_D) \times CF$$

Here, $kW_{CONTROLLED}$ is the amount of lighting wattage controlled by the occupancy sensor, ESF is an energy savings factor that depends on the type of occupancy sensor, and CF is a coincidence factor that also depends on the type of occupancy sensor.

## A.12.6 Refrigeration

The predominant measure upgrade for refrigeration was upgrading commercial freezers and/or refrigerators to an ENERGY STAR model. Cadmus evaluated savings based on the 2015 Indiana TRM equations:

$$\Delta kWh = (kWh_{BASE} - kWh_{EE}) * 365$$

$$\Delta kW = \frac{\Delta kWh}{HOURS} \times CF$$

However, Cadmus used the updated federal standards as the baseline and pulled the daily energy consumption of the efficient unit ($kWh_{EE}$) from the ENERGY STAR Qualified Products List. For the equation, kWh terms are available in the 2015 Indiana TRM based on the size of the unit. Hours equal 8,760, and CF equals 1.

## A.12.7 Thermostat

The implementer currently uses an energy modeling tool for determining savings for thermostat measures because neither the Indiana TRM nor Illinois TRM provides savings algorithms for thermostats in commercial applications. In 2018, similar to the previous two program years, the implementer continued to use an eQuest model of a 15,000-square-foot office building, which estimates savings for each thermostat project according to the project's claimed thermostat schedule. The *ex ante* simulations determine energy savings by modeling the heating, cooling, and ventilation savings for 360 different thermostat configurations for two different weather locations in eQuest: Indianapolis and Evansville. Configurations varied by degree heating/cooling setback, hours of setback per day, and days the business was closed per week. Simulations assumed a 15,000-square-foot office building as representative of the typical building type for this measure.

Last year, in the 2017 evaluation, Cadmus ran a comparison model for Evansville and Indianapolis using an EnergyPlus model available from the U.S. Department of Energy. The EnergyPlus model was developed as a benchmarking tool for commercial reference building consumption. Cadmus's model confirmed that percentage savings from the implementer's energy model were reasonable, and Cadmus found no reason to adjust thermostat savings based on the *ex ante* model in 2017.

A conclusion from this analysis was that a more accurate approach to determining *ex ante* savings would be to incorporate a greater variety of building types in the model. The office building characteristics used in the eQuest and EnergyPlus models did not represent the typical building, since schools and religious worship are generally overrepresented in the populations compared to office buildings. Cadmus looked further into this during this year's evaluation because the *ex ante* model remained unchanged during the 2018 program year. Cadmus compared the baseline consumption estimates from the implementer's model to the EnergyPlus models for a sample of common building types in the program population. Figure A-1 illustrates the results.

Cadmus found that compared to typical commercial building types, the baseline consumption (in terms of HVAC energy use intensity [EUI]) in the implementer's model is quite conservative. Although religious worship was not an EnergyPlus building type to compare to, Cadmus again found that the implementer's approach was reasonable considering the available data and found no reason to adjust thermostat savings based on the *ex ante* model in 2018.

**Figure A-1. 2018 HVAC Baseline EUI (kBtu/sq. ft.) Comparison for Thermostat Model**

### A.12.8 VFD/Motor

Variable frequency drive (VFD) controls added to HVAC fans and pumps were the predominant measure type, and Cadmus evaluated its savings using these 2015 Indiana TRM algorithms:

$$\Delta kWh = hp \times SF_{kWh}$$

$$\Delta kW = hp \times SF_{kW}$$

Here, hp is the size of the motor in horsepower, and SF is a savings factor derived from the city and other system configurations. These details included the fan type, which could be supply, return, or tower fans, or water pumps. These details also included what type of system the fan was part of, such as variable or constant air volume and with or without an economizer.

## *A.13 Commercial and Industrial Custom Program*

Cadmus' impact evaluation of the C&I Custom Program included projects with attributable electric savings. Cadmus performed desk reviews of all available project documentation for most program projects. For 10 participating customers, spanning 22 program projects, Cadmus performed on-site measurement and verification (M&V) inspections to verify certain critical factors and inputs affecting the project's continued savings. Table A-78 summarizes the results of the different evaluation methodologies.

**Table A-78. Summary of C&I Custom Program Data Collection Methodology**

| Evaluation Methodology | Total Projects | Projects Requiring Update |
|---|---|---|
| On Site M&V | 22 | 7 |
| Desk Review Only | 18 | 1 |
| **Total** | **40** | **8** |

### A.13.1 Desk Reviews

Each customer (or participating contractor) provided initial documentation of the project's energy saving and demand reduction, which the program implementer then reviewed, adjusted where necessary, and finalized. To evaluate the reasonableness of the savings calculations, Cadmus reviewed all project documentation, including invoices, technical specifications, and verification reports (if applicable) supplied by the program implementer .

Cadmus then reviewed each project's analysis workbook (supplied by the program implementer), upon which each project's incentives were based, verifying these items:

- Calculation assumptions matched equipment specifications and supporting project documentation (including verification reports)
- Reported savings calculations follow accepted engineering methodologies
- All assumed baselines are appropriate for project type (new construction, retrofit, etc.)

- All calculation assumptions were reasonable, justified, and properly cited
- Reported savings fell within a reasonable range given the project's scope

Cadmus performed desk review only (no on-site M&V) on 18 of the 40 C&I Custom electrical projects for program year 2018. Of these 18, only one required an update based on the data available to Cadmus. This update resulted in a net increase in estimated savings for the project.

### A.13.2 On-Site M&V

To increase the accuracy of evaluated savings, Vectren tasked Cadmus with conducting on-site M&V for a sample of the C&I Custom projects. To maximize the amount of program savings that could be directly verified, Cadmus prioritized projects in the following order:

- Project savings percentage of total program savings
- Likelihood of project parameters to differ from the original assumptions over time
- Project's location in Vectren territory (to maximize travel cost-effectiveness)

Cadmus sampled 20 of the project measures based on these criteria. However, not all of the originally sampled sites were able to be visited, primarily because contacts could not be reached or declined to participate in a site visit. However, Cadmus was able to find suitable replacements for all of these cases and in total, Cadmus conducted on-site evaluation inspections on 22 program projects for 10 participants.

Cadmus contacted all targeted program participants, using the contact information in the program tracking data, and explained the reason for the M&V process. To encourage cooperation, $100 gift cards were offered to all sites that agreed to a visit. Site visits was scheduled and conducted in January of 2019.

A typical M&V site visit went as follows:

- Cadmus met with site staff at the agreed scheduled time and location.
- Cadmus briefly explained again that the M&V process would not adversely affect them, their incentive, or their relationship with Vectren and answered any questions about the process.
- Cadmus briefly interviewed site staff regarding general parameters about the equipment, such as typical system run hours and loading.
- Cadmus collected observable data on the equipment. Data collection varied for different sites depending on the type of project and accessibility of information. Cadmus' primary objective was to verify that the affected equipment was still installed, energized, and properly functioning and to obtain typical operational characteristics.
- For select sites, Cadmus installed power metering equipment to log electrical power to the equipment.

- After collecting all available data, Cadmus let site staff know that it was finished and, if metering equipment was deployed, that someone from Cadmus would contact them in the future to remove it.

Seven of the 22 verified measures required updates to the savings estimates based on on-site data. These on-site observations proved to be critical to Cadmus' ability to provide an accurate analysis of the program. For example, Cadmus made a single observation on one project that resulted in a 242,000 kWh (9%) gross reduction in program savings that would otherwise not been determined.

Table A-79 shows the seven projects, reported and evaluated savings, realization rates, project types, and notes about the adjustment.

**Table A-79. On-Site Evaluated C&I Custom Measures Requiring Adjustment**

| Measure | Reported *Ex Ante* kWh Savings | Evaluated *Ex Post* kWh Savings | Realization Rate | Project Type | Reason for Adjustment |
|---|---|---|---|---|---|
| Custom Project 3 | 831,365 | 589,450 | 71% | New construction HVAC equipment efficiency and controls | Cadmus found that several large VFD controlled fan speed setpoints were higher than was assumed in the *ex ante* calculations, resulting in lower estimated savings. |
| Custom Project 15 | 225,874 | 216,973 | 96% | Retrofit HVAC controls | Cadmus found that only a fraction of the building's HVAC system and floorspace was tied into the new control systems. Thus, the controls upgrade did not have as much of an affect as assumed in the *ex ante* calculations, resulting in lower savings estimation. |
| Custom Project 18 | 217,782 | 237,342 | 109% | Retrofit Interior LED Lighting | Based on typical lighting design practices and observations of similar Vectren projects, Cadmus assumed approximately 10% of the lights are on an "emergency" circuit and do not turn off during unoccupied hours. This increased the baseline and measure burn hours for this fraction of lamps, thus increasing the energy savings estimations. |
| Custom Project 24 | 41,474 | 44,840 | 108% | Retrofit HVAC equipment efficiency and controls | Cadmus found that the minimum VFD speed setpoint on several main supply fans were lower than was assumed in the *ex ante* calculations, resulting in greater savings. |
| Custom Project 28 | 59,161 | 63,666 | 108% | Retrofit advanced exterior lighting controls | Cadmus found that the minimum lighting levels were lower than what was assumed in the *ex ante* calculations, resulting in greater in a greater-savings estimation. |

| Measure | Reported *Ex Ante* kWh Savings | Evaluated *Ex Post* kWh Savings | Realization Rate | Project Type | Reason for Adjustment |
|---|---|---|---|---|---|
| Custom Project 36 | 26,753 | 28,714 | 107% | Retrofit interior LED lighting | Cadmus found that approximately 10% of the lights are on an "emergency" circuit and do not turn off during unoccupied hours. This increased the baseline and measure burn hours for this fraction of lamps, thus increasing the energy-savings estimations. |
| Custom Project 45 | 10,807 | 9,047 | 84% | Retrofit commercial refrigeration controls | Metering power data collected by Cadmus was used to inform the *ex post* savings calculations. The resulting savings were slightly lower than the *ex ante* savings. |
| Custom Project 46 | 10,807 | 10,209 | 94% | Retrofit commercial refrigeration controls | Metering power data collected by Cadmus was used to inform the *ex post* savings calculations. The resulting savings were slightly lower than the *ex ante* savings. |

## *A.14 Commercial and Industrial Small Business Direct Install Program*

Cadmus' impact evaluation of the Small Business Direct Install (SBDI) program included these measures with attributable electric savings:

- Direct install and low-cost interior and exterior energy-efficient lighting
- LED refrigerated case lighting
- LED exit signs
- Lighting occupancy sensors
- Smart Wi-Fi-enabled or programmable thermostats
- Refrigerator/freezer efficiency measures, including ECMs and vending machine occupancy sensors

The following sections provide the evaluation assumptions and calculations Cadmus used for each measure category. Table A-80 provides per-unit annual gross savings for each program measure.

**Table A-80. 2018 Small Business Direct Install Per-Unit Gross Savings**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| ECMs | 397.5 | 397.5 | 0.05 | 0.05 |
| Exterior Lighting | 1,583.6 | 1,583.6 | 0.00 | 0.00 |
| Interior Lighting | 194.1 | 193.7 | 0.06 | 0.06 |
| LED Exit Signs | 82.5 | 83.3 | 0.01 | 0.01 |
| Occupancy Sensors | 136.1 | 136.3 | 0.03 | 0.03 |
| Programmable Thermostats | 1,974.6 | 1,975.6 | 0.00 | 0.00 |
| Refrigerated Case Lighting | 230.4 | 230.4 | 0.03 | 0.03 |
| Vending Machine Occupancy Sensors | 1,611.8 | 1,611.8 | 0.00 | 0.00 |

### A.14.1 Electronically Commutated Motors (ECMs) for Walk-In Coolers and Freezers

Cadmus did not update any algorithm savings inputs for ECMs and deemed the *ex ante* inputs as appropriate. In 2018, on a per-unit basis, the program achieved 397.5 kWh of savings—354 kWh for three walk-in coolers and 528 kWh for one walk-in freezer. These deemed values were taken from the 2015 program-specific TRM, Vectren Small Business Energy Solutions Technical Reference Manual, that covers measures not included in the 2015 Indiana TRM.[156]

### A.14.2 Exterior Lighting

In 2018, exterior lighting included only outdoor high intensity discharge (HID) LED lighting. Cadmus relied on the 2015 Indiana TRM and the 2015 Vectren Small Business Direct Install TRM to verify the assumed baseline wattages. Cadmus did not update any algorithm savings inputs for exterior lighting and determined that all inputs were appropriate. Cadmus found no deviation from reported baseline wattages. Cadmus found that all *ex ante* and *ex post* savings matched with no difference between per-unit *ex ante* and *ex post* exterior lighting savings.

### A.14.3 Interior Lighting

Interior lighting included these direct install and low-cost measures:

- HID and fluorescent tube to linear LED
- Incandescent to LED, both standard and down-light bulb applications
- T12 delamping

Table A-81 presents the per-unit deemed savings for each measure in the interior lighting category. Cadmus relied on the 2015 Indiana TRM and the 2015 Vectren Small Business Direct Install TRM to verify the assumed baseline wattages. Cadmus found four sites where the program implementer applied an incorrect waste heat factor, based on the type of space in which the lighting was installed; nevertheless, the difference between reported and evaluated per-unit savings was less than 0.5%. Of this difference, 73% of the savings came from HID and fluorescent tube to linear LED replacements and nearly all of the remaining 27% came from incandescent to LED replacements. Less than 0.2% came from T12 delamping.

[156] Vectren. 2015. *Vectren Small Business Energy Solutions Technical Reference Manual*.

**Table A-81. 2018 Small Business Direct Install Program Interior Lighting Per-Unit Deemed Savings Review**

| Measure | Annual Gross Savings (kWh) | | Annual Gross Savings (Coincident Peak kW) | |
|---|---|---|---|---|
| | Reported | Evaluated | Reported | Evaluated |
| HID and fluorescent tube to LED | 200.0 | 199.8 | 0.1 | 0.1 |
| Incandescent to LED | 126.7 | 127.9 | 0.0 | 0.0 |
| T12 delamping | 386.4 | 386.2 | 0.1 | 0.1 |

## A.14.4 LED Exit Signs

Cadmus relied on the 2015 Indiana TRM to determine evaluated savings for LED exit signs. Cadmus did not update any algorithm savings inputs for LED exit signs and determined that all inputs were appropriate. Cadmus found two sites where the program implementer applied an incorrect waste heat factor, based on the type of building in which the lighting was installed. On a per-unit basis, in 2018, the program achieved 83.3 kWh of savings, which resulted in a realization rate of 101%.

## A.14.5 Occupancy Sensors

Cadmus relied on the 2015 Indiana TRM to determine evaluated savings for occupancy sensors. The evaluated savings nearly matched the per-unit deemed kWh savings reported. On a per-unit basis, the program achieved 136.3 kWh of savings in 2018, which was largely the result of how many fixtures were controlled by each sensor, which resulted in a realization rate of 100%.

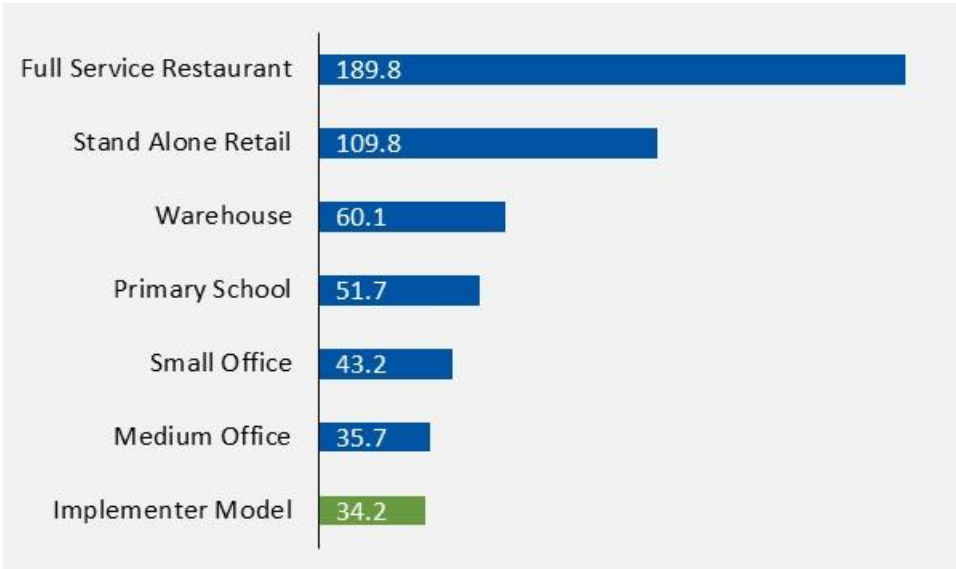
## A.14.6 Programmable Thermostats

The program implementer currently uses an energy modeling tool for determining savings for thermostat measures because neither the Indiana nor Illinois TRM provides savings algorithms for thermostats in commercial applications. In 2018, as in the previous two program years, the implementer used an eQuest model of a 15,000-square-foot office building, which estimates savings for each thermostat project according to the project's claimed thermostat schedule. The *ex ante* simulations determine energy savings by modeling the heating, cooling, and ventilation savings for 360 different thermostat configurations for two different weather locations: Indianapolis and Evansville. Configurations varied by degree heating/cooling setback, hours of setback per day, and days the business was closed per week. Simulations assumed a 15,000-square-foot office building as representative of the typical building type for this measure.

In the 2017 evaluation, Cadmus ran a comparison model for Evansville and Indianapolis using an EnergyPlus model developed by the U.S. Department of Energy as a benchmarking tool for commercial reference building consumption. Cadmus's model confirmed that the percentage savings from the implementer's energy model were reasonable for 2018, and Cadmus found no reason to adjust thermostat savings based on the *ex ante* model in 2017.

A conclusion from this analysis was that a more accurate approach to determining *ex ante* savings would be to incorporate a greater variety of building types in the model. The office building characteristics used in the eQuest and EnergyPlus models did not represent the typical participant building, since schools and religious worship are generally overrepresented in the SBDI Program population compared to office buildings. Cadmus looked further into this in 2018 and compared the baseline consumption estimates from the implementer's model to the EnergyPlus models for a sample of common building types in the population. Figure A-2 illustrates the results.

**Figure A-2. 2018 HVAC Baseline EUI (kBtu/sq ft) Comparison for Thermostat Model**




Cadmus found that, compared to typical commercial building types, the baseline consumption (in terms of HVAC energy use intensity [EUI]) in the implementer's model in eQuest is quite conservative. Although EnergyPlus did not have a comparable religious worship building type, Cadmus again determined that the implementer's approach was reasonable considering the available data and found no reason to adjust thermostat savings based on the *ex ante* model in 2018. On a per-unit basis, the program achieved 1,975.6 kWh of savings in 2018, which resulted in a realization rate of 100%.

### A.14.7 Vending Machine Occupancy Sensors

Cadmus relied on the 2015 Indiana TRM to determine evaluated savings for vending machine occupancy sensors. The evaluated savings matched the per-unit deemed kWh savings as reported. On a per-unit basis, the program achieved 1,611.8 kWh of savings in 2018, which resulted in a realization rate of 100%, the same as in the 2013, 2014, and 2015 evaluations.

## *A.15 Conservation Voltage Reduction*

The following describes the analysis Cadmus conducted to estimate the energy and demand savings achieved during 2018 by the CVR Program. These estimates were developed using regression models for the four feeders served by the Buckwood substation.

## A.15.1 Data Sources

Cadmus retrieved program data from Vectren's SFTP site. These data were exported from AdaptiVolt, Utilidata's volt/VAR optimization (VVO) software, which records multiple measurements for each feeder at 15-second intervals that can be used for modeling. In its analysis of each feeder, Cadmus used specific measurements—start and end of line voltage, demand, and CVR system status (on or off).

Cadmus also collected local climatological data from the National Oceanic and Atmospheric Administration (NOAA) for the weather station at the Evansville Regional Airport. These data contain hourly, historical records of temperature and relative humidity that are coincident with the supplied power distribution data.

## A.15.2 Savings Analysis

Cadmus used statistical modeling to develop estimates of energy and demand savings. This technique empirically quantifies savings by modeling feeder-level power demand as a response to local meteorological and temporal variables. These models are used to predict what a feeder's power demand would have been in the absence of an operating CVR system. The savings attributed to this period are calculated as the difference between these counterfactual predictions of power demand and the actual measurements recorded during that time. Energy savings are calculated by summing demand savings over time.

The first step in developing a model is to separate in the data the periods of time when a feeder's CVR system was not engaged. These periods are referred to as the baseline period, and a model fit to these data is called a baseline model.

The periods when a feeder's CVR system was turned on are referred to as reporting periods because savings estimates are reported for these hours. Figure A-3 illustrates a single feeder's power demand for one week when the CVR system was cycled on and off. The complete data used in the evaluation for this feeder are shown in Figure A-4.

**Figure A-3. Example Activation of CVR for Single Feeder, One Week**

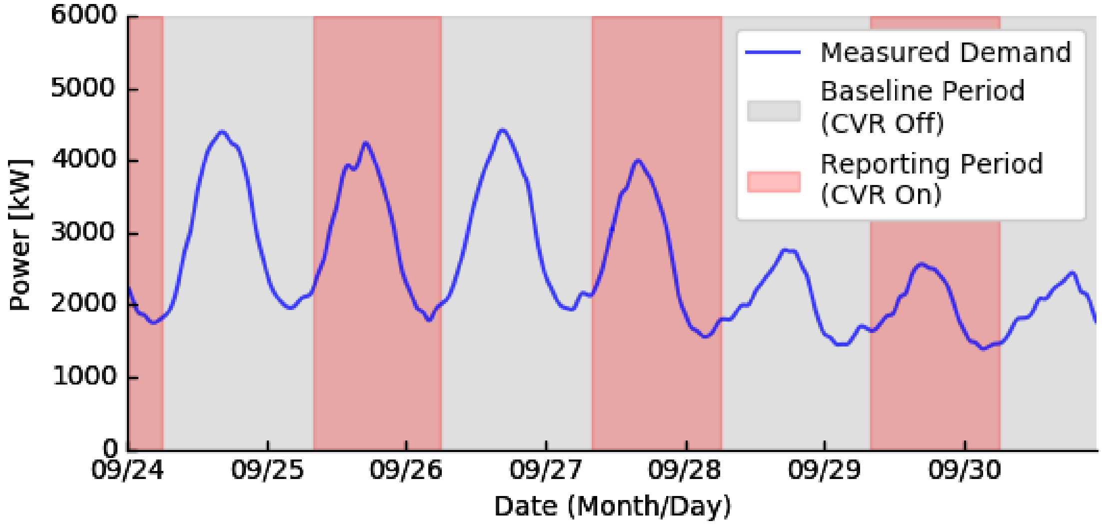
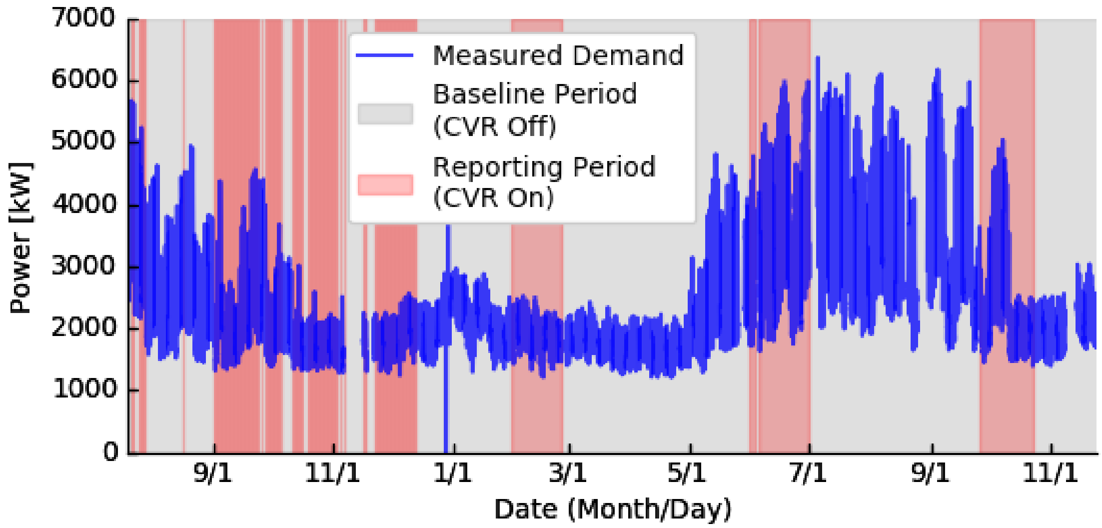


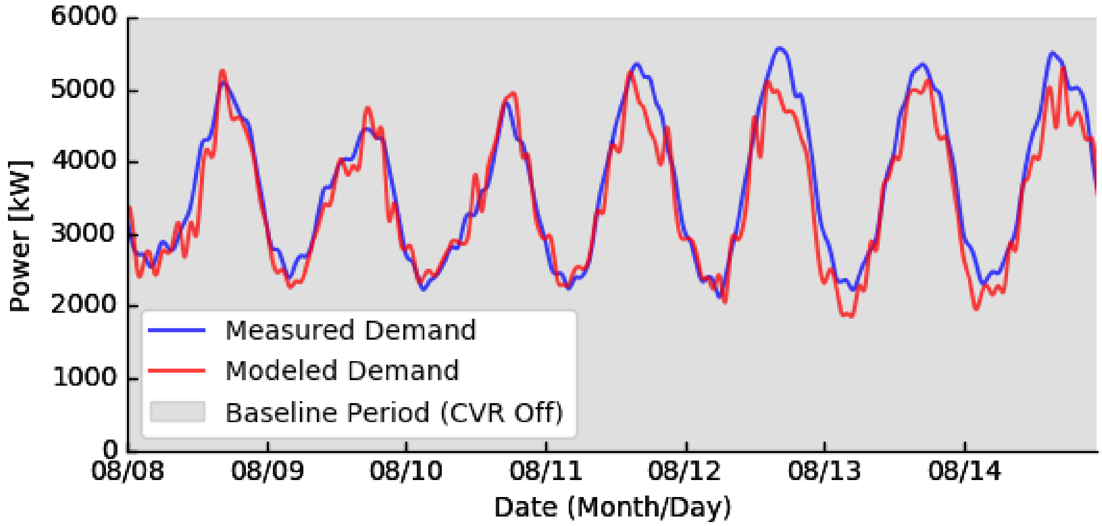

**Figure A-4. Example Activation of CVR for Single Feeder, 2018**




Cadmus used random forest regression to fit baseline models of demand for each feeder to outdoor air temperature and relative humidity, the hour of the day, and the day of the week.[157] A sample of predictions from a baseline model fit to a single feeder are shown in Figure A-5 along with the measured values used for model fitting. For each of the four feeders, the coefficient of determination of the baseline model exceeded 0.9, implying greater than 90% of the variability in demand is explained by the model.

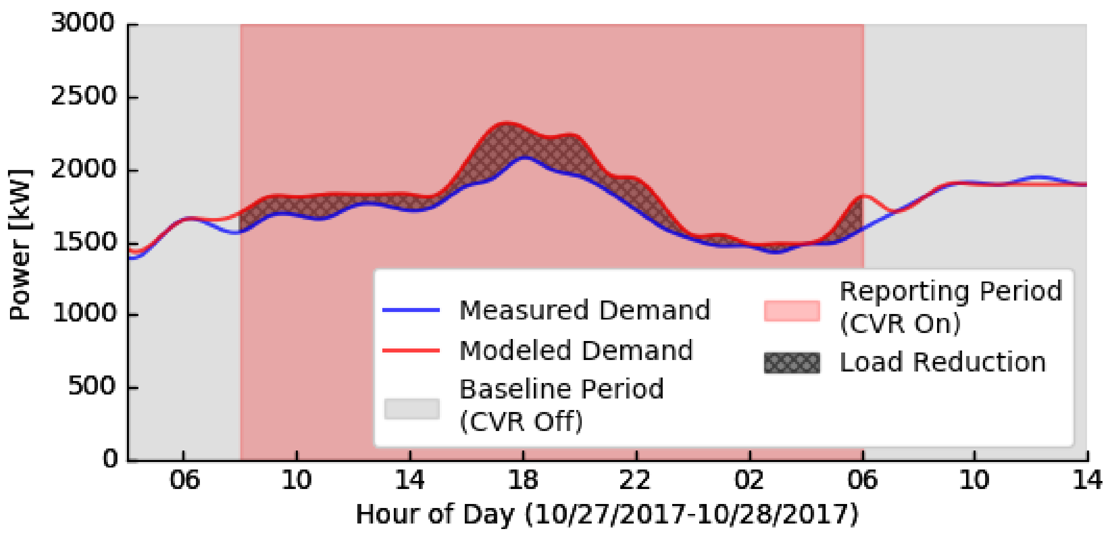
157 Random forest regression is an ensemble machine learning method that fits many decision trees on subsamples of data.

**Figure A-5. Example Baseline Modeling for Single Feeder**




Cadmus estimated energy and demand savings by predicting a feeder's baseline power demand when the CVR system was turned on and taking the difference between these values and the values measured on the feeder. This application of the baseline model is shown in Figure A-6.

**Figure A-6. Example Calculating Savings for Single Feeder**




As Figure A-6 above illustrates, and is supported by the high coefficients of determination of the four baseline models, most of the variability in the demand on a feeder is explained by the weather, the time of day, and the day of the week. However, because CVR generally achieves savings in the low single digits in percentage terms,[158] it is important to average demand savings over the summer season and total energy savings over the program year. Vectren's CVR system achieved approximately 2.2% energy saving while active during the 2018 program year.

Savings results are reported in Table A-82, with savings determined by each specific feeder.

**Table A-82. 2018 CVR Energy Savings by Feeder**

| Feeder | Energy Savings (kWh) | Percentage of Energy Savings | Demand Savings [kW] |
|---|---|---|---|
| FR188 | 84,950 | 1.7% | -8.25 |
| FR 288 | 129,936 | 2.5% | -50.48 |
| FR 388 | -5,310 | 0.0% | -62.54 |
| FR 488 | 677,838 | 3.4% | 134.8 |
| **Total** | **887,414** | **2.2%** | **13.53** |

There are several limitations to the analysis that should be considered in the context of demand savings. Primarily, during an evaluation, if the CVR system is not operated in an alternating day on/day off schedule (or similar schedule with multiple days on/off) then it must be assumed that no major changes in power consumption occurred that were uncorrected for by the baseline model.

Unlike the 2017 evaluation, this year the operation did not follow a consistent on/off scheduling and required using baseline data from the previous year to develop savings estimates. Looking specifically at the peak coincident period during the summers of 2017 and 2018 there are large differences in average power consumption on each three of the four feeders, with ranging from 15% to 45%. The magnitude of these percent differences suggests the consumption on these feeders changed in a way that a weather-based model cannot correct for. Also modeling a smaller number of hours that occur during higher temperatures results in more variable estimates than modeling annual energy savings.

[158] Pacific Northwest National Laboratory. *Evaluation of CVR on a National Level.* 19596. July 2010.

# Appendix B. Net-to-Gross Detailed Findings

## B.1 Residential Prescriptive Program

Cadmus calculated freeridership and spillover for the Residential Prescriptive Program as a whole using findings from a survey conducted with 709 program participants. After including spillover, the program resulted in a 63% NTG ratio. Table B-1 summarizes the freeridership, spillover, and NTG estimates by measure category. The overall program NTG of 63% is weighted by the combination of electric and gas gross evaluated program population savings.

However, the electric-specific NTG ratio of 68% presented in Table B-1 is weighted specifically to electric savings due to the application of measure category level NTG estimates to evaluated gross population electric savings. The overall program NTG of 63% is heavily weighted toward the gas-specific NTG estimate of 62% because *ex post* gross gas savings account for 94% of the total 2018 Residential Prescriptive Program energy savings.

**Table B-1. 2018 Residential Prescriptive Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio | Total Program *Ex Post* MMBTU Savings |
|---|---|---|---|---|
| Furnace (n=191) | 45% | 1% | 56% | 112,730 |
| Heat Pump/CAC (n=57) | 38% | 3% | 65% | 6,992 |
| Smart Thermostat (n=280) | 25% | 3% | 78% | 37,198 |
| Wi-Fi-Enabled Thermostat (n=108) | 27% | 5% | 78% | 4,677 |
| Weatherization (n=26) | 34% | 2% | 68% | 4,625 |
| Other (n=47) | 32% | 1% | 69% | 1,452 |
| **Total Program (n=709)[2]** | **39%[1]** | **2%[1]** | **63%[1]** | **167,675** |
| **Electric-Specific NTG** | | | **68%** | **10,471** |
| **Gas-Specific NTG** | | | **62%** | **157,216** |

[1] Weighted by evaluated *ex post* program population MMBtu savings
[2] 709 respondents answered the NTG questions

Cadmus attempted to collect freeridership data from contractors during interviews, however, the data we received represented less than 2% of the program's furnace and thermostat sales and Cadmus did not apply these data to the measure-level freeridership findings.

### B.1.1 Detailed Freeridership Findings

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[159]

Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[160] as shown in this equation:

$$\text{Final Freeridership \%} = \frac{\textit{Intention}\ \text{FR Score}(0\%\ \text{to}\ 100\%) + \textit{Influence}\ \text{FR Score}(0\%\ \text{to}\ 100\%)}{2}$$

#### *Intention Freeridership Score*

Cadmus estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. As part of past Vectren evaluations, Cadmus developed a transparent, straightforward matrix approach to assign a single score to each participant based on their objective responses.

Determining *intention* freeridership estimates from a series of questions rather than using a single question helps to form a picture of the program's influence on the participant. (For example, "Did the program affect the timing of their decision and, if so, by how many months/years?" "Did the program affect the efficiency of equipment installed and, if so, by how much?" "Did the program affect the quantity of technology installed and, if so, by how much?"). Use of multiple questions also checks consistency.

Not all questions are weighted equally. For example, if respondents would not have installed measures at the same efficiency level without the program, they automatically become a 0% *intention* freerider. If they would not have installed the measures within one year without the program, they also automatically become a 0% *intention* freerider. Other questions included in the *intention* freeridership analysis are assigned partial weights for responses indicative of a non-freerider.

After assigning an *intention* freeridership score to every survey respondent, Cadmus calculated a savings-weighted average *intention* freerider score for each measure category.

Table B-2 illustrates how initial responses are translated into whether the response is "yes," "no," or "partially" indicative of freeridership (in parentheses). The value in brackets is the scoring decrement associated with each response option. Each participant freeridership score starts with 100%, which Cadmus then decrement based on their responses to the eight questions.

---

[159] *Intention* and *influence* freeridership scores both have a maximum of 100%.

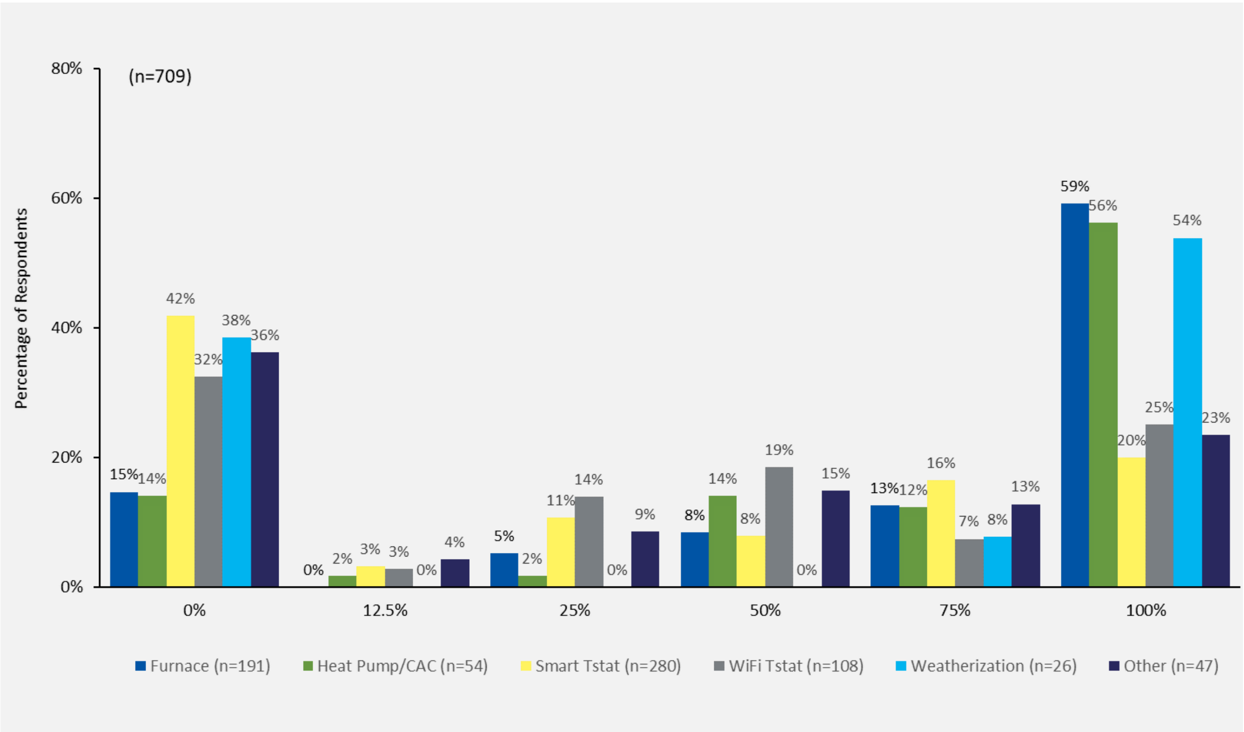
[160] *Ex post* gross program savings.

**Table B-2. Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology Residential Prescriptive Program and Scoring**

| C1. BEFORE you heard about the Vectren Residential Efficient Products Rebate Program, had you already planned to purchase the [MEASURE 1]? | C2. BEFORE you heard anything about the Vectren Residential Efficient Products Rebate program, had you already purchased or installed your [MEASURE 1]? | C3. So, just to be clear, you installed your new [MEASURE 1] before you heard anything about the Vectren Residential Efficient Products Rebate Program, correct? | C4. Would you have installed the same [MEASURE 1] without the rebate from Vectren? | C5. Just so I understand, would you have installed a different [MEASURE 1] without the Vectren rebate or would you have decided not to purchase it? NOT READ RESPONSES] | C6. When you say you would have installed a [MEASURE 1] without the rebate from Vectren, would you still have purchased and installed [MEASURE 1] that was just as efficient, less efficient or more efficient than what you purchased? | C7. When you say you would have installed a thermostat without the rebate from Vectren, what kind of thermostat would you have installed? | C8. And would you have installed the same quantity of [MEASURE 1] without the incentive from Vectren? | C9. And, thinking about timing, without the Vectren rebate, would you have installed the [MEASURE 1]... |
|---|---|---|---|---|---|---|---|---|
| Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes, that is correct (Yes) [100% FR Assigned] | Yes (Yes) [-0%] | Yes, I would have installed a different MEASURE_1 (Yes) [-0%] | Just as efficient (Yes) [-0%] | A smart or learning thermostat (Yes) [-0%] | Yes, the same quantity (No) [-0%] | At the same time (No) [-0%] |
| No (No) [-50%] | No (No) [-0%] | No, that's not correct (No) [-0%] | No (No) [-25%] | I would have decided not to replace it (No) [-25%] | Less efficient (No) [-100%] | A Wi-Fi thermostat (non-learning) (Yes) [-0%] | No, would have installed fewer (No) [-50%] | Within the same year (No) [-50%] |
| DK/RF (Partial) [-25%] | DK/RF (No) [-0%] | DK/RF (No) [-0%] | DK/RF (Partial) [-0%] | DK/RF (Partial) [-25%] | More efficient (Yes) [-0%] | A programmable thermostat (No) [-100%] | No, would have installed more (No) [-0%] | One to two years out (No) [-100%] |
| | | | | | DK/RF (Partial) [-25%] | A manual thermostat (Yes) [-100%] | DK/RF (Partial) [-25%] | More than two years out (No) [-100%] |
| | | | | | | Would not have installed a new thermostat (Yes) [-100%] | | Never (No) [-100%] |
| | | | | | | DK/RF (Partial) [-25%] | | DK/RF (Partial) [-25%] |

Figure B-1 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

**Figure B-1. Residential Prescriptive Program Self-Report *Intention* Freeridership Distribution by Estimate**




## *Influence Freeridership Score*

Table B-3 shows the distribution of responses to the question: "Please rate the influence of the following program elements on your decision to purchase and install [the product]. Please use a scale from 1, meaning *not at all influential*, to 4, meaning the item was *very influential* to your decisions." From responses to this question, Cadmus obtained data about how participants learned about the program from their contractor, rebates for the equipment, and information about energy efficiency from Vectren. Cadmus assessed influence freeridership from participants' ratings to how important various program elements were in their decision to purchase energy-efficient products.

**Table B-3. Residential Prescriptive Program Freeridership *Influence* Responses by Measure Category (n=709)**

| Response Options | Influence Score | Information about the program from your contractor | | | | | | Rebates for the equipment | | | | | | Information about energy efficiency that Vectren provided | | | | | | Previous participation in a Vectren energy efficiency program | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Furnace | Heat Pump/CAC | Smart Thermostat | Wi-Fi Thermostat | Weatherization | Other | Furnace | Heat Pump/CAC | Smart Thermostat | Wi-Fi Thermostat | Weatherization | Other | Furnace | Heat Pump/CAC | Smart Thermostat | Wi-Fi Thermostat | Weatherization | Other | Furnace | Heat Pump/CAC | Smart Thermostat | Wi-Fi Thermostat | Weatherization | Other |
| 1 - Not at all influential | 100% | 22 | 2 | 70 | 9 | 3 | 7 | 27 | 5 | 9 | 4 | 1 | 3 | 28 | 5 | 25 | 6 | 3 | 8 | 38 | 8 | 50 | 13 | 2 | 8 |
| 2 - Not too influential | 75% | 13 | 1 | 5 | 5 | 0 | 2 | 23 | 2 | 11 | 10 | 1 | 3 | 25 | 7 | 51 | 23 | 5 | 7 | 13 | 2 | 25 | 8 | 2 | 5 |
| 3 - Somewhat influential | 25% | 44 | 7 | 14 | 18 | 9 | 10 | 54 | 16 | 81 | 32 | 8 | 14 | 59 | 19 | 90 | 37 | 5 | 15 | 23 | 15 | 35 | 19 | 6 | 11 |
| 4 - Very influential | 0% | 104 | 43 | 41 | 59 | 13 | 24 | 71 | 31 | 171 | 57 | 13 | 26 | 59 | 21 | 94 | 36 | 10 | 13 | 25 | 13 | 43 | 18 | 6 | 11 |
| Don't Know | 50% | 8 | 4 | 150 | 16 | 1 | 3 | 16 | 3 | 8 | 4 | 3 | 0 | 20 | 5 | 20 | 5 | 3 | 3 | 92 | 19 | 127 | 48 | 10 | 11 |
| Refused | 50% | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Average Rating** | | **3.3** | **3.7** | **2.2** | **3.4** | **3.3** | **3.2** | **3.0** | **3.4** | **3.5** | **3.4** | **3.4** | **3.4** | **2.9** | **3.1** | **3.0** | **3.0** | **3.0** | **2.8** | **2.4** | **2.9** | **2.5** | **2.7** | **3.0** | **2.7** |

Cadmus used the maximum rating given by each participant for any factor in Table B-3 to determine the participant's influence score, presented in Table B-4. Cadmus weighted individual influence scores by their respective total survey sample *ex post* gross savings to arrive at savings-weighted average influence scores by measure category.

**Table B-4. Residential Prescriptive Program Influence Freeridership Score (n=709)**

| Maximum Influence Rating | Influence Score | Furnace | Heat Pump/ Central Air Conditioner | Smart Thermostat | Wi-Fi Thermostat | Weatherization | Other |
|---|---|---|---|---|---|---|---|
| 1 – Not at all influential | 100% | 8 | 1 | 7 | 3 | 0 | 2 |
| 2 – Not too influential | 75% | 12 | 1 | 10 | 4 | 0 | 1 |
| 3 – Somewhat influential | 25% | 39 | 5 | 57 | 16 | 8 | 5 |
| 4 – Very influential | 0% | 129 | 48 | 204 | 83 | 17 | 38 |
| Not Applicable | 50% | 3 | 2 | 2 | 2 | 1 | 1 |
| **Average Maximum Influence Rating - Simple Average** | | **3.5** | **3.8** | **3.6** | **3.7** | **3.7** | **3.7** |
| **Average Influence Score - Weighted by *Ex Post* Savings** | | **15%** | **4%** | **10%** | **10%** | **11%** | **19%** |

Cadmus then calculated the arithmetic mean of the intention and influence freeridership components to estimate final freeridership by measure category, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-5 summarizes the intention, influence, and overall freeridership scores for each measure category.

**Table B-5. Residential Prescriptive Program Intention, Influence and Overall Freeridership Scores by Measure Category**

| Measure Category | n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|---|
| Furnace | 191 | 75% | 15% | 45% |
| Heat Pump/CAC | 57 | 71% | 4% | 38% |
| Smart Thermostat | 280 | 39% | 10% | 25% |
| Wi-Fi Enabled Thermostat | 108 | 44% | 10% | 27% |
| Weatherization | 26 | 57% | 11% | 34% |
| Other | 47 | 44% | 19% | 32% |

## B.1.2 Detailed Spillover Findings

Thirty participants reported installing a total of 56 high-efficiency measures after participating in the program. These respondents did not receive an incentive and said participation in the program was very influential on their decision to install additional measures. The measures types to which Cadmus attributed spillover savings included high-efficiency clothes washers, dishwashers, dehumidifiers, refrigerators, water heaters, insulation, windows, duct sealing, smart thermostats, and HVAC equipment.

Cadmus used *ex post* savings estimated for the 2018 Residential Prescriptive Program evaluation in combination with the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the program. Cadmus divided the total survey sample spillover savings for each measure category by the gross program savings from the survey sample to obtain the measure category spillover estimates in Table B-6.

**Table B-6. Residential Prescriptive Spillover Estimates by Measure Category**

| Measure Category | Survey Sample Spillover MMBtu Savings | Survey Sample Program MMBtu Savings | Percentage Spillover Estimate |
|---|---|---|---|
| Furnace | 20.1 | 2,651.2 | 1% |
| Heat Pump/CAC | 7.4 | 229.6 | 3% |
| Smart Thermostat | 65.2 | 2,139.3 | 3% |
| Wi-Fi Enabled | 13.7 | 276.9 | 5% |
| Weatherization | 7.7 | 373.5 | 2% |
| Other | 2.0 | 273.4 | 1% |

## *B.2 Residential New Construction Program*

Cadmus analyzed NTG for the 2018 Residential New Construction (RNC) Program through interviews with 10 participating builders. Cadmus calculated a freeridership score from these builders' responses about how their organization's building practices would have differed in the absence of the program. Respondents were also asked to rate the influence of program elements on their building practices. The RNC Program follows the intention/influence freeridership method that was first used in the 2015 evaluation. Table B-7 presents the freeridership, spillover, and NTG results for the 2018 RNC Program.

**Table B-7. 2018 Residential New Consruction Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 46% | 0% | 54%[1] |

[1]Absolute precision at 90% confidence interval is ±6%.

### B.2.1 Detailed Freeridership Findings

#### *Intention Method*

The initial intention freeridership questions and answers are shown in Table B-8. The table also contains the analysis of responses to the follow-up questions associated with each response option (which Cadmus used to determine each builder's final intention score). To calculate intention-based freerider savings, Cadmus multiplied each builder's intention score by the respective verified gross program savings. In the table, the sum of the intention score MMBtu savings divided by the evaluated *ex post* MMBtu savings of the total survey sample produces a weighted MMBtu savings intention score of 45%.

**Table B-8. 2018 Residential New Construction Program Evaluated Net Savings**

| Intention Question / Response Options<br>Thinking about the Vectren Residential New Construction Program homes you built in 2018, which of the following would have happened if you had not received incentives and assistance from Vectren? | Intention Score | Count | Total Survey Sample *Ex Post* MMBtu Savings | Intention Score MMBtu Savings |
|---|---|---|---|---|
| ***Adopted some of the Residential New Construction Program building practices but not enough to meet the HERS 63 standards.*** **Just to confirm, would your company have adopted most, some or a few of the building practices required to meet the HERS 63 standards?** | | | | |
| Most | 37.5% | 2 | 439 | 165 |
| Some | 25% | 1 | 432 | 108 |
| A few | 12.5% | 0 | 0 | 0 |
| ***Continued with current practices, which were not Residential New Construction Program standards.*** **Would your company have adopted some of the Vectren Residential New Construction Program building practices in the last 12 months?** | | | | |
| Yes, within the last 12 months | 25% | 0 | 0 | 0 |
| No, but within one to two years | 0% | 0 | 0 | 0 |
| No, not in the near future | 0% | 0 | 0 | 0 |
| Don't know | 12.5% | 1 | 66 | 8 |
| ***Continued with current practices, which were a mix of Residential New Construction Program standards and less efficient than the program standards.*** **Would your firm have continued to build some of your homes to the New Construction Program standards of at least a HERS 63 without any incentives or assistance from Vectren?** | | | | |
| Yes, would have adopted 100% of New Construction Program standards within the last 12 months | 50% | 0 | 0 | 0 |
| Yes, would have adopted 100% of New Construction Program standards for some homes within one to two years | 25% | 2 | 519 | 130 |
| No, not in the near future for any homes | 0% | 0 | 0 | 0 |
| Don’t know | 12.5% | 0 | 0 | 0 |
| ***Continued with current practices, the Residential New Construction program standards are my standard practices and I build to HERS 63 and below.*** **Would your firm have built all of your homes to the HERS 63 standards without the incentives or assistance from Vectren?** | | | | |
| Yes | 50% | 4 | 5,355 | 2,677 |
| No | 0% | 0 | 0 | 0 |
| **Total** | | **10** | **6,811** | **3,088** |
| **Intention Score - Weighted by *Ex Post* MMBtu Savings (Intention Score MMBtu Savings Divided by Total Survey Sample *Ex Post* MMBtu Savings)** | **45%** | | | |

## *Influence Method*

Table B-9 shows the distribution of responses to the influence question: "Please rate each item on how influential it was to your decision to build homes to Vectren RNC Program standards of at least a HERS 63 or below. Please use a scale from 1, meaning *not influential*, to 4, meaning the item was *very influential* to your decisions.”

Cadmus assessed influence freeridership from participants' ratings to determine how important various program elements were in their decision to purchase the home, such as the information about energy-efficient practices that Vectren provided, incentives for the homes, program marketing, information from HERS raters, and previous participation in a Vectren energy efficiency program. The table shows the program elements that participants rated for influence, along with a count and average rating for each factor.

**Table B-9. 2018 Residential New Construction Program Freeridership Influence Responses (n=10)**

| Question D9 Response Options | Influence Score | Vectren Program Incentives | Vectren Program Marketing | Information about energy-efficient building practices that Vectren provided | Obtaining information from HERS rater who rates homes | Previous participation in a Vectren energy efficiency program |
|---|---|---|---|---|---|---|
| 1 - Not at all influential | 50% | 3 | 5 | 2 | 1 | 2 |
| 2 – Not too influential | 37.5% | 3 | 0 | 3 | 0 | 1 |
| 3 – Somewhat influential | 12.5% | 0 | 4 | 3 | 4 | 3 |
| 4 – Very influential | 0% | 4 | 1 | 1 | 5 | 4 |
| Don't Know | 25% | 0 | 0 | 1 | 0 | 0 |
| **Average** | | **2.5** | **2.1** | **2.3** | **3.3** | **2.9** |

Cadmus used the maximum rating given by each participant for any factor in Table B-9 to determine their influence score, which is presented in Table B-10. The counts refer to the number of responses for each factor/influence score response option. Cadmus weighted individual influence scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 1% for the RNC Program.

**Table B-10. 2018 Residential New Construction Program Influence Freeridership Score (n=10)**

| Maximum Influence Rating | Influence Score | Count | Total Survey Sample *Ex Post* MMBtu Savings | Influence Score MMBtu Savings |
|---|---|---|---|---|
| 1 - Not at all influential | 50% | 0 | 0 | 0 |
| 2 – Not too influential | 37.5% | 1 | 66 | 25 |
| 3 – Somewhat influential | 12.5% | 2 | 121 | 15 |
| 4 – Very influential | 0% | 7 | 6,624 | 0 |
| **Average Maximum Influence Rating - Simple Average** | | **3.6** | | |
| **Average Influence Score - Weighted by Ex Post MMBtu Savings** | | **1%** | | |

Next, Cadmus summed the intention and influence components to estimate the total intention/influence method freeridership of 46%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates.

### B.2.2 Detailed Spillover Findings

The 2018 RNC Program spillover estimate is 0%. None of the surveyed builders reported voluntarily raising the energy efficiency standard of the appliances or materials they used to build homes that were not eligible for the Vectren program.

## *B.3 Home Energy Assessment (HEA 2.0) Program*

Cadmus calculated freeridership and spillover for the HEA 2.0 Program as a whole using findings from a survey conducted with 72 program participants.[161] The overall program NTG of 78% is weighted by the combination of electric and gas gross evaluated program population savings. However, the electric-specific NTG ratio of 75% is weighted specifically to electric savings due to the application of measure category level NTG estimates to evaluated gross population electric savings.

Table B-11 lists the presents the NTG results for the program.

**Table B-11. Home Energy Assessment Program NTG by Measure**

| Measure | Freeridership | Spillover | NTG Ratio | Total Program *Ex Post* MMBTU Savings |
|---|---|---|---|---|
| **Total Program** | **25%**[1] | **3%**[1] | **78%**[1] | **2,585** |
| **Electric-Specific NTG** | | | **75%** | **1,164** |
| **Gas-Specific NTG** | | | **82%** | **1,421** |

[1] Weighted by evaluated *ex post* program population MMBtu savings.

### B.3.1 Detailed Freeridership Findings

Cadmus estimated freeridership using a pure intentions-based method.[162] Cadmus asked respondents freeridership questions then weighted their measure-level freeridership scores by their verified installed units to arrive at measure-level freeridership estimates. Some respondents had multiple measures installed and were asked freeridership questions about each measure, which allowed for the estimation of measure level freeridership. Cadmus then weighted these estimates by the evaluated *ex post* gross population savings for each measure type. The resulting program freeridership estimate is 25%. Table B-12 lists the freeridership results by measure.

[161] 72 respondents answered freeridership questions for at least one measure.

[162] An *influence* score component is not included in the freeridership methodology of direct install measures.

**Table B-12. Home Energy Assessment Program Freeridership by Measure**

| Measure | n | Freeridership | Evaluated *Ex Post* Population Savings (MMBtu) |
|---|---|---|---|
| Smart Strips | 27 | 25% | 15 |
| Audit Fee[1] | 0 | 0% | 251 |
| LED Light Bulbs | 48 | 34% | 727 |
| LED Nightlight[1] | 0 | 0% | 21 |
| Filter Whistle | 4 | 5% | 40 |
| Pipe wrap (number of jobs) | 9 | 2% | 22 |
| Smart Thermostat | 30 | 28% | 1,215 |
| Water Heater Setback[1] | 0 | 0% | 62 |
| Bathroom Aerator | 27 | 12% | 24 |
| Kitchen Aerator | 15 | 20% | 58 |
| Efficient Showerhead | 25 | 17% | 146 |
| TSV | 5 | 13% | 4 |
| **Overall** | **N/A** | **25%[2]** | **2,584** |

[1] No NTG surveys completed, assuming 0% freeridership.
[2] Weighted by evaluated ex post program population MMBtu savings.

## *Freeridership Scoring*

Table B-13 shows three items under each of the freeridership questions in the participant survey. All respondents start with a freeridership score of 100% and show they are not freeriders through answers to the survey questions. The value *in parentheses* represents whether the response option is coded as "yes," "no," or "partially" as indicative of freeridership. The value *in brackets* is the discount applied to a respondent's freeridership score if they answer with the specific response.

**Table B-13. Home Energy Assessment Program Freeridership Scoring**

| If you had not received the [MEASURE] that the program gave you during the assessment, would you have…? | When would you have purchased them on your own? |
|---|---|
| Purchased the same amount at the same time (Yes) [-0%] | Within a few months (Yes) [-50%] |
| Purchased fewer at the same time (No) [-50%] | Within a year (Partial) [-75%] |
| Purchased the same amount at a later time (Yes) [-0%] | More than a year (No) [-100%] |
| Purchased fewer at a later time (Partial) [-50%] | Don't know/refused (Partial) [–25%] |
| Not purchased [MEASURE] at all (No) [-100%] | |
| DK/RF (Partial) [-75%] | |

### B.3.2 Detailed Spillover Findings

Three participants reported that after participating in the HEA 2.0 Program they installed an additional high-efficiency measure for which they did not receive an incentive.[163] These respondents said participation in the program was very important in their decision.

Cadmus used *ex post* savings estimated for the 2018 Residential Prescriptive Program along with the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the HEA 2.0 Program. Cadmus divided the total survey sample spillover savings by the gross program savings from the survey sample to obtain the 4% spillover estimate for the program, as shown in Table B-14.

**Table B-14. Home Energy Assessment Program Spillover Estimate**

| Survey Sample Spillover MMBtu Savings | Survey Sample Program MMBtu Savings | Spillover Percentage Estimate |
|---|---|---|
| 22 | 518[1] | 4% |

[1] 2018 evaluated gross energy savings.

## *B.4 Residential Lighting Program*

Cadmus calculated an NTG ratio for the Residential Lighting Program measures using findings from a demand elasticity model of program LED sales to estimate freeridership by measure. After weighting by savings, Cadmus estimated a 58% NTG ratio for the program overall. Table B-15 lists the freeridership, spillover, and NTG results for the program.

**Table B-15. 2018 Residential Lighting Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| LED Fixture | 93% | 0% | 7% |
| LED General Service | 26% | 0% | 74% |
| LED Reflector | 61% | 0% | 41% |
| LED Specialty | 77% | 0% | 23% |
| **Total Program** | **42%** | 0% | **58%** |

### B.4.1 Detailed Freeridership Findings

To estimate net savings, Cadmus developed a demand elasticity model using Residential Lighting Program tracking data. Examining changes in the quantity of program LEDs in response to price changes and promotion during the program period provides valuable information regarding the correlation between sales and prices.

[163] These measures were a gas tank-less water heater, clothes washer, refrigerator, and attic insulation.

Demand elasticity modeling draws upon the same economic principle that drives program design: changes in price and promotion generate changes in quantities sold (i.e., the upstream buy-down approach). Demand elasticity modeling uses sales and promotion information to achieve the following:

- Quantify the relationship of price and promotion to sales
- Determine likely sales levels without the program's intervention (baseline sales)
- Estimate freeridership by comparing modeled baseline sales with actual sales

After estimating the relationship between prices and sales, Cadmus used the resulting model to predict the following:

- Sales that would occur *without* the program's price impact or promotions
- Sales that would occur *with* the program (and should be close to actual sales with a representative model)

Cadmus applied evaluated per-unit savings, calculated as part of this evaluation, to these sales predictions then calculated savings freeridership using this equation:

$$FR\ Ratio = \left(\frac{Predicted\ Savings\ without\ Program}{Predicted\ Savings\ with\ Program}\right)$$

### *Input Data*

Because the demand elasticity approach relies exclusively on program data, a model's robustness depends on data quality. The program implementer provided Cadmus with detailed program tracking data that included product sales by unique product number and by retailer and unique store number. Sales were reported monthly.

### *Price Variation*

Cadmus modeled sales as a panel (multiple observations of each cross-sectional lamp SKU over time), with cross-sections of program bulbs modeled over time as a function of price. The cross-sections were defined as sales and prices across all comparable products within each unique retailer's store location. The average price for each bulb type within each store reflects the monthly sales-weighted, per-bulb price across all comparable products. Monthly sales equaled the sum of all sales within each store, across the same group of comparable products (e.g., monthly prices and sales for all 60-watt, incandescent-equivalent, general purpose LED bulbs at a single Home Depot store).

Combining sales and prices this way (rather than observing price and sales changes for individual model numbers) presented an advantage because it captured any substitutions between comparable products (e.g., a decrease in the average price per bulb when adding a three-pack of an existing bulb to the program and a corresponding increase in total program sales of that bulb type).

Similarly, suppose an updated version of a bulb (with a different model number) replaced an original bulb model. The first model's sales would likely drop because the retailer sells through back stock, even as the second model's sales would increase. Aggregating prices and sales captures variations across both products rather than controlling for the sales impacts of factors unrelated to price (i.e., products phased out and replaced).

Cadmus included only sales of products with price variations in the model, because products with no variations in price did not contribute any information to the model. The greater the price variations across retailers and lamp styles, the more representative the elasticity estimates became when applied to sales of products that did not exhibit price variations. Overall, the model included 99% of all LED sales. Only outdoor fixtures were excluded from the model.

### *Merchandising Displays*

As part of the evaluation, Cadmus received merchandising information from the implementer regarding special promotions. Merchandising often leads to more pronounced sales lift than price changes alone. The program included three types of merchandising events:

- Off-shelf placement of program SKUs
- Additional manufacturer point-of-sale discounts
- Manufacturer coupons with additional discounts

These merchandising events showed a sales increase of 32.5%, on average, for general service LEDs at participating retailers.

### *Seasonality Adjustment*

Conducting accurate economic analysis depends critically on separating data variations that result from seasonality from those that result from relevant external factors. For example, suppose umbrella prices fell at the beginning of the rainy season. One might erroneously conclude that the price reductions drove sales, when in actuality, the increase in precipitation very probably had more to do with it. In this example, estimations were skewed because they did not account for the natural seasonality of umbrella sales.

For the Residential Lighting Program, Cadmus included a seasonal trend that represented the proportion of annual national lighting sales expected to occur in a given month from a major national lighting manufacturer. Using data at a national aggregation level, including non-program products and areas without programs, limited the degree to which resulting trends correlated with program activity.

For example, lighting sales drop during July (presumably because of longer daylight hours); if program activity increases sales in July, the analysis underestimates the program's impact if it does not control for seasonal variations. Alternatively, sales tend to rise in October so not controlling for seasonality likely overestimates program activity impacts during that month.

### *Model Specification*

Cadmus modeled bulb pricing, using an econometric model and addressing these data as a panel, with a cross-section of program package quantities modeled over time as a function of prices and retail channels. This involved testing a variety of specifications to ascertain price impacts—the main instrument affected by the program—on bulb demand. Cadmus used this equation for the model (for bulb model *i*, in month *t*):

$$\ln(Q_{it}) = \sum_{\pi}\left(\beta_{\pi} Store\ ID_{\pi,\mathrm{i}}\right) * (Measure_{\theta,\mathrm{i}}) + \sum_{\theta}\left(\beta_{\theta 1}\left[ln(P_{it}) * (Retailer_{\theta,\mathrm{i}}) * (Measure_{\theta,\mathrm{i}})\right]\right) + \sum_{\theta}\left(\beta_{\theta 2}\left[ln(Promo_{it}) * (Measure_{\theta,\mathrm{i}})\right]\right) + \alpha Seasonal\ Trend_t + \varepsilon_i$$

Where:

| | | |
|---|---|---|
| $\ln$ | = | Natural log |
| Q | = | Quantity of bulbs sold during the month |
| P | = | Per-bulb retail price (after markdown) in that month |
| Promo | = | Merchandising promotion occurred in month *t* featuring product *i* |
| Retailer | = | Retail channel with each retailer categorized as Do-It-Yourself retailers or Other |
| Bulb Type | = | Product category (standard, specialty, reflector) |
| Seasonal Trend | = | Seasonal trend representing expected share of annual sales for month t |
| $\varepsilon_{it}$ | = | Cross-sectional random-error term |

The model specification assumed a negative binomial distribution (rather than a normal distribution as is often the case for regression analyses), which served as the best fit. The normal distribution assumes sales volumes for each bulb are normally distributed, which is often not true for residential lighting programs. Typically, there are a large number of model numbers that account for a small share of sales (lower sales of ceiling fan bulbs) and a relatively small number of model numbers that account for a disproportionate number of sales (multipacks of general service bulbs at membership club stores). Assuming that a negative binomial distribution provided accurate predictions for a small number of high-volume sale bulbs, the other distributions underpredicted sales for those bulbs.

Using the following criteria, Cadmus ran multiple model scenarios to identify the one with the best parsimony (not unnecessarily complex) and explanatory power (most accurately predicts actual program sales):

- Model coefficient p-values (keeping values less than <0.1)[164]
- Explanatory variable cross-correlation (minimizing where possible)
- Minimizing the number of coefficients signs (+/-) contrary to expectations and economic theory

---

164 Where a qualitative variable had many states (such as bulb types), Cadmus did not omit variables if one state was insignificant; rather, the analysis considered the joint significance of all states.

- Model Akaike's Information Criteria (AIC) (minimizing between models)[165]
- Minimizing multicollinearity
- Optimizing model fit

Overall, the modeled sales were within 4% of actual sales.

Table B-16 shows the average elasticity estimate by bulb type. Demand for general service LEDs (which accounted for over 60% of program savings) was considerably more elastic than demand for reflector and specialty bulbs.

**Table B-16. Price Elasticities by Retail Channel and Bulb Type**

| Bulb Type | Average Elasticity Coefficient |
|---|---|
| General Service LED | –1.98 |
| Reflector LED | –0.82 |
| Specialty LED | –0.48 |

Table B-17 shows the incentive as a share of the original retail price and the estimated freeridership ratio by bulb type and retail channel. Typically, the proportional price reduction and the freeridership trend correlate—the greater the markdown and/or elasticity, the lower the freeridership. In this case, price markdowns were comparable across all bulb types except for fixtures. General service bulbs had the lowest price per bulb even with similar relative discounts and much lower freeridership. This could be due to a higher number of potential sockets in a home that could take a general service bulb. Bulb types with fewer applications within the home typically show lower price elasticities because consumers tend to buy these products only when needed.

**Table B-17. Modeling Results by Bulb Type and Retail Channel**

| Measure | Promo Price per Bulb | Regular Price per Bulb | Markdown Percentage | Freeridership |
|---|---|---|---|---|
| LED Fixture | $19.16 | $22.25 | 14% | 93% |
| LED General Service | $1.65 | $3.23 | 49% | 26% |
| LED Reflector | $2.81 | $5.30 | 47% | 61% |
| LED Specialty | $2.15 | $3.81 | 44% | 77% |

## B.4.2 Detailed Spillover Findings

The demand elasticity analysis observes only the sales of bulbs that have been discounted through the program. Therefore, the model captures only freeridership and not spillover.

165 Cadmus used Akaike's Information Criteria (AIC) to assess model fit because nonlinear models do not define the R-square statistic. AIC also offers a desirable property in that it penalizes overly complex models, similar to the effect of the adjusted R-square.

## B.5 Appliance Recycling Program

Appliance recycling programs generate net savings only when the recycled appliance would have continued to operate absent program intervention (either in the participating customer's home or at the home of another utility customer).

Cadmus employed a decision-tree approach to calculate net program savings and used a weighted average of these scenarios to calculate the net savings attributable to the ARP. The decision tree—populated by the responses of 113 surveyed 2018 participants—presents all of the program's possible savings scenarios.

The decision tree accounts not only for what the participating household would have done independent of the program but also for the possibility that the unit would have transferred to another household *and* whether the would-be acquirer of that refrigerator would have found an alternate unit instead. Table B-18 lists the presents the NTG results for the program.

**Table B-18. 2018 Appliance Recycling Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Refrigerator | 32% | 0% | 68% |
| Freezer | 38% | 0% | 62% |
| **Total Program**[1] | **33%** | **0%** | **67%** |

[1]Program level estimates are weighted by each measure's *ex post* gross evaluated population energy savings.

Cadmus calculated the final verified per-unit net savings using the following equation:

$$Net\ Program\ Savings\ (kWh\ per\ year) = Gross\ Program\ Savings - FR\ and\ SMI\ - Induced\ Consumption + Spillover$$

Table B-19 lists the per-unit net impacts and overall NTG ratio by appliance type. NTG results are completely reliant on self-reported responses, and therefore considerable changes can occur from one year to the next.

**Table B-19. 2017 Appliance Recycling Program NTG by Appliance Type**

| Appliance | Gross Per-Unit Savings (kWh/Year) | Freeridership and Secondary Market Impacts (kWh) | Additional kWh Savings (Spillover) | Net kWh | NTG | Absolute Precision (90% Confidence) |
|---|---|---|---|---|---|---|
| Refrigerator | 1,096 | 352 | 0 | 744 | 68% | ±10 |
| Freezer | 706 | 265 | 0 | 441 | 62% | ±14 |

## B.5.1 Detailed Freeridership Findings

In general, independent of program intervention, participant refrigerators and freezers are subject to one of three scenarios:

- **Scenario 1:** The participant keeps the refrigerator.
- **Scenario 2:** The participant discards the refrigerator by a method that transfers it to another customer for continued use.
- **Scenario 3:** The participant discards the refrigerator by a method that removes the unit from service.

Cadmus applies freeridership only under Scenario 3 because the unit has been removed from the grid and destroyed, although it has not been recycled through the program. As a result, the program cannot claim energy savings generated by recycling this appliance.

To determine the percentage of participants in each of the scenarios and to assess freeridership, Cadmus asked each surveyed participant what would likely have occurred to the appliance had it not been recycled by Vectren. Participants' provided these responses:

- Kept it and continued to operate the appliance
- Kept it, but stored it unplugged indefinitely
- Sold it to a private party, either to someone they knew or by running an ad
- Sold it to a used appliance dealer
- Gave it to a private party, such as a friend or neighbor
- Had it removed by the dealer from whom the new or replacement appliance was purchased
- Hauled it to the dump or recycling center
- Hired someone to haul it away for junking or dumping

To ensure the highest quality of responses possible and to mitigate a socially responsible response bias, Cadmus asked some participants follow-up questions to test the reliability of their initial responses. For example, through interviews it has conducted with market actors for other evaluations, Cadmus has determined that used appliance dealers usually do not purchase appliances more than 15 years old. Therefore, Cadmus asked any participants with an appliance more than 15 years old, who indicated they would have sold their unit to a used appliance dealer, what they would have done had they been unable to carry through with their plans.

Upon determining the final assessments of participants' actions independent of the ARP, Cadmus calculated the percentage of refrigerators and freezers that would have been kept or discarded. Table B-20 shows the results.

**Table B-20. Final Distribution of Kept and Discarded Appliances**

| Stated Action Absent Program | Indicative of Freeridership | Refrigerators (n=64)[1] | Freezers (n=39)[1] |
|---|---|---|---|
| Kept | No | 46% | 49% |
| Discarded | Varies by discard method | 54% | 51% |
| **Total Program** | | **100%** | **100%** |

[1] Does not include *don't know* responses and refusals.

As shown in Table B-21, more 2018 ARP participants said they would have kept their refrigerators in the absence of the program than in 2017. This increase is the main factor contributing to higher refrigerator and overall program NTG estimates in 2018 than in 2017.

For freezers, the main factor contributing to the lower NTG estimate in 2018 compared to 2017 is that there was a 5% decrease in 2018 of participants who would have kept their refrigerators in absence of the program.

**Table B-21. Vectren Historical Kept and Discarded Scenarios**

| Program Year | Percentage Likely to Have Been Kept Independent of Program | |
|---|---|---|
| | Refrigerators | Freezers |
| 2012 | 35% | 67% |
| 2013 | 37% | 49% |
| 2014 | 38% | 43% |
| 2015 | 42% | 31% |
| 2016 | 54% | 63% |
| 2017 | 30% | 54% |
| 2018 | 46% | 49% |

### *Secondary Market Impacts*

After determining whether a participant would have directly or indirectly (i.e., through a market actor) transferred the unit to another customer on the grid, Cadmus addressed what that would-be acquirer would have done if the recycled unit was unavailable. There are three possible scenarios:

- **Scenario 1: None of the would-be acquirers would find another unit.** That is, program participation would result in a one-for-one reduction in the total number of refrigerators operating on the grid. In this case, the total energy consumption of avoided transfers (participating appliances that otherwise would have been used by another customer) should be credited as savings to the program. This position is consistent with the theory that participating appliances are essentially convenience goods for would-be acquirers. That is, the would-be acquirer would have accepted the refrigerator had it been readily available but, since the refrigerator was not a necessity, would not have sought out an alternate unit.
- **Scenario 2: All of the would-be acquirers would find another unit.** Thus, program participation has no effect on the total number of refrigerators operating on the grid. This position is

consistent with the notion that participating appliances are necessities and that customers will always seek alternative units when participating appliances are unavailable.

- **Scenario 3: Some of the would-be acquirers would find another unit, while others would not.** This scenario reflects the awareness that some acquirers were in the market for an appliance and would acquire another unit, while others were not and would have taken the unit only opportunistically.

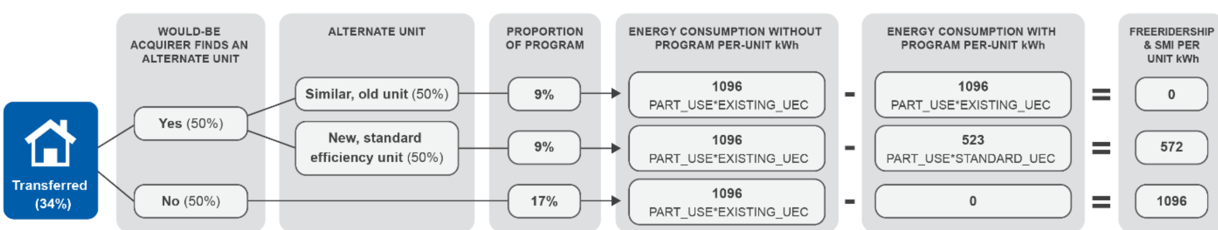
Cadmus assumed one-half of would-be acquirers of avoided transfers would have found an alternate unit, an assumption consistent with the UMP.

The next issue Cadmus addressed was the likelihood that the alternate unit would be another used appliance (similar to those recycled through the program) or—with fewer used appliances presumably available in the market due to program activity—the customer would acquire a new standard-efficiency unit. Even if a would-be acquirer could select a new ENERGY STAR unit, Cadmus assumed it was likely that a customer in the market for a used appliance would upgrade to the next-lowest price point. Cadmus applied a midpoint approach, with one-half of would-be acquirers of program units finding a similar used appliance and one-half acquiring a new standard-efficiency unit.[166]

Figure B-2 explains the methodology used for assessing the program's impact on the secondary refrigerator market and the application of the recommended midpoint assumptions (when primary data were unavailable). As shown, accounting for market impacts resulted in three savings scenarios:

- Full savings (i.e., per-unit gross savings)
- No savings (i.e., the difference in energy consumption of the program unit and a similar, old unit)
- Partial savings (i.e., the difference between the energy consumption of the program unit and that of the new, standard-efficiency appliance acquired)

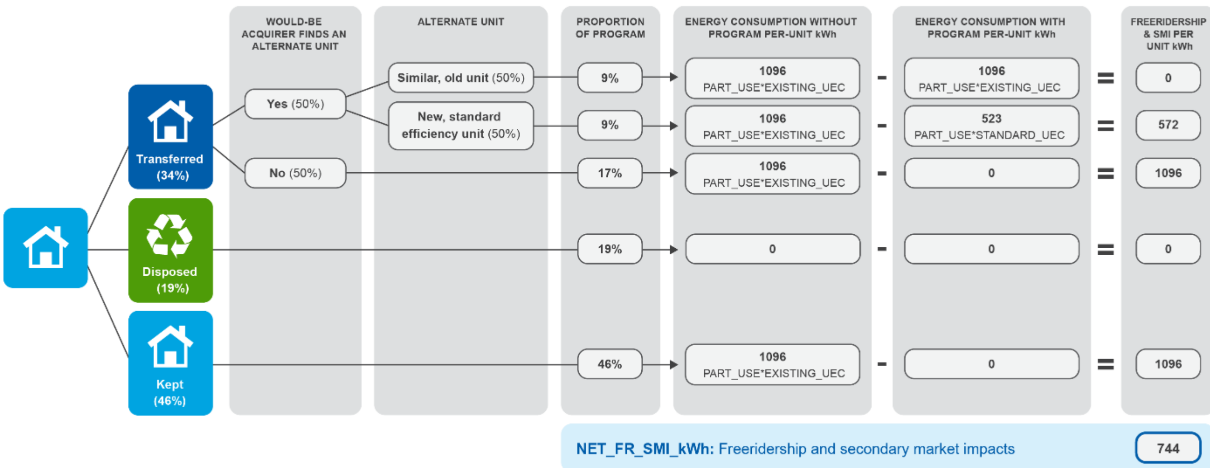
**Figure B-2. Secondary Market Impacts—Refrigerators**




166 Cadmus calculated the energy consumption of a new, standard-efficiency appliance using the ENERGY STAR website, taking the average energy consumption of new, comparably sized, and standard-efficiency appliances with similar configurations as the program units. U.S. Environmental Protection Agency. ENERGY STAR. "Refrigerator Retirement Savings Calculator." Accessed February 2018: http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

After estimating the parameters of the freeridership impacts and secondary market impacts, Cadmus used the UMP decision tree to calculate average per-unit program savings, net of their combined effect. Figure B-3 shows how these values integrated into a combined savings estimate, net of freeridership and secondary market impacts.

**Figure B-3. Savings Net of Freeridership and Secondary Market Impacts—Refrigerators**




## B.5.2 Detailed Spillover Findings

Spillover refers to additional savings generated by program participants because of their program participation but that were not captured by program records. Spillover occurs when participants choose to purchase energy-efficient measures or adopt energy-efficient practices due to being influenced by a program or marketing activities, but they do not apply for an incentive and are, therefore, not captured through any other programs offered through Vectren. These customers' savings are not automatically counted toward the utility's programmatic savings. In contrast with freeridership impacts (which reduce net program savings), spillover impacts increase net program savings.

As recommended in the UMP, Cadmus did not include spillover in program net savings estimates for 2018. The UMP suggests that although appliance recycling programs promote enrollment in other energy efficiency programs, spillover of unrelated measures is unlikely to occur.

# *B.6 Commercial and Industrial Prescriptive Program*

Cadmus calculated freeridership and spillover for the C&I Prescriptive Program as a whole using findings from a survey conducted with 70 program participants. After including spillover, the program resulted in an 84% NTG ratio. Table B-22 presents the NTG results for the program.

**Table B-22. 2018 C&I Prescriptive Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 16% | 0% | 84%[1] |

[1] Absolute precision at 90% confidence interval is ± 5%.

## B.6.1 Detailed Freeridership Findings

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[167]

Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[168] as shown in this equation:

$$\text{Final Freeridership \%} = \frac{Intention\ \text{FR Score}(0\%\ \text{to}\ 100\%) + Influence\ \text{FR Score}(0\%\ \text{to}\ 100\%)}{2}$$

### *Intention Freeridership Score*

Cadmus estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. As part of past Vectren evaluations, Cadmus developed a transparent, straightforward matrix approach to assign a single score to each participant based on his or her objective responses.

Determining *intention* freeridership estimates from a series of questions rather than using a single question helps to form a picture of the program's influence on the participant. (For example, "Did the program affect the timing of your decision and, if so, by how many months/years?" "Did the program affect the efficiency of equipment installed and, if so, by how much?" "Did the program affect the quantity of technology installed and, if so, by how much?"). Use of multiple questions also checks consistency.

Not all questions are weighted equally. For example, if respondents would not have installed measures at the same efficiency level without the program, they automatically become a 0% *intention* freerider. If they would not have installed the measures within one year without the program, they also automatically become a 0% *intention* freerider. Other questions included in the *intention* freeridership analysis are assigned partial weights for responses indicative of a non-freerider.

After assigning an *intention* freeridership score to every survey respondent, the Cadmus calculated a savings-weighted average *intention* freerider score of 20% for the program.

167 *Intention* and *influence* freeridership scores both have a maximum of 100%.

168 *Ex post* gross program savings.

Table B-23 illustrates how initial responses are translated into whether the response is "yes," "no," or "partially" indicative of freeridership (in parentheses). The value in brackets is the scoring decrement associated with each response option. Each participant freeridership score starts with 100%, which Cadmus then decrement based on their responses to the nine questions.

**Table B-23. 2018 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology C&I Prescriptive Program and Scoring**

| FR1. Did your organization have specific plans to install the [MEASURE 1] before learning about the Business Rebate Program? | FR2. Had you already purchased or installed the [MEASURE 1] before you learned about the program? | FR2a. Just to be clear, you installed your [MEASURE 1] before you heard anything about the Vectren program, correct? | FR3. Would you have installed the same [MEASURE 1] in absence of the Vectren program and rebates? | FR4. Would you have installed a [MEASURE 1] that (was/were) just as energy efficient without the Vectren program and rebates? | FR5. Without the Vectren program and rebates, would you have installed the same quantity of [MEASURE 1]? | FR6. Without the Vectren program and rebates, would you have installed the [MEASURE 1]… | FR7. Did the incentive help the [MEASURE 1] project receive implementation approval from your organization? | FR8. Prior to participating in this rebate program, was the purchase and installation of the [MEASURE 1] included in your organization's most recent capital budget? |
|---|---|---|---|---|---|---|---|---|
| Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes, that is correct (Yes) [100% FR Assigned] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes, same quantity (Yes) [-0%] | Within the same year? (Yes) [-0%] | Yes (No) [-50%] | Yes (Yes) [-0%] |
| No (No) [-50%] | No (No) [-0%] | No, that's not correct (No) [-0%] | No (No) [-25%] | No (No) [-100%] | No, I would have installed less (No) [-50%] | Within one to two years? (Partial) [-25%] | No (Yes) [-0%] | No (No) [-50%] |
| DK/RF (Partial) [-25%] | DK/RF (No) [-0%] | DK/RF (No) [-0%] | DK/RF (Partial) [-0%] | DK/RF (Partial) [-25%] | No, I would have installed more (Yes) [-0%] | Within three to five years? (No) [-100%] | DK/RF (Partial) [-25%] | DK/RF (Partial) [-25%] |
| | | | | | DK/RF (Partial) [-25%] | In more than five years? (No) [-100%] | | |
| | | | | | | DK/RF (Partial) [-25%] | | |

Figure B-4 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

**Figure B-4. 2018 C&I Prescriptive Program Self-Report *Intention* Freeridership Distribution by Estimate**

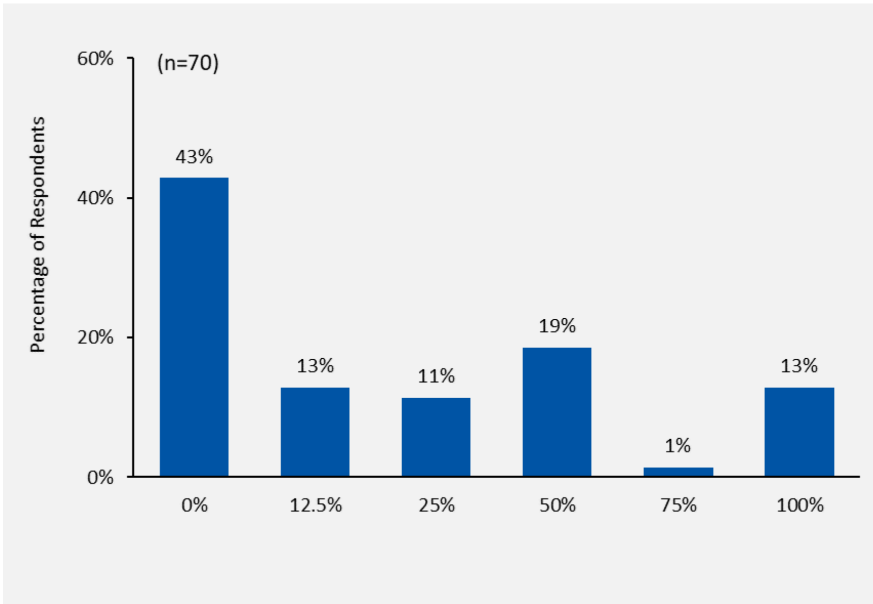



Table B-24 shows the distribution of responses to the influence question: "Please rate each item on how important it was to your decision to complete the [MEASURE] project the way it was done. Please use a scale from 1, meaning *not at all important*, to 4, meaning the item was *very important* to your decisions." This question pertains to information about the program from the participants' contractor, incentives for the equipment, energy efficiency information that Vectren provided, the free energy assessment for the business, and previous participation in a Vectren energy efficiency program.

Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions. Table B-24 shows the program elements that participants rated for influence, along with a count and average rating for each factor.

Cadmus used the maximum rating given by each participant for any factor in Table B-24 to determine the participant's influence score presented in Table B-25. The counts refer to the number of responses for each factor/influence score response option. Cadmus weighted individual influence scores by each participant's respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 12% for C&I Prescriptive Program participants.

**Table B-24. 2018 C&I Prescriptive Program Freeridership Influence Responses (n=70)**

| Question G5 Response Options | Influence Score | Vectren or Nexant staff | Rebates for the equipment | Information about energy efficiency provided by Vectren | Information about energy efficiency from program staff or my contractor provided | Previous participation in a Vectren energy efficiency program |
|---|---|---|---|---|---|---|
| 1 – Not at all important | 100% | 22 | 4 | 16 | 10 | 18 |
| 2 – Not too important | 75% | 12 | 5 | 7 | 8 | 4 |
| 3 – Somewhat important | 25% | 12 | 16 | 17 | 24 | 10 |
| 4 - Very important | 0% | 18 | 42 | 25 | 22 | 18 |
| Not Applicable | 50% | 6 | 3 | 5 | 6 | 20 |
| **Average** | | **2.4** | **3.4** | **2.8** | **2.9** | **2.6** |

**Table B-25. 2018 C&I Prescriptive Program Influence Freeridership Score (n=70)**

| Maximum Influence Rating | Influence Score | Count | Total Survey Sample *Ex Post* MMBtu Savings | Influence Score MMBtu Savings |
|---|---|---|---|---|
| 1 – Not at all important | 100% | 1 | 59 | 59 |
| 2 – Not too important | 75% | 1 | 17 | 13 |
| 3 – Somewhat important | 25% | 17 | 3,550 | 887 |
| 4 - Very important | 0% | 50 | 5,125 | 0 |
| Not Applicable | 50% | 1 | 171 | 85 |
| **Average Maximum Influence Rating - Simple Average** | | **3.7** | | |
| **Average Influence Score - Weighted by *Ex Post* Savings** | | **12%** | | |

Next, Cadmus calculated the arithmetic mean of the intention and influence freeridership components to estimate a final freeridership value of 16%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-26 presents the intention, influence, and freeridership scores for the C&I Prescriptive Program.

**Table B-26. 2018 C&I Prescriptive Program Intention/Influence Freeridership Score**

| n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|
| 70 | 20% | 12% | 16% |

## B.6.2 Detailed Spillover Findings

None of the interviewed participants reported that, after participating in the program, they had installed additional high-efficiency equipment for which they did not receive an incentive and that participation in the program was very important in their decision. Therefore, there is no spillover attributed to the program.

## *B.7 Commercial and Industrial Custom Program*

Cadmus calculated freeridership and spillover for the C&I Custom Program as a whole using findings from a survey conducted with 10 program participants. After including spillover, the program resulted in an 85% NTG ratio. Table B-27 lists the presents the NTG results for the program.

**Table B-27. C&I Custom Program Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 15% | 0% | 85%[1] |

[1] Absolute precision at 90% confidence interval is ± 9%.

### B.7.1 Detailed Freeridership Findings

Cadmus estimated freeridership by combining two methods—the standard self-report intention method and the intention/influence method. By combining the standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[169]

Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[170] as shown in this equation:

$$\text{Final Freeridership \%} = \frac{Intention\ \text{FR Score}(0\%\ \text{to}\ 100\%) + Influence\ \text{FR Score}(0\%\ \text{to}\ 100\%)}{2}$$

#### *Intention Freeridership Score*

Cadmus estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. As part of past Vectren evaluations, Cadmus developed a transparent, straightforward matrix approach to assign a single score to each participant based on his or her objective responses.

Determining *intention* freeridership estimates from a series of questions rather than using a single question helps to form a picture of the program's influence on the participant. (For example, "Did the program affect the timing of your decision and, if so, by how many months/years?" "Did the program affect the efficiency of equipment installed and, if so, by how much?" "Did the program affect the quantity of technology installed and, if so, by how much?"). Use of multiple questions also checks consistency.

Not all questions are weighted equally. For example, if respondents would not have installed measures at the same efficiency level without the program, they automatically become a 0% *intention* freerider. If they would not have installed the measures within one year without the program, they also

[169] *Intention* and *influence* freeridership scores both have a maximum of 100%.

[170] *Ex post* gross program savings.

automatically become a 0% *intention* freerider. Other questions included in the *intention* freeridership analysis are assigned partial weights for responses indicative of a non-freerider.

After assigning an *intention* freeridership score to every survey respondent, the Cadmus calculated a savings-weighted average *intention* freerider score of 27% for the program.

Table B-28 illustrates how initial responses are translated into whether the response is “yes,” “no,” or “partially” indicative of freeridership (in parentheses). The value in brackets is the scoring decrement associated with each response option. Each participant freeridership score starts with 100%, which Cadmus then decrement based on their responses to the nine questions.

**Table B-28. 2018 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology C&I Custom Program and Scoring**

| F1. First, did your organization have specific plans to install the [MEASURE 1] BEFORE learning about Vectren's Commercial Custom Program rebate? | F2. [DO NOT ASK IF F1 = 2] Had you already purchased or installed the new [MEASURE 1] before you learned about the program? | F3. Just to be clear, you installed the [MEASURE 1] before you heard anything about the Vectren program, correct? | F4. Would you have installed the same [MEASURE 1] equipment if the Vectren program did not exist? | F5. Would you have installed a [MEASURE 1] that (was/were) just as energy-efficient without the Vectren program and rebates? | F6. And would you have installed the same quantity of [MEASURE 1] in absence of the Vectren program and rebates? | F7. Without the Vectren program and rebates, would you have installed the [MEASURE 1] … [READ LIST]? | F8. Did the incentive help the [MEASURE 1] project receive implementation approval from your organization? | F9. Prior to participating in the Commercial Custom Program, was the purchase and installation of the [MEASURE 1] included in your organization's capital budget? |
|---|---|---|---|---|---|---|---|---|
| Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes, that is correct (Yes) [100% FR Assigned] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes, same quantity (Yes) [-0%] | Within the same year? (Yes) [-0%] | Yes (No) [-50%] | Yes (Yes) [-0%] |
| No (No) [-50%] | No (No) [-0%] | No, that's not correct (No) [-0%] | No (No) [-25%] | No (No) [-100%] | No, I would have installed less (No) [-50%] | Within one to two years? (Partial) [-25%] | No (Yes) [-0%] | No (No) [-50%] |
| DK/RF (Partial) [-25%] | DK/RF (No) [-0%] | DK/RF (No) [-0%] | DK/RF (Partial) [-0%] | DK/RF (Partial) [-25%] | No, I would have installed more (Yes) [-0%] | Within three to five years? (No) [-100%] | DK/RF (Partial) [-25%] | DK/RF (Partial) [-25%] |
| | | | | | DK/RF (Partial) [-25%] | In more than five years? (No) [-100%] | | |
| | | | | | | DK/RF (Partial) [-25%] | | |

Figure B-5 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

**Figure B-5. 2018 C&I Custom Program Self-Report *Intention* Freeridership Distribution by Estimate**

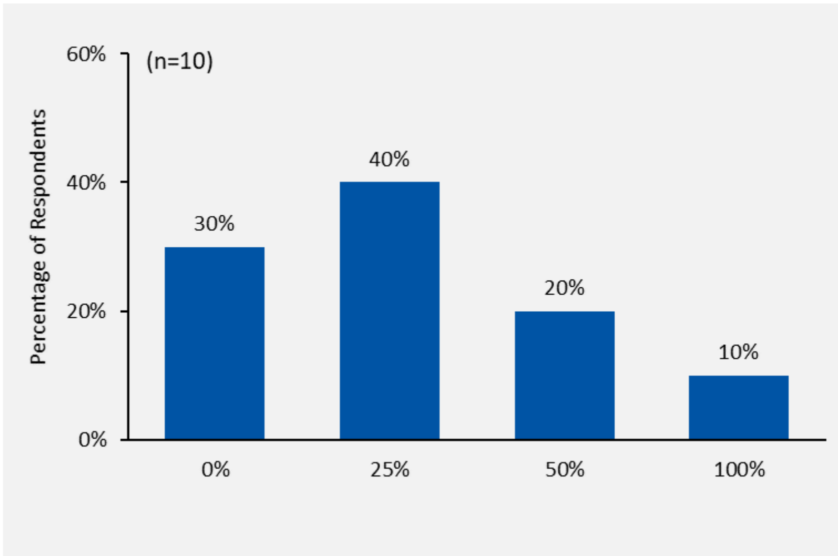



Table B-29 shows the distribution of responses to the influence question: "Please rate each item on how important it was to your decision to complete the [MEASURE] project the way it was done. Please use a scale from 1, meaning *not at all important*, to 4, meaning the item was *very important* to your decisions." This question pertains to information about the program from the participants' contractor, Vectren, or the implementer, incentives for the equipment, energy efficiency information that Vectren provided, and previous participation in a Vectren energy efficiency program.

Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions. Table B-24 shows the program elements that participants rated for influence, along with a count and average rating for each factor.

**Table B-29. 2018 C&I Custom Program Freeridership Influence Responses (n=10)**

| Question E10 Response Options | Influence Score | Vectren or Nexant staff | Rebates for the equipment | Information about energy efficiency provided by Vectren | Information about energy efficiency from program staff or my contractor provided | Previous participation in a Vectren energy efficiency program |
|---|---|---|---|---|---|---|
| 1 – Not at all important | 100% | 0 | 0 | 0 | 0 | 0 |
| 2 – Not too important | 75% | 1 | 0 | 0 | 0 | 0 |
| 3 – Somewhat important | 25% | 1 | 1 | 6 | 5 | 0 |
| 4 - Very important | 0% | 4 | 9 | 2 | 3 | 4 |
| Don't Know | 50% | 1 | 0 | 1 | 1 | 0 |
| Not Applicable | 50% | 3 | 0 | 1 | 1 | 6 |
| **Average** | | **2.1** | **3.9** | **2.6** | **2.7** | **1.6** |

Cadmus used the maximum rating given by each participant for any factor in Table B-29 to determine the participant's influence score presented in Table B-30. The counts refer to the number of responses for each factor/influence score response option. Cadmus weighted individual influence scores by each participant's respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 2% for C&I Custom Program participants.

**Table B-30. 2018 C&I Custom Program Influence Freeridership Score (n=10)**

| Maximum Influence Rating | Influence Score | Count | Total Survey Sample *Ex post* MMBtu Savings | Influence Score MMBtu Savings |
|---|---|---|---|---|
| 1 – Not at all influential | 100% | 0 | 0 | 0 |
| 2 – Not too influential | 75% | 0 | 0 | 0 |
| 3 – Somewhat important | 25% | 1 | 307 | 77 |
| 4 - Very important | 0% | 9 | 4,523 | 0 |
| **Average Maximum Influence Rating - Simple Average** | | **3.9** | | |
| **Average Influence Score - Weighted by *Ex post* Savings** | | | **2%** | |

Cadmus calculated the arithmetic mean of the intention and influence freeridership components to estimate a final freeridership value of 15%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-31 presents the intention, influence, and freeridership scores for the C&I Custom Program.

**Table B-31. 2018 C&I Custom Program Intention/Influence Freeridership Score**

| n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|
| 10 | 27% | 2% | 15% |

### B.7.2 Detailed Spillover Findings

None of the interviewed participants reported that, after participating in the program, they had installed additional high-efficiency equipment for which they did not receive an incentive and that participation in the program was very important in their decision. Therefore, no spillover is attributed to the program.

## *B.8 Commercial and Industrial Small Business Direct Install Program*

Cadmus calculated freeridership and spillover for the Small Business Direct Install (SBDI) program as a whole using findings from a survey conducted with 27 program participants. After including spillover, the program resulted in a 101% NTG ratio. Table B-32 lists the NTG results for the program.

**Table B-32. 2018 Small Business Direct Program Install Net-to-Gross Ratio**

| Measure | Freeridership | Spillover | NTG Ratio |
|---|---|---|---|
| Total Program | 0%[1] | 1% | 101% |

[1] Weighted by evaluated *ex post* program MMBtu savings

### B.8.1 Detailed Freeridership Findings

Cadmus estimated freeridership by combining two methods used in prior evaluations—the standard self-report intention method and the intention/influence method. By combing the previously used standard self-report *intention* methodology with an *influence* methodology, Cadmus produced a program freeridership score.[171]

Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[172] as shown in this equation:

$$\text{Final Freeridership \%} = \frac{\mathit{Intention}\ \text{FR Score}(0\% \text{ to } 100\%) + \mathit{Influence}\ \text{FR Score}(0\% \text{ to } 100\%)}{2}$$

#### *Intention Freeridership Score*

Cadmus estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. As part of past Vectren evaluations, Cadmus developed a transparent, straightforward matrix approach to assign a single score to each participant based on his or her objective responses.

Determining *intention* freeridership estimates from a series of questions rather than using a single question helps form a picture of the program's influence on the participant. (For example, "Did the program affect the timing of your decision and, if so, by how many months/years?" "Did the program

171 *Intention* and *influence* freeridership scores both have a maximum of 100%.

172 *Ex post* gross program savings.

affect the efficiency of equipment installed and, if so, by how much?" "Did the program affect the quantity of technology installed and, if so, by how much?"). Use of multiple questions also checks consistency.

Not all questions are weighted equally. For example, if respondents would not have installed measures at the same efficiency level without the program, they automatically become a 0% *intention* freerider. If they would not have installed the measures within one year without the program, they also automatically become a 0% *intention* freerider. Other questions included in the *intention* freeridership analysis are assigned partial weights for responses indicative of a non-freerider.

After assigning an *intention* freeridership score to every survey respondent, Cadmus calculated a savings-weighted average *intention* freerider score for the program.

Table B-33 illustrates how initial responses are translated into whether the response is "yes," "no," or "partially" indicative of freeridership (in parentheses). The value in brackets is the scoring decrement associated with each response option. Each participant freeridership score starts with 100%, which Cadmus then decrement based on the participant's responses to the eight questions.

**Table B-33. 2018 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology Small Business Direct Install Program and Scoring**

| F1. Did you have specific plans to install any additional energy efficient measures BEFORE learning about the program? | F2. Would you have installed the same low cost measures if they had not been recommended to you in the assessment report? | F3. Would you have installed the same low cost measures without the instant discount? | F4. Just to confirm, you would have installed the exact same set of measures and the same quantity without the audit and the discount? | F5. In absence of the program, would you have installed the low cost measures to at least the same level of efficiency? | D6. In absence of the program, would you have installed the same quantity of [MEASURE]? | F7. And would you have installed it/them...? | F8. Prior to participating in this program, was the purchase and installation of the low cost measures included in your organization's most recent capital budget? |
|---|---|---|---|---|---|---|---|
| Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | Yes (Yes) [-0%] | At the same time (No) [-0%] | Yes (Yes) [-0%] |
| No (No) [-50%] | No (No) [-25%] | No (No) [-25%] | No (No) [-25%] | No (No) [-100%] | No (No) [-50%] | Later but within the same year (No) [-50%] | No (No) [-50%] |
| DK/RF (Partial) [-25%] | DK/RF (No) [-0%] | DK/RF (No) [-0%] | DK/RF (Partial) [-0%] | DK/RF (No) [-25%] | DK/RF (Partial) [-0%] | Within one to two years (No) [-100%] | DK/RF (Partial) [-25%] |
| | | | | | | Within three to five years (No) [-100%] | |
| | | | | | | In more than five years (No) [-100%] | |
| | | | | | | DK/RF (Partial) [-25%] | |

Figure B-6 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

**Figure B-6. 2018 Small Business Direct Install Program Self-Report *Intention* Freeridership Distribution by Estimate**

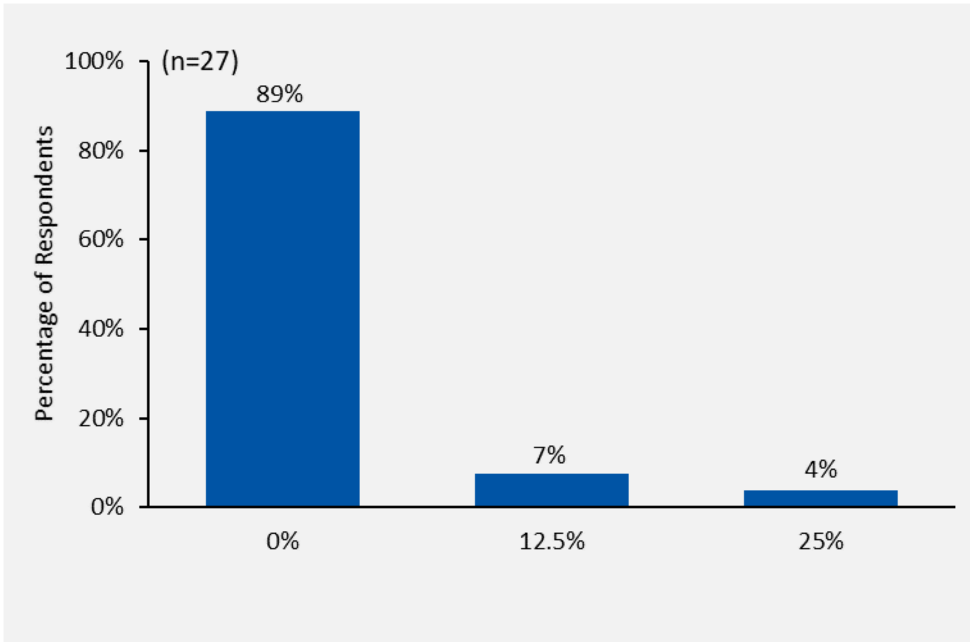



Table B-34 shows the distribution of responses to the influence question: "Please rate each item on how influential it was to your decision to complete the project the way it was done. Please use a scale from 1, meaning *not at all influential*, to 4, meaning the item was *very influential* to your decisions." This question pertains to information about the program from the participants' contractor, incentives for the equipment, energy efficiency information that Vectren provided, the free energy assessment for the business, and previous participation in a Vectren energy efficiency program.

Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions. Table B-34 shows the program elements that participants rated for influence, along with a count and average rating for each factor.

**Table B-34. 2018 Small Business Direct Install Program Freeridership Influence Responses (n=27)**

| Question D9 Response Options | Influence Score | Vectren Staff or Trade Ally | Instant Discount for Equipment | Information About Energy Efficiency Provided by Vectren | Free Energy Assessment for your Business | Previous Participation in a Vectren Energy Efficiency Program |
|---|---|---|---|---|---|---|
| 1 – Not at all influential | 100% | 6 | 0 | 2 | 0 | 11 |
| 2 – Not too influential | 75% | 1 | 2 | 1 | 0 | 3 |
| 3 – Somewhat influential | 25% | 3 | 1 | 10 | 8 | 4 |
| 4 – Very influential | 0% | 16 | 23 | 12 | 18 | 4 |
| Don't Know | 50% | 1 | 1 | 2 | 1 | 1 |
| Not Applicable | 50% | 0 | 0 | 0 | 0 | 4 |
| **Average** | | **3.1** | **3.8** | **3.3** | **3.7** | **2.0** |

Cadmus used the maximum rating given by each participant for any factor in Table B-34 to determine their influence score presented in Table B-35. The counts refer to the number of responses for each factor/influence score response option. Cadmus weighted individual influence scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 0% for SBDI Program participants.

**Table B-35. 2018 Small Business Direct Install Program Influence Freeridership Score (n=27)**

| Maximum Influence Rating | Influence Score | Count | Total Survey Sample *Ex Post* MMBtu Savings | Influence Score MMBtu Savings |
|---|---|---|---|---|
| 1 – Not at all influential | 100% | 0 | 0 | 0 |
| 2 – Not too influential | 75% | 0 | 0 | 0 |
| 3 – Somewhat influential | 25% | 3 | 16 | 2 |
| 4 – Very influential | 0% | 24 | 1,769 | 4 |
| **Average Maximum Influence Rating - Simple Average** | | **3.9** | | |
| **Average Influence Score - Weighted by *Ex Post* Savings** | | **0%** | | |

Next, Cadmus calculated the arithmetic mean of the intention and influence freeridership components to estimate a final freeridership value of 0%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-36 summarizes the intention, influence, and freeridership scores for the SBDI Program.

**Table B-36. 2018 Small Business Direct Install Program Intention/Influence Freeridership Score**

| n | Intention Score | Influence Score | Freeridership Score |
|---|---|---|---|
| 27 | 0% | 0% | 0% |

## B.8.2 Detailed Spillover Findings

After participating in the program, one respondent reported installing 30 LEDs and one energy-efficient central air conditioning unit for which the company did not receive an incentive and said participation in the program was very important in the company's decision to install the additional measures. Cadmus used two per-unit evaluated gross savings estimates—one for interior lighting (193.7kWh) from the 2018 SBDI Program and one for HVAC (1,094.0 kWh) from the 2018 C&I Prescriptive Program—to calculate spillover for the additional equipment attributed to the program. Cadmus the divided the total survey sample spillover savings (23.5 MMBtu) by the gross program savings from the survey sample (1,785 MMBtu) to obtain the 1% spillover estimate for the program, as shown in Table B-37.

**Table B-37. 2018 Small Business Direct Install Program Spillover Estimate**

| Survey Sample Spillover Savings (MMBtu) | Survey Sample Program Savings (MMBtu) | Spillover Percentage Estimate |
|---|---|---|
| 23.5 | 1,785 | 1% |