CADMUS

2020 VECTREN DEMAND-SIDE MANAGEMENT PORTFOLIO PROCESS AND ELECTRIC IMPACTS EVALUATION

June 4, 2021

PREPARED FOR

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Acronyms

Acronym	Definition
AFUE	Annual fuel utilization efficiency
AHRI	Air Conditioning, Heating, & Refrigeration Institute
AMI	Advanced metering infrastructure
ASHP	Air-source heat pump
BTUH	British thermal units per hour
C&I	Commercial and industrial
CAC	Central air conditioner
CDD	Cooling degree days
CF	Coincidence factor
CFL	Compact fluorescent lamp
CFM	Cubic feet per minute
COP	Coefficient of performance
CVR	Conservation voltage reduction
DHP	Ductless heat pump
DHW	Domestic hot water
DK/RF	Don't know/refused
DOE	U.S. Department of Energy
DSM	Demand-side management
ECM	Electronically commutated motor
EER	Energy efficiency ratio
EES Program	Energy Efficient Schools Program
EFLH	Effective full-load hours
EISA	Energy Security and Independence Act of 2007
ERI	Energy Rating Index
FLH	Full load hours
GSL	General service LED
HDD	Heating degree days
HEA Program	Home Energy Assessment Program
HER	Home energy report
HERS	Home Energy Rating System
HEW	Home Energy Worksheet
HOU	Hours of use
hp	Horsepower

Acronym	Definition
HSPF	Heating seasonal performance factor
IHCDA	Indiana Housing and Community Authority
IQW Program	Income Qualified Weatherization Program
IRC	Indiana Residential Code
ISR	In-service rate
kBtu	Kilowatt per British thermal unit
kBtuh	Kilowatt per British thermal unit per hour
KPI	Key performance indicator
Kw	Kilowatt
kWh	Kilowatt per hour
LED	Light-emitting diode
MMBTU	One million British thermal units
MFDI Program	Multifamily Direct Install Program
NEF	National Energy Foundation
NTG	Net to gross
OLS	Ordinary least square
QA/QC	Quality assurance/quality control
RBS Program	Residential Behavioral Savings Program
RECS	Residential Energy Consumption Survey
RESNET	Residential Energy Services Network
RNC Program	Residential New Construction Program
SBES Program	Small Business Energy Solutions Program
SEER	Seasonal energy efficiency ratio
SKU	Stock keeping unit
TMY3	Typical meteorological year
TRM	Technical reference manual
UMP	Uniform Methods Project
VFD	Variable frequency drive
VVO	Volt/var optimization
WHF	Waste heat factor

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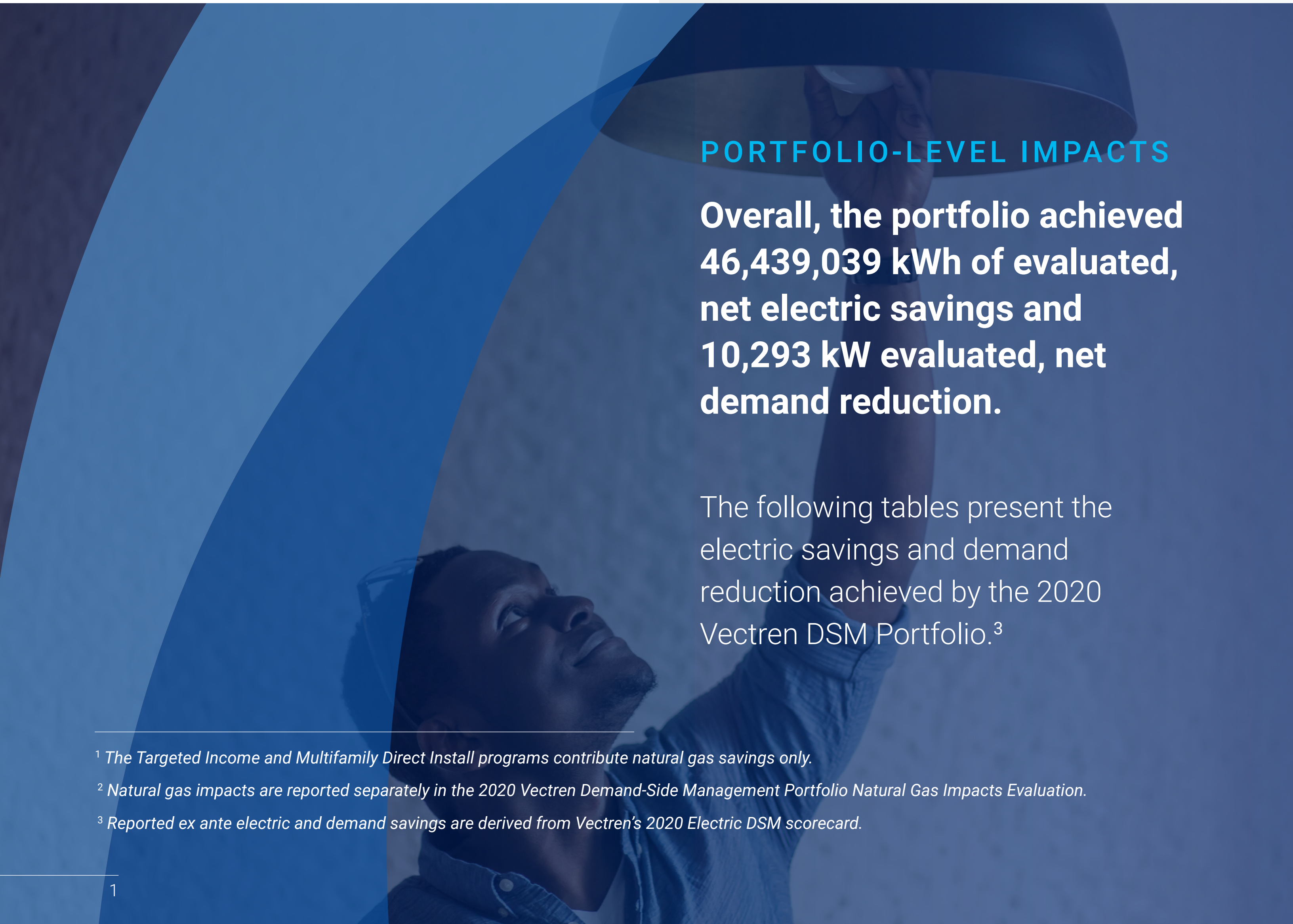
EXECUTIVE SUMMARY

Vectren Energy Delivery of Indiana, a subsidiary of CenterPoint Energy, has a demand-side management (DSM) portfolio containing 16 programs, 14 of which contribute electric energy savings and demand reductions to the portfolio.[1] Vectren administers the portfolio in conjunction with several third-party implementers. The programs serve the residential, income-qualified, multifamily, commercial, and industrial sectors.

This report provides the results of Cadmus' evaluation of Vectren's 2020 DSM electric portfolio.[2] It presents key findings related to program operations, performance, electric and demand impacts, and market performance indicators.

The DSM portfolio affected more than ***60,000 residential and 1,000 commercial and industrial customers.*** Cadmus interviewed nearly 3,000 customers, trade allies, and program staff about energy efficiency and program performance. Cadmus also measured and verified the electric and demand impacts for each program.



PORTFOLIO-LEVEL IMPACTS

Overall, the portfolio achieved 46,439,039 kWh of evaluated, net electric savings and 10,293 kW evaluated, net demand reduction.

The following tables present the electric savings and demand reduction achieved by the 2020 Vectren DSM Portfolio.[3]

[1] *The Targeted Income and Multifamily Direct Install programs contribute natural gas savings only.*

[2] *Natural gas impacts are reported separately in the 2020 Vectren Demand-Side Management Portfolio Natural Gas Impacts Evaluation.*

[3] *Reported ex ante electric and demand savings are derived from Vectren's 2020 Electric DSM scorecard.*

2020 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 Lighting	9,452,864	9,459,804	8,877,988	8,875,699	94%	54%	4,768,371	5,106,646	93%
Residential Prescriptive	2,910,524	2,910,524	2,882,238	2,826,351	97%	78%	2,217,385	1,460,363	152%
Midstream Pilot[1]	129,868	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential New Construction	329,698	329,698	324,158	364,825	111%	60%	218,161	117,277	186%
Home Energy Assessment 2.0 (HEA 2.0)	207,003	207,003	203,113	212,397	103%	84%	179,038	468,959	38%
Income Qualified Weatherization	462,680	462,680	450,124	425,947	92%	100%	425,947	581,262	73%
Energy Efficient Schools	771,703	771,703	810,688	773,578	100%	100%	773,578	771,703	100%
Residential Behavioral Savings	9,402,082	9,402,082	9,402,082	9,492,007	101%	N/A	9,492,007	6,430,000	148%
Appliance Recycling	1,722,294	1,735,644	1,735,644	1,621,008	94%	62%	1,001,198	909,568	110%
Smart Cycle	31,321	31,321	30,945	43,196	138%	94%	40,713	364,200	11%
Food Bank Initiative	1,488,420	1,488,420	1,200,623	1,206,151	81%	100%	1,206,151	1,488,420	81%
Commercial and Industrial Programs									
C&I Prescriptive	10,440,016	10,440,016	10,434,950	10,025,648	96%	86%	8,649,572	11,004,000	79%
C&I Custom	5,416,874	5,416,874	5,416,874	5,242,176	97%	96%	5,032,489	4,590,000	110%
Small Business Energy Solutions	10,869,170	10,869,170	10,869,170	10,841,359	100%	93%	10,047,846	3,636,000	276%
Cross-Sector Program									
Conservation Voltage Reduction	1,571,569	1,571,569	1,571,569	1,370,455	87%	N/A	1,370,455	1,571,569	87%
Total	**55,206,086**	**55,096,508**	**54,210,166**	**53,320,800**	**97%**	**85%**	**45,422,911**	**38,499,968**	**118%**
Nonparticipant Spillover	N/A	N/A	N/A	N/A	N/A	5%	1,016,127	N/A	N/A
Total Adjusted Portfolio	**55,206,086**	**55,096,508**	**54,210,166**	**53,320,800**	**97%**	**87%**	**46,439,039**	**38,499,968**	**121%**

[1] *Due to delays related to the COVID-19 pandemic, the Midstream Pilot did not have a full year to realize energy savings. Therefore, Cadmus did not evaluate this pilot.*

2020 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)[1]	NTG Ratio	Evaluated Net Savings (Coincident Peak kW)	Net Savings Goal (Coincident Peak kW)	Percent Net Savings Goal Achieved
	Reported	Audited	Verified						
Residential Programs[1]									
Residential Lighting	1,284	1,151	1,085	1,224	95%	54%	657	702	94%
Residential Prescriptive	1,723	1,740	1,728	1,594	92%	77%	1,223	895	137%
Midstream Pilot[2]	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Residential New Construction	105	105	105	99	94%	58%	58	36	163%
HEA 2.0	42	42	41	22	53%	82%	18	72	25%
Income Qualified Weatherization	113	62	62	68	60%	100%	68	131	52%
Energy Efficient Schools	82	82	90	116	141%	100%	116	82	142%
Residential Behavioral Savings	832	832	832	2,842	342%	N/A	2,842	832	342%
Appliance Recycling	230	231	231	250	109%	63%	158	127	124%
Smart Cycle	95	95	93	0	0%	N/A	0	1,100	0%
Food Bank Initiative	207	207	167	166	80%	100%	166	207	80%
Commercial and Industrial Programs									
C&I Prescriptive	2,197	2,197	2,196	2,205	100%	86%	1,902	2,111	90%
C&I Custom	250	250	250	254	102%	96%	244	553	44%
Small Business Energy Solutions	2,342	2,342	2,342	2,314	99%	93%	2,144	362	593%
Cross-Sector Program									
Conservation Voltage Reduction	471	471	471	430	91%	N/A	430	0	N/A
Total	**9,974**	**9,808**	**9,695**	**11,583**	**116%**	**87%**	**10,027**	**7,210**	**139%**
Nonparticipant Spillover	N/A	N/A	N/A	N/A	N/A	5%	265	N/A	N/A
Total Adjusted Portfolio	**9,974**	**9,808**	**9,695**	**11,583**	**116%**	**89%**	**10,293**	**7,210**	**143%**

[1] *Vectren forecasts demand reductions using a program average for the residential portfolio. Because forecasting is at the program-level rather than the measure-level, kW realization rates are expected to fluctuate more so than energy realization rates (kWh). Vectren uses evaluated kW for planning purposes only.*

[2] *Due to delays related to the COVID-19 pandemic, the Midstream Pilot did not have a full year to realize demand savings. Therefore, Cadmus did not evaluate this pilot.*

SUMMARY OF RECOMMENDATIONS

Based on the findings from the 2020 evaluation, Cadmus proposed several recommendations to enhance Vectren's DSM portfolio. Detailed findings and conclusions in support of these recommendations are included in the individual program chapters. Below is a summary of these recommendations.

2020 Program Recommendations

Residential Programs

Residential Lighting

While considering new products to add to the program, work with vendors (program implementers and evaluators) to define per-unit energy savings to inform accurate planning for new products that may not be included in the 2015 Indiana TRM V2.2.

Residential Prescriptive

Document *ex ante* per-unit savings assumptions as new electric and natural gas measures are added to the program. Provide these assumptions to evaluators so measure-level realization rates can be accurately explained. The implementer is working on this recommendation for any new measures in 2021.

To maintain overall portfolio savings from measures that Vectren will move to the Midstream Pilot, ensure contractors and distributors are prepared by sending advance communication that clearly explains the new program design, timing of the transition, and recommendations on how to communicate incentives under the new design to customers. Continue to allow a grace period for accepting downstream rebate applications until there is adequate distributor participation to serve participating contractors. The implementer is working on this recommendation in 2021.

Residential New Construction

Vectren should anticipate potentially significant changes to home savings due to the difference in the baseline. For planning purposes, Vectren should use baseline savings that comply with the 2020 Indiana Residential Code.

Home Energy Assessment 2.0

Because the program is being discontinued in 2021, Cadmus does not have any recommendations for program refinements.

Income Qualified Weatherization

Encourage more thorough documentation of each Whole Homes IQW project and require descriptions of all measures exclusively installed under each Whole Home IQW project.

Energy Efficient Schools

Because the program will no longer claim electric savings in 2021, Cadmus does not have any recommendations for program refinements.

Residential Behavioral Savings

If Vectren wishes to calculate differences in low-income and standard-income savings, identify which control group customers are low-income in the same way treatment group customers are identified.

Appliance Recycling

If deemed cost-effective, continue offering the contactless pick-up option. With or without COVID-19 restrictions, customers may prefer the opportunity to choose traditional or contactless pick-up services.

Consider testing marketing messages that highlight the specific appliance features that offer the greatest energy cost savings for customers (e.g., chest freezers, side-by-side refrigerator door configurations, appliances that are plugged in year-round, and units more than 30 years old). Consider marketing a promotion for an "Oldest Appliance Contest" to encourage the recycling of customers' oldest appliances. Utilities in other jurisdictions have found success in uncovering new program savings with these type of promotions.

Smart Cycle

For planning purposes, assume no coincident peak demand savings for normal use of smart thermostats until the new Indiana TRM is released and provides updated guidance.

Food Bank Initiative

If contactless options remain in place during the 2021 LED bulb distributions, consider mechanisms such as outdoor drop-off boxes, an online response option, and/or a higher incentive to increase the postcard response rate.

Collect baseline data for the types of bulbs replaced by program bulbs in income-qualified customer homes to better understand customers' baseline conditions during halogen phase-out periods. These data can be collected through the postcard surveys or evaluation surveys (evaluation surveys are preferred since the postcard survey response rate is historically low).

Commercial and Industrial Programs

C&I Prescriptive

The implementer should include waste heat factors and coincidence factors in the tracking database and, if this is not possible, provide Cadmus the factor assumptions used for its reported savings.

Track baseline equipment assumptions for all LED measures, especially fluorescent to LED replacements. For fluorescent to LED replacements, the tracking database reports all baselines as "T12 or T8." Specify actual equipment data to assess savings more accurately, even as federal standards shift.

C&I Custom

If achieving demand reduction is important in the future, consider targeting projects that include process electric heating, chiller upgrades, or demand limiting through building management systems. Process heating and chiller upgrades contributed to a significant reduction in demand in previous program years.

Small Business Energy Solutions

Update the tracking system to clearly delineate which lighting measures are interior and which are exterior. Because trade allies input the site conditions via the Mobile Assessment Tool and online application submissions, the implementer should review if a measure's use or location reflects an interior or exterior application and adjust the measure name as needed.

Update the thermostat savings calculation to account for multiple thermostat installations.

Update *ex ante* savings for exit signs to use a coincidence factor of 100% and an in-service rate of 100%.

Update the program tracking data to capture all information required for assessing thermostat energy savings, including the facility's annual energy consumption. Energy consumption information may be difficult to collect during the site visit, and Vectren may be able to provide support for the implementation team.

Update the data collection tool or provide additional guidance to participating contractors about assigning the correct building type. In some cases, it may also be appropriate to have different building types within a single site to distinguish multibuilding facilities such as schools, hospitals, or other "campus" buildings.

Cross-Sector Program

Conservation Voltage Reduction

Identify additional substations viable for CVR to generate greater portfolio savings.

Vectren should monitor and claim conservation voltage reduction (CVR) energy savings for the East Side substation for three years. Though Vectren first intended the East Side substation CVR Program to claim first-year savings in the same fashion as the Buckwood substation CVR Program, Vectren can go beyond claiming only first-year savings and continue to claim annual savings for a three-year period, subject to monthly and annual evaluation.

INTRODUCTION

Vectren tasked Cadmus with evaluating its 2020 demand-side management (DSM) programs. Cadmus evaluated 14 electric-saving programs, which involved conducting process and impact evaluations and a market performance indicator assessment for most of the programs (each program chapter describes the specific evaluation activities Cadmus performed).

Program Descriptions

This section briefly summarizes each program.

Residential Programs

Through the ***Residential Lighting Program***, Vectren provides upstream discounts on a variety of lighting products (LED bulbs and specialty bulbs). Vectren works with retailers and manufacturers to offer reduced prices at the point of sale.

Through the ***Residential Prescriptive Program***, Vectren seeks to achieve energy savings by influencing residential customers to purchase energy-efficient residential products. The program includes a variety of measures, such as smart thermostats, heat pumps, air conditioners, and insulation. All residential customers are eligible to participate and receive rebates that vary by measure.

Through the ***Residential Midstream Pilot***, Vectren provides incentives directly to distributors for sales of qualifying HVAC equipment. These distributors are required to pass some of the incentive onto customers and inform them of their rebate from Vectren. The pilot focuses primarily on higher-efficiency HVAC equipment models than those that are included in the Residential Prescriptive Program.

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 (HEA 2.0)***, Vectren offers a walk-through home audit to analyze participant energy use. The assessor recommends efficiency upgrades and facilitates the direct installation of energy-saving measures, including smart thermostats, energy-efficient showerheads, LED bulbs, 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 ***Energy Efficient Schools Program***, Vectren works with fifth-grade teachers to educate students about energy efficiency and how they can make an energy-saving 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 actions.

Through the ***Appliance Recycling Program***, Vectren provides removal and recycling services for operable refrigerators, freezers, and room air conditioners to prevent older appliances from remaining in service at a participant's premise or elsewhere in Vectren's service territory.

Through the ***Smart Cycle Program***, Vectren direct installs smart thermostats for residential customers in order 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.

Through the ***Food Bank Initiative***, Vectren partners with food banks and trustee offices in its electric service territory to give away LED bulbs at no cost to qualifying food bank and trustee office patrons.

Commercial and Industrial Programs

Through the ***Commercial and Industrial Prescriptive Program***, Vectren provides prescriptive rebates to facilities, based on the installation of energy-efficient equipment and system improvements. Rebates address lighting, variable frequency drives, HVAC, refrigeration, and commercial kitchen appliances.

Through the ***Commercial and Industrial Custom Program***, Vectren focuses on energy-saving projects unique to the commercial participant's facility. Customers and/or their trade allies submit engineering analyses showing first-year savings to qualify for program incentives.

Through the ***Small Business Energy Solutions Program***, Vectren helps qualifying businesses identify savings opportunities by providing free on-site energy assessments, installation of energy-efficient measures, and low-cost pricing for energy-efficient measures recommended in the assessments.

Cross-Sector Program

Through the ***Conservation Voltage Reduction Program***, Vectren seeks to achieve energy and demand savings by reducing the voltage on distribution feeders while remaining above the allowable minimum voltage set by the American National Standards Institute. Under this approach the end user's energy consumption is reduced without altering behavior or equipment, and savings are generated unbeknownst to customers in the residential and the commercial and industrial (C&I) segments.

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.

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 measures.

To assess **market performance indicators**, Cadmus reviewed and updated logic models to map each program's activities and established key performance indicators (KPIs) to track market trends over time.

This table shows the evaluation tasks completed for each of Vectren's programs.

2020 EVALUATION TASKS BY PROGRAM

Program	Process Evaluation	Impact Evaluation	Market Performance Indicators
Residential Programs			
Residential Lighting	✓	✓	✓
Residential Prescriptive	✓	✓	✓
Residential New Construction	✓	✓	✓
HEA 2.0	--	✓	--
Income Qualified Weatherization	✓	✓	✓
Energy Efficient Schools	--	✓	--
Residential Behavioral Savings	✓	✓	✓
Smart Cycle	✓	✓	--
Appliance Recycling	✓	✓	✓
Food Bank Initiative	✓	✓	✓
Commercial and Industrial Programs			
C&I Prescriptive	✓	✓	✓
C&I Custom	✓	✓	✓
Small Business Energy Solutions	✓	✓	✓
Cross-Sector Program			
Conservation Voltage Reduction	✓	✓	--

RESEARCH APPROACH

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

Process Evaluation

For the process evaluation of the 2020 Vectren DSM portfolio, Cadmus assessed program strengths, areas for improvement, and best practices to optimize the customer experience. For most programs, Cadmus conducted a condensed process evaluation to follow up on previous years' evaluation recommendations and monitor program activities and changes. Cadmus did not conduct any process evaluation activities for the HEA 2.0 or Energy Efficient Schools programs because Vectren discontinued the HEA 2.0 Program and will no longer claim electric savings for the Energy Efficient Schools Program beginning in 2021.

This table lists the process evaluation research topics by data collection activity. In addition to interviews and surveys, Cadmus reviewed status reports and other program materials to obtain a complete understanding of all activities conducted to reach program goals.

PROCESS EVALUATION TOPICS BY RESEARCH ACTIVITY

In-Depth Program Staff Interviews

- Implemented and proposed program changes
- Program design and delivery
- Program administration
- Quality control
- Marketing strategies and effectiveness
- Target audiences and program participation

Trade Ally Interviews

- Program awareness
- Reasons for participation
- Aspects of program delivery and program process effectiveness
- Interactions with program staff
- Program satisfaction and value
- Changes in business practices or performance as a result of program participation
- Program strengths and suggestions for improvement

Participant Surveys

- Program awareness
- Reasons for participation and installation of specific measures
- Customer experience including program satisfaction and likelihood to recommend
- Trade ally experience
- Freeridership and spillover
- Verification of measure installation
- Program strengths and suggestions for improvement

Nonparticipant Surveys

- Program awareness
- COVID-19 impacts on energy use
- Utility satisfaction
- Willingness to participate in programs
- Spillover

The following table shows the number of interviews and surveys Cadmus completed for the 2020 Vectren DSM portfolio evaluation.[4] Where noted in the individual program chapters, Cadmus tested for statistically significant differences in historical customer survey response data using t-tests at the $p \leq 0.1$ level.[5] Cadmus also conducted a nonparticipant survey with 350 residential customers who had not participated in Vectren programs in the previous three years to calculate nonparticipant spillover.

[4] *Cadmus conducted online customer surveys for the Residential Prescriptive, Home Energy Assessment 2.0, and Income Qualified Weatherization programs. The Residential Behavioral Savings Program was a mixed-mode survey (Cadmus collected online and telephone responses). All other customer surveys were conducted via telephone.*

[5] *The Residential Behavioral Savings Program used t-tests at the p ≤ 0.01 level to test for differences in low-income and standard-income customer responses.*

SURVEY RESPONDENT GROUPS BY PROGRAM

Respondent Group	Population[1]	Included in Sample Frame[2]	Target Completes	Achieved Completes
Residential Programs				
Residential Lighting				
Vectren Staff	1	1	1	1
CLEAResult Staff	1	1	1	1
Residential Prescriptive				
Vectren Staff	1	1	1	1
CLEAResult Staff	1	1	1	1
Participating Customers (Quarterly Freeridership and Customer Experience Surveys)	12,162	8,446	1,000+	1,165
Participating Customers (Annual Spillover Surveys)	12,162	4,310	300+	436
Participating Contractors	902	84	20	21
Residential New Construction				
Vectren Staff	1	1	1	1
CLEAResult Staff	1	1	1	1
Participating Builders	50	37	10	10
HEA 2.0				
Participating Customers	228	154	80+	32
Income Qualified Weatherization				
Vectren Staff	1	1	1	1
CLEAResult Staff	1	1	1	1
Participating Customers	807	392	70+	73
Energy Efficient Schools				
Vectren Staff	1	1	1	1
Oracle Staff	1	1	1	1
Treatment Group Customers in 2020 Wave (Wave 2 Dual Fuel)	13,697	12,103	300	429

[1] *Population includes electric and gas participants.*

[2] *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 they had missing contact information.*

Respondent Group	Population[1]	Included in Sample Frame[2]	Target Completes	Achieved Completes
Appliance Recycling				
Vectren Staff	1	1	1	1
ARCA Staff	1	1	1	1
Participating Customers	1,703	1,342	120	120
Smart Cycle				
Vectren Staff	1	1	1	1
A+Derr Staff	1	1	1	1
Food Bank Initiative				
Vectren Staff	1	1	1	1
CLEAResult Staff	1	1	1	1
Participating Customers	178	109	Census	11
Commercial and Industrial Programs				
C&I Prescriptive				
Vectren Staff	N/A	1	1	1
Nexant Staff	N/A	1	1	1
Participating Customers	227	218	70	70
C&I Custom				
Vectren Staff	N/A	1	1	1
Nexant Staff	N/A	1	1	1
Participating Customers	36	35	Census	10
Small Business Direct Install				
Vectren Staff	N/A	1	1	1
Nexant Staff	N/A	1	1	1
Participating Customers	244	243	70	70
Cross-Sector Program				
Conservation Voltage Reduction				
Vectren Staff	1	1	1	1
Utilidata Staff	1	1	1	1

[1] *Population includes both electric and gas participants.*

[2] *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 they had missing contact information.*

Impact Evaluation

As a part of the impact evaluation, Cadmus reviewed gross savings, verified measure installation, and determined freeridership and spillover to calculate a NTG ratio and estimated realized program savings. The impact evaluation reports the following metrics:

Reported *ex ante* savings. Annual gross savings for the evaluation period, as reported by Vectren in the 2020 Electric DSM Scorecard.

Audited savings. Annual gross savings after Vectren's per-unit calculations and measure counts were confirmed by Cadmus (using 2020 program tracking data).

Verified savings. Annual gross savings adjusted for an in-service rate.

Evaluated *ex post* savings. Annual gross savings adjusted for an in-service rate and savings adjustments resulting from the gross savings review.

Realization rate (percentage). The percentage of savings the program actually realized, calculated as follows:

$$\text{REALIZATION RATE} = \frac{\textit{EX POST}\text{ SAVINGS}}{\textit{EX ANTE}\text{ SAVINGS}}$$

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

Gross Savings Review

Cadmus calculated electric energy savings and demand reduction for all programs. *Appendix A. Impact Evaluation Methodology* details the specific methodology Cadmus used to determine per-unit gross savings. The next table lists the evaluation activities Cadmus performed for each program, including these:

Engineering analysis. To assess Vectren's claimed energy savings and coincident peak demand reduction, Cadmus conducted an engineering desk review for most of Vectren's 2020 DSM programs. Cadmus used 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 and program tracking data, 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 a baseline home, which Cadmus compared to participant homes that received program incentives. Cadmus relied on the HERS certificates for the key data inputs that modeled home savings.

Regression/billing analysis. Through billing analyses, Cadmus modeled savings by comparing the consumption of program participants to nonparticipants while controlling for exogenous factors such as weather.

GROSS SAVINGS REVIEW TASK BY PROGRAM

Program	Engineering Analysis	REM/Rate Analysis	Regression/Billing Analysis
Residential Programs			
Residential Lighting	✓	--	--
Residential Prescriptive	✓	--	--
Residential New Construction	✓	✓	--
Midstream Pilot[1]	--	--	--
HEA 2.0	✓	--	--
Income Qualified Weatherization	✓	--	--
Energy Efficient Schools	✓	--	--
Residential Behavioral Savings	--	--	✓
Appliance Recycling	✓	--	✓
Smart Cycle	✓	--	--
Food Bank Initiative	✓	--	--
Commercial and Industrial Programs			
C&I Prescriptive	✓	--	--
C&I Custom	✓	--	--
Small Business Energy Solutions	✓	--	--
Cross-Sector Program			
Conservation Voltage Reduction	--	--	✓

[1] *Cadmus did not evaluate the Midstream Pilot in 2020.*

Measure Verification

Cadmus reviewed tracking data to audit measure installations for all programs. As shown in the following table, for most programs, Cadmus relied on surveys with program participants (including participant builders) 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 in-service rate for each program:

$$\text{IN-SERVICE RATE} = \frac{\text{VERIFIED INSTALLATIONS}}{\text{REPORTED INSTALLATIONS}}$$

MEASURE VERIFICATION METHOD BY PROGRAM

Program	Program Data Review	Participant Surveys	Deemed Value from 2019[1]	Secondary Resource[2]
Residential Programs				
Residential Lighting	✓	--	--	✓
Residential Prescriptive	✓	✓	--	--
Residential New Construction	✓	✓	✓	--
HEA 2.0	✓	--	✓	--
Income Qualified Weatherization	✓	✓	--	--
Energy Efficient Schools	✓	--	✓	--
Residential Behavioral Savings	✓	--	--	--
Appliance Recycling	✓	✓	--	--
Smart Cycle	✓	--	✓	--
Food Bank Initiative	✓	--	✓	--
Commercial and Industrial Programs				
C&I Prescriptive	✓	✓	--	--
C&I Custom	✓	✓	--	--
Small Business Energy Solutions	✓	✓	--	--
Cross-Sector Program				
Conservation Voltage Reduction	✓	--	--	--

[1] *Cadmus applied in-service rates from surveys conducted as part of the program's 2019 evaluation..*

[2] *Cadmus used the discounted future savings approach from the Uniform Methods Project to account for lifetime in-service rates and savings for installations in future years.*

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:

Self-report surveys utilize survey results to derive net savings by adjusting *ex post* gross savings to account for a 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 a freeridership score for each participant by calculating the arithmetic mean of the intention and influence scores.

- **Participant spillover** is the program's influence on customers' decisions to invest in additional energy efficiency measures for which they did not receive any Vectren incentives. Cadmus gathered the necessary data from the self-report surveys to calculate participant spillover. 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 by Vectren's marketing and education efforts among residential customers who did not participate in any program.

Deemed NTG is applied to programs where the participant is unlikely to have taken energy-saving action without program intervention (for example, programs targeting low-income and student households). Cadmus also applied deemed NTG ratios from the 2019 impact evaluation for programs for which a participant survey was not conducted in 2020 or the 2020 survey did not generate a significant response (given small program population).

Control group comparison generates inherently net savings. Cadmus used billing/regression analysis to estimate net impacts for the Residential Behavioral Savings and Conservation Voltage Reduction programs. In this method, Cadmus calculated net savings by developing a comparison (control) group, which isolates the program impacts from exogenous effects.

This table 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.

NET-TO-GROSS METHOD BY PROGRAM

Program	Self-Report Surveys	Deemed NTG	Control Group
Residential Programs			
Residential Lighting	--	✓	--
Residential Prescriptive	✓	--	--
Residential New Construction	✓	✓	--
Home Energy Assessment 2.0 (HEA 2.0)	--	✓	--
Income Qualified Weatherization	--	✓	--
Energy Efficient Schools	--	✓	--
Residential Behavioral Savings	--	--	✓
Appliance Recycling	✓	--	--
Smart Cycle	--	✓	--
Food Bank Initiative	--	✓	--
Commercial and Industrial Programs			
C&I Prescriptive	✓	--	--
C&I Custom	✓	--	--
Small Business Energy Services	✓	--	--
Cross-Sector Program			
Conservation Voltage Reduction	--	--	✓

Market Performance Indicators

The primary objective of the market performance indicators evaluation was to assess changes and trends from 2011 to 2020 in the activities and KPIs for the DSM programs in Vectren's Indiana 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 performance indicator questions informed updates to program logic models.

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

Cadmus assessed market performance indicators for most Vectren electric-only and integrated dual-fuel DSM programs with available longitudinal data.

Nonparticipant Spillover Survey Results

NONPARTICIPANT SPILLOVER SURVEY RESULTS

2020 Process Analysis Activities

2020-2022 nonparticipant spillover:

5%

350 phone surveys with residential customers who have not participated in a Vectren rebate program for the past 3 years

Key Nonparticipant Survey Findings

96% (n=350) satisfied with Vectren

95% (n=296) satisfied with Vectren's service to customers during COVID-19 pandemic

91% (n=348) said it's important to conserve as much energy as possible

86% (n=345) said it's important to reduce monthly energy bills

70% (n=337) are willing to pay more for environmentally-friendly products

68% (n=339) said it's easy to save energy in their home

Impacts of COVID-19 on Household Energy Concerns

As a result of COVID-19:

64% (n=345) have made efforts to reduce household expenses

25% (n=348) have struggled to pay their energy bill

16% (n=343) have asked Vectren about lowering their bill

11% (n=335) have asked Vectren about alternative rate plans

Reported increases in energy-related home activities since COVID-19 pandemic began: (n=350)

57% Cooking

53% Electronics

45% Lighting

43% Heating/ cooling

40% Water

Future Energy Efficiency Program Participation

16% (n=335) aware of Vectren's energy efficiency programs

Most commonly recalled programs (n=25)

19% Residential Prescriptive

12% Income-Qualified Weatherization

90% (n=111) satisfied with variety of energy efficiency programs offered by Vectren

Value proposition for future energy efficiency program participation* (n=294)

81% to save money on utility bills

26% to save energy

12% to help protect the environment

*Multiple response allowed

Most common sources of program awareness (n=116)

38% direct mail*

17% email*

16% word of mouth

*Most preferred communication channels for future Vectren rebate program information

67% (n=339) likely to participate in a Vectren energy efficiency program in the next 12 months

Top three energy-efficient technologies nonparticipants interested in installing*

49% (n=328) smart thermostats

48% (n=331) high-efficiency water heater

46% (n=330) high-efficiency air conditioner

*Multiple response allowed

Residential Lighting Program

The Residential Lighting Program targets residential customers in Vectren South's service territory and works with retail outlets and manufacturers to offer regular and specialty ENERGY STAR-certified lighting products at reduced prices. CLEAResult, the program implementer, works with 11 retailers across 24 storefronts to promote and deliver the program. Participating retailers include big box stores, discount stores, wholesale stores, hardware stores, and general retailers.

Accomplishments

Table 1 shows the program's achievements against goals in 2020. The Residential Lighting Program achieved 108% of its participation target and 109% of its gross energy savings goal. Despite the COVID-19 pandemic, the program continued to provide offerings to Vectren customers. In addition, in 2020 Vectren expanded its offerings of specialty lighting to help the program meet its goals.

Table 1. 2020 Residential Lighting Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	9,452,864	8,640,656	109%
Gross kW Savings	1,284	1,187	108%
Participants (measures)	274,078	253,394	108%
Program Expenditures	$794,340	$823,521	96%

[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 2 lists the evaluated savings summary for the Residential Lighting Program. Variance in realization rates is largely because Cadmus' calculation of *ex post* savings differed from Vectren's calculation of *ex ante* savings. To determine *ex ante* savings, Vectren applied fixed per-unit kWh and kW for each bulb category, based on 2018 evaluated savings. To determine *ex post* savings, Cadmus used the ENERGY STAR lumens binning approach recommended in the Uniform Methods Project to determine replacement baseline wattages for each program lamp.[6]

Table 2. 2020 Residential Lighting Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	9,452,864	9,459,804	8,877,988	8,875,699	94%	54%	4,768,371
Total kW	1,284	1,151	1,085	1,224	95%	54%	657

[6] Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68562.pdf

Conclusions and Recommendations

General Service LED Phase-Out

In 2021, general service LEDs (GSLs) will no longer be offered through the program. In late 2020, Vectren began eliminating program-sponsored incentives for GSLs from participating retailer stores. With the impending absence of GSLs, Vectren is focusing on promoting specialty lighting offerings. Specialty bulbs have been successful in driving participation, and Vectren plans to continue offering these measures in future program years. Vectren is also exploring savings opportunities for new cost-effective measures such as smart lighting products.

Program Delivery

Strong retailer engagement and a diverse selection of participating retailers enabled the program to continue serving customers during periods of uncertainty in 2020. The upstream delivery mechanism was able to remain stable during the COVID-19 pandemic. Vectren has established a strong program infrastructure and is able to pursue additional retail products when it chooses. The implementer is considering adding new measures to the program in 2021.

Recommendation: While considering new products to add to the program, work with vendors (program implementers and evaluators) to define per-unit energy savings to inform accurate planning for new products that may not be included in the 2015 Indiana TRM V2.2.

Process Evaluation

RESIDENTIAL LIGHTING PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

2020 Program Changes

VECTREN

- Expanded offerings on specialty lighting
- Removed LED fixtures due to low NTG

Due to COVID-19, most retailers were able to stay open during economic shutdown, but marketing efforts changed to minimize health and safety risk:

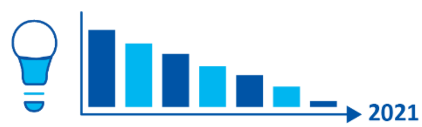
No in-store events took place

Use of point-of-purchase materials was suspended for part of the year

EISA 2020 Backstop Update

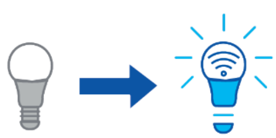
The U.S. DOE decision to withdraw support for EISA remains unchanged

Despite EISA 2020 not going into effect, Vectren will phase out general service LED incentives in 2021 and beyond



2021 Planned Program Changes

Vectren seeking cost-effective alternatives to general service lamps to include in program; exploring smart bulbs as a program offering



Program savings goal will decrease to account for phase out of general service lamps

Key Process Evaluation Findings

Consistent with 2019, big box retailers with dedicated lighting departments and low manager turnover were influential in bringing customer attention to program offerings; these retailers tend to have a higher level of understanding about the program and its products

Impact Evaluation

Impact Evaluation Methods and Findings

The Residential Lighting Program impact evaluation included multiple data collection efforts 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 Uniform Methods Project and deemed savings inputs established in the 2015 Indiana TRM v2.2
- Application of an in-service rate (ISR), established in the Uniform Methods Project to account for delayed installation of lamps after purchase
- Application of NTG rate, established through demand elasticity modeling conducted during the 2019 Residential Lighting Program impact evaluation

Gross Savings Review

Cadmus determined Vectren's reported savings by applying fixed per-unit kWh and kW per lamp to the total number of bulbs sold through the program in each measure category (lamp type). Table 3 provides per-unit annual gross savings for each program lighting measure. Additional details for measure-level savings can be found in the *Appendix A. Impact Evaluation Methodology.*

Table 3. 2020 Residential Lighting Program Per-Unit Gross Savings

Measure Category	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Audited	Evaluated	Audited[1]	Evaluated
LED Fixture	48	35	0.006	0.005
LED General Service	30	31	0.003	0.004
LED Reflector	48	49	0.006	0.007
LED Specialty	35	29	0.006	0.004

[1] The 2020 Electric DSM Scorecard did not include per-unit demand savings. Data in this table are the audited per-unit savings from the 2020 program tracking data.

Vectren's program tracking data included some carry-over bulbs from the end of 2019. These 2019 bulbs used reported savings assumptions based on 2017 evaluation results, while 2020 reported savings were based on 2018 evaluation results. Cadmus applied a weighted average to determine per-unit reported energy savings for 2020 (shown in Table 3).

As shown in Table 4, Vectren split reflectors and specialty lamps into separate categories for 2020 for energy but not for demand. There were no LED fixtures sold in 2020.

Table 4. 2020 Residential Lighting Program Tracking Data Per-Unit Gross Savings

Measure Category	Reported Per-Unit Gross Savings (kWh)		Reported Per-Unit Gross Savings (kW)	
	2019 Carry-Over	2020	2019 Carry-Over	2020
LED Fixture	47.9	N/A	0.006	N/A
LED General Service	30.7	30.0	0.003	0.003
LED Reflector	40.7	49.1	0.006	0.006
LED Specialty		34.1		

Because LEDs have become more efficient over time, using fewer watts to generate the same amount of light, the Uniform Methods Project method of calculating delta watts, which is based on regularly updated ENERGY STAR lumens bins, is the best practice methodology. Cadmus used the Uniform Methods Project-specified delta watts approach and the deemed values from the 2015 Indiana TRM v2.2 for hours of use (HOU), waste heat factor (WHF), and coincidence factor (CF) to determine the *ex post* savings for each lamp's stock keeping unit (SKU) in Vectren's tracking database.[7] Cadmus then totaled the savings by each specific lamp type.

All lamp types (except fixtures) had, in aggregate, per-unit evaluated savings that closely matched reported savings. As previously mentioned, Vectren removed LED fixtures from the program in 2020. All fixtures in the tracking data were sold in November or December of 2019. Therefore, in 2020 only 529 fixtures were evaluated, and the measure mix was heavily skewed toward lower wattage fixtures. The 2020 tracking data recorded no high wattage, high energy-saving fixtures as in 2019, resulting in a decrease in per-unit savings in 2020 relative to previous years.

Table 5 lists the evaluated gross per-unit energy savings for each measure by year.

Table 5. Residential Lighting Program Historical Per-Unit Savings

Measure Category	Evaluated Annual Gross Savings (kWh)					
	2015[1]	2016	2017	2018	2019	2020
LED Fixture	46.6	46.2	47.9	48.5	50.2	35.1[2]
LED General Service	21.4	19.7	30.7	30.0	31.2	31.3
LED Reflector	46.6	46.2	49.2	49.1	48.8	49.5
LED Specialty	46.6	46.2	40.7	34.1	28.7	29.0

[1] LEDs represented less than 7% of program lamps prior to 2015.
[2] Fixtures were not sold in 2020. Fixtures appearing here were sold at the end of 2019.

Between 2015 and 2020, the proportion of LEDs has grown from 7% to 100% of program lamps. The mix of lamp types has shifted as well, as more reflector, specialty, and higher wattage lamps have been added to the program. Since 2017, general service lamps and reflectors have had relatively stable per-unit energy savings. Fixtures were not a part of the program for 2020, and average savings does not

[7] 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.

represent a full year of program activity but instead only November and December 2019. Additionally, in 2019 and 2020, substantially more low-watt equivalent candelabra lamps were sold, which lowered the average per-unit savings in the specialty measure category compared to previous program years.

Measure Verification

Cadmus reviewed the 2020 program tracking database to check savings estimates and calculations against Vectren's reported savings from the 2020 Electric DSM Scorecard and to confirm the accurate application of the savings assumptions. Cadmus exactly matched total program lamps in the tracking data to the scorecard but found a difference of 1 kWh in total energy and 121 kW in total demand savings. The difference is minor for energy but, for demand, means the tracking data report 9.4% kW less than shown in the scorecard.

Cadmus calculated verified savings by applying an in-service rate to program-sponsored bulbs by lamp type. Retailers participating in upstream lighting programs do not track installation of program-sponsored bulbs, so Cadmus could not determine how many bulbs customers installed after purchase. Therefore, Cadmus calculated in-service rates based on the discounted future savings approach from the Uniform Methods Project to account for lifetime in-service rates and savings for installations in future years.[8] Cadmus applied an in-service rate of 100% to LED fixtures, which is in line with other evaluations for this measure category and also provided in the 2018 Mid-Atlantic TRM.[9] Table 6 lists the in-service rates for each program measure.

Table 6. 2020 Residential Lighting Program Measure Verification Results – In-Service Rates

Measure Category	Installations			In-Service Rate[1]
	Reported	Audited	Verified	
LED Fixture	529	529	529	100%
LED General Service	171,825	170,327	156,701	92%
LED Reflector	54,808	54,808	52,616	96%
LED Specialty	46,916	48,414	46,477	96%
Total	**274,078**	**274,078**	**256,323**	**94%**

[1] ISRs are adjusted to include savings for lamps installed in future years.

[8] Dimetrosky, S., K. Parkinson, and N. Lieb. 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

[9] 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

In-service rates 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 purchase.[10] In subsequent years, additional lamps are installed. The Uniform Methods Project 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.[11] 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 2023, applied in-service rates of 92% of general service LEDs and 96% of specialty and reflector LEDs to 2020 lamps.

Table 7 shows historical in-service rates for each program measure. In-service rates have fallen as LED lighting has become more common, though most bulbs are still installed in the first two years after purchase. In 2015 and 2016, Cadmus used the LED in-service rate of 100%, as recommended in the 2015 Indiana TRM v2.2. However, this percentage can no longer be considered current, and Cadmus has applied updated values based on the Uniform Methods Project approach since 2017. In-service rates from 2018 through 2020 remain consistent.

Table 7. Residential Lighting Program Historical In-Service Rates

Measure Category	In-Service Rate					
	2015	2016	2017	2018	2019	2020
LED Fixture	100%	100%	97%	100%	100%	100%
LED General Service	100%	100%	97%	92%	92%	92%
LED Reflector	100%	100%	97%	96%	96%	96%
LED Specialty	100%	100%	97%	96%	96%	96%

Net-to-Gross Analysis

Vectren removed general service LEDs from its portfolio in 2021; therefore, Cadmus did not use demand elasticity modeling in 2020 to update NTG for the program. Instead, Cadmus applied the NTG estimated as part of the 2019 Residential Lighting Program impact evaluation to 2020 gross savings (Table 8).[12] This approach was approved by the Indiana DSM/Energy Efficiency Oversight Board for use in 2019 and 2020.

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[10] Cadmus applied first-year in-service 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).

[11] Dimetrosky, S., K. Parkinson, and N. Lieb. 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

[12] Cadmus. June 5, 2020. *2019 Vectren Demand-Side Management Portfolio Process and Electric Impacts Evaluation*.

Table 8. 2020 Residential Lighting Program Net-to-Gross Ratio by Measure Category

Measure Category	Freeridership	Spillover	NTG Ratio[1]
LED Fixture	61%	0%	39%
LED General Service	48%	0%	52%
LED Reflector	46%	0%	54%
LED Specialty	41%	0%	59%
All Lighting	**46%**	**0%**	**54%**

[1]Calculated in 2019 using demand elasticity modeling.

Freeridership and Spillover

Table 9 lists the 2019 NTG ratios Cadmus applied to the 2020 evaluated *ex post* savings by measure category to calculate net savings and program-level NTG. Program-level NTG ratio increased from 53% in 2019 to 54% in 2020 due to a lower share of LED fixture savings compared to 2019.

Table 9. 2020 Residential Lighting Net Savings by Measure Category and Program NTG Ratio

Measure Category	2020 Evaluated Ex Post Savings (kWh)	NTG Ratio by Measure Category	2020 Evaluated Net Savings (kWh)
LED Fixture	18,557	39%	7,258
LED General Service	4,907,388	52%	2,557,669
LED Reflector	2,604,208	54%	1,415,979
LED Specialty	1,345,546	59%	787,465
Total	**8,875,699**	**54%**	**4,768,371**

Table 10 lists historical program-level NTG ratios by year. The demand elasticity model observes only sales of incented program bulbs and therefore cannot capture spillover. Any subsequent purchases of non-program LEDs after a customer purchases a program LED are not observed.

Table 10. Residential Lighting Program Historical 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%
2019	47%	0%	53%
2020	46%	0%	54%

Evaluated Net Savings Adjustments

Table 11 and Table 12 list evaluated net savings for the Residential Lighting Program. The program achieved net savings of 4,768,371 kWh and 657 coincident kW demand reduction.

Table 11. 2020 Residential Lighting Program Electric Savings (kWh)

Measure Category	*Ex Ante* Savings (kWh)			Evaluated *Ex Post* Savings (kWh)	Realization Rates (kWh)	NTG Ratio	Evaluated Net Savings (kWh)
	Reported	Audited	Verified				
LED Fixture	25,351	25,351	25,351	18,557	73%	39%	7,258
LED General Service	5,155,889	5,110,939	4,702,064	4,907,388	96%	52%	2,557,669
LED Reflector	2,646,488	2,646,488	2,540,629	2,604,208	98%	54%	1,415,979
LED Specialty	1,625,136	1,677,025	1,609,944	1,345,546	80%	59%	787,465
Total Program[1]	**9,452,864**	**9,459,804**	**8,877,988**	**8,875,699**	**94%**	**54%**	**4,768,371**

[1] Totals may not add up to the sum of the column due to rounding.

Table 12. 2020 Residential Lighting Program Demand Reduction (Coincident Peak kW)

Measure Category	*Ex Ante* Savings (Coincident Peak kW)			Evaluated *Ex Post* Savings (Coincident Peak kW)	Realization Rates (Coincident Peak kW)[1]	NTG Ratio	Evaluated Net Savings (Coincident Peak kW)
	Reported	Audited	Verified				
LED Fixture	1,284	3	3	3	75%	39%	1
LED General Service		502	462	677	135%	52%	353
LED Reflector		352	338	359	102%	54%	195
LED Specialty		294	282	185	63%	59%	109
Total Program[2]	**1,284**	**1,151**	**1,085**	**1,224**	**95%**	**54%**	**657**

[1] Vectren did not report measure-level demand savings. Realization rates are based on audited savings.
[2] Totals may not add up to the sum of the column due to rounding.

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the Residential Lighting. 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 Product 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 (e.g., shape, color)
- Low penetration in hard to reach communities (i.e. income-qualified)
- COVID-19 created limited capacity for shoppers at some retailers

Intervention Strategies / Activities

- Lighting product discounts at point of purchase
- Target retailers in hard to reach communities
- In-store program signage
- Lighting product discounts for multiple specialty bulbs
- Recruit wide variety of retailers (many of which remain open during COVID-19 shutdown)
- Digital and broadcast media promotion of the program
- Information on Vectren website
- Increased number of participating retailers

Outcomes

- Increased awareness
- Increased participation
- Increased customer satisfaction
- Increased participation among income-qualified customers
- Improved customer perception of efficient lighting
- Increased energy savings
- Increased penetration of efficient lighting technologies

Key Indicators

- Efficient lighting saturation/ penetration in Vectren's territory
- Percentage of income-qualified customers purchasing discounted bulbs
- Product satisfaction ratings
- Achievement of program participation and savings goals
- Number of participating retailers

Market Actor: Trade Allies | Retail Store Staff

Market Barriers

- Lack of program awareness
- COVID-19 creates health/safety concern for in-store staff
- Lack of understanding of efficient lighting benefits

Intervention Strategies / Activities

- In-store program signage
- Retail staff training on the program and efficient lighting
- Implementer providing retail personnel with lighting brochures
- Flexibility in point of purchase material distribution during COVID-19

Outcomes

- Increased awareness
- Increased participation
- Increased energy savings
- Increased retailer participation

Key Indicators

- Efficient lighting saturation/ penetration in Vectren's territory
- Achievement of program participation and savings goals
- Number of participating retailers

Program Performance

Cadmus measured 2015 to 2020 program performance against the KPIs listed in Table 13.

Table 13. Residential Lighting KPI and 2015-2020 Performance

KPI	Performance					
	2015	2016	2017	2018	2019	2020
Achievement of program kWh savings goals	Met goal; 101%	Met goal; 104%	Met goal; 105%	Did not meet goal; 99%	Met goal; 134%	Met goal: 109%
Achievement of program participation goals	Met goal; 101%	Did not meet goal; 86%	Met goal; 111%	Met goal; 100%	Met goal; 135%	Met goal: 108%
Percentage of income-qualified customers purchasing program bulbs	N/A	N/A	N/A	N/A	48% [2]	45%[1]
Number of participating retailers	8	9	9	9	11	11

[1] This is assumed based on responses to Food Bank Initiative survey question "Before receiving these bulbs, had you used an LED light bulb in your home?" (n=67 in 2019, n=11 in 2020)

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 (non-learning) and smart (learning) thermostats, heat pumps, central air conditioners, weatherization, and pool equipment. All residential Vectren customers are eligible to participate in the program and receive rebates. CLEAResult is the program implementer overseeing program delivery.

Accomplishments

Table 14 shows the program's achievements against goals in 2020. The Residential Prescriptive Program exceeded its goals by more than 30%. During the COVID-19 pandemic, Vectren checked in with trade allies to ensure they were following safety protocols and had adequate personal protective equipment, but it did not regulate trade allies working in homes. Vectren thought more people spending more time at home due to the pandemic may have increased participation for some measures in the Residential Prescriptive Program.

Central air conditioners, heat pumps, and smart thermostats were top performers in 2020, accounting for 73% of the program's reported gross electric savings.[13] The temporary direct ship offer, which Vectren launched as a response to the COVID-19 pandemic, sold smart thermostats online with a $75 instant rebate. This offer contributed significantly to smart thermostat sales through the Residential Prescriptive Program, selling approximately 1,050 thermostats (combined electric, gas, and dual fuel) in 2020.

Table 14. 2020 Residential Prescriptive Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	2,910,524	2,116,105	138%
Gross kW Savings	1,723	1,316	131%
Participants (measures)	4,983	3,806	131%
Program Expenditures	$1,033,532	$1,033,532	100%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 15 lists the evaluated savings summary for the Residential Prescriptive Program. Overall, the program achieved a 97% realization rate for energy and a 92% realization rate for demand savings. Annual variance in survey responses and program tracking data drove the energy and demand realization rates. Vectren's *ex ante* savings are predominantly derived from 2018 evaluated savings (only one measure—duct sealing electric resistance furnace—is derived from the 2017 evaluated savings).

[13] These measures include central air conditioner SEER 16, central air conditioner SEER 18, air source heat pump 16 SEER, air source heat pump 18 SEER, dual fuel air source heat pump 16 SEER, dual fuel air source heat pump 18 SEER, ductless heat pump 17 SEER 9.5 HSPF, ductless heat pump 19 SEER 9.5 HSPF, ductless heat pump 21 SEER 10 HSPF, ductless heat pump 23 SEER 10 HSPF, smart programmable thermostat (electric), and smart programmable thermostat (dual).

Table 15. 2020 Residential Prescriptive Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	2,910,524	2,910,524	2,882,238	2,826,351	97%	78%	2,217,385
Total kW	1,723	1,740	1,728	1,594	92%	77%	1,223

[1] NTG estimates are weighted specifically to electric and demand savings due to the application of measure category-level NTG ratios to evaluated gross population savings. Because population savings are distributed differently for kWh and kW at the measure-category level, NTG ratios for each metric are different.

Conclusions and Recommendations

Satisfaction

Overall satisfaction was high for the Residential Prescriptive Program in 2020. All 21 interviewed trade allies were satisfied with their program experience and very satisfied with the support they received from program representatives. Likewise, 98% of surveyed customers were satisfied with the program, 99% were satisfied with their contractors, and 99% were satisfied with their program measures.

Program Design

Electric savings attributable to the Residential Prescriptive Program may decline when heat pump measures shift from this program to the Midstream Pilot. Vectren plans to move all tiers of ductless and air source heat pumps to the Midstream Pilot in 2021 and shift heat pump water heaters midyear. Vectren will stop accepting rebate applications for these measures under the Residential Prescriptive Program. These measures contributed 29% of reported gross electric program savings in 2020. Vectren already moved three high-efficiency tier measures (ductless heat pumps 21+ SEER, air source heat pumps 18+ SEER, and natural gas furnaces 97%+ AFUE) from the downstream rebate component to the Midstream Pilot in 2020, but it still accepted rebate applications for these measures through the Residential Prescriptive Program.

Recommendation: To maintain overall portfolio savings from measures that Vectren will move to the Midstream Pilot, ensure contractors and distributors are prepared by sending advance communication that clearly explains the new program design, timing of the transition, and recommendations on how to communicate incentives under the new design to customers. Continue to allow a grace period for accepting downstream rebate applications until there is adequate distributor participation to serve participating contractors. The implementor is working on this recommendation in 2021.

Federal Standards Change

A new federal standard will impact pool pump savings beginning in 2021. A federal standard requiring that pool pumps be variable speed is expected to come into effect on July 18, 2021.[14] The regulation

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[14] Regulations.gov. May 18, 2017. "2017-01-18 Energy Conservation Program: Conservation Standards for Dedicated-Purpose Pool Pumps; Direct final rule." https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0109

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 hp and 5 hp.[15]

Vectren will continue to offer the variable speed pool pump rebate until December 31, 2021. The implementer has already started to ramp up marketing for variable speed pool pump rebates for 2020 through 2021 to encourage participation before Vectren can no longer claim energy savings from the measure. Vectren can claim savings through the end of 2021, as retailers sell through their stock. Marketing efforts appear to have worked, as participation for the pool pump measure increased 10% between 2019 and 2020.

Ex Ante Savings

Proper documentation of reported savings assumptions for new program measures is important to understanding measure-level realization rates. It is difficult to explain differences in reported and evaluated per unit savings when *ex ante* assumptions are unknown. All 2020 reported savings for electric measures were based on 2018 evaluated savings (except duct sealing electric resistance furnace, which was derived from the 2017 evaluated savings). However, Cadmus was unable to reproduce the *ex ante* per-unit savings for two new measures—natural gas tankless water heaters and natural gas storage water heaters—using the 2015 Indiana TRM v2.2 equation and inputs.[16] Vectren can use previous evaluated per unit savings as the *ex ante* savings for measures that have been offered for several years, but the *ex ante* savings for new measures must be sourced elsewhere. In 2021, Vectren is planning to add several measures to the program, including clothes washers and dryers and dehumidifiers.

Recommendation: Document *ex ante* per-unit savings assumptions as new electric and natural gas measures are added to the program. Provide these assumptions to evaluators so measure-level realization rates can be accurately explained. The implementer is working on this recommendation for any new measures in 2021.

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15 Robledo, R. May 24, 2017. "Federal Pump Rule Established." *Pool and Spa News.* https://www.poolspanews.com/business/legal-regulatory/federal-pump-rule-established_o

16 Reported savings for these measures were based on the 2019 Market Potential Study. However, without access to the underlying savings calculations and assumptions, Cadmus cannot speak to the difference between reported and evaluated savings.

GDS Associates Inc, EMI Consulting. "2020-2025 Integrated Natural Gas DSM Market Potential Study & Action Plan". January 2019.

Process Evaluation

RESIDENTIAL PRESCRIPTIVE PROGRAM

2020 Process Analysis Activities

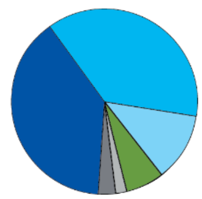
1 VECTREN staff interview

1 CLEAResult® staff interview

21 trade ally interviews
- 8 high volume (101+ projects)
- 10 mid-volume (31-100 projects)
- 3 low volume (10-30 projects)

1,165 quarterly online customer experience surveys

- 456 Furnace participants
- 435 Thermostat participants
- 141 Water heater participants
- 75 Heat pump / central AC participants
- 23 Weatherization participants
- 35 Other participants



436 participant customer online spillover surveys

2020 Program Changes

New measures: tankless and storage natural gas water heaters

Temporary offer in response to COVID-19 (July to December): direct-ship smart thermostats

Efficiency criteria for ductless heat pumps increased from 17 to 19 SEER

Reduced heat pump incentives by $100

Measures shifted to Residential Midstream Pilot (Vectren allowed applications for these measures in Residential Prescriptive Program during 2020):
- Ductless Heat Pumps **21+ SEER**
- Air Source Heat Pumps **18+ SEER**
- Natural Gas Furnaces **97%+ AFUE**

2021 Planned Program Changes

New Measures:
- Clothes Washers
- Clothes Dryers
- Dehumidifiers

Shifting all ductless heat pumps and air source heat pumps to Residential Midstream Pilot at start of 2021

Heat pump water heaters will shift mid-year 2021

Key Process Evaluation Findings

Customer Survey Results:

98% (n=1,109)	**99%** (n=1,105)	**99%** (n=818)	**97%** (n=1,100)
satisfied with program	satisfied with measure	satisfied with contractor	likely to recommend program

Trade Ally Interview Results:

21/21 satisfied with overall program experience and very satisfied with program support

16/21 preferred source for program information is email
- 4 specified they prefer emails directly from program representatives

8/19 trade allies reported project delays due to COVID-19 ranging from 2-12 weeks

Trade allies primarily use email to submit rebate applications (n=20)

Primary Submission Methods:
- 14 Email
- 6 Contractor Portal
- 1 Paper Mail

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
- Online survey with 1,165 program participants, stratified by measure category, administered on a quarterly basis throughout the year to capture measure verification and freeridership data
- Online survey with 436 program participants, stratified by measure category, administered after the conclusion of the program year to gather spillover data

Gross Savings Review

Cadmus evaluated savings for each measure in the tracking database using savings analyses derived primarily from the 2015 Indiana TRM v2.2 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 16 provides per-unit annual gross savings for each program measure.

Table 16. 2020 Residential Prescriptive Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
HVAC				
AC Tune-Up	111	89	0.12	0.15
Air Source Heat Pump 16 SEER	881	825	0.46	0.45
Air Source Heat Pump 18 SEER	1,590	1,457	0.53	0.25
CAC 16 SEER	435	377	0.54	0.47
CAC 18 SEER	666	695	0.58	0.59
Dual Fuel Air Source Heat Pump 16 SEER	695	609	0.33	0.37
Dual Fuel Air Source Heat Pump 18 SEER	992	956	0.32	0.55
Ductless Heat Pump 17 SEER 9.5 HSPF	3,804	3,316	0.41	0.14
Ductless Heat Pump 19 SEER 9.5 HSPF	3,067	2,911	0.38	0.34
Ductless Heat Pump 21 SEER 10 HSPF	2,932	3,301	0.37	0.39
Ductless Heat Pump 23 SEER 10 HSPF	4,306	2,614	0.71	0.36
ECM HVAC Motor	303	294	0.05	0.05
Heat Pump Tune-Up	285	289	-	0.14
Thermostats				
Smart Programmable Thermostat (Dual Fuel)	299	282	-	-
Smart Programmable Thermostat (Electric)	740	888	-	-
Wi-Fi Thermostat (Dual Fuel)	295	282	-	-
Wi-Fi Thermostat (Electric)	295	444	-	-

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Weatherization				
Attic Insulation (All Electric)	3,019	4,041	0.10	0.43
Attic Insulation (Dual Fuel)	304	451	0.46	0.38
Duct Sealing Electric Resistive Furnace	1,359	1,366	0.38	0.37
Duct Sealing Gas Heating with Air Conditioner	218	210	0.38	0.37
Wall Insulation (All Electric)	801	869	0.02	0.07
Wall Insulation (Dual Fuel)	29	94	0.26	0.09
Other				
Air Purifier	681	681	0.08	0.08
Heat Pump Water Heater	2,557	2,505	0.35	0.34
Pool Heater	1,267	1,234	-	-
Variable Speed Pool Pump	1,173	1,173	1.72	1.72

Vectren's *ex ante* savings are mainly derived from the 2018 evaluated savings (one measure—duct sealing electric resistance furnace—is derived from the 2017 evaluated savings). In general, Cadmus' 2020 evaluation used the same methodology as in 2018, so differences between *ex ante* and *ex post* are primarily due to differences in participant survey results and program tracking data.[17] The following are the exceptions:

- **Ductless heat pumps.** The differences in reported and evaluated savings observed in ductless heat pump 17 SEER and ductless heat pump 23 SEER are unique cases that demonstrate the impact of differences in program data each year:
  - The ductless heat pump 17 SEER measure had two installations in 2020 and 11 in 2018. The year-to-year differences in program data are especially impactful due to so few installations. In 2020, one installation had lower than average efficiency metrics compared to 2018, but because it was the larger heat pump (by BTUH), its savings were more heavily represented in the savings for this measure, thereby decreasing the realization rate.
  - The ductless heat pump 23 SEER measure had a lower realization rate because units in 2020 were smaller—approximately 60% of the average capacity of units in 2018. This directly correlates to the difference in reported and evaluated savings for this measure.
- **Wi-Fi thermostats.** The Wi-Fi thermostat (electric) measure has a large difference in reported and evaluated savings. Its *ex ante* savings are the same as the Wi-Fi thermostat (dual fuel) measure. The 2018 evaluation evaluated only Wi-Fi thermostat (dual fuel). Vectren used 2018 evaluated savings for both the electric and dual fuel measures. The difference in reported and evaluated savings reflects Cadmus' adjustments to savings for heating fuel type.

[17] Changes in year-to-year program tracking data include installed equipment efficiencies, equipment age, home square footage, installation location, baseline information (i.e., programmable thermostat prevalence and usage patterns), percentage of installations considered to be early replacements, and other data.

- **Insulation.** Differences in reported and evaluated savings for the two all-electric insulation measures are due to shifts in equipment saturations based on participant surveys. In 2018, saturations for heat pumps, electric furnaces, and electric baseboard were 85%, 15%, and 0%, respectively. In 2020, these saturations changed to 34%, 62%, and 4%. Electric resistance heating is less efficient than heat pump heating, so savings are greater when more homes are estimated to be heated this way. Reported savings for insulation also included a duct loss factor of 76% to account for energy losses in ductwork. However, such losses are already incorporated into the deemed consumption tables in the 2015 Indiana TRM v2.2 as the values are intended for gas heat HVAC systems with air conditioning. Cadmus removed this duct loss factor for 2020 insulation measures.

Table 17 lists the evaluated gross per-unit energy savings for each program measure by year. Similar to differences in reported and evaluated savings, historical differences in savings are also primarily due to differences in yearly program tracking data (measure specifications) and participant survey results.

Table 17. Residential Prescriptive Historical Per-Unit Savings

<table>
<tr><th rowspan="2">Measure</th><th colspan="6">Evaluated Annual Gross Savings (kWh)</th></tr>
<tr><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th></tr>
<tr><td colspan="7">HVAC</td></tr>
<tr><td>AC Tune-Up</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>100</td><td>89</td></tr>
<tr><td>Air Source Heat Pump 16 SEER</td><td>1,155</td><td>852</td><td>694</td><td>881</td><td>970</td><td>825</td></tr>
<tr><td>Air Source Heat Pump 18 SEER</td><td>1,626</td><td>1,444</td><td>1,294</td><td>1,590</td><td>1,784</td><td>1,457</td></tr>
<tr><td>CAC 16 SEER</td><td>295</td><td>300</td><td>328</td><td>435</td><td>486</td><td>377</td></tr>
<tr><td>CAC 18 SEER</td><td>574</td><td>705</td><td>448</td><td>666</td><td>774</td><td>695</td></tr>
<tr><td>Dual Fuel Air Source Heat Pump 16 SEER</td><td>767</td><td>787</td><td>567</td><td>695</td><td>835</td><td>609</td></tr>
<tr><td>Dual Fuel Air Source Heat Pump 18 SEER</td><td>1,499</td><td>1,089</td><td>890</td><td>992</td><td>1,768</td><td>956</td></tr>
<tr><td>Ductless Heat Pump 17 SEER 9.5 HSPF</td><td>3,847</td><td>3,625</td><td>3,751</td><td>3,804</td><td>2,986</td><td>3,316</td></tr>
<tr><td>Ductless Heat Pump 19 SEER 9.5 HSPF</td><td>3,920</td><td>3,675</td><td>3,792</td><td>3,066</td><td>2,887</td><td>2,911</td></tr>
<tr><td>Ductless Heat Pump 21 SEER 10 HSPF</td><td>3,925</td><td>3,770</td><td>3,835</td><td>2,932</td><td>2,547</td><td>3,301</td></tr>
<tr><td>Ductless Heat Pump 23 SEER 10 HSPF</td><td>4,032</td><td>3,788</td><td>3,640</td><td>4,306</td><td>1,963</td><td>2,614</td></tr>
<tr><td>ECM HVAC Motor</td><td>385</td><td>298</td><td>303</td><td>301</td><td>314</td><td>294</td></tr>
<tr><td>Heat Pump Tune-Up</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>281</td><td>289</td></tr>
<tr><td colspan="7">Thermostats</td></tr>
<tr><td>Smart Programmable Thermostat (Dual Fuel)</td><td>412</td><td>370</td><td>344</td><td>299</td><td>305</td><td>282</td></tr>
<tr><td>Smart Programmable Thermostat (Electric)</td><td>N/A</td><td>N/A</td><td>937</td><td>740</td><td>844</td><td>888</td></tr>
<tr><td>Wi-Fi Thermostat (Dual Fuel)</td><td>N/A</td><td>N/A</td><td rowspan="2">311</td><td rowspan="2">295</td><td>279</td><td>282</td></tr>
<tr><td>Wi-Fi Thermostat (Electric)</td><td>N/A</td><td>N/A</td><td>418</td><td>444</td></tr>
</table>

Measure	Evaluated Annual Gross Savings (kWh)					
	2015	2016	2017	2018	2019	2020
Weatherization						
Attic Insulation (All Electric)	3,383	2,625	4,260	3,019	3,457	4,041
Attic Insulation (Dual Fuel)	340	296	337	399	433	451
Duct Sealing Electric Resistive Furnace	1,352	1,380	1,359	N/A	1,390	1,366
Duct Sealing Gas Heating with AC	229	239	260	218	226	210
Wall Insulation (All Electric)	1,158	889	782	801	777	869
Wall Insulation (Dual Fuel)	60	59	57	29	88	94
Other						
Air Purifier	N/A	N/A	N/A	681	540	681
Heat Pump Water Heater	2,291	2,295	2,431	2,557	2,376	2,505
Pool Heater	667	971	1,135	1,266	1,255	1,234
Variable Speed Pool Pump	1,173	1,220	1,173	1,173	1,173	1,173

Measure Verification

Cadmus calculated verified savings for the Residential Prescriptive Program by applying an in-service rate by survey measure category, as shown in Table 18. The measure counts in the tracking data matched the 2020 Electric DSM Scorecard perfectly. Three percent of participant survey respondents for thermostats and other equipment (air purifiers, pool heaters, pool pumps) said the device was not installed in the home, resulting in a 97% in-service rate for these measures.

Table 18. 2020 Residential Prescriptive Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
HVAC				
AC Tune-Up	224	224	224	100%
Air Source Heat Pump 16 SEER	293	293	293	100%
Air Source Heat Pump 18 SEER	37	37	37	100%
CAC 16 SEER	1,653	1,653	1,653	100%
CAC 18 SEER	162	162	162	100%
Dual Fuel Air Source Heat Pump 16 SEER	11	11	11	100%
Dual Fuel Air Source Heat Pump 18 SEER	1	1	1	100%
Ductless Heat Pump 17 SEER 9.5 HSPF	2	2	2	100%
Ductless Heat Pump 19 SEER 9.5 HSPF	83	83	83	100%
Ductless Heat Pump 21 SEER 10 HSPF	30	30	30	100%
Ductless Heat Pump 23 SEER 10 HSPF	28	28	28	100%
ECM HVAC Motor	2	2	2	100%
Heat Pump Tune-Up	50	50	50	100%

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
Thermostats				
Smart Programmable Thermostat (Dual Fuel)	1,072	1,072	1,042	97%
Smart Programmable Thermostat (Electric)	388	388	377	97%
Wi-Fi Thermostat (Dual Fuel)	310	310	301	97%
Wi-Fi Thermostat (Electric)	64	64	62	97%
Weatherization				
Attic Insulation (All Electric)	41	41	41	100%
Attic Insulation (Dual Fuel)	140	140	140	100%
Duct Sealing Electric Resistive Furnace	2	2	2	100%
Duct Sealing Gas Heating with AC	2	2	2	100%
Wall Insulation (All Electric)	29	29	29	100%
Wall Insulation (Dual Fuel)	89	89	89	100%
Other				
Air Purifier	11	11	11	97%
Heat Pump Water Heater	16	16	16	100%
Pool Heater	8	8	8	97%
Variable Speed Pool Pump	235	235	228	97%
Total	**4,983**	**4,983**	**4,925**	**99%**

Table 19 shows historical in-service rates for each program measure. In-service rates can vary year to year because of annual differences in reported (2020 Electric DSM Scorecard) to audited (program tracking data) installations and participant survey self-report measure persistence data; however, in-service rates for the Residential Prescriptive Program remain relatively stable over time.

Table 19. Residential Prescriptive Historical In-Service Rates

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
HVAC						
AC Tune-Up	N/A	N/A	N/A	N/A	100%	100%
Air Source Heat Pump 16 SEER	100%	103%	97%	100%	100%	100%
Air Source Heat Pump 18 SEER	100%	100%	97%	100%	100%	100%
CAC 16 SEER	100%	100%	97%	100%	100%	100%
CAC 18 SEER	101%	101%	97%	100%	100%	100%
Dual Fuel Air Source Heat Pump 16 SEER	100%	200%	97%	100%	100%	100%
Dual Fuel Air Source Heat Pump 18 SEER	80%	100%	97%	100%	100%	100%
Ductless Heat Pump 17 SEER 9.5 HSPF	100%	100%	97%	100%	100%	100%
Ductless Heat Pump 19 SEER 9.5 HSPF	100%	100%	97%	100%	100%	100%
Ductless Heat Pump 21 SEER 10 HSPF	100%	106%	97%	100%	100%	100%
Ductless Heat Pump 23 SEER 10 HSPF	100%	100%	97%	100%	100%	100%
ECM HVAC Motor	100%	100%	99%	100%	100%	100%
Heat Pump Tune-Up	N/A	N/A	N/A	N/A	100%	100%

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
Thermostats						
Smart Programmable Thermostat (Dual Fuel)	100%	102%	100%	98%	100%	97%
Smart Programmable Thermostat (Electric)	100%	102%	100%	98%	100%	97%
Wi-Fi Thermostat (Dual Fuel)	N/A	N/A	99%	96%	100%	97%
Wi-Fi Thermostat (Electric)	N/A	N/A	99%	96%	100%	97%
Weatherization						
Attic Insulation (All Electric)	103%	92%	100%	100%	100%	100%
Attic Insulation (Dual Fuel)	99%	95%	100%	100%	101%	100%
Duct Sealing Electric Resistive Furnace	100%	98%	100%	N/A	100%	100%
Duct Sealing Gas Heating with AC	100%	100%	100%	100%	100%	100%
Wall Insulation (All Electric)	100%	114%	100%	100%	100%	100%
Wall Insulation (Dual Fuel)	100%	102%	100%	100%	100%	100%
Other						
Air Purifier	N/A	N/A	N/A	100%	98%	97%
Heat Pump Water Heater	100%	69%	99%	100%	98%	100%
Pool Heater	100%	99%	94%	100%	98%	97%
Variable Speed Pool Pump	100%	99%	94%	100%	98%	97%

Net-to-Gross Analysis

Cadmus stratified the 2020 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 61%, as shown in Table 20. The overall program NTG ratio is weighted by the combination of electric and gas gross evaluated program population savings. The electric-specific NTG ratio of 78% is weighted specifically to electric savings due to the application of measure category NTG estimates. The overall program NTG ratio is heavily weighted toward the gas-specific NTG estimate of 60% because *ex post* gross gas savings accounted for 94% of the total 2020 program energy savings.

Table 20. 2020 Residential Prescriptive Net-to-Gross Ratio

Measure Category	Freeridership	Spillover	NTG Ratio	Total Program *Ex Post* MMBTU Savings
Furnace/Boiler (n=416 for FR, 128 for SO)	46%	1%	55%	108,922
Heat Pump/CAC (n=66 for FR, 15 for SO)	31%	14%	83%	5,095
Thermostat (n=411 for FR, 197 for SO)	25%	4%	79%	27,726
Weatherization (n=22 for FR, 8 for SO)	27%	0%	73%	970
Water Heater (n=136 for FR, 55 for SO)	35%	1%	66%	8,127
Other (n=35 for FR, 14 for SO)[1]	40%	0%	60%	4,590
Total Program (n=1,503)[2]	**41%[3]**	**2%[3]**	**61%[3]**	**155,430**
Electric-Specific NTG			**78%**	**9,636**
Demand-Specific NTG			**77%**	**5.43[4]**
Gas-Specific NTG			**60%**	**145,793**

[1] The "other" category for NTG included air purifiers, pool heaters, and pool pumps.
[2] 1,086 respondents answered the freeridership questions through the quarterly freeridership survey. 417 respondents answered the spillover questions through the annual spillover-specific survey. Not all respondents surveyed answered the freeridership and spillover questions.
[3] Weighted by evaluated *ex post* program population MMBtu savings
[4] MMBTU/hour savings

Table 21 lists historical program-level NTG ratios by year.

Table 21. 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%
2019	43%	1%	58%
2020	41%	2%	61%

Freeridership and Spillover Findings

Cadmus estimated freeridership by combining the standard self-report intention method and the intention/influence method.[18] Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[19] as shown in the following equation:

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

Table 22 summarizes intention, influence, and overall freeridership scores for each measure category.

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

[19] *Ex post* gross program savings.

Table 22. 2020 Residential Prescriptive Intention, Influence and Overall Freeridership Score by Measure Category

Measure Category	n	Intention Score	Influence Score	Freeridership Score
Furnace/Boiler	416	76%	15%	46%
Heat Pump/CAC	66	51%	11%	31%
Thermostat	411	40%	10%	25%
Weatherization	22	47%	7%	27%
Water Heater	136	63%	6%	35%
Other	35	64%	16%	40%

Twelve participants reported installing a total of 16 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 a high-efficiency clothes washer, dishwashers, water heaters, duct sealing, a smart thermostat, and HVAC equipment.

Cadmus used *ex post* savings estimated for the 2020 Residential Prescriptive Program evaluation along with the 2015 Indiana TRM v2.2 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 23.

Table 23. 2020 Residential Prescriptive Program Spillover Estimates by Measure Category

Measure Category	Survey Sample Spillover MMBtu Savings	Survey Sample Program MMBtu Savings	Percentage Spillover Estimate
Furnace/Boiler	14.3	1,666.7	1%
Heat Pump/CAC	4.5	31.9	14%
Thermostat	40.1	1,087.1	4%
Weatherization	0.0	150.0	0%
Water Heater	2.8	371.3	1%
Other	0.0	54.3	0%

Evaluated Net Savings Adjustments

Table 24 and Table 25 list evaluated net savings for the Residential Prescriptive Program. The overall program-level NTG estimates in these tables are weighted specifically to electric and demand savings due to the application of measure category-level NTG ratios to evaluated gross population savings. The program achieved net savings of 2,201,394 kWh and 1,223.14 coincident kW demand reduction.

Table 24. 2020 Residential Prescriptive 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				
HVAC							
AC Tune-Up	24,897	24,897	24,897	20,035	80%	83%	16,629
Air Source Heat Pump 16 SEER	258,078	258,078	258,078	241,740	94%	83%	200,644
Air Source Heat Pump 18 SEER	58,828	58,828	58,828	53,895	92%	83%	44,733
CAC 16 SEER	718,916	718,916	718,916	622,920	87%	83%	517,024
CAC 18 SEER	107,890	107,890	107,890	112,654	104%	83%	93,502
Dual Fuel Air Source HP 16 SEER	7,648	7,648	7,648	6,703	88%	83%	5,564
Dual Fuel Air Source HP 18 SEER	992	992	992	956	96%	83%	793
Ductless HP 17 SEER 9.5 HSPF	7,607	7,607	7,607	6,633	87%	83%	5,505
Ductless HP 19 SEER 9.5 HSPF	254,520	254,520	254,520	241,590	95%	83%	200,520
Ductless HP 21 SEER 10 HSPF	87,967	87,967	87,967	99,019	113%	83%	82,186
Ductless HP 23 SEER 10 HSPF	120,572	120,572	120,572	73,195	61%	83%	60,752
ECM HVAC Motor	607	607	607	588	97%	83%	488
HP Tune-Up	14,250	14,250	14,250	14,433	101%	83%	11,988
Thermostats							
Smart Programmable Thermostat (Dual Fuel)	320,996	320,996	312,100	294,248	92%	79%	232,456
Smart Programmable Thermostat (Electric)	287,218	287,218	279,258	334,974	117%	79%	264,630
Wi-Fi Thermostat (Dual Fuel)	91,334	91,334	88,803	84,967	93%	79%	67,124
Wi-Fi Thermostat (Electric)	18,857	18,857	18,334	27,619	146%	79%	21,819
Weatherization							
Attic Insulation (All Electric)	123,765	123,765	123,765	165,681	134%	73%	120,947
Attic Insulation (Dual Fuel)	42,503	42,503	42,503	63,117	149%	73%	46,076
Duct Sealing Electric Resistive Furnace	2,718	2,718	2,718	2,732	101%	73%	1,995
Duct Sealing Gas Heating with AC	435	435	435	420	97%	73%	307
Wall Insulation (All Electric)	23,229	23,229	23,229	25,194	108%	73%	18,392
Wall Insulation (Dual Fuel)	2,611	2,611	2,611	8,402	322%	73%	6,133
Other							
Air Purifier	7,491	7,491	7,277	7,274	97%	60%	4,364
Heat Pump Water Heater	40,907	40,907	40,907	40,082	98%	66%	26,454
Pool Heater	10,132	10,132	9,843	9,588	95%	60%	5,753
Variable Speed Pool Pump	275,554	275,554	267,681	267,682	97%	60%	160,609
Total[1]	**2,910,524**	**2,910,524**	**2,882,238**	**2,826,351**	**97%**	**78%[2]**	**2,217,385**

[1] Totals may not add up to the sum of the column due to rounding.
[2] Electric-specific NTG based on electric savings only.

Table 25. 2020 Residential Prescriptive Demand Reduction (Coincident Peak kW)

Measure	*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				
HVAC							
AC Tune-Up	26.91	26.91	26.91	32.65	121%	83%	27.10
Air Source Heat Pump 16 SEER	135.81	135.81	135.81	132.10	97%	83%	109.64
Air Source Heat Pump 18 SEER	19.62	19.62	19.62	9.20	47%	83%	7.64
CAC 16 SEER	892.83	892.83	892.83	780.95	87%	83%	648.18
CAC 18 SEER	93.43	93.43	93.43	96.26	103%	83%	79.90
Dual Fuel Air Source HP 16 SEER	3.63	3.63	3.63	4.03	111%	83%	3.34
Dual Fuel Air Source HP 18 SEER	0.32	0.32	0.32	0.55	170%	83%	0.46
Ductless HP 17 SEER 9.5 HSPF	0.81	0.81	0.81	0.28	35%	83%	0.23
Ductless HP 19 SEER 9.5 HSPF	31.51	31.51	31.51	27.98	89%	83%	23.22
Ductless HP 21 SEER 10 HSPF	11.04	11.04	11.04	11.77	107%	83%	9.77
Ductless HP 23 SEER 10 HSPF	19.92	19.92	19.92	10.04	50%	83%	8.33
ECM HVAC Motor	0.09	0.09	0.09	0.09	104%	83%	0.08
Heat Pump Tune-Up	N/A	N/A	N/A	7.06	N/A	83%	5.86
Thermostats							
Smart Programmable Thermostat (Dual Fuel)	N/A	N/A	N/A	N/A	N/A	79%	N/A
Smart Programmable Thermostat (Electric)	N/A	N/A	N/A	N/A	N/A	79%	N/A
Wi-Fi Thermostat (Dual Fuel)	N/A	N/A	N/A	N/A	N/A	79%	N/A
Wi-Fi Thermostat (Electric)	N/A	N/A	N/A	N/A	N/A	79%	N/A
Weatherization							
Attic Insulation (All Electric)	4.21	4.21	4.21	17.62	419%	73%	12.86
Attic Insulation (Dual Fuel)	64.90	64.90	64.90	53.22	82%	73%	38.85
Duct Sealing Electric Resistive Furnace	0.75	0.75	0.75	0.74	98%	73%	0.54
Duct Sealing Gas Heating with AC	0.76	0.76	0.76	0.74	97%	73%	0.54
Wall Insulation (All Electric)	0.54	0.54	0.54	2.10	392%	73%	1.53
Wall Insulation (Dual Fuel)	23.02	23.02	23.02	8.03	35%	73%	5.86
Other							
Air Purifier	0.85	0.85	0.83	0.83	97%	60%	0.50
Heat Pump Water Heater	5.59	5.59	5.59	5.48	98%	66%	3.61
Pool Heater	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Variable Speed Pool Pump	403.35	403.35	391.83	391.82	97%	60%	235.09
Total[1]	**1,723[2]**	**1,740**	**1,728**	**1,594**	**92%**	**77%[3]**	**1,223**

[1] Totals may not add up to the sum of the column due to rounding.
[2] Vectren's Electric 2020 DSM Scorecard did not report measure-level demand impacts, the measure-level kW in this column represent audited values from the 2020 program tracking data. The total represents the program-level kW from the scorecard. The measure-level values do not sum to the reported total on the scorecard.
[3] Demand-specific NTG based on coincident demand savings only.

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and 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
- Customer perception of application process as a hassle
- Lack of customer knowledge about efficiency of existing equipment
- Lack of awareness about monetary benefits of high-efficiency equipment
- Lack of program awareness
- Energy-efficiency home upgrades are low priority

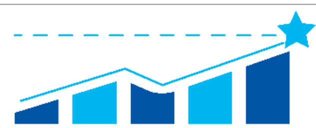
Intervention Strategies / Activities

- Program information and eligibility requirements available on Vectren website
- Program marketing (mailings and digital)
- Trade ally option to provide rebate as a direct discount to customers at time of purchase (trade allies apply for rebate)
- Incentives for equipment tune-up provide a low-cost option to increase efficiency and receive expert assessment of existing equipment
- Multiple methods available for rebate submission, including mail and online applications
- Marketing campaigns coordinated with trade allies
- Rebates for energy-efficient products

Outcomes

- Increased program awareness
- Increased participation
- Increased availability of high-efficiency products in the marketplace
- Increased customer satisfaction
- Reduced energy use

Key Indicators



- Likelihood to recommend rating
- Achievement of program participation and savings goals
- Customer familiarity with marketing materials
- Program satisfaction rating

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

- Perceived difficulty selling high-efficiency equipment with higher upfront cost

Intervention Strategies / Activities

- Multiple methods available for rebate submission, including mail and online applications
- Rebates used as a sales tool
- Experienced program implementer who continually works with trade allies to promote program's success
- Program support with rebate applications
- Reliable and timely rebate payment
- Marketing material and messages for contractors to use with customers

Outcomes

- Increased sales of high-efficiency equipment
- Greater number of trade allies participating in program
- Greater trade ally satisfaction ratings

Key Indicators

- Percentage of participants learning about the program through a contractor
- Achievement of program participation and savings goals
- Number of trade allies participating in program
- Trade ally satisfaction with program

Program Performance

Cadmus measured 2015 to 2020 program performance against the KPIs listed in Table 26.

Table 26. Residential Prescriptive KPI and 2015-2020 Performance

Key Performance Indicator	Performance					
	2015	2016	2017	2018	2019	2020
Achievement of Program Participation Goals	279%	149%	193%	105%	115%	131%
Achievement of Gross kWh Savings Goals	251%	154%	233%	105%	104%	138%
Achievement of Gross kW Savings Goals	252%	N/A	193%	106%	104%	131%
Customer Familiarity with Marketing Materials	16%	19%	21%	36%	38%	44%
Program Satisfaction Rating (% *very satisfied* or *somewhat satisfied*)	N/A	99%	98%	98%	99%	99%
Likelihood to Recommend Ratings	N/A	96%	100%	98%	98%	97%
Percentage of Participants Learning about the Program through a Contractor	53%	55%	51%	42%	48%	44%
Trade Ally Satisfaction with Program	N/A	N/A	N/A	95%	100%	100%
Number of Trade Allies Participating in Program	169[1]	594	885	806	809	902

[1] Includes electric program participation only, subsequent program years include total program participation (both electric and gas projects).

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. Builders can submit applications for homes in both Vectren South (dual fuel) and Vectren 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.[20] In 2020, Vectren provided three incentive tiers: one for Gold Star homes (rating 61 to 63), one for Platinum Star homes (rating 60 or less), and one for Platinum Star Plus homes (rating 60 or less, including installation of a natural gas tankless water heater). Vectren added the Platinum Star Plus tier in 2019. The rating thresholds and incentive tiers are shown in Table 27.

Table 27. 2020 Residential New Construction Program Incentive Summary

Tier	HERS Rating	Total Incentive (Dual Fuel Homes)	Electric Only Incentive	Gas Only Incentive
Gold Star	61 to 63	$700	$700	$350
Platinum Star	60 or less	$1,000	$1,000	$500
Platinum Star Plus	60 or less, with natural gas tankless water heater	$1,200	$1,200	$700

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

Vectren also provides energy efficiency kits to new homes constructed by Habitat for Humanity to target low-income home recipients. The program implementer distributes kits directly to the Habitat for Humanity offices and relies on the program builders to install every measure. Kit contents vary depending on the Vectren territory in which the home is constructed, as shown in Table 28.

Table 28. 2020 Residential New Construction Program Habitat for Humanity Kit Contents

Measure	Vectren Fuel Service Territory (Measures per Kit)		
	Dual Fuel	Electric Only	Gas Only
9 W LED	5	5	0
LED 5W Globe	3	3	0
LED R30 Dimmable	1	1	0
5W Candelabra	3	3	0
Bathroom Aerator 1.0 gpm	1	1	1
Kitchen Flip Aerator 1.5 gpm	1	1	1
Energy-Efficient Showerhead 1.5 gpm	1	1	1
Smart Thermostat	1	1	1

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

Accomplishments

Table 29 shows the program's achievements against goals in 2020. The RNC Program exceeded its participation and savings goals. During interviews, Vectren and the implementer attributed the program's success to the strong market demand for housing in Indiana, which led to an increase in new home construction.

Table 29. 2020 Residential New Construction Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	329,698	188,636	175%
Gross kW Savings	105	66	160%
Participants (Homes)	273	171	160%
Program Expenditures	$56,995	$56,995	100%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 30 lists the evaluated savings summary for the RNC Program. In 2020, Vectren's reported savings for new construction homes were based on 2018 evaluated savings. However, the measure mix installed in program homes varies each year. For 2020, evaluated electric energy savings were higher than reported primarily due to an increase in crawlspace wall insulation and higher window efficiency in program homes. Evaluated demand savings were lower than reported due to lower efficiencies in wall insulation and ceiling insulation and more air leakage in homes and ducts.

Ex post energy savings for Habitat for Humanity kits are identical to *ex post* energy savings from 2019. However, because reported savings were higher for Habitat for Humanity kits in 2020 than in 2019, the measures exhibited lower realization rates.

Freeridership for participating homes increased from 36% in 2019 to 42% in 2020 resulting in a lower NTG ratio in 2020.

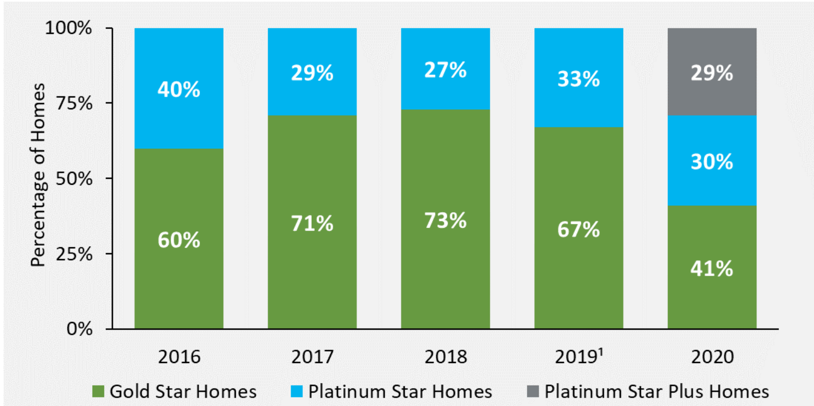
Table 30. 2020 Residential New Construction Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio[1]	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	329,698	329,698	324,158	364,825	111%	60%	218,161
Total kW	105	105	105	99	94%	58%	58

[1] Evaluated *ex post* savings weighted average of the new construction incentives NTG ratio of 58% and deemed 100% NTG for Habitat for Humanity Kits that target low-income home recipients.

Figure 1 shows the historical proportion of Gold Star, Platinum Star, and Platinum Star Plus homes.

Figure 1. Residential New Construction Historical Gold vs Platinum Homes (Electric and Dual Fuel Homes Only)



[1] Vectren added the Platinum Star Plus tier to the program in 2019.
Note: Percentages do not include Habitat for Humanity Kits

Conclusions and Recommendations

High Participant Satisfaction

Builders are satisfied with the RNC Program. All 10 interviewed builders were satisfied with their overall program experience and all were likely to recommend the program to another builder. Eight builders said they were satisfied with the application component of the program. Two builders did not complete the application themselves, as their HERS raters completed them. All 10 builders were satisfied with the HERS rating process.

Platinum Star Plus Tier Requirements

Changes to program requirements effectively encouraged greater participation in the Platinum Star Plus tier in 2020 compared to 2019. In 2020, Vectren changed the Platinum Star Plus tier to require a tankless water heater EF≥ 0.90 instead of high-efficiency HVAC equipment. Though this tier had greater participation in 2020 (78 homes across fuels) compared to 2019 (no homes), four of 10 builders said the tankless water heater requirement, specifically the added cost, was a barrier to building more Platinum Star Plus homes. These builders said they could still build highly efficient homes even without a tankless water heater.

Building Code Changes

Indiana adopted the 2020 Indiana Residential Code (IRC) in December 2019. The adoption of the 2020 IRC did not impact savings for the evaluation this year. The HERS rating period occurs at the end of construction and the average construction period is 10.7 months from permit date to completion, so Cadmus assumed that all homes submitted to the RNC Program in 2020 were permitted under the previous building code. For the 2020 evaluation, Cadmus used the 2011 Indiana Residential Code as the baseline for estimating savings. However, evaluations in future years will be impacted as this code change will establish a new baseline for program savings.

Recommendation: Vectren should anticipate potentially significant changes to home savings due to the difference in the baseline. For planning purposes, Vectren should use baseline savings that comply with the 2020 IRC. Cadmus modeled the sampled projects from the 2020 evaluation based on the 2020 IRC and found energy savings to be significantly lower than energy savings based on the 2011 IRC. Table 31 indicates the modeled energy savings by tier from the 2020 sample population. Cadmus recommends the use of these savings estimates for future program savings.0

Table 31. Residential New Construction Gross Savings based on the 2020 Indiana Residential Code

Tier	2020 IRC Modeled Energy Savings (kWh)	2020 IRC Modeled Demand Savings (kW)
Gold Star (Electric Only)	1,641	0.14
Gold Star (Dual Fuel)	435	0.14
Platinum Star (Dual Fuel)	481	0.14
Platinum Star Plus (Dual Fuel)	608	0.14

Process Evaluation

RESIDENTIAL NEW CONSTRUCTION PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

10 builder interviews

↳ 1 Habitat for Humanity builder

2020 Program Changes

Indiana adopted the 2020 Indiana Residential Code (equivalent to 2018 International Energy Conservation Code) in December 2019; all homes permitted in 2020 required this code

Vectren revised the Platinum Plus tier to require a tankless water heater EF≥ 0.90 instead of high-efficiency HVAC

- Some builders recommended the Platinum Plus tier be tied to lower HERS rating scores rather than specific equipment

Due to COVID-19, the Habitat for Humanity builder distributed kits by dropping them off at homes instead of installing them in-person

2021 Planned Program Changes

Vectren will:

Lower HERS rating requirements for Gold tier from (61 to 63) to (61 to 62)

61-63 → 61-62

Discontinue Habitat for Humanity kits because builders did not directly install kit measures, as required, resulting in lower energy savings achieved for income-qualified households

Key Process Evaluation Findings

Builder Interview Results:

10/10 satisfied with overall program experience

10/10 likely to recommend program to another builder

10/10 satisfied with the HERS rating process

8/8 satisfied with application process

- Remaining two builders said HERS rater completed their applications

9/10 aware of residential code change

- Only three said it had a noticeable impact on their building practices due to increased cost to comply

10/10 experienced project disruptions due to COVID-19 and expect these disruptions to continue in 2021:

- Equipment sourcing delays
- Increases pricing for raw materials
- Crew scheduling difficulties

Impact Evaluation

Impact Evaluation Methods and Findings

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

- Review tracking data for completeness and errors
- Review of a random sample of 39 HERS certificates (of 245) for home characteristics
- Develop characteristic energy models using REM/Rate V16.0 to verify energy savings based on home characteristics from sample of 39 homes
- Conduct interviews with 10 builder participants to self-report NTG
- Conduct an engineering analysis of measures included in the Habitat for Humanity kits based on builder interviews and secondary research

Building Code Changes

In late 2019, Indiana adopted the 2020 IRC as the default residential building code. Builders were given a grace period to adapt to the new code requirements. Any homes permitted in 2019 (even if construction had not started) could be completed under either the old or the new code, whereas any homes permitted on or after January 1, 2020, were required to be completed under the new code.

According to the U.S. Census, the average length of home construction from start to finish in 2020 was 10.7 months for contractor-built homes.[21] Permit drawings are issued prior to construction, and homes are permitted based on the building code at the permit date. RNC Program documentation does not include the permit date, construction date, or applicable residential code. Because the HERS rating period occurs at the end of construction, there is no way to determine when the home was permitted through program documentation. To calculate evaluated savings, Cadmus needed to determine if the old or new residential building code should be used in the model. Since home construction has such a long construction time, Cadmus assumed a large percentage of homes submitted to the RNC Program were primarily permitted under the previous building code in 2019. Therefore, for the 2020 evaluation, Cadmus used the 2011 Indiana Residential Code as the baseline for estimating savings.

Cadmus developed energy models for the sampled projects in the 2020 evaluation based on the 2011 IRC and used the 2020 IRC for prospective energy savings comparison. As shown in Table 34, based on the 2020 IRC, gross *ex post* energy savings from the sample population are significantly lower than energy savings using the 2011 IRC baseline.

[21] U.S. Census Bureau. "Average Length of Time from Start to Completion of New Privately Owned Residential Buildings." Accessed April 2021. avg_starttocomp_cust.xls (census.gov)

Table 32. Residential New Construction Gross Savings Energy Code Comparison

Tier	2011 IRC Modeled Energy Savings		2020 IRC Modeled Demand Savings	
	kWh	kW	kWh	kW
Gold Star (Electric Only)	4,598	0.43	1,641	0.14
Gold Star (Dual Fuel)	1,218	0.43	435	0.14
Platinum Star (Dual Fuel)	1,349	0.43	481	0.14
Platinum Star Plus (Dual Fuel)	1,703	0.43	608	0.14

When asked about the new code, all 10 interviewed builders said local building commissions are strictly enforcing the new code. Two builders specifically said home inspectors and energy auditors were being proactive about the code changes and helping builders identify any deficiencies early in the process. This activity indicates a need for a change in the baseline for the 2021 program year.

Gross Savings Review

In 2020, the program realized 111% of its reported energy savings and 94% of its reported demand savings. Table 33 provides per-unit annual gross savings for each program measure. Gold Star electrically heated homes, characterized as “Electric Only,” produced the highest per-unit energy and demand savings because of the installation of electric heating equipment. There were no Platinum Star electrically heated homes submitted to the program in 2020.

Table 33. 2020 Residential New Construction Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
New Construction Homes				
Gold Star (Electric Only)	3,900	4,598	0.43	0.40
Gold Star (Dual Fuel)	1,033	1,218	0.43	0.40
Platinum Star (Electric Only)	N/A	N/A	N/A	N/A
Platinum Star (Dual Fuel)	1,144	1,349	0.43	0.40
Platinum Star Plus (Dual Fuel)	1,445	1,703	0.43	0.40
Habitat for Humanity Kits				
Habitat for Humanity Kit (Electric Only)	2,393	878	0.01	0.05
Habitat for Humanity Kit (Dual Fuel)	718	585	0.00	0.05

Cadmus identified the following discrepancies in reported and evaluated savings:

- **New construction homes.** Evaluated energy savings were higher than reported due to an increase in crawlspace wall insulation, improved furnace efficiency, and higher window efficiency in 2020 homes. Evaluated demand savings were lower than reported due to lower efficiencies in wall insulation and ceiling insulation and more air leakage in 2020 homes and ducts.
- **Habitat for Humanity kits.** Evaluated energy savings for 2020 were very close to evaluated energy savings for the 2019 program year. Vectren’s assumptions for reported energy savings are unknown.

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

Table 34 lists the evaluated gross per-unit energy savings for each program measure by year since 2015. Evaluated per-unit savings for electric only homes have increased from 3,900 kWh in 2018 to 4,598 kWh in 2020. Evaluated per-unit savings for dual fuel homes have increased from an average of 1,089 kWh in 2018 to an average of 1,423 kWh in 2020.

Table 34. Residential New Construction Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)					
	2015	2016	2017	2018	2019[1]	2020
New Construction Homes						
Gold Star (Electric Only)	N/A	7,624	N/A	3,900	4,540	4,598
Gold Star (Dual Fuel)	954	2,020	842	1,033	980	1,218
Platinum Star (Electric Only)	N/A	9,763	N/A	4,995	5,815	N/A
Platinum Star (Dual Fuel)	1,419	2,236	1,252	1,144	1,458	1,349
Platinum Star Plus (Dual Fuel)	N/A	N/A	N/A	N/A	N/A	1,703
Habitat for Humanity Kits						
Habitat for Humanity Kit (Electric Only)	N/A	N/A	N/A	N/A	878	878
Habitat for Humanity Kit (Dual Fuel)	N/A	N/A	N/A	N/A	585	585

[1] Vectren launched the Platinum Star Plus tier and Habitat for Humanity Kits in 2019.

Measure Verification

Table 35 lists the in-service rates for each program measure. After reviewing the program tracking data, Cadmus verified 100% of reported program homes were included in the database.

The kit in-service rates are the average weighted measure in-service rate, based on research conducted for the Energy Efficient Schools Program in 2019,[22] and these rates vary by measure. (In 2020, aerators exhibited 36% to 43% in-service rates while LEDs exhibited 92% to 95% in-service rates.) The quantity of installed measures, by type, impacts the overall in-service rates for the kits.

[22] Cadmus did not conduct a student household survey for the 2020 Energy Efficient Schools Program.

Table 35. 2020 Residential New Construction Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
New Construction Homes				
Gold Star (Electric Only)	2	2	2	100%
Gold Star (Dual Fuel)	99	99	99	100%
Platinum Star (Electric Only)	0	0	0	N/A
Platinum Star (Dual Fuel)	73	73	73	100%
Platinum Star Plus (Dual Fuel)	71	71	71	100%
Habitat for Humanity Kits				
Habitat for Humanity Kit (Electric Only)	8	8	7	83%
Habitat for Humanity Kit (Dual Fuel)	20	20	17	83%
Total	**273**	**273**	**268**	**98%**

Table 36 shows that the program has achieved 100% in-service rates since 2015 for home measures.

Table 36. Residential New Construction Historical In-Service Rates

Measure[1]	In-Service Rate					
	2015	2016	2017	2018	2019	2020
New Construction Homes						
Gold Star (Electric Only)	N/A	N/A	N/A	100%	100%	100%
Gold Star (Dual Fuel)	100%	100%	100%	100%	100%	100%
Platinum Star (Electric Only)	N/A	100%	N/A	100%	100%	N/A
Platinum Star (Dual Fuel)	100%	100%	100%	100%	100%	100%
Platinum Star Plus (Dual Fuel)	N/A	N/A	N/A	N/A	N/A	100%
Habitat for Humanity Kits						
Habitat for Humanity Kit (Electric Only)	N/A	N/A	N/A	N/A	67%	83%
Habitat for Humanity Kit (Dual Fuel)	N/A	N/A	N/A	N/A	83%	83%

[1] Vectren launched the Platinum Star Plus tier and Habitat for Humanity Kits in 2019.

Net-to-Gross Analysis

Cadmus analyzed NTG for the 2020 RNC Program through interviews with 10 participating builders. Cadmus estimated freeridership using the intention/influence freeridership method.[23] Table 37 presents the NTG results for the program. Cadmus applied 100% NTG to Habitat for Humanity Kit measures because it targets low-income home recipients. These findings are described in greater detail in *Appendix B. Net-to-Gross Detailed Findings*.

23 The intention score and influence score each have maximum values of 50%. They are then added to arrive at the final freeridership score. Other programs use a maximum value of 100% for the intention score and influence score, which are then averaged to arrive at the final freeridership score.

Table 37. 2020 Residential New Construction Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
New Construction Homes	42%	0%	58%[1]
Habitat for Humanity Kit	N/A	N/A	100%

[1]Absolute precision at 90% confidence interval is ±9%.

Table 38 lists historical program-level NTG ratios by year for the new construction homes component. Due to the relatively small sample size of interviews, NTG can vary year to year based on builder response and level of individual respondent's contribution to overall program savings. In 2020, the three interviewed builders with the most program savings represented 82% of the analysis sample *ex post* gross MMBtu savings, and their combined savings-weighted average freeridership was 44%. (In 2019, the three interviewed builders with the most savings represented 71% of the analysis sample *ex post* gross MMBtu savings, and their combined savings-weighted average freeridership was 23%.)

Table 38. Residential New Construction Incentives Historical Net-to-Gross Ratios

Program Year	Freeridership	Spillover	NTG Ratio
2015 (n=5)	50%	0%	50%
2016 (n=10)	64%	0%	36%
2017 (n=10)	50%	0%	50%
2018 (n=10)	46%	0%	54%
2019 (n=8)	36%	0%	64%
2020 (n=10)	42%	0%	58%

Freeridership and Spillover

The intention freeridership score derives from builders' responses about how their organization's building practices would have differed in absence of the program. The influence freeridership score was calculated by asking respondents to rate the influence of program elements on their building practices. The intention score and influence score each have maximum values of 50%, and then are summed to arrive at the final freeridership score.

Table 39 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 influential on their decision to build homes to the RNC Program requirement of HERS 63 standard or lower.

Table 39. 2020 Residential New Construction Program Intention/Influence Freeridership Scores

n	Intention Score	Influence Score	Freeridership Score
10	32%	10%	42%

The 2020 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 program.

Evaluated Net Savings Adjustments

Table 40 and Table 41 list evaluated net savings for the RNC Program. The program achieved net savings of 218,161 kWh and 58 coincident kW demand reduction.

Table 40. 2020 Residential New Construction 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				
New Construction Homes							
Gold Star (Electric Only)	7,800	7,800	7,800	9,196	118%	58%	5,333
Gold Star (Dual Fuel)	102,288	102,288	102,288	120,596	118%	58%	69,946
Platinum Star (Electric Only)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Platinum Star (Dual Fuel)	83,517	83,517	83,517	95,464	118%	58%	57,109
Platinum Star Plus (Dual Fuel)	102,585	102,585	102,585	120,946	118%	58%	70,148
Habitat for Humanity Kits							
Habitat for Humanity Kit (Electric Only)	19,140	19,140	15,976	5,864	31%	100%	5,864
Habitat for Humanity Kit (Dual Fuel)	14,368	14,368	11,993	9,760	68%	100%	9,760
Total	**329,698**	**329,698**	**324,158**	**364,825**	**111%**	**60%**	**218,161**

Table 41. 2020 Residential New Construction Demand Reduction (Coincident Peak kW)

Measure	*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				
New Construction Homes							
Gold Star (Electric Only)	0.86	0.86	0.86	0.80	93%	58%	0.46
Gold Star (Dual Fuel)	42.54	42.54	42.54	39.58	93%	58%	22.96
Platinum Star (Electric Only)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Platinum Star (Dual Fuel)	31.37	31.37	31.37	29.19	93%	58%	16.93
Platinum Star Plus (Dual Fuel)	30.51	30.51	30.51	28.39	93%	58%	16.46
Habitat for Humanity Kits							
Habitat for Humanity Kit (Electric Only)	0.06	0.06	0.05	0.33	543%	100%	0.33
Habitat for Humanity Kit (Dual Fuel)	0.04	0.04	0.03	0.84	2,332%	100%	0.84
Total	**105**	**105**	**105**	**99**	**94%**	**58%**	**58**

[1] The 2020 Electric DSM Scorecard did not report kW savings at the measure level. These per-unit kW savings reflect audited savings from the 2020 program tracking data.

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and key performance indicators (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 PROGRAM

Market Actor	Market Barriers	Intervention Strategies / Activities	Outcomes	Key Indicators
End-Use Customer Homebuyers	• 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 program access among income-qualified homebuyers • Lack of understanding about benefits of energy-efficient home construction	• Incentives to builders to construct and market efficient homes • Free energy efficiency kit for Habitat for Humanity home recipients • Trainings to builders on energy-efficient homes, e.g., building practices and marketing strategies • Incentives help offset increased costs passed on to homebuyer • Vectren outreach to local builders and HERS raters	• 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 • Increased engagement with income-qualified homeowners	• Achievement of participation and savings goals • Percentage of homebuyers seeking energy-efficient homes • Saturation of homes more efficient than Indiana residential energy code • Number of Habitat for Humanity kits installed • Average HERS rating of homes built through the program • Number of participating builders
Trade Allies Builders	• 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 home efficiency, HERS ratings, etc. • Project delays due to shortage of high-efficiency equipment and qualified labor	• Builder incentives to offset higher construction costs and cost of HERS rating • Program promotion through homebuilders' association and other industry groups • Quarterly e-mail reminder of upcoming application deadlines • Program information and material readily available on Vectren website • Trainings to builders on energy-efficient building practices and marketing strategies • Platnum Plus tier with bonus incentives for water heating equipment • Builders encouraged to use low HERS rating as selling point • Program staff assist with paperwork; streamlined application for multiple submissions • Yearly kickoff meeting with builders to review program changes • Midstream Pilot encourages distributors to carry inventory of energy-efficient equipment	• Increased program awareness • Increased program satisfaction • Increased energy efficiency within homes • Increased program participation and uptake (lower HERS rating, additional high-efficiency measures installed, etc.) per builder • Increased energy savings • Increased builder participation • Increased familiarity with energy-efficient equipment	• 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 • Number of homes in Platinum Plus Tier
HERS Raters	• Lack of program awareness	• Outreach and education direct to HERS raters	• Increased HERS rater participation • Increased builder satisfaction with the program	• Builder satisfaction with the program

Program Performance

Cadmus measured 2015 to 2020 program performance against the KPIs listed in Table 42. This table combines metrics for the gas and electric programs to be consistent with reporting for prior years. HERS ratings in this table are an average from all program homes, including homes with no Vectren electric service. HERS scores for all homes, including homes with no Vectren electric service, may differ. REM/Rate software versions may also impact HERS scores over time.

Table 42. Residential New Construction Program KPI and 2015-2020 Performance

KPI	Performance					
	2015	2016	2017	2018	2019	2020
Achievement of electric program participation goals	86%	124%	155%	101%	130%	160%
Achievement of gross kWh savings goals	70%	137%	143%	101%	154%	175%
Achievement of gross kW savings goals	N/A	N/A	N/A	101%	130%	160%
Percent of ≤60 HERS rated homes in program (all fuels)	53%	40%	29%	27%	33%	37%
Average HERS rating of home built through program (all fuels)	58	59	59	61	61	60
Number of participating builders (all fuels)	47	56	48	47	44	50
Builder satisfaction with program (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	10 out of 10	10 out of 10
Average number of homes per builder (all fuels)	20	17	17	18	22	22
Number of home builders building homes to ≤60 HERS score through the program (all fuels)	N/A	12	31	33	36	43
Number of Habitat for Humanity Kits installed (all fuels)	N/A	N/A	N/A	N/A	33	50
Home builder attendance at outreach events (all fuels)	N/A	28–38[1]	107-127[2]	20-48[3]	5-32[4]	38[5]
Number of homes in the Platinum Star Plus Tier (all fuels)	N/A	N/A	N/A	N/A	0	78
Saturation of homes more efficient than Indiana residential energy code in Vectren territory	N/A	N/A	N/A	N/A	N/A	Track in future years
Percentage of home buyers seeking energy-efficient homes	N/A	N/A	N/A	N/A	N/A	Track in future years

[1] Vectren provided attendance estimates of 20 to 30 builders for the first of two outreach events in 2016. The program implementer reported that eight builders attended the second event.
[2] The program implementer 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 the program implementer.
[3] The program implementer reported presenting at Builders Association events in five Indiana cities, with four events having an attendance of 20 to 26 builders and one event having an attendance of 48 builders.
[4] The program implementer reported various attendance at Builder Association events, counting 21 at the January SIBA Parade Preview, 19 at the March 2019 SIBA Meeting Sponsor, 32 at the April IBA Meeting Sponsor, 15 at the July SIBA Golf Outing, and five at the August YPC Energy Efficiency Panel Discussion.
[5] Due to COVID-19 restrictions, the program implementer participated in only one event for builders in 2020: the SIBA Parade Preview. All other planned events were cancelled.

The percentage of homes with a HERS rating ≤60 and the number of homes in the Platinum Star Plus tier increased from 2019 (33% rated ≤60 and 0 homes in Platinum Star Plus) to 2020 (37% rated ≤60 and 78 homes in Platinum Star Plus).

Seven of the 10 interviewed builders noted challenges with meeting the Platinum Star certification. Four of these specifically mentioned that the tankless water heater requirement costs more than a traditional water heater. They suggested improving the program by removing the tankless water heater requirement and instead tying the Platinum Star Plus tier to a lower HERS rating. One of these builders summed up with this statement: “I think a tankless water heater isn’t needed to achieve high efficiency [in a home].” The other three builders said building shell measures were a barrier, specifically for getting the home sealed tightly.

Home Energy Assessment 2.0 (HEA 2.0) Program

The Home Energy Assessment 2.0 (HEA 2.0) Program offers a walk-through assessment and direct installation of energy efficiency measures for single-family homes (building up to four units) at no cost to the customer.[24] A local contracting company, J.E. Shekell, implements the program and is responsible for recruiting participants, conducting on-site home energy assessments, installing program measures, and recommending further energy-saving home improvements. While at the home, energy assessors employed by the program implementer provide energy education, a detailed report about the home's energy use, and suggestions for further actions to reduce energy consumption.

Energy assessors install the following electric-saving measures through the HEA 2.0 Program:

Lighting

- Exterior LED lamp
- LED 6W globe
- LED 9W bulb
- LED R30 dimmable
- LED downlight retrofit
- LED candelabra
- LED 0.3W nightlight

Plug load reduction

- Smart power strips

HVAC and water heating measures

- Filter whistle
- Pipe wrap
- Water heater temperature setback
- Smart thermostat
- Duct sealing (required co-pay)
- Insulation referral

Water-saving devices

- Bathroom aerator
- Kitchen aerator
- Efficient showerhead

General Service LEDs will no longer be offered in 2021; therefore, the HEA 2.0 Program will be discontinued in 2021 due to low cost-effectiveness.

Accomplishments

Table 43 shows the program's achievements against goals in 2020. The program did not meet its goals in 2020. Like other on-site programs in Vectren's portfolio, the HEA 2.0 Program was impacted by Indiana's mandatory shutdown due to the COVID-19 pandemic.

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24 In 2018, Vectren revamped the 2017 version of the program to reset savings goals and focus on treating fewer participants with deeper savings. The HEA 2.0 Program ran as a pilot in 2018 and became an official program in 2019.

Table 43. 2020 HEA 2.0 Program Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	207,003	473,696	44%
Gross kW Savings	42	73	57%
Participants	229	400	57%
Program Expenditures	$247,615	$258,333	96%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 44 lists the evaluated savings summary for the 2020 HEA 2.0 Program. The energy realization rate of 103% was driven primarily by Cadmus' application of electric cooling savings to thermostats installed in natural gas-heated homes with central air conditioners. Vectren did not claim these electric cooling savings. Demand savings were available only in the 2020 Electric DSM Scorecard, and measure-level demand savings were not available and/or not calculated in the program tracking data. For this reason, it was not clear which measures drove the demand realization rate. Per-unit evaluated savings are comparable to evaluated per-unit savings in the 2019 HEA 2.0 Program evaluation, which had a 109% realization rate.

Table 44. 2020 HEA 2.0 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	207,003	207,003	203,113	212,397	103%	84%	179,038
Total kW	42	42	41	22	53%	82%	18

Conclusions and Recommendations

Because the program is being discontinued in 2021, Cadmus does not have any recommendations for program refinements.

Impact Evaluation

Impact Evaluation Methods and Findings

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

- Tracking database review of the number of measures installed
- Engineering analysis of *ex ante* energy savings per measure and per home
- Application of 2019 in-service rates and NTG ratios[25]

[25] Cadmus conducted a survey with 2020 HEA 2.0 Program participants, but responses were limited due to the small program population. Cadmus used 2019 HEA 2.0 Program participant survey data to inform the 2020 impact analysis.

Gross Savings Review

Cadmus conducted an engineering desk review to determine energy and demand savings for the electric-saving measures distributed through the HEA 2.0 Program. Cadmus also determined the savings achieved by participants' implementation of additional recommendations from the home energy assessment. Table 45 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.*

Table 45. 2020 HEA 2.0 Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported *Ex Ante*[1]	Evaluated *Ex Post*	Reported *Ex Ante*[2]	Evaluated *Ex Post*
Audit Education				
Audit Fee (Electric)	61	85	N/A	0.0033
Lighting				
LED 6W Globe	10	21	N/A	0.0028
LED 8W Bulb	53	54	N/A	0.0070
LED 9W Bulb	32	31	N/A	0.0041
LED 9W Bulb (Exterior)	92	84	N/A	0.0000
LED Candelabra	41	22	N/A	0.0029
LED Downlight Retrofit	35	39	N/A	0.0051
LED Nightlight	14	13	N/A	0.0000
Plug Load Reduction				
Smart Strips	103	25	N/A	0.0019
HVAC and Water Heating Measures				
Filter Whistle (Dual Fuel, Gas Heat with CAC)	0	56	N/A	0.0904
Filter Whistle (Electric)	61	120	N/A	0.1956
Insulation Referral[3]	304	451	N/A	0.3800
Pipe Wrap (Electric)	65	91	N/A	0.0104
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	0	351	N/A	0.0000
Smart Thermostat (Electric)	370	1,402	N/A	0.0000
Water Heater Setback (Electric)	87	82	N/A	0.0093
Water-Saving Devices				
Bathroom Aerator (Electric)	9	19	N/A	0.0026
Kitchen Aerator (Electric)	115	143	N/A	0.0070
Showerhead (Electric)	206	225	N/A	0.0148

[1] The 2020 Electric DSM Scorecard did not include per-unit electric savings. These are the audited per-unit electric savings from the 2020 program tracking data.
[2] Vectren did not provide demand savings at the measure level. The only source of demand savings was the 2020 Electric DSM Scorecard for the program overall.
[3] Two customers were referred for attic insulation at the end of their assessment and received a $450 rebate for installed insulation. These savings are not double-counted in another program.

Cadmus used inputs and algorithms from the 2015 Indiana TRM v2.2 with the following exceptions:

- For lighting measures, the baseline wattage was determined following guidelines from the Uniform Methods Project 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 8.0 to evaluate savings.
- For smart thermostats, Cadmus used an evaluation from 2013–2014 of programmable and smart thermostats in Vectren South territory.
- For pipe wrap, Cadmus found that the 2015 Indiana TRM v2.2 algorithm made assumptions that most likely led to overestimating savings and instead used an energy savings factor of 3%.[26]

Differences in reported and evaluated savings are primarily driven by annual differences in participant survey data and program tracking data. Vectren's 2020 reported savings are based primarily on 2016 evaluated savings. Larger discrepancies in 2020 reported and evaluated savings are explained as follows:

- **Audit education.** Audit education savings were adjusted to take into account all efficient equipment that was installed, such as lighting, showerheads, and thermostats. As Cadmus used the 2019 HEA 2.0 Program participant survey to determine savings for this measure, the percentage of respondents who took action on energy-saving items was the same in 2019 and 2020.[27] Compared to the 2016 evaluation, more respondents took additional energy-saving actions in 2020. Savings for air sealing were also higher on average in the 2020 IQW Program evaluation, on which savings from installing additional air sealing are based. This resulted in higher evaluated savings for the HEA 2.0 Program in 2020.
- **Lighting.** Lighting measures generally had comparable reported and evaluated savings, with an overall realization rate of 95% when excluding globes and candelabras. The large differences for globes and candelabras are likely due to different methodologies to determine baseline wattages. *Ex ante* sources for non-9 watt interior LEDs are unknown Cadmus used guidelines in the Uniform Methods Project 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.
- **Plug load reduction.** Tier 1 smart strips had lower evaluated savings than reported savings, possibly due a different methodology in evaluating savings. Cadmus used the 2015 Indiana TRM v2.2 and the average of computer and television savings. Vectren did not provide measure-level assumptions and *ex ante* savings for this measure do not appear to be based on prior evaluations, so it was difficult to predict differences between reported and evaluated savings. Results in 2020 are comparable to the 24 kWh per-unit savings from last year's evaluation.
- **HVAC and water-heating measures:**

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

27 Cadmus did not apply 2020 HEA 2.0 participant survey data to impact analysis because of small sample size.

- Vectren did not claim savings for filter whistles installed in gas-heated homes with central air conditioning. However, these installations generate electric cooling savings, resulting from the increased efficiency of the central cooling system (from the furnace whistle). To correct for this, Cadmus evaluated 56 kWh of electric cooling savings for homes that were confirmed to have central air conditioning in the tracking data. Only one electric-only furnace whistle was installed, which received high savings due to the high capacity of the installed HVAC system.
- Cadmus evaluated additional heating savings for smart thermostats. For thermostats installed in gas-heated homes with central cooling systems, Vectren claimed only gas savings. To correct for this, Cadmus evaluated cooling savings of 421 kWh for homes that were confirmed to have central air conditioning in the tracking data. Evaluated savings were also higher due to an increase in the saturation of manual thermostats in homes where smart thermostats were installed in 2020.
- Insulation referrals are a new measure in the 2020 HEA 2.0 Program. Two recipients received attic insulation only. The pre- and post-insulation conditions at the homes were unavailable, so Cadmus used the program average kWh and kW savings for attic insulation from the 2020 Residential Prescriptive Program evaluation. *Ex ante* savings are from an unknown source, making reasons for savings differences difficult to determine.

- **Water-saving devices.** Annual differences in survey responses for people per home, bathroom faucets per home, and showers per home creates variations in savings. In 2020, savings for water-saving devices were higher due to a higher number of people per home, which used 2019 HEA 2.0 participant survey data, compared to 2018, on which reported savings were based. 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 46 lists the evaluated gross per-unit energy savings for each program measure by year. Evaluated savings in 2019 and 2020 are very similar due to the application of 2019 participant survey data to inform 2020 measure-level savings.

Table 46. HEA 2.0 Program Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)					
	2015	2016	2017	2018	2019	2020
Audit Education						
Audit Fee (Electric)	113	61	32	63	58	85
Lighting						
LED 6W Globe	-	-	19	21	21	21
LED 8W Bulb	-	-	32	53	51	54
LED 9W Bulb	-	32	33	32	30	31
LED 9W Bulb (Exterior)	-	-	-	84	84	84
LED Candelabra	-	-	-	33	21	22

Measure	Evaluated Annual Gross Savings (kWh)					
	2015	2016	2017	2018	2019	2020
LED Downlight Retrofit	-	-	-	42	38	39
LED Nightlight	-	14	14	13	13	13
Plug Load Reduction						
Smart Strips	-	23	-	26	24	25
HVAC and Water Heating Measures						
Filter Whistle[1]	64	61	52	84	55	68
Insulation Referral	-	-	-	-	-	451
Pipe Wrap (Electric)	114	65	83	75	74	91
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	-	161	161	277	298	351
Smart Thermostat (Electric)	-	161	279	1,224	1,018	1,402
Water Heater Setback (Electric)	-	87	82	66	82	82
Water-Saving Devices						
Bathroom Aerator (Electric)	11	9	23	24	19	19
Kitchen Aerator (Electric)	150	115	148	163	143	143
Showerhead (Electric)	249	206	254	259	225	225

[1] 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 of the direct install nature of the program.

Table 47 lists the in-service rates for each program measure. Due to insufficient responses to the 2020 HEA 2.0 Program participant survey, Cadmus applied ISRs from the 2019 HEA 2.0 Program impact evaluation to verify installations.

Table 47. 2020 HEA 2.0 Program Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
Audit Education				
Audit Fee (Electric)	229	229	229	100%
Lighting				
LED 6W Globe	241	241	238	99%
LED 8W Bulb	616	616	608	99%
LED 9W Bulb	2,887	2,887	2,851	99%
LED 9W Bulb (Exterior)	34	34	34	100%
LED Candelabra	722	722	713	99%

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
LED Downlight Retrofit	103	103	102	99%
LED Nightlight	595	595	574	96%
Plug Load Reduction				
Smart Strips	150	150	139	93%
HVAC and Water Heating Measures				
Filter Whistle (Dual Fuel, Gas Heat with CAC)	4	4	4	100%
Filter Whistle (Electric)	1	1	1	100%
Insulation Referral	2	2	2	100%
Pipe Wrap (Electric)	6	6	6	100%
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	60	60	60	100%
Smart Thermostat (Electric)	4	4	4	100%
Water Heater Setback (Electric)	3	3	3	100%
Water-Saving Devices				
Bathroom Aerator (Electric)	18	18	17	93%
Kitchen Aerator (Electric)	8	8	7	92%
Showerhead (Electric)	14	14	12	86%
Total[1]	**5,697**	**5,697**	**5,604**	**98%**

[1] Program totals reflect total number of measures installed. The scorecard tracks participation by number of households.

Table 48 shows historical in-service rates for each program measure. In-service rates have been relatively stable over time, with the exception of filter whistles. There are very few recipients of this measure each year, which creates volatility in the in-service rate.

Table 48. HEA 2.0 Program Historical In-Service Rates

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
Audit Education						
Audit Fee (Electric)	100%	100%	100%	100%	100%	100%
Lighting						
LED 6W Globe	94%	97%	92%	98%	99%	99%
LED 8W Bulb	94%	97%	92%	98%	99%	99%
LED 9W Bulb	94%	100%	92%	98%	99%	99%
LED 9W Bulb (Exterior)	94%	100%	-	100%	100%	100%
LED Candelabra	94%	97%	-	98%	99%	99%
LED Downlight Retrofit	94%	97%	-	98%	99%	99%
LED Nightlight	94%	100%	91%	99%	96%	96%
Plug Load Reduction						
Smart Strips	-	100%	-	93%	93%	93%
HVAC and Water Heating Measures						

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
Filter Whistle (Dual Fuel, Gas Heat with CAC)	100%	44%	71%	57%	100%	100%
Filter Whistle (Electric)	100%	44%	71%	57%	100%	100%
Insulation Referral	-	-	-	-	-	100%
Pipe Wrap (Electric)	100%	100%	100%	100%	100%	100%
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	-	88%	100%	100%	100%	100%
Smart Thermostat (Electric)	-	88%	100%	100%	100%	100%
Water Heater Setback (Electric)	100%	100%	100%	100%	100%	100%
Water-Saving Devices						
Bathroom Aerator (Electric)	100%	93%	95%	84%	93%	93%
Kitchen Aerator (Electric)	87%	93%	100%	90%	92%	92%
Showerhead (Electric)	83%	96%	90%	89%	86%	86%

Net-to-Gross Analysis

Due to a small sample size in survey respondents, Cadmus calculated freeridership and spillover for the HEA 2.0 Program using the freeridership and spillover ratios from the program's 2019 impact evaluation. The overall program NTG ratio of 87% is weighted by the combination of electric and gas gross evaluated program population savings. The electric-specific NTG ratio of 84% is weighted specifically to electric savings due to the application of measure-category level NTG estimates. Table 49 presents the NTG results for the program.

Table 49. 2020 HEA 2.0 Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio	Total Program *Ex Post* MMBTU Savings
Total Program	**16%[1]**	**3%[1]**	**87%[1]**	**1,417[2]**
Electric-Specific NTG			**84%**	**724**
Demand-Specific NTG			**82%**	**0.08[3]**
Gas-Specific NTG			**93%**	**693**

[1] Weighted by evaluated *ex post* program population MMBtu savings.
[2] Totals may not sum due to rounding.
[3] MMBtu/hour savings.

Table 50 lists historical program-level NTG ratios by year.

Table 50. HEA 2.0 Program 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%
2019	16%	3%	87%
2020	16%	3%	87%

Freeridership and Spillover

Cadmus estimated freeridership and spillover using measure-specific freeridership and spillover ratios from the 2019 HEA 2.0 Program evaluation. Cadmus weighted these estimates to the 2020 evaluated *ex post* gross population savings for each measure type. The resulting program NTG ratio is 87% after including spillover of 3%. Table 51 lists NTG results by measure.

Table 51. HEA 2.0 Program NTG by Measure

Measure	Freeridership[1]	Spillover[1]	NTG[1]	Evaluated *Ex Post* Population Savings (MMBtu)
Audit Education				
Audit Fee[2]	0%	0%	100%	241
Lighting				
LED Light Bulbs	24%	4%	80%	509
LED Nightlight[2]	0%	0%	100%	26
Plug Load Reduction				
Smart Strips	13%	4%	91%	12
HVAC and Water Heating Measures				
Filter Whistle[2]	0%	0%	100%	5
Insulation Referral[2]	0%	0%	100%	52
Pipe Wrap	12%	4%	92%	17
Smart Thermostat	13%	4%	91%	432
Water Heater Setback[2]	0%	0%	100%	25
Water-Saving Devices				
Bathroom Aerator	16%	4%	88%	9
Kitchen Aerator	16%	4%	88%	22
Efficient Showerhead	26%	4%	78%	68
Overall	**16%**	**3%**	**87%**	**1,417[4]**

[1] From 2019 HEA 2.0 Program evaluation. Cadmus sampled and estimated NTG ratios at the measure level and encompassing both fuel types. The same measure-level NTG ratios are applied to electric and natural gas evaluated *ex post* gross savings. Cadmus is including the same NTG information in both the electric and natural gas reports for transparency. This is consistent with prior evaluation reporting.

[2] No NTG surveys completed; assuming 0% freeridership.

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

[4] Totals may not sum due to rounding

Evaluated Net Savings Adjustments

Table 52 and Table 53 list evaluated net savings for the 2020 HEA 2.0 Program. The program achieved net savings of 179,038 kWh and 18.08 coincident kW demand reduction.

Table 52. 2020 HEA 2.0 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				
Audit Education							
Audit Fee (Electric)	14,018	14,018	14,018	19,419	139%	100%	19,419
Lighting							
LED 6W Globe	2,499	2,499	2,468	5,038	202%	80%	4,030
LED 8W Bulb	32,634	32,634	32,232	32,780	100%	80%	26,224
LED 9W Bulb	91,114	91,114	89,991	88,784	97%	80%	71,027
LED 9W Bulb (Exterior)	3,127	3,127	3,127	2,861	91%	80%	2,289
LED Candelabra	29,694	29,694	29,328	15,732	53%	80%	12,586
LED Downlight Retrofit	3,598	3,598	3,554	4,018	112%	80%	3,214
LED Nightlight	8,114	8,114	7,823	7,538	93%	100%	7,538
Plug Load Reduction							
Smart Strips	15,450	15,450	14,306	3,438	22%	91%	3,129
HVAC and Water Heating Measures							
Filter Whistle (Dual Fuel, Gas Heat with CAC)	0	0	0	222	N/A	100%	222
Filter Whistle (Electric)	61	61	61	120	197%	100%	120
Insulation Referral	607	607	607	902	148%	100%	902
Pipe Wrap (Electric)	392	392	392	547	139%	92%	504
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	0	0	0	21,061	N/A	91%	19,165
Smart Thermostat (Electric)	1,479	1,479	1,479	5,609	379%	91%	5,104
Water Heater Setback (Electric)	260	260	260	245	94%	100%	245
Water-Saving Devices							
Bathroom Aerator (Electric)	162	162	150	325	200%	88%	287
Kitchen Aerator (Electric)	916	916	844	1,053	115%	88%	923
Showerhead (Electric)	2,880	2,880	2,475	2,706	94%	78%	2,110
Total	**207,003**	**207,003**	**203,113**	**212,397**	**103%**	**84%**	**179,038**

Table 53. 2020 HEA 2.0 Program Demand Reduction (Coincident Peak kW)

Energy Savings Unit	*Ex Ante* Savings (kW)			Evaluated *Ex Post* Savings (kW)	Realization Rates (kW)	NTG Ratio	Evaluated Net Savings (kW)
	Reported	Audited	Verified				
Audit Education							
Audit Fee (Electric)	N/A	N/A	N/A	0.76	N/A	100%	0.76
Lighting							
LED 6W Globe	N/A	N/A	N/A	0.67	N/A	80%	0.53
LED 8W Bulb	N/A	N/A	N/A	4.23	N/A	80%	3.39
LED 9W Bulb	N/A	N/A	N/A	11.82	N/A	80%	9.46
LED 9W Bulb (Exterior)	N/A	N/A	N/A	0.00	N/A	80%	0.00
LED Candelabra	N/A	N/A	N/A	2.09	N/A	80%	1.67
LED Downlight Retrofit	N/A	N/A	N/A	0.52	N/A	80%	0.42
LED Nightlight	N/A	N/A	N/A	0.00	N/A	100%	0.00
Plug Load Reduction							
Smart Strips	N/A	N/A	N/A	0.26	N/A	91%	0.24
HVAC and Water Heating Measures							
Filter Whistle (Dual Fuel, Gas Heat with CAC)	N/A	N/A	N/A	0.36	N/A	100%	0.36
Filter Whistle (Electric)	N/A	N/A	N/A	0.20	N/A	100%	0.20
Insulation Referral	N/A	N/A	N/A	0.76	N/A	100%	0.76
Pipe Wrap (Electric)	N/A	N/A	N/A	0.06	N/A	92%	0.06
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	N/A	N/A	N/A	0.00	N/A	91%	0.00
Smart Thermostat (Electric)	N/A	N/A	N/A	0.00	N/A	91%	0.00
Water Heater Setback (Electric)	N/A	N/A	N/A	0.03	N/A	100%	0.03
Water-Saving Devices							
Bathroom Aerator (Electric)	N/A	N/A	N/A	0.04	N/A	88%	0.04
Kitchen Aerator (Electric)	N/A	N/A	N/A	0.05	N/A	88%	0.05
Showerhead (Electric)	N/A	N/A	N/A	0.18	N/A	78%	0.14
Total	**41.79**	**41.79**	**41.24**	**22.03**	**53%**	**82%**	**18.08**

Income Qualified Weatherization Program

The Income-Qualified Weatherization (IQW) Program, referred to customers as the Neighborhood Weatherization Program, offers a walk-through audit and direct installation of energy efficiency measures for income-qualified 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, is responsible for recruiting income-qualified participants and providing turnkey implementation services. Energy auditors employed by CLEAResult conduct on-site assessments and install or recommend three categories of program measures:

- **Phase 1 measures** are installed by an energy auditor during the on-site assessment. These measures include LEDs, specialty candelabra LEDs, showerheads, aerators, and smart thermostats.
- **Phase 2 measures** include air and duct sealing. After initial recommendation by the energy auditors during the on-site assessment, phase 2 measures are installed by the implementer's energy auditor.
- **Phase 3 measures** offer deeper household energy savings, including insulation, refrigerator replacement, and air conditioner tune-ups and replacements. After initial recommendation by an energy auditor during the on-site assessment, phase 3 measures are installed by a participating trade ally.

To facilitate these energy efficiency upgrades, the IQW Program also offers funding for health and safety improvements (up to $5,000 per home with case-by-case approval).

Vectren also offers Whole Home IQW to customers up to 200% of the federal poverty level if they received air or duct sealing, but the energy advisor was unable to record pre- and post-upgrade measurements. This offer includes whole-home weatherization with more comprehensive upgrades than described above. In addition to greater funding for health and safety, Whole Home IQW participants are eligible for water heater replacement, wall insulation, interior caulking, further improvements to HVAC systems, and central air conditioner or furnace replacement.

Accomplishments

Table 54 shows the program's achievements against goals in 2020. According to program staff, the COVID-19 pandemic was the primary driver for the underperformance of the IQW Program. An Indiana statewide shutdown halted all program activity from March to August 2020. Despite the five-month program suspension, IQW met 86% of its gross kW savings goal and 80% of its gross kWh and participation goals.

Table 54. 2020 Income Qualified Weatherization Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	462,680	581,262	80%
Gross kW Savings	113	131	86%
Participants (households)	807	938	86%
Program Expenditures	$612,735	$685,062	89%
[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values.			

Table 55 lists the evaluated savings summary for the IQW Program. Overall, the program achieved an energy realization rate of 92% and a demand realization rate of 60%.[28] Cadmus made minor adjustments resulting in lower than expected evaluated kWh savings for HVAC and water heating measures. Reported demand savings are based on a deemed demand per-participant factor in the electric scorecard, whereas audited savings are calculated based on the per-measure *ex ante* demand savings in the tracking data. As a consequence, audited savings have historically been about 60% of reported savings.

Table 55. 2020 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	462,680	462,680	450,124	425,947	92%	100%	425,947
Total kW	113	62	62	68	60%	100%	68

Conclusions and Recommendations

Program Delivery

Despite being suspended for five months, the IQW program was able to achieve a significant portion of its goals for the year. Due to the COVID-19 pandemic, the IQW Program was on hold from March to August 2020 and some recruitment methods, such as canvassing, were not widely used when the program was running. Nevertheless, the program was still able to achieve 86% of its participation goals. The IQW Program proved flexible in its ability to ramp up after the shutdown to ensure it was available to customers who needed its services delivered in a safe way. Program savings kept pace with the rate of participation by achieving 80% of gross kWh savings goal and 86% gross kW savings goal. Savings per home decreased from 544 kWh in 2019 to 503 kWh in 2020.

Whole Home IQW savings were much lower than reported. Only air sealing and water heater replacement measures were implemented this year under the Whole Home IQW measure. The locations where these measures were installed did have additional measures installed (such as aerators or LEDs). However, these additional measures were accounted for under other measure categories. Only air

[28] Realization rates are based on reported values in the 2020 Electric DSM Scorecard. If compared to audited savings from the 2020 program tracking data, the demand realization rate would be 108%.

sealing and water heater replacement activities were captured under this Whole Home IQW measure. Cadmus used a program average from other duct and air sealing measures to determine savings for the two Whole Home IQW measures (duct or air sealing). A third Whole Home IQW project was a health and safety measure involving replacement of a broken electric water heater with another electric water heater to avoid fuel switching. Cadmus assumed the new water heater adhered to federal standard efficiency requirements for electric resistance water heaters and used program data to inform the efficiency of the replaced unit.

Recommendation: Encourage more thorough documentation of each Whole Home IQW project and require descriptions of all measures installed exclusively under each Whole Home IQW project.

Process Evaluation

INCOME-QUALIFIED WEATHERIZATION PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

73 online participant customer surveys

2020 Program Changes

Whole Home IQW (previously piloted in 2019) integrated as component of the program

Minor changes to lighting measures: candelabras offered and bulb measure caps "softened," meaning number of bulbs provided varied slightly depending on customer need

Vectren enacted temporary delivery changes due to COVID-19:

- No program activity during stay-at-home order (March - August 2020)
- Socially distanced canvassing for recruitment and program representatives wore masks
- Assessors and installers were required to wear personal protective equipment while in customer homes

2021 Planned Program Changes

Continue COVID considerations, as needed

Customers with annual household income within 200%-300% of the Federal Poverty Level will no longer be eligible for the program

100% ✓ 200% ✗ 300%

Key Process Evaluation Findings

93% (n=68) satisfied with the IQW program overall — **2/5** dissatisfied participants felt they did not receive sufficient services; **2/5** did not receive follow-up they were expecting

Participant satisfaction with program measures:

Satisfaction	n	Measure
100%	(n=30)	Smart strip
100%	(n=4)	Furnace tune-up
100%	(n=3)	Attic insulation
100%	(n=3)	Exterior LED
100%	(n=1)	Refrigerator
100%	(n=1)	Furnace
100%	(n=1)	AC tune-up
98%	(n=53)	LED lighting
94%	(n=17)	Thermostat
90%	(n=41)	LED night light
89%	(n=19)	Kitchen aerator
87%	(n=23)	Bathroom aerator
83%	(n=12)	Showerhead
67%	(n=3)	Pipe wrap

Reasons for Lower Satisfaction:

Bathroom aerator (n=2)
- Low water pressure after installation

Showerhead (n=2)
- Broken
- Low water pressure

Kitchen aerator (n=2)
- Broken
- Preferred functionality of old aerator

Pipe wrap (n=1)
- Savings not obvious

75% (n=57) took action on recommended energy-saving behaviors

Impact Evaluation

Impact Evaluation Methods and Findings

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

- Tracking database review of measures installed
- Survey of 73 program participants to verify measures installed
- Engineering analysis of *ex ante* energy savings per measure

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 from the on-site assessment. Table 56 provides per-unit annual gross savings for each program measure. Specific details on measure-level savings can be found in *Appendix A. Impact Evaluation Methodology*.

Table 56. 2020 Income Qualified Weatherization Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Audited[1]	Evaluated
Audit Education				
Audit Fee (Multifamily, Dual Fuel)	37	20	0.0017	0.0093
Audit Fee (Multifamily, Electric)	46	54	0.0000	0.0096
Audit Fee (Single-Family, Dual Fuel)	83	81	0.0038	0.0199
Audit Fee (Single-Family, Electric)	102	114	0.0033	0.0208
Lighting				
Exterior LED Lamps	99	92	0.0000	0.0000
LED 5W Bulb (Multifamily)	20	19	0.0024	0.0024
LED 5W Bulb (Single-Family)	20	18	0.0024	0.0024
LED 5W Candelabra	10	23	0.0014	0.0030
LED 9W Bulb (Multifamily)	33	28	0.0040	0.0041
LED 9W Bulb (Single-Family)	33	32	0.0041	0.0041
LED R30 Bulb (Multifamily)	32	55	0.0040	0.0070
LED R30 Bulb (Single-Family)	33	54	0.0040	0.0069
LED Nightlight	14	13	0.0000	0.0000
Water-Saving Devices				
Bathroom Aerator (Multifamily, Electric)	29	27	0.0026	0.0026
Bathroom Aerator (Single-Family, Electric)	35	27	0.0026	0.0026
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	97	132	0.0070	0.0070
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	146	117	0.0070	0.0070
Energy-Efficient Showerhead (Multifamily, Electric)	267	257	0.0148	0.0148
Energy-Efficient Showerhead (Single-Family, Electric)	343	293	0.0148	0.0148

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Audited[1]	Evaluated
HVAC and Water Heating Measures				
AC Tune-Up	155	70	0.1973	0.1146
Central Air Conditioner 16 SEER	587	228	1.0465	0.3259
Filter Whistle (Single-Family)	46	46	0.0760	0.0746
Furnace Tune-Up (Electric)	155	0	0.1973	0.0000
Pipe Wrap (Single-Family, Electric)	99	89	0.0113	0.0102
Smart Thermostat (Multifamily, Dual Fuel)	720	225	0.0000	0.0000
Smart Thermostat (Single-Family, Dual Fuel)	429	377	0.0000	0.0000
Smart Thermostat (Single-Family, Electric)	1,580	1,364	0.0000	0.0000
Appliance and Plug Load Reduction				
Refrigerator Replacement	360	735	0.0529	0.1079
Smart Power Strips	26	25	0.0019	0.0018
Weatherization Measures				
Air Sealing 20% Infil. Reduction (Dual Fuel)	125	213	0.1622	0.3120
Attic Insulation (Dual Fuel)	367	446	0.3620	0.4201
Duct 10% leakage Reduction (Dual Fuel)	155	165	0.2688	0.2694
Wall Insulation (Dual Fuel)	58	78	0.0416	0.0840
IQW Whole Home (Dual Fuel)	1,316	910	0.0000	0.3832

[1] Vectren's 2020 DSM Scorecard did not have kWh or kW savings at the measure level. These per-unit savings reflect audited savings from the 2020 program tracking data.

Reported savings for single-family homes are primarily based on 2018 evaluated findings. Reported savings for multifamily measures are primarily single-family savings multiplied by an adjustment factor. The following caused discrepancies in reported and evaluated 2020 savings:

- **Audit education.** The audit education measures vary from year to year depending on how many surveyed participants say they have implemented energy-saving actions. In 2020, 46% of respondents reported taking shorter showers compared to 37% in 2018 (on which reported savings are based), and 12% reported installing air sealing measures outside of the IQW Program compared to 8% in 2018. However, only 61% of respondents in 2020 reported turning off the lights when not in use, compared to 65% in 2018. Overall, evaluated 2020 energy savings are comparable to reported energy savings. Evaluated demand savings increased primarily due to an increase in program average air sealing demand savings from 2018, on which audit savings from additional weatherization are based.
- **Lighting.** All bulb types had realization rates around 100% except for the 5-watt candelabra and the R30 dimmable LED.
  - For the **5-watt candelabra**, reported and evaluated savings differed because Cadmus used a different methodology to determine the baseline wattage. Reported savings for candelabras were not based on evaluations in prior years because this measure was new in 2019. Reported savings appeared to be from the 2015 Indiana TRM v2.2, which uses a multiplier of the efficient bulb to determine the baseline value. However, 2020 evaluated savings use

guidelines in the Uniform Methods Project based on the style and lumen output of the bulb.[29] This matches the approach taken in the Residential Lighting Program and is appropriate for the IQW Program because field technicians are instructed by the program implementer to only change out inefficient bulbs (incandescent or halogens) to install LEDs.

  - For **R30 dimmable LEDs**, Cadmus updated the baseline wattage, which led to higher evaluated savings than in 2018. The baseline wattage was previously based on lumen bins for standard bulbs; however, reflector bulbs are still currently exempt from EISA so it was appropriate to update the baseline wattage for reflectors, consistent with the Residential Lighting Program.[30]

- **Water-saving devices.** Differences in savings for water-saving devices were driven by differences in survey inputs, such as people per home, showers per home, and bathroom faucets per home, from year to year. People per home was 2.01 for single-family in 2020 compared to 2.52 in 2018. There were too few multifamily responses in the 2020 IQW survey data, so savings inputs, that is, people per home and water fixtures per home, were based on survey data from the 2020 Multifamily Direct Install Program.[31]
- **HVAC and water-heating measures.** Differences in savings varied by measure.
  - **Pipe wrap** installations had lower evaluated savings than reported primarily due to demographic differences in people per home.
  - **Air conditioner (AC) tune-ups** had substantially lower evaluated savings than reported savings. This measure was not offered prior to 2019 so reported savings are not based on previous evaluation findings. Cadmus used the average capacity of program-installed central air conditioners as an input into the 2015 Indiana TRM v2.2 algorithm for determining energy and demand savings. It is likely that the planning methodology differed from the TRM for this measure.32
  - **Electric furnace tune-up** has no basis for savings, as it is impossible to tune up an electric furnace since electric resistance efficiency does not change. Only one electric furnace tune-up was reported.
  - **Smart thermostats** had lower savings than reported due to an increase in programmable thermostat baseline saturation in 2020. More than half (53%) of respondents to the 2020 IQW survey reported owning a programmable thermostat prior to installing a smart thermostat, compared to 0% in the 2018 Residential Prescriptive survey, which was used to evaluate thermostat savings in the 2018 IQW Program.

[29] Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68562.pdf

[30] Current U.S. Department of Energy restrictions exempt reflectors and specialty bulbs from EISA requirements.

[31] *2020 Vectren DSM Portfolio Natural Gas Impacts Evaluation.*

[32] Vectren did not provide *ex ante* assumptions for air conditioner tune-ups.

    - **Central air conditioner** reported savings are based on a single, high-saving central air conditioner replacement in 2018. Per unit savings are lower in 2020 due to capacity differences.
- Appliance and plug load reduction.
    - **Refrigerator replacement** received high evaluated per-unit savings compared to reported savings primarily because the program installed only one high-saving early replacement. With more installations, it may be possible to point to wider shifts in the population of refrigerators replaced.
- **Weatherization measures.** Reported and evaluated savings for weatherization measures differed widely because each installation had site-specific data that affected the amount of savings given each home.
    - **Air sealing** had higher evaluated savings, primarily due to higher infiltration reduction in 2020 compared to 2018. The average difference in pre- and post-installation air flow in 2020 was 1,156 cfm, compared to 879 cfm in 2018.
    - **Attic and wall insulation** per-unit savings differences are the result of different values for installed square footage between 2018 and 2020. Reported per-unit savings for wall insulation is derived from an unknown source and does not match evaluated 2018 per-unit savings.
    - **Whole Home IQW** measures received low evaluated savings compared to reported savings based on a variety of factors. Each Whole Home IQW project is unique. One measure was an electric water heater that replaced another standard electric water heater as a health and safety measure to avoid a fuel change. The new water heater was assumed to adhere to the federal standard efficiency requirements for electric resistance water heaters. The other two measures were one duct sealing project and another project with both duct sealing and air sealing measures. Pre-existing and post-installation conditions were unavailable for these two weatherization projects, so Cadmus used program-average duct and air sealing kWh and kW savings to estimate savings for these projects. The source for reported savings is unknown. *Ex ante* savings likely account for the installation of additional measures besides the air sealing and water heater replacements. However, the only measures exclusively accounted for under this Whole Home IQW measure in 2020 were related to air sealing and water heater replacement.

Table 57 lists the evaluated gross per-unit energy savings for each program measure by year. Evaluated per-unit savings vary over time primarily because of annual variance in survey response data and project-specific inputs.

Table 57. Income Qualified Weatherization Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)					
	2015[1]	2016[1]	2017[1]	2018[1]	2019	2020
Audit Education						
Audit Fee (Multifamily, Dual Fuel)	-	-	-	-	17	20
Audit Fee (Multifamily, Electric)	-	-	-	-	53	54

Measure	Evaluated Annual Gross Savings (kWh)					
	2015[1]	2016[1]	2017[1]	2018[1]	2019	2020
Audit Fee (Single-Family, Dual Fuel)[2]	68[2]	46[2]	32[2]	83	90	81
Audit Fee (Single-Family, Electric)	-	-	-	102	112	114
Lighting						
Exterior LED Lamps	-	99	99	99	99	92
LED 5W Bulb (Multifamily)	-	-	-	-	20	19
LED 5W Bulb (Single-Family)	-	-	19	20	19	18
LED 5W Candelabra	-	-	-	-	24	23
LED 9W Bulb (Multifamily)	-	-	-	-	34	28
LED 9W Bulb (Single-Family)	-	-	32	33	33	32
LED R30 Bulb (Multifamily)	-	-	-	-	57	55
LED R30 Bulb (Single-Family)	-	-	32	33	56	54
LED Nightlight	-	14	14	14	13	13
Water-Saving Devices						
Bathroom Aerator (Multifamily, Electric)	-	-	-	-	28	27
Bathroom Aerator (Single-Family, Electric)	12	17	38	37	35	27
Kitchen Flip Aerator (Multifamily, Electric)	-	-	-	-	-	132
Kitchen Flip Aerator (Single-Family, Electric)	120	136	155	155	141	117
Energy-Efficient Showerhead (Multifamily, Electric)	-	-	-	-	247	257
Energy-Efficient Showerhead (Single-Family, Electric)	300	362	369	343	321	293
HVAC and Water Heating Measures						
AC Tune-Up	-	-	-	-	65	70
Central Air Conditioner 16 SEER	-	-	-	587	277	228
Filter Whistle	55	119	44	46	38	46
Furnace Tune-Up (Electric)	-	-	-	-	-	0
Pipe Wrap (Single-Family, Electric)	148	166	104	104	101	89
Smart Thermostat (Multifamily, Dual Fuel)	-	-	-	-	242	225
Smart Thermostat (Single-Family, Dual Fuel)	-	-	429	429	408	377
Smart Thermostat (Single-Family, Electric)	-	-	-	1580	1,436	1,364
Appliance and Plug Load Reduction						
Refrigerator Replacement	442	420	414	360	474	735
Smart Power Strips	-	23	25	26	24	25
Weatherization Measures						
Air Sealing 20% Infil. Reduction (Dual Fuel)	-	227	137	125	136	213
Attic Insulation (Dual Fuel)	-	253	365	383	486	446
Duct 10% leakage Reduction (Dual Fuel)	-	251	162	155	152	165
Wall Insulation (Dual Fuel)	-	-	-	58	99	78
IQW Whole Home (Dual Fuel)	-	-	-	-	-	910

[1] Savings for measures with single-family and multifamily distinctions in 2019 and 2020 have their pre-2019 average savings reflected in the single-family row for each measure type.

[2] Savings for single-family, dual fuel audits before 2018 are a weighted average of dual fuel and electric single-family audit savings.

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 installation. Cadmus used the persistence rate as the in-service rate, assuming reported installations were accurate because the program implementer's quality control process ensured that actual and reported measure installations matched. Table 58 lists the in-service rates for each program measure.

Table 58. 2020 Income Qualified Weatherization Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported[1]	Audited	Verified	
Audit Education				
Audit Fee (Multifamily, Dual Fuel)	52	52	52	100%
Audit Fee (Multifamily, Electric)	32	32	32	100%
Audit Fee (Single-Family, Dual Fuel)	701	701	701	100%
Audit Fee (Single-Family, Electric)	23	23	23	100%
Lighting				
Exterior LED Lamps	95	95	95	100%
LED 5W Bulb (Multifamily)	10	10	10[1]	99%
LED 5W Bulb (Single-Family)	920	920	907	99%
LED 5W Candelabra	1,577	1,577	1,555	99%
LED 9W Bulb (Multifamily)	314	314	310	99%
LED 9W Bulb (Single-Family)	4,097	4,097	4,041	99%
LED R30 Bulb (Multifamily)	9	9	9[1]	99%
LED R30 Bulb (Single-Family)	278	278	274	99%
LED Nightlight	1,270	1,270	1,138	90%
Water-Saving Devices				
Bathroom Aerator (Multifamily, Electric)	25	25	25	100%
Bathroom Aerator (Single-Family, Electric)	88	88	88	100%
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	29	29	28	95%
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	64	64	61	95%
Energy-Efficient Showerhead (Multifamily, Electric)	10	10	9	93%
Energy-Efficient Showerhead (Single-Family, Electric)	51	51	48	93%
HVAC and Water Heating Measures				
AC Tune-Up	33	33	33	100%
Central Air Conditioner 16 SEER	15	15	15	100%
Filter Whistle (Single-Family)	3	3	2	67%[1]
Furnace Tune-Up (Electric)	1	1	1	100%
Pipe Wrap (Single-Family, Electric)	5	5	5	100%
Smart Thermostat (Multifamily, Dual Fuel)	36	36	34	94%
Smart Thermostat (Single-Family, Dual Fuel)	180	180	169	94%
Smart Thermostat (Single-Family, Electric)	1	1	1	94%
Appliance and Plug Load Reduction				
Refrigerator Replacement	1	1	1	100%

Measure	Installations			In-Service Rate
	Reported[1]	Audited	Verified	
Smart Power Strips	416	416	416	100%
Weatherization Measures				
Air Sealing 20% Infil. Reduction (Dual Fuel)	6	6	6	100%
Attic Insulation (Dual Fuel)	24	24	24	100%
Duct 10% leakage Reduction (Dual Fuel)	1	1	1	100%
Wall Insulation (Dual Fuel)	11	11	11	100%
IQW Whole Home (Dual Fuel)	3	3	3	100%
Total	**10,381**	**10,381**	**10,127**	**98%**

[1] Rounded to whole measure.

[2] The 2020 IQW survey received no responses from filter whistle recipients. Cadmus used the ISR from the 2019 IQW Program evaluation.

Table 59 shows historical in-service rates for each program measure. In-service rates are comparable to 2019's in-service rates for all measures.

Table 59. Income Qualified Weatherization Historical In-Service Rates

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
Audit Education						
Audit Fee (Multifamily, Dual Fuel)	-	100%	100%	100%	100%	100%
Audit Fee (Multifamily, Electric)	-	100%	100%	100%	100%	100%
Audit Fee (Single-Family, Dual Fuel)	-	100%	100%	100%	100%	100%
Audit Fee (Single-Family, Electric)	-	100%	100%	100%	100%	100%
Lighting						
Exterior LED Lamps	-	-	96%	100%	100%	100%
LED 5W Bulb (Multifamily)	-	-	100%	93%	96%	99%
LED 5W Bulb (Single-Family)	-	-	100%	93%	96%	99%
LED 5W Candelabra	-	-	100%	93%	96%	99%
LED 9W Bulb (Multifamily)	-	-	100%	93%	96%	99%
LED 9W Bulb (Single-Family)	-	-	100%	93%	96%	99%
LED R30 Bulb (Multifamily)	-	-	100%	93%	96%	99%
LED R30 Bulb (Single-Family)	-	-	100%	93%	96%	99%
LED Nightlight	-	-	92%	93%	94%	90%
Water-Saving Devices						
Bathroom Aerator (Multifamily, Electric)	99%	100%	98%	93%	100%	100%
Bathroom Aerator (Single-Family, Electric)	99%	100%	98%	93%	100%	100%
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	-	-	-	-	-	95%
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	99%	99%	99%	99%	96%	95%
Energy-Efficient Showerhead (Multifamily, Electric)	100%	92%	92%	91%	89%	93%
Energy-Efficient Showerhead (Single-Family, Electric)	100%	92%	92%	91%	89%	93%
HVAC and Water Heating Measures						
AC Tune-Up	-	-	-	-	100%	100%
Central Air Conditioner 16 SEER	0%	0%	0%	0%	100%	100%
Filter Whistle (Single-Family)	97%	50%	71%	50%	67%	67%[1]

Measure	In-Service Rate					
	2015	2016	2017	2018	2019	2020
Furnace Tune-Up (Electric)	-	-	-	-	-	100%
Pipe Wrap (Single-Family, Electric)	-	-	100%	100%	100%	100%
Smart Thermostat (Multifamily, Dual Fuel)	-	88%[2]	100%	100%	100%	94%
Smart Thermostat (Single-Family, Dual Fuel)	-	88%[2]	100%	100%	100%	94%
Smart Thermostat (Single-Family, Electric)	-	88%[2]	100%	100%	100%	94%
Appliance and Plug Load Reduction						
Refrigerator Replacement	100%	100%	100%	100%	100%	100%
Smart Power Strips	-	100%	100%	96%	96%	100%
Weatherization Measures						
Air Sealing 20% Infil. Reduction (Dual Fuel)	100%	100%	100%	100%	100%	100%
Attic Insulation (Dual Fuel)	100%	100%	100%	100%	100%	100%
Duct 10% leakage Reduction (Dual Fuel)	100%	100%	100%	100%	100%	100%
Wall Insulation (Dual Fuel)	-	-	-	100%	100%	100%

[1] Cadmus received no responses in the 2020 Participant Survey from filter whistle recipients. The ISR from 2019 is used in the impact analysis.
[2] 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 net-to-gross (NTG) ratio is assumed to be 100%.

Evaluated Net Savings Adjustments

Table 60 and Table 61 list evaluated net savings and demand reduction, respectively, for the Income Qualified Weatherization. The program achieved net savings of 423,759 kWh and 67.57 coincident kW demand reduction.

Table 60. 2020 Income Qualified Weatherization 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				
Audit Education							
Audit Fee (Multifamily, Dual Fuel)	1,944	1,944	1,944	1,066	55%	100%	1,066
Audit Fee (Multifamily, Electric)	1,475	1,475	1,475	1,739	118%	100%	1,739
Audit Fee (Single-Family, Dual Fuel)	58,103	58,103	58,103	56,630	97%	100%	56,630
Audit Fee (Single-Family, Electric)	2,350	2,350	2,350	2,611	111%	100%	2,611
Lighting							
Exterior LED Lamps	9,405	9,405	9,405	8,700	92%	100%	8,700
LED 5W Bulb (Multifamily)	196	196	193	190	97%	100%	190
LED 5W Bulb (Single-Family)	18,016	18,016	17,769	16,775	93%	100%	16,775
LED 5W Candelabra	16,352	16,352	16,127	35,251	216%	100%	35,251
LED 9W Bulb (Multifamily)	10,459	10,459	10,316	8,687	83%	100%	8,687

Measure	*Ex Ante* Savings (kWh)			Evaluated *Ex Post* Savings (kWh)	Realization Rates (kWh)	NTG Ratio	Evaluated Net Savings (kWh)
	Reported	Audited	Verified				
LED 9W Bulb (Single-Family)	136,816	136,816	134,937	128,114	94%	100%	128,114
LED R30 Bulb (Multifamily)	284	284	280	488	172%	100%	488
LED R30 Bulb (Single-Family)	9,062	9,062	8,937	14,784	163%	100%	14,784
LED Nightlight	17,318	17,318	15,514	14,949	86%	100%	14,949
Water-Saving Devices							
Bathroom Aerator (Multifamily, Electric)	734	734	734	671	91%	100%	671
Bathroom Aerator (Single-Family, Electric)	3,047	3,047	3,047	2,343	77%	100%	2,343
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	2,805	2,805	2,672	3,637	130%	100%	3,637
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	9,323	9,323	8,879	7,106	76%	100%	7,106
Energy-Efficient Showerhead (Multifamily, Electric)	2,667	2,667	2,490	2,395	90%	100%	2,395
Energy-Efficient Showerhead (Single-Family, Electric)	17,472	17,472	16,308	13,958	80%	100%	13,958
HVAC and Water Heating Measures							
AC Tune-Up	5,120	5,120	5,120	2,322	45%	100%	2,322
Central Air Conditioner 16 SEER	8,808	8,808	8,808	3,422	39%	100%	3,422
Filter Whistle (Single-Family)	138	138	92	92	66%	100%	92
Furnace Tune-Up (Electric)	155	155	155	0	0%	100%	0
Pipe Wrap (Single-Family, Electric)	496	496	496	447	90%	100%	447
Smart Thermostat (Multifamily, Dual Fuel)	25,917	25,917	24,392	7,612	29%	100%	7,612
Smart Thermostat (Single-Family, Dual Fuel)	77,220	77,220	72,678	63,917	83%	100%	63,917
Smart Thermostat (Single-Family, Electric)	1,580	1,580	1,487	1,284	81%	100%	1,284
Appliance and Plug Load Reduction							
Refrigerator Replacement	360	360	360	735	204%	100%	735
Smart Power Strips	10,746	10,746	10,746	10,294	96%	100%	10,294
Weatherization Measures							
Air Sealing 20% Infil. Reduction (Dual Fuel)	749	749	749	1,276	170%	100%	1,276
Attic Insulation (Dual Fuel)	8,815	8,815	8,815	10,704	121%	100%	10,704
Duct 10% leakage Reduction (Dual Fuel)	155	155	155	165	107%	100%	165
Wall Insulation (Dual Fuel)	641	641	641	853	133%	100%	853
IQW Whole Home (Dual Fuel)	3,949	3,949	3,949	2,731	69%	100%	2,731
Total	**462,680**	**462,680**	**450,124**	**425,947**	**92%**	**100%**	**425,947**

Table 61. 2020 Income Qualified Weatherization Demand Reduction (Coincident Peak kW)

Measure	*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 (Multifamily, Dual Fuel)	N/A	0.09	0.09	0.48	N/A	100%	0.48
Audit Fee (Multifamily, Electric)	N/A	0.00	0.00	0.31	N/A	100%	0.31
Audit Fee (Single-Family, Dual Fuel)	N/A	2.65	2.65	13.96	N/A	100%	13.96
Audit Fee (Single-Family, Electric)	N/A	0.08	0.08	0.48	N/A	100%	0.48
Lighting							
Exterior LED Lamps	N/A	0.00	0.00	0.00	N/A	100%	0.00
LED 5W Bulb (Multifamily)	N/A	0.02	0.02	0.02	N/A	100%	0.02
LED 5W Bulb (Single-Family)	N/A	2.19	2.16	2.21	N/A	100%	2.21
LED 5W Candelabra	N/A	2.20	2.17	4.65	N/A	100%	4.65
LED 9W Bulb (Multifamily)	N/A	1.26	1.25	1.28	N/A	100%	1.28
LED 9W Bulb (Single-Family)	N/A	16.61	16.38	16.72	N/A	100%	16.72
LED R30 Bulb (Multifamily)	N/A	0.04	0.04	0.06	N/A	100%	0.06
LED R30 Bulb (Single-Family)	N/A	1.11	1.10	1.90	N/A	100%	1.90
LED Nightlight	N/A	0.00	0.00	0.00	N/A	100%	0.00
Water-Saving Devices							
Bathroom Aerator (Multifamily, Electric)	N/A	0.07	0.07	0.07	N/A	100%	0.07
Bathroom Aerator (Single-Family, Electric)	N/A	0.23	0.23	0.23	N/A	100%	0.23
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	N/A	0.20	0.19	0.19	N/A	100%	0.19
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	N/A	0.45	0.43	0.43	N/A	100%	0.43
Energy-Efficient Showerhead (Multifamily, Electric)	N/A	0.15	0.14	0.14	N/A	100%	0.14
Energy-Efficient Showerhead (Single-Family, Electric)	N/A	0.75	0.70	0.70	N/A	100%	0.70
HVAC and Water Heating Measures							
AC Tune-Up	N/A	6.51	6.51	3.78	N/A	100%	3.78
Central Air Conditioner 16 SEER	N/A	15.70	15.70	4.89	N/A	100%	4.89
Filter Whistle (Single-Family)	N/A	0.23	0.15	0.15	N/A	100%	0.15
Furnace Tune-Up (Electric)	N/A	0.20	0.20	0.00	N/A	100%	0.00
Pipe Wrap (Single-Family, Electric)	N/A	0.06	0.06	0.05	N/A	100%	0.05
Smart Thermostat (Multifamily, Dual Fuel)	N/A	0.00	0.00	0.00	N/A	100%	0.00
Smart Thermostat (Single-Family, Dual Fuel)	N/A	0.00	0.00	0.00	N/A	100%	0.00
Smart Thermostat (Single-Family, Electric)	N/A	0.00	0.00	0.00	N/A	100%	0.00
Appliance and Plug Load Reduction							
Refrigerator Replacement	N/A	0.05	0.05	0.11	N/A	100%	0.11
Smart Power Strips	N/A	0.79	0.79	0.77	N/A	100%	0.77

Measure	*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				
Weatherization Measures							
Air Sealing 20% Infil. Reduction (Dual Fuel)	N/A	0.97	0.97	1.87	N/A	100%	1.87
Attic Insulation (Dual Fuel)	N/A	8.69	8.69	10.08	N/A	100%	10.08
Duct 10% leakage Reduction (Dual Fuel)	N/A	0.27	0.27	0.27	N/A	100%	0.27
Wall Insulation (Dual Fuel)	N/A	0.46	0.46	0.92	N/A	100%	0.92
IQW Whole Home (Dual Fuel)	N/A	0.00	0.00	1.15	N/A	100%	1.15
Total	**112.70**	**62.02**	**61.53**	**67.87**	**60%**	**100%**	**67.87**

Market Performance Indicators

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

Program Performance

Cadmus measured 2012 to 2020 program performance against the KPIs listed in Table 62.

Table 62. Income Qualified Weatherization KPI and 2012-2020 Performance

KPI	Performance					
	2015	2016	2017	2018	2019	2020
Achievement of program participation goals	123%	153%	156%	226%	169%	86%
Achievement of gross kWh savings goals	62%	88%	87%	134%	129%	80%
Number of Participating Households	692	485	719	2,138	1,437	807
Number of Measures Installed[1]	13,179	4,400	11,682	22,464	16,657	10,127
Participant Program Satisfaction (*very satisfied* or *somewhat satisfied*)	97% (n=77)	98% (n=69)	90% (n=69)	93% (n=85)	89% (n=71)	93% (n=68)
Percent of Participant-Adopted Energy-Saving Behaviors	31% (n=77)	52% (n=61)	48% (n=56)	61% (n=75)	76% (n=62)	75% (n=57)
Ease of Program Participation Rating (*very easy* or *somewhat easy*)	N/A	N/A	N/A	98% (n=84)	N/A	Track in future years
Average kWh per household	1,022	1,308	637	435	529	503
Persistence of measures[2]	N/A	N/A	98%	94%	97%	98%
Participant Measure Satisfaction[3]						
Light Bulbs	CFLs: 93%	CFLs: 95%	LEDs: 92%	LEDs: 99%	LEDs: 97%	LEDs: 98%
Night Light	N/A	94%	97%	91%	97%	90%
Smart Strip	N/A	97%	98%	85%	100%	100%
Showerhead	86%	94%	90%	93%	N/A	83%
Aerators	94%	94%	90%	88%	91%	88%

[1] Includes both electric and gas measures.
[2] There was no program-level persistence calculated in 2015-2016.
[3] To account for potential variance in annual satisfaction, here we have reported on measures where the number of responses is at least 20. Combined *very satisfied* and *somewhat satisfied* responses for percentages.

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 natural gas. The EES Program is designed to help students and their families identify opportunities to manage their energy consumption. The EES Program targets 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 kits also contain a self-report survey, the Home Energy Worksheet (HEW), which students and their guardians fill out to indicate which kit measures they installed at home. Teachers and students receive incentives for returning the HEWs to the program implementer. These are the contents in the energy-saving kits.

Electric measures

- One 15-watt LED
- Two 11-watt LEDs
- LED nightlight

Dual fuel measures

- Kitchen faucet aerator (1.5 gpm)
- Two bathroom faucet aerators (1.0 gpm)
- Energy-efficient showerhead (1.5 gpm)
- Furnace filter whistle alarm

Vectren works directly with the National Energy Foundation (NEF) to implement the EES Program. The program implementer 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 2,600 kits in 2020. Table 63 shows the program's achievements against goals in 2020.

Table 63. 2020 Energy Efficient Schools Program Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	771,703	771,703	100%
Gross kW Savings	82	82	100%
Participants (Kits)	2,600	2,600	100%
Program Expenditures	$134,779	$136,900	98%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 64 lists the evaluated savings for the EES Program. Cadmus did not conduct a student household survey in 2020, as parent/guardian contact data was limited. Instead, Cadmus applied the in-service rates calculated using 2019 survey data from student households that received kits in 2018 and 2019.

In 2019, survey data supported a higher in-service rate for LEDs than in previous program years when in-service rates were based on benchmarking data. This was counteracted somewhat by a lower in-service rate for bathroom aerators and showerheads, however, the higher in-service rate for LEDs and a higher saturation of central cooling systems among kit recipients (which affects furnace filter whistles) led to a significant increase in evaluated demand, resulting in a 142% kW realization rate.[33]

Table 64. 2020 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	771,703	771,703	810,688	773,578	100%	100%	773,578
Total kW	82	82	90	116	141%	100%	116

Conclusions and Recommendations

The EES Program will no longer claim electric energy savings in 2021 and beyond. According to Vectren's 2021 Operating Plan, modifications to the EUL baseline for general service LEDs means the Energy Efficient Schools Program will no longer be cost-effective in the electric portfolio. Vectren will instead offer a Modified School Education Program funded through its marketing budget. This program will continue to help students learn about ways to conserve energy through teaching materials and a take-home energy kit. The kit will still include LEDs, but Vectren will claim savings only for the included gas measures.

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 kit measures
- Database review of the number of kits distributed
- Review of data collected from the HEWs (n=1,303)

Gross Savings Review

Table 65 provides per-unit annual gross savings for each program measure contained in the energy-saving kits. Note that each kit contains two 11W LEDs and two bathroom aerators, but the table shows savings for only one unit of each. For the EES Program, Vectren includes in-service rates in reported savings so evaluated savings also include all adjustments for in-service rates 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.*

[33] These data are derived from the 2020 Home Energy Worksheets (HEWs).

Table 65. 2020 Energy Efficient Schools Program Per-Unit Gross Savings

Measure	Annual Gross Savings[1] (kWh)		Annual Gross Savings[1] (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
11W LED (one unit only)[2]	31.2	38.0	0.0034	0.0042
15W LED	42.3	59.2	0.0046	0.0065
Energy-Efficient Bathroom Aerator (one unit only)[2]	8.9	6.4	0.0004	0.0004
Energy-Efficient Kitchen Aerator	45.4	49.4	0.0012	0.0013
Energy-Efficient Showerhead	109.9	80.0	0.0029	0.0027
Furnace Filter Whistle	12.3	16.5	0.0153	0.0251
LED Nightlight	6.6	3.8	0.0000	0.0000

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

Table 66 lists the 2020 EES Program's per-kit annual gross energy and demand savings.

Table 66. 2020 Energy Efficient Schools Program Per-Kit Gross Savings

Measure	Annual Gross Savings[1] (kWh)		Annual Gross Savings[1] (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
11W LED[2]	62.4	75.9	0.0068	0.0083
15W LED	42.3	59.2	0.0046	0.0065
Energy-Efficient Bathroom Aerator[2]	17.9	12.8	0.0009	0.0008
Energy-Efficient Kitchen Aerator	45.4	49.4	0.0012	0.0013
Energy-Efficient Showerhead	109.9	80.0	0.0029	0.0027
Furnace Filter Whistle	12.3	16.5	0.0153	0.0251
LED Nightlight	6.6	3.8	0.0000	0.0000
Total Per Kit[2]	**296.8**	**297.5**	**0.0317**	**0.0447**

[1] Reported and evaluated savings include in-service rates.
[2] These savings account for two 11W LEDs and two bathroom aerators in each kit. Savings is slightly different than per-unit because values are rounded.

Differences in reported and evaluated savings are primarily driven by in-service rates and household characteristics that vary from year to year:

- **Lighting measures.** Evaluated savings for the 11W LEDs and the 15W LED in each kit are higher than reported savings because of higher in-service rates compared to the 2018 evaluation (on which reported savings are based). Cadmus' 2019 student household survey supported a higher in-service rate for LEDs than benchmarking data in previous program years. For LED nightlights, 2019 student household survey data indicated a decrease in the incandescent replacement rate compared to previous student household survey data.
- **Water-saving measures.** Cadmus used the program's 2020 HEW data to determine that kit recipients' hot water fuel saturation was 43% electric in 2020 compared to 40% in 2018. Using the 2019 student household survey, Cadmus assumed the average number of showers per home was 1.95 in 2020 compared to 1.52 in 2018 and the average number of bathroom faucets per

home was 2.36 in 2020 compared to 1.91 in 2018. Larger home sizes correlate with more bathrooms which means less usage per fixture, which resulted in lower electric energy savings for water-saving measures (showerheads and bathroom aerators). These measures also had lower in-service rates than were previously benchmarked. Kitchen aerators did not experience the same decrease since there is typically still only one kitchen faucet per home.

- **Furnace filter whistle.** 2019 student household survey data indicated an increase in the number of central cooling systems compared to Residential Energy Consumption Survey (RECS) 2009 data, and this increased evaluated savings.[34]

Table 67 lists the evaluated gross per-unit energy savings for each program measure by year. 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 and in-service rates. Most measures have relatively stable savings over time, but household demographic inputs cause variances each year (number of fixtures per home, cooling system saturation, etc.).

Table 67. Energy Efficient Schools Program Historical Per-Unit Savings

Measure	Evaluated Annual Gross Per-Unit Savings (kWh)[1]								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
11W LED (one unit only)[2]	N/A	N/A	N/A	N/A	N/A	46.0	46.0	46.0	46.0
15W LED	N/A	N/A	N/A	N/A	N/A	62.5	62.5	62.5	62.5
Energy-Efficient Bathroom Aerator (one unit only)[2]	N/A	N/A	N/A	49.0	49.4	53.6	52.2	43.4	41.5
Energy-Efficient Kitchen Aerator	256.8	614.8	530.6	272.8	258.2	280.1	272.5	279.5	267.1
Energy-Efficient Showerhead	633.8	424.4	266.1	539.3	538.6	584.3	568.3	452.7	432.7
Furnace Filter Whistle	45.4	45.4	45.4	N/A	47.0	44.0	44.0	58.4	58.4
LED Nightlight	17.3	8.1	8.1	8.1	8.1	8.1	8.1	5.4	5.4

[1] These values do not include water heater fuel type saturation rates and in-service rates.
[2] 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 program tracking data to confirm the number of kits distributed and to verify that program savings were accurately tracked and reported. Cadmus verified kit quantity by comparing reported quantities from the Vectren 2020 Electric DSM Scorecard with year-end shipment data from the program implementer. Both sources confirmed shipment of 2,600 kits.

Measure-Level In-Service Rates

Cadmus did not field student household surveys in 2020. Cadmus used the results of the 2019 student household surveys and applied the 2019 in-service rate adjustments to reported 2020 savings to generate verified savings for each measure in the kit, as shown in Table 68. Evaluated in-service rates

[34] U.S. Energy Information Administration. Residential Energy Consumption Survey (RECS). "2009 RECS Survey Data." https://www.eia.gov/consumption/residential/data/2009/

account for measure persistence after initial receipt of the kit according to self-reported survey response.

Table 68. 2020 Energy Efficient Schools Program Measure Verification Results – In-Service Rates

Measure	Measures Distributed			In-Service Rate	
	Reported	Audited	Verified	Reported	Verified
11W LED	5,200	5,200	4,286	68%	82%
15W LED	2,600	2,600	2,463	68%	95%
Energy-Efficient Bathroom Aerator	5,200	5,200	1,857	43%	36%
Energy-Efficient Kitchen Aerator	2,600	2,600	1,114	42%	43%
Energy-Efficient Showerhead	2,600	2,600	1,114	49%	43%
Furnace Filter Whistle	2,600	2,600	733	28%	28%
LED Nightlight	2,600	2,600	1,839	81%	71%
Total	**23,400**	**23,400**	**13,408**	**54%**	**57%**

Table 69 shows historical in-service rates for each program measure. Student household surveys conducted in 2019 resulted in higher in-service rates for LEDs compared to benchmarking data used in 2018. Conversely, 2019 student household survey data indicated a decrease in in-service rates for bathroom aerators, showerheads, and nightlights compared to 2018. Other kit measures remain stable.

Table 69. Energy Efficient Schools Program Historical In-Service Rates

Measure	In-Service Rate								
	2012	2013	2014	2015	2016	2017	2018	2019	2020[2]
11W/13W LED[1]	N/A	N/A	N/A	N/A	78%	76%	68%	82%	82%
15W/16W LED[1]	N/A	N/A	N/A	N/A	78%	76%	68%	95%	95%
Energy-Efficient Bathroom Aerator	60%	48%	47%	47%	47%	47%	43%	36%	36%
Energy-Efficient Kitchen Aerator	60%	48%	47%	47%	47%	47%	42%	43%	43%
Energy-Efficient Showerhead	60%	50%	52%	52%	52%	52%	49%	43%	43%
Furnace Filter Whistle	45%	43%	43%	N/A	43%	43%	28%	28%	28%
LED Nightlight	80%	88%	86%	86%	86%	86%	81%	71%	71%

[1] Vectren distributed 13W and 16W LEDs in 2016 and switched to 11W and 15W in 2017.
[2] 2020 ISRs used results from 2019 surveys.

Water Heating Fuel Saturation

Cadmus also adjusted the reported electric water heater fuel saturation rates for water-saving measures by analyzing data from the 2020 HEWs. For 2020, 43% of homes used electricity as their water heater fuel. This rate is comparable to previous years' rates.

Table 70. Energy Efficient Schools Program Historical Electric Water Heater Saturation Rates

Program Year	Electric Saturation Rate
2020	43%
2019	46%
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 estimate or apply any NTG adjustments to the *ex post* gross savings for the EES Program. NTG ratios for school kit programs tend to be close to 100%, and this is consistent with previous years' evaluations.

Evaluated Net Savings Adjustments

Table 71 and Table 72 list evaluated net savings for the Energy Efficient Schools Program. The program achieved net savings of 773,578 kWh and 116 coincident kW demand reduction.

Table 71. 2020 Energy Efficient Schools 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				
11W LED	162,231	162,231	197,389	197,389	122%	100%	197,389
15W LED	110,086	110,086	153,936	153,936	140%	100%	153,936
Energy-Efficient Bathroom Aerator	46,498	46,498	38,619	33,223	71%	100%	33,223
Energy-Efficient Kitchen Aerator	117,913	117,913	121,040	128,334	109%	100%	128,334
Energy-Efficient Showerhead	285,696	285,696	252,456	207,896	73%	100%	207,896
Furnace Filter Whistle	32,074	32,074	32,276	42,801	133%	100%	42,801
LED Nightlight	17,205	17,205	14,972	9,999	58%	100%	9,999
Total[1]	**771,703**	**771,703**	**810,688**	**773,578**	**100%**	**100%**	**773,578**

[1] Totals may not add up to the sum of the column due to rounding.

Table 72. 2020 Energy Efficient Schools Program Demand Reduction (Coincident Peak kW)

Measure	*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	17.8	17.8	21.6	21.6	122%	100%	21.6
15W LED	12.1	12.1	16.9	16.9	140%	100%	16.9
Energy-Efficient Bathroom Aerator	2.3	2.3	1.9	2.1	90%	100%	2.1
Energy-Efficient Kitchen Aerator	3.0	3.0	3.1	3.4	111%	100%	3.4
Energy-Efficient Showerhead	7.4	7.4	6.6	7.1	96%	100%	7.1
Furnace Filter Whistle	39.8	39.8	40.1	65.3	164%	100%	65.3
LED Nightlight	0.0	0.0	0.0	0.0	N/A	100%	0.0
Total[1]	**82**	**82**	**90**	**116**	**141%**	**100%**	**116**

[1]Totals may not add up to the sum of the column due to rounding.

Residential Behavioral Savings Program

Since 2012, the Residential Behavioral Savings (RBS) Program has been sending customers home energy reports (HERs), which provide energy consumption information and encourage the adoption of energy-saving behaviors and home improvements. These reports contain the household's energy use data, a similar neighbor comparison on energy use, and energy-saving tips. The program also provides all residential Vectren customers with their energy usage information through a widget (i.e., display) found on the customers' online utility account webpage.

The RBS Program uses an experimental design called a randomized control trial wherein customers are randomly assigned to either a treatment group (recipients of HERs) or a control group (nonrecipients). Treatment group customers are mailed print HERs, and those with valid email addresses also receive the reports via email. Control group customers do not receive the HERs; the control group's consumption provides a baseline for measuring the program's energy savings.

Treatment and control group customers are further segmented into "waves" according to their Vectren fuel service (electric only or dual fuel) and the year in which they started or would have started receiving the HERs. For several years, Vectren operated the program with one electric-only wave and one dual fuel wave. In 2020, Vectren launched a second dual fuel wave to address customer attrition and to incorporate more low-income customers into the program. Attrition occurs when customers close their Vectren accounts. Long-running programs like Vectren's can lose a large portion of the originally randomized customers as the program ages.

In 2020, the program population contained 51,895 treatment group customers and 15,268 control group customers, as shown in Table 73.[35]

Table 73. 2020 RBS Program Design

Group and Wave	Program Treatments	Customer Count
Treatment Group		
Wave 1 Electric Only (2012)	4 print HERs; 12 email HERs	11,414
Wave 1 Dual Fuel (2013)	4 print HERs; 12 email HERs	27,480
Wave 2 Dual Fuel (2020)	2 print HERs; 6 email HERs	13,001
Total Treatment Group[1]		**51,895**
Control Group		
Wave 1 Electric Only (2012)	--	2,747
Wave 1 Dual Fuel (2013)	--	3,053
Wave 2 Dual Fuel (2020)	--	9,468
Total Control Group		**15,268**

[1] Total count of 51,895 for the treatment group does not match participant count of 38,058 reported in Vectren's 2020 Electric DSM Scorecard because Cadmus relies on program tracking data provided by the program implementer to track participation. It appears the scorecard customer count does not include the new (2020) dual fuel wave (Wave 2).

[35] Treatment group count does not include customers who became inactive or opted out of the program prior to 2020. This methodology for determining participant count is consistent with previous evaluations.

During 2020, treatment group customers from Wave 1 received four print HERs in the mail and, if an email address was provided, 12 (monthly) email HERs. Treatment group customers in the new Wave 2 received two print HERs, and if an email address was provided, six (monthly) email HERs. The program implementer, Oracle, was responsible for forecasting and tracking savings, producing the report content, distributing the reports to customers, and running the energy usage widget found on the customers' online utility account webpage.

In the last quarter of 2020, Vectren ran a promotion to specifically encourage treatment groups customers to complete the Home Energy Analysis Survey online. Customers who completed the survey qualified to request and receive a warm kit that contained a wool blanket, weather stripping foam, and energy savings tips for the winter season. The warm kit offer was promoted through the Oracle-hosted widget on the Vectren website. Vectren reported shipping 2,176 kits to customers in 2020.

Accomplishments

Table 74 shows the program's achievements against goals in 2020. The program exceeded its 2020 electric energy savings goal due to very strong savings performance from the two legacy waves, Wave 1 Electric Only and Wave 1 Dual Fuel.

Table 74. 2020 RBS Program Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	9,402,082	6,430,000	146%
Gross kW Savings	832	832	100%
Participants	38,058	38,058	100%
Program Expenditures	$246,712	$246,712	100%

[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 75 lists the evaluated savings summary for the RBS Program. The 2020 evaluation resulted in a 101% energy savings realization rate and a 342% demand realization rate. The high demand realization rate was likely driven by differences in methodology. Reported demand savings were based on kW per home savings, while evaluated demand savings were based on the estimated energy savings per home. The reported energy and demand savings are within Cadmus' 90% confidence interval for evaluated *ex post* savings, suggesting that reported and evaluated savings are not statistically different.

Table 75. 2020 RBS Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	9,402,082	9,402,082	9,402,082	9,492,007	101%	N/A	9,492,007
Total kW	832	832	832	2,842	342%	N/A	2,842

Conclusions and Recommendations

Savings and Uplift

Savings for the legacy waves peaked in 2020. Savings for both legacy waves peaked in 2020, with savings of 2.05% and 2.03% of baseline consumption for electric only and dual fuel segments, respectively. There were no obvious external reasons, such as more extreme temperatures, why savings were higher in 2020 than other years, so Cadmus hypothesized it could be related to the COVID-19 pandemic. The 2020 HERs included modules containing pandemic-appropriate tips and messaging, which were featured at the top of the HERs. Tips that ran counter to the Center for Disease Control (CDC) guidance (such as having an in-home visit for audits and installations) were removed. Cadmus hypothesizes that the pandemic-related modules and customers' concern about the economic uncertainty due to the pandemic could have re-engaged legacy customers to more carefully read the reports and act on recommended tips and products. Cadmus also hypothesized that many legacy customers, by having to spend more time at home, increased savings by applying tips that helped run their products more efficiently.

As expected, electric savings were low for the new dual fuel wave. The new dual fuel wave achieved savings of 0.51% of baseline consumption. Though these savings are low, this is typical for HERs programs in the early months of ramp-up after launch and are in line with the 0.64% in the first year of the legacy dual fuel wave. As time progresses, savings for the new dual fuel wave should ramp up similar to the legacy waves.

The program's experimental design was not set up to identify differences in savings between low-income and standard-income customers for the new dual-fuel wave. The program implementer identified treatment group customers by their income status, but control group customers were not stratified in a similar way. Since the wave is still very new and savings are still low overall, it is unlikely Cadmus would have been able to identify any differences in savings by low-income status in the first five months of treatment.

Recommendation: If Vectren wishes to calculate differences in low-income and standard-income savings, identify which control group customers are low-income in the same way treatment group customers are identified.

The legacy electric only and the new dual fuel waves experienced participation uplift. In 2020, uplift savings for the legacy electric only segment were positive (unlike the previous four years), primarily due to treatment group participation in the Appliance Recycling, Residential Prescriptive, and Home Energy Assessment 2.0 programs. In 2020, the new dual fuel wave experienced the highest uplift participation rates of all three waves, with 24% more participation by treatment customers than control customers. This is probably because the pool of prospective participants is larger compared to the legacy waves in which fewer potential treatment customers have not yet participated in other programs.

Demand Savings Estimates

Availability of advanced metering infrastructure (AMI) data may improve the accuracy of demand savings estimates. Vectren fully deployed AMI in 2018. If enough RBS Program customers currently have AMI data available, Vectren should consider using AMI data to perform a demand analysis using treatment and control hourly data similar to the energy savings analysis. This will provide more granular consumption data for Vectren customers during the actual peak period and improve the accuracy of the demand savings estimates.

Home Energy Report Engagement

The HERs sent to customers in the new dual fuel wave achieved strong readership and provided value. Cadmus conducted a survey with treatment group customers in the new dual fuel wave. Most survey respondents (96%, n=420) said they read or skimmed the last HER they received. Most agreed with the statements that the reports were easy to understand (92%, n=399) and relevant to their home (68%, n=358) and that they had adopted the tips recommended in the reports (68%, n=375). Less than half agreed with the statement about installing products recommended in reports (44%, n=378). This rate of adopting tips and installing products aligns with the new dual fuel wave's savings of 0.179 kWh/day equivalent to 0.51% of baseline consumption. As these customers continue to receive the reports, their adoption of tips and products, and consequently their savings, is expected to rise.

Customers in the new dual fuel wave had a positive reception of the HERs. After receiving the reports for half a year, 80% of survey respondents were satisfied with the reports (n=395) and 54% were likely to recommend them (n=404). The reports did not have a negative impact on customer satisfaction with Vectren (80% of respondents were satisfied with Vectren, n=407).

Low-income and standard-income customers did not differ in their engagement with the HERs. There was no statistically significant difference between low-income and standard-income respondents on the following:

- Readership of the reports (95% low-income, n=183; 96% standard-income, n=237)
- Tip adoption (69% low-income, n=170; 68% standard-income, n=205)
- Product installation (45% low-income, n=162; 44% standard-income, n=216)
- Satisfaction with the reports (84% low-income, n=173; 76% standard-income, n=222)
- Satisfaction with Vectren (81% low-income, n=176; 79% standard-income, n=231)

The evaluation did not expect to find significant differences at this time because customers had received the reports for only half the year in 2020.

Process Evaluation

RESIDENTIAL BEHAVIORAL SAVINGS PROGRAM

2020 Process Analysis Activities

1 staff interview

1 ORACLE staff interview

429 mixed mode surveys with treatment group customers in 2020 wave, stratified by income

Low-income (n=188)

Standard income (n=241)

2020 Program Changes

Vectren launched a new wave consisting of: **50%** low-income and **50%** standard income customers

Oracle added modules to the home energy reports addressing COVID-19

2021 Planned Program Changes

Oracle will launch new design and content for the home energy reports

Key Process Evaluation Findings

Customer Survey Results

LI = Low-income | SI = Standard-income

80% (n=395) satisfied with reports
LI **84%** (n=173) | SI **76%** (n=222)

96% (n=420) read reports
LI **95%** (n=183) | SI **96%** (n=237)

68% (n=358) agreed tips were relevant to their home
LI **71%** (n=162) | SI **66%** (n=196)

58% (n=427) familiar with energy efficiency programs and Vectren rebates
LI **52%** (n=188) | SI **62%** (n=239)

68% (n=375) did easy, everyday tips recommended in the reports
LI **69%** (n=170) | SI **68%** (n=205)

44% (n=378) installed products recommended in the reports
LI **45%** (n=162) | SI **44%** (n=216)

92% (n=399) agreed that reports are easy to understand
LI **95%** (n=170) | SI **91%** (n=229)

54% (n=404) likely to recommend the reports
LI **61%** (n=176) | SI **48%** (n=228)

80% (n=407) satisfied with Vectren
LI **81%** (n=176) | SI **79%** (n=231)

84% (n=281) satisfied with variety of energy efficiency programs offered by Vectren
LI **85%** (n=124) | SI **83%** (n=157)

75% (n=370) satisfied with Vectren's efforts to help manage monthly usage
LI **78%** (n=162) | SI **73%** (n=208)

70% (n=377) rated Vectren's suggestions on ways to reduce usage/bills as useful
LI **75%** (n=161) | SI **66%** (n=216)

No statistically significant differences between low-income and standard income responses (tested at 90% confidence level with Bonferroni-corrected significance level of $p<0.01$)

Impact Evaluation

Impact Evaluation Methods and Findings

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

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

The methods Cadmus used to complete each task are detailed in *Appendix A. Impact Evaluation Methodology.*

Gross Savings Review

Table 76 and Table 77 show the 2020 reported and evaluated program net energy and demand savings and the realization rates for the RBS Program.[36] The reported energy savings are within Cadmus' 90% confidence interval for evaluated *ex post* savings, suggesting that reported and evaluated savings are not statistically different. Savings in these tables do not include the uplift findings.

Table 76. 2020 RBS Program Energy Savings

Customer Segment	Annual Net Electricity Savings (MWh/year)		90% Confidence Interval		Relative Precision	Realization Rate
	Reported	Evaluated[1]	Lower Bound	Upper Bound		
Wave 1 Electric Only (2012)	N/A	3,334	1,559	5,110	±53%	N/A
Wave 1 Dual Fuel (2013)	N/A	5,773	2,764	8,782	±52%	N/A
Wave 2 Dual Fuel (2020)	N/A	423	40	806	±90%	N/A
Total	**9,402**	**9,531**	**6,016**	**13,046**	**±37%**	**101%**

[1] Evaluated savings have not been adjusted for uplift.

Table 77. 2020 RBS Program Demand Savings

Customer Segment	Annual Net Electricity Savings (MW/year)[1]		90% Confidence Interval		Relative Precision	Realization Rate
	Reported	Evaluated	Lower Bound	Upper Bound		
Wave 1 Electric Only (2012)	N/A	1.00	0.37	1.64	±63%	N/A
Wave 1 Dual Fuel (2013)	N/A	1.74	0.66	2.81	±62%	N/A
Wave 2 Dual Fuel (2020)	N/A	0.13	0.00	0.26	±108%	N/A
Total	**0.83**	**2.87**	**1.61**	**4.13**	**±44%**	**344%**

[1] Evaluated savings have not been adjusted for uplift.

[36] Because the experimental design uses a control group as the savings baseline, the regression analysis produces only net savings estimates (no gross estimates).

Table 78 lists the evaluated average daily savings per home (kWh/day) relative to control group consumption, for each customer segment (wave) in the program.

Table 78. RBS Program Historical Daily Savings per Customer

Program Year	Wave 1 Electric Only		Wave 1 Dual Fuel		Wave 2 Dual Fuel	
	kWh/day [1]	Percentage [2]	kWh/day [1]	Percentage [2]	kWh/day [1]	Percentage [2]
2012	-0.422 (0.092) ***	1.08%	-0.201 (0.083) **	0.64%	N/A	N/A
2013	-0.646 (0.139) ***	1.52%	-0.318 (0.099) ***	0.97%	N/A	N/A
2014	-0.735 (0.174) ***	1.67%	-0.436 (0.118) ***	1.37%	N/A	N/A
2015	-0.694 (0.174) ***	1.68%	-0.471 (0.127) ***	1.51%	N/A	N/A
2016	-0.674 (0.188) ***	1.65%	-0.446 (0.144) ***	1.35%	N/A	N/A
2017	-0.747 (0.198) ***	1.88%	-0.41 (0.15) ***	1.30%	N/A	N/A
2018	-0.815 (0.244) ***	1.85%	-0.308 (0.171) *	0.92%	N/A	N/A
2019	-0.67 (0.251) ***	1.60%	-0.482 (0.181) ***	1.59%	N/A	N/A
2020	-0.819 (0.265) ***	2.05%	-0.585 (0.188) ***	2.03%	-0.179 (0.098) *	0.51%

[1] Standard errors clustered on customers are presented after the estimated treatment effect in parentheses (*** Significant at 1%; ** Significant at 5%; * Significant at 10%). The treatment effects represent the average daily savings per treatment group customer.
[2] Percentage savings are relative to control group consumption in the same time period.

As expected, electric only customers continued to achieve higher absolute savings and higher percentage savings because they had higher pretreatment consumption than dual fuel customers and, therefore, a greater capacity to save. In 2020, savings increased for both Wave 1 segments, from 1.6% to 2.05% for the electric only and 1.59% to 2.03% for the dual fuel. This increase did not appear to be driven by different temperatures, as temperatures have been relatively stable in 2019 and 2020.

For legacy electric only, one driver was that 8% more treatment customers participated in other programs compared to the control group (see *Uplift Analysis* section). Increased savings for both Wave 1 segments in 2020 may have been driven by more opportunity to save electricity during the COVID-19 pandemic as people spent more time at home. Wave 2 Dual Fuel launched midway through 2020, so it is not clear if the pandemic had a similar impact on its energy savings.

The new dual fuel wave (Wave 2) had savings of 0.179 kWh/day equivalent to 0.51% of baseline consumption, in line with the first year of the legacy dual fuel wave (Wave 1) and what Cadmus typically sees in the first six months of a new wave. For 2020, Cadmus was unable to determine differences in savings between low-income and standard-income customers in Wave 2. One reason was that, unlike the treatment group, there is no low-income identifier for the control group. Another reason was that Wave 2 had not been in operation long enough for significant precision to detect any statistical differences between these two groups.

Table 79 shows historical evaluated and claimed demand savings dating back to 2016. As described in detail in *Appendix A. Impact Evaluation Methodology* , Cadmus evaluates demand savings by applying residential load shapes to the evaluated energy savings and converting the annual energy savings to peak demand reductions. This is a typical way to estimate peak demand savings in absence of an hourly demand analysis using AMI data, as described in the Uniform Methods Project.[37] Reported savings were based on per-home kW savings from Vectren. Differences in methodologies can lead to diverging realization rates if energy savings fluctuate over time, such as the increase in per-home savings from 2017 and 2018 to 2019 and 2020. Using load shapes to identify peak demand savings based on energy savings is preferrable and more accurate than using fixed per-household demand savings because it considers the actual achieved energy savings during the evaluation period. A better method to estimate peak demand reductions would be to perform an hourly analysis of treatment and control customers using AMI data, similar to the energy savings analysis.

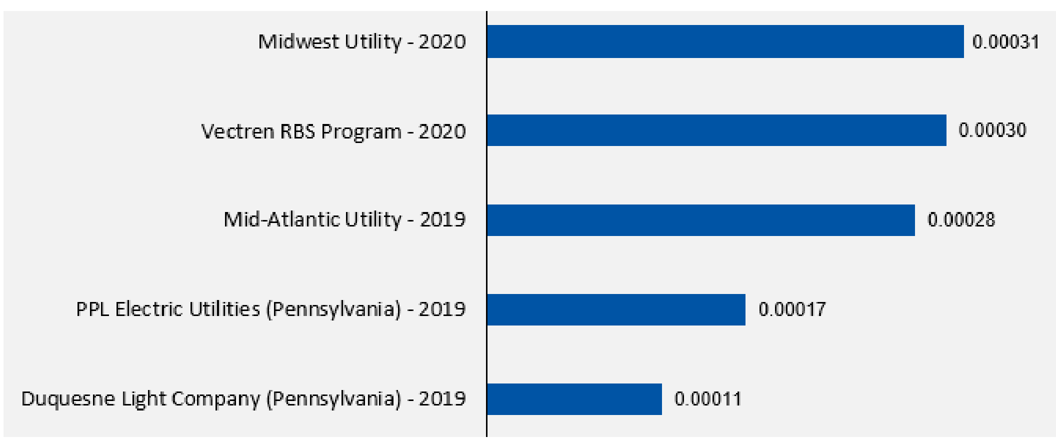
Table 79 shows the coincidence factor by year, the ratio of evaluated kW to evaluated kWh. Since 2018, the coincidence factor has remained relatively stable. Changes in annual demand savings are primarily driven by higher energy savings and any differences in the applied load shapes from year to year.

Table 79. RBS Program Historical Demand Savings

Year	Evaluated Energy Savings Per Household (kWh)	Claimed Demand Savings Per Household (kW)	Evaluated Demand Savings Per Household (kW)	Realization Rates	Evaluated kWh to kW ratio
2016	175	0.0280	0.0298	106%	0.000170
2017	168	0.0296	0.0261	88%	0.000156
2018	169	0.0354	0.0440	124%	0.000260
2019	191	0.0232	0.0489	211%	0.000255
2020	183	0.0219	0.0547	341%	0.000299

Figure 2 shows some recent coincidence peak factors developed using load shapes and energy savings results from a billing analysis. The coincidence peak factor for Vectren's RBS Program was in line with coincidence factors developed for other programs using a similar methodology.

Figure 2. Benchmarking of Coincidence Peak Factors for Programs Using Energy Billing Analysis



[37] Stern, F., and J. Spencer. October 2017. "Chapter 10: Peak Demand and Time-Differentiated Energy Savings Cross-Cutting Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68566.pdf

Uplift Analysis

The HERs distributed by the RBS Program can raise customers' general awareness and knowledge of energy efficiency and promote and encourage participation in other Vectren efficiency programs. This effect is known as participation and savings uplift. The 2020 HERs promoted the Smart Cycle Program and the Appliance Recycling Program.

Uplift savings appeared in the regression-based estimates of RBS Program savings and in the savings evaluated for other programs that experienced uplift due to the HERs. It is standard evaluation practice to remove uplift savings that occur from a DSM portfolio to avoid double-counting. Uplift savings are estimated by wave and are removed from the wave level savings. For wave's with negative uplift savings, no adjustment is made because savings are not being double counted in other programs.

Table 80 shows the rate of participation uplift per 1,000 treated homes and as a percentage of control group participation rates for each program in the uplift analysis by customer segment.

Table 80. 2020 RBS Program Electricity Savings from Uplift

Program	Wave 1 Electric Only		Wave 1 Dual Fuel		Wave 2 Dual Fuel		Total Uplift Savings (kWh/yr)
	Uplift Savings per Home (kWh/yr)	Total Uplift Savings (kWh/yr)	Uplift Savings per Home (kWh/yr)	Total Uplift Savings (kWh/yr)	Uplift Savings per Home (kWh/yr)	Total Uplift Savings (kWh/yr)	
Appliance Recycling	0.40	4,554	-2.12	-58,175	0.29	3,827	-49,795
Home Energy Assessment 2.0	0.45	5,163	-0.37	-10,104	0.14	1,850	-3,090
Income Qualified Weatherization	0.00	31	0.94	25,837	0.12	1,531	27,398
Residential Prescriptive	1.21	13,839	0.00	55	0.64	8,381	22,275
Smart Cycle	-0.03	-374	-0.05	-1,469	0.00	0	-1,843
Total	**2.03**	**23,212**	**-1.60**	**-43,856**	**1.21**	**15,733**	**-4,911**

In 2020, the legacy electric-only wave had positive uplift (unlike the negative uplift in the previous three years), meaning treatment group customers participated in other Vectren programs at a higher rate than control group customers. This was largely driven by participation in the Appliance Recycling, Home Energy Assessment 2.0, and Residential Prescriptive programs.

The legacy dual fuel wave continued to have negative uplift, with 3.54 more control group customers participating in other Vectren programs than treatment group customers (per 1,000 customers). The new dual fuel wave had the highest uplift, with 6.18 more treatment group customers participating in other Vectren programs than control group customers (per 1,000 customers), possibly because with its recent launch more potential treatment customers have not yet participated in other Vectren programs.

As discussed in prior evaluations, possible reasons uplift savings were lower in the legacy waves is that many treatment group customers who would have participated in other programs may have already done so in prior years and that more control group customers now participate who were not encouraged to do so early on. This is supported by positive uplift in the early years of the RBS Program and negative or smaller uplift in the past four years.

In the 2020 HERs, promotion of the Appliance Recycling Program appeared to be successful as both Wave 1 Electric Only and Wave 2 Dual Fuel achieved positive participation for that program. The Smart Cycle program did not have positive participation uplift for any of the waves, probably because this program was suspended from April through September 2020 due to the pandemic.

As expected, uplift savings for each program aligned with participation uplift rates—the electric only and new dual fuel waves had positive uplift savings while the legacy dual fuel wave had negative uplift savings. Though Wave 2 Dual Fuel had the highest participation uplift, it still had lower absolute uplift savings than the legacy waves because it launched midway through 2020, with only five months data on installations instead of the 12 months for the legacy waves. The only programs with positive uplift savings across all waves were Income Qualified Weatherization and Residential Prescriptive. Cadmus adjusted the positive savings from the RBS Program for Wave 1 Electric Only and Wave 2 Dual Fuel to avoid double-counting. For Wave 1 Dual Fuel, uplift savings were negative so none of its savings were double-counted in Vectren's other efficiency programs.

Cadmus also evaluated demand savings from uplift, shown in Table 81.

Table 81. 2020 RBS Program Demand Savings from Uplift

Program	Wave 1 Electric Only		Wave 1 Dual Fuel		Wave 2 Dual Fuel		Total Uplift Savings (kW)
	Uplift Savings per Home (kW)	Total Uplift Savings (kW)	Uplift Savings per Home (kW)	Total Uplift Savings (kW)	Uplift Savings per Home (kW)	Total Uplift Savings (kW)	
Appliance Recycling	0.0000	0.43	-0.0004	-11.03	0.0001	0.96	-9.64
Home Energy Assessment 2.0	0.0000	0.48	0.0000	-1.23	0.0000	0.11	-0.63
Income Qualified Weatherization	0.0000	-0.28	0.0003	7.84	0.0000	0.08	7.65
Residential Prescriptive	0.0002	2.47	0.0003	8.02	0.0012	16.17	26.66
Total	**0.0003**	**3.10**	**0.0001**	**3.61**	**0.0013**	**17.33**	**24.04**

Cadmus assumed that any measures installed and operating between June and September 2020 contributed to demand uplift. Demand results aligned with energy uplift savings. Wave 1 achieved positive demand uplift overall. This was primarily driven by installation of higher demand savings measures in the residential prescriptive program. Treatment group customers installed measures with relatively higher demand savings than energy savings, particularly 18 SEER air conditioners. Comparison group customers had more smart thermostats installed, which had no demand savings but somewhat high energy savings.

Evaluated Net Savings Adjustments

Table 82 and Table 83 list evaluated net savings for the RBS Program. The program achieved net savings of 9,492,007 kWh and 2,842 coincident kW demand reduction. Because the program uses a control group to estimate program savings, the evaluated savings are inherently net. Cadmus made energy uplift adjustments for Wave 1 Electric Only and Wave 2 Dual Fuel, as they achieved positive uplift savings. Cadmus adjusted demand uplift for all waves.

Table 82. 2020 RBS Program Electric Savings (kWh)

	Ex Ante Savings (kWh)			Evaluated *Ex Post* Savings (kWh)	Realization Rates (kWh)	NTG Ratio	Evaluated Net Savings (kWh)
	Reported	Audited	Verified				
Total kWh	9,402,082	9,402,082	9,402,082	9,530,953	101%	N/A	9,530,953
Uplift	N/A	N/A	N/A	38,946	N/A	N/A	38,946
Total Adjusted for Uplift	**9,402,082**	**9,402,082**	**9,402,082**	**9,492,007**	**101%**	**N/A**	**9,492,007**

Table 83. 2020 RBS Demand Reduction (Coincident Peak kW)

	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				
Total kW	832.00	832.00	832.00	2,865.95	344%	N/A	2,865.95
Uplift	N/A	N/A	N/A	24.04	N/A	N/A	24.04
Total Adjusted for Uplift	**832**	**832**	**832**	**2,842**	**342%**	**N/A**	**2,842**

Market Performance Indicators

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

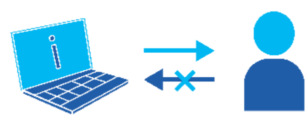
- Existing program design and administration
- Market barriers discovered through evaluation activities
- Current intervention strategies and activities
- Expected outcomes from implementing current intervention strategies

Logic Model

RESIDENTIAL BEHAVIORAL SAVINGS PROGRAM

Market Actor: End-Use Customer — Residential Home Energy Report Recipients (Treatment Group Customers)

Market Barriers



- Lack of engagement with home energy reports
- Lack of engagement with online energy efficiency resources
- Lack of home energy use benchmark
- Lack of understanding of how home uses energy
- Lack of awareness of energy efficiency options
- Lack of energy education among hard to reach customers (e.g., income-qualified)

Intervention Strategies / Activities

- Print reports mailed 4 times per year and online reports emailed monthly
- Home energy use comparison to a group of similar homes included in report
- Embed energy usage widget within customer's Vectren online account
- Historical energy use data shown in the reports and available in online widget
- Incorporation of income-qualified customers in new treatment wave
- Energy-saving tips included in reports and online widget
- Cross-promotion of other Vectren DSM programs

Outcomes

- Increased adoption of energy-saving behaviors
- Increased participation in other Vectren DSM programs
- Reduced per-customer energy use and demand
- Increased readership of reports
- Increased customer understanding of energy efficiency actions
- Increased engagement with online energy efficiency resources
- Increased energy education among income-qualified customers

Key Indicators

- Percentage of customers who read the reports
- Annual logins to the online widget
- Average energy savings per treatment home
- Achievement of program participation and savings goal
- Percentage of customers adopting energy-saving behaviors
- Percentage of income-qualified customers adopting energy-saving behaviors

Market Actor: Program Implementer — Home Energy Reports Distributor

Market Barriers

- Complacency with tips during world events that impact energy use (e.g., COVID-19 pandemic)
- Delivering the same content and design of the reports/widget disengages customers
- Lack of detailed energy use data make it difficult to deliver accurate, disaggregated reports
- Lack of customer information make it difficult to incorporate personalized tips

Intervention Strategies / Activities

- Integrate AMI data and home energy analysis survey data for more accurate, detailed, and personalized reports
- Update content and look of the reports/widget
- Regularly review tips for appropriateness and update the tips library on a regular basis

Outcomes

- An effective, well-designed report/widget that delivers strong and reliable energy savings

Key Indicators

- Achievement of energy savings against goals
- Realization rate

Program Performance

Cadmus measured 2012 to 2020 program performance against the KPIs listed in Table 84.

Table 84. RBS Program KPI and 2012-2020 Performance

KPI	Performance								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Achievement of Program Participation Goals	N/A	N/A	N/A	N/A	100%	100%	100%	100%	100%
Achievement of kWh Savings Goals	N/A	N/A	132%	158%	115%	120%	96%	109%	146%
Achievement of kW Savings Goals	N/A	N/A	N/A	N/A	N/A	N/A	100%	100%	100%
Realization Rate	N/A	N/A	104%	91%	92%	93%	98%	99%	101%
Per Participant Average Energy Savings[1]	0.7%	1.2%	1.5%	1.6%	1.5%	1.5%	1.2%	1.6%	1.8%
Per Participant Average Program Uplift	N/A	N/A	2.48%	0.12%	0.51%	-0.77%	-1.78%	-1.33%	0.01%
Percentage of Customers Who Read Reports	98%	95%	96%	98%	89%	91%	N/A[2]	84%	96%[3]
Percentage of Customers Adopting Energy-Saving Behaviors	85%	93%	94%	88%	N/A	43%	N/A[2]	68%	68%[3]
Annual Treatment Group Customer Logins to Portal/Online Widget	1,208	688	148	199	1,050	4,866	6,881	7,433	N/A[4]

[1] These values are weighted by participant counts for electric and for dual fuel customer segments. They are based on the customers included in the current evaluation year's regression analysis and may change slightly across evaluation years.
[2] Cadmus did not conduct a customer survey in 2018.
[3] For the 2020 evaluation, Cadmus surveyed only customers in the 2020 dual fuel wave. Among the low-income respondents in the 2020 dual fuel wave, 69% adopted energy-saving behaviors.
[4] In late 2019, the program implementer stopped hosting the program's online portal and instead embedded widgets directly on the customers' online utility account webpage. As a result, logins to the portal are no longer tracked.

Appliance Recycling Program

The Appliance Recycling Program is designed to reduce electricity use through the removal and environmentally sound recycling of old inefficient refrigerators, freezers, and air conditioning units in Vectren's service territory.[38] The program implementer, ARCA Recycling Inc., works with Vectren to deliver the program. ARCA operates a recycling facility that follows U.S. Environmental Protection Agency best practices and recycles close to 100% of each unit.

In 2020, customers could recycle up to two working refrigerators or freezers, sized 10 to 30 cubic feet, along with an air conditioning unit, by scheduling a pick-up of the units through ARCA. Vectren provides a $50 incentive to customers for each qualifying refrigerator or freezer unit picked up, along with a $25 incentive for window air conditioning units.

Accomplishments

The Appliance Recycling Program exceeded its participation and savings goals in 2020. During interviews, the program implementer attributed the program's success to alternative delivery options that overcame challenges presented by the COVID-19 pandemic. In response to social distancing requirements in Indiana, Vectren offered a contactless pick-up solution to maintain program services during the pandemic. To promote the new service, Vectren offered a bonus $25 per qualifying refrigerator or freezer to customers who opted for it. The program implementer also streamlined the scheduling process and added window air conditioners as a qualifying appliance, which increased customer engagement.

Table 85 shows the program's achievements against goals in 2020.

Table 85. 2020 Appliance Recycling Goals and Achievements

Unit	2020 Actual	2020 Planning Goal[1]	Percentage of Goal[1]
Gross kWh Savings	1,722,294	1,353,797	127%
Gross kW Savings	230	189	122%
Participants (unit)	1,703	1,400	122%
Program Expenditures	$278,727	$278,727	100%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 86 lists the evaluated savings summary for the Appliance Recycling Program. The difference in reported and evaluated savings is primarily due to the different mix of recycled appliances in 2020 compared to 2018 (Vectren's reported savings are based on the 2018 evaluated results). Compared to 2018, Cadmus found fewer recycled units in 2020 with these features:

- Manufactured before 1990 (older appliances consume more energy and therefore generate more savings when removed from the grid)

[38] 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.

- Side-by-side door (refrigerator) or chest (freezer) configurations (these types of appliances consume more energy than other configurations)

Table 86. 2020 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	1,722,294	1,735,644	1,735,644	1,621,008	94%	62%	1,001,198
Total kW	230	231	231	250	109%	63%	158

Conclusions and Recommendations

Program Delivery

Despite the challenges created by the COVID-19 pandemic, the Appliance Recycling Program was able to offer an effective delivery option that drove high customer satisfaction. According to the implementer, 80% of 2020 participants took advantage of the contactless pick-up service. Appliance removal staff used personal protective equipment and safety procedures, following COVID-19 restrictions. Cadmus found that 98% of survey respondents (n=84) said they were satisfied with their contactless participation experience. All but one survey respondent was satisfied with the program overall and likely to recommend it to family, friends, or neighbors.

Recommendation: If deemed cost-effective, continue offering the contactless pick-up option. With or without COVID-19 restrictions, customers may prefer the opportunity to choose traditional or contactless pick-up services.

Gross Savings Review

Per-unit savings are decreasing because newer refrigerators are being recycled. In 2020, evaluated per-unit gross kWh savings were 8% lower for refrigerators compared to Vectren's reported savings (based on 2018 evaluated savings). The main reasons for lower savings were a 16% decrease in units manufactured before 1990 and an 11% decrease in average age. Recycled units with a side-by-side refrigerator configuration also decreased by 2%.

Recommendation: Consider testing marketing messages that highlight the specific appliance features that offer the greatest energy cost savings for customers (e.g., chest freezers, side-by-side refrigerator door configurations, appliances that are plugged in year-round, and units more than 30 years old). Consider marketing a promotion for an "Oldest Appliance Contest" to encourage customers' oldest appliances to be recycled. Utilities in other jurisdictions have found success in uncovering new program savings with these type of promotions.

Process Evaluation

APPLIANCE RECYCLING PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 ARCA staff interview

120 participant customer phone surveys

70 refrigerator participants

50 freezer participants

2020 Program Changes

VECTREN

made room air conditioners eligible for pickup when recycled with a refrigerator or freezer

In response to COVID-19, Vectren offered:

- **Contactless pickup**
- **Bonus $25 incentive** to customers who chose to participate in contactless service

ARCA

- Updated online scheduling site to be more mobile-friendly
- Added **resolution specialists** to de-escalate customer disputes at call center
- Required personal protective equipment for removal staff in response to COVID-19

2021 Planned Program Changes

ARCA to explore including **mini refrigerators** or **dehumidifiers** as eligible appliances for pickup

Key Process Evaluation Findings

Customer Survey Results:

- **99%** (n=120) satisfied with program
- **99%** (n=120) likely to recommend program
- **98%** (n=84) satisfied with contactless pick-up service
- **96%** (n=119) said scheduling process was easy
- **96%** (n=120) satisfied with length of time between scheduled appointment and pick-up
- **96%** (n=106) satisfied with variety of energy efficiency programs offered by Vectren
- **90%** (n=106) satisfied with Vectren's efforts to help customers manage monthly energy usage
- **81%** (n=108) said Vectren's suggestions to reduce energy use were useful

Impact Evaluation

Impact Evaluation Methods and Findings

The impact evaluation of the Appliance Recycling Program involved 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 2020 using a multivariate regression model on an aggregated *in situ* dataset of 591 appliances metered for evaluations conducted in California, Wisconsin, and Michigan
- Conduct phone surveys with 120 program participants (stratified by measure type, refrigerators or freezers) to estimate the partial use of recycled appliances during 2020 and the NTG ratio

Cadmus' methodology for estimating program savings and NTG is consistent with the U.S. Department of Energy's Uniform Methods Project (UMP) evaluation protocol for refrigerator recycling.[39]

Gross Savings Review

Table 87 lists the 2020 Appliance Recycling Program's per-unit annual gross savings for each measure. Vectren's 2020 reported savings are based on 2018 evaluated savings. *Appendix A. Impact Evaluation Methodology* provides detailed information on the 2020 evaluated gross savings methodology for refrigerators, freezers, and window air conditioners.

Table 87. 2020 Appliance Recycling Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Refrigerator	1,096	1,012	0.14	0.15
Freezer	706	722	0.14	0.11
Window Air Conditioner	304	304	0.14	0.21

For 2020, Cadmus found an 8% decrease in per-unit evaluated gross energy savings for refrigerators compared to the reported value, primarily due to the following:

- 16% decrease in the percentage of refrigerators manufactured before 1990[40]
- 11% decrease in the average age of refrigerators

[39] U.S. Department of Energy. October 2017. "Chapter 7: Refrigerator Recycling Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.energy.gov/eere/about-us/ump-protocols

[40] The U.S. Department of Energy's energy conservation standards for consumer refrigerators and freezers started in 1990.

- 2% decrease in the percentage of refrigerators with a side-by-side door configuration. Refrigerators with side-by-side door configuration often have water and ice dispensing features through one door, which typically makes them less insulated than a refrigerator with a solid door configuration. The UMP savings model states that average daily consumption is 1.12 kWh higher for a side-by-side refrigerator compared to one that does not have this configuration.[41]

These three factors are key drivers in how much energy a refrigerator consumes, and the mix of refrigerators collected will drive the per unit savings up and down.

For freezers, Cadmus found a 2% increase in per-unit gross energy savings compared to the reported value, primarily due to a 12% increase in the freezer part-use factor, which is described in detail below.

Vectren qualified window air conditioners for recycling for the first time in 2020. Reported savings and evaluated gross savings were calculated using the same inputs and methods prescribed in the 2015 Indiana TRM V2.2.

Table 88 lists historical per-unit evaluated gross energy savings for Appliance Recycling Program. Refrigerator savings are decreasing minimally each year mostly due to the decreasing age of recycled appliances.

Table 88. Appliance Recycling Program Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Refrigerator	1,260	1,092	1,090	1,000	986	1,044	1,096	1,024	1,012
Freezer	1,115	990	924	809	820	797	706	709	722
Window Air Conditioner	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	304

Measure Verification

Cadmus verified quantity and type of measure recycled by conducting a survey with Appliance Recycling Program participants and reviewing the program tracking database. The in-service rate is a comparison of appliance removal dates in the program tracking database to reported participation. During the database review, Cadmus found the following:

- **Refrigerators.** Program tracking data contained 21 more recycled units than reported on Vectren's 2020 Electric DSM Scorecard. One refrigerator was less than 10 cubic feet and was excluded from the number of verified installations.[42]

[41] U.S. Department of Energy. September 2017. "Chapter 7: Refrigerator Recycling Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.energy.gov/eere/about-us/ump-protocols

[42] Program rules dictate refrigerators and freezers must meet the size requirement (10 cubic ft. - 30 cubic ft.) to be eligible for participation.

- **Freezers.** Program tracking data contained 11 fewer recycled units than reported on Vectren's 2020 Electric DSM Scorecard. Two freezers were less than 10 cubic feet and were excluded from the number of verified installations.
- **Window air conditioners.** Program tracking data contained two more units than reported on Vectren's 2020 Electric DSM Scorecard.

All 120 survey respondents verified their participation in the program and removal of the appliances. Table 89 lists the in-service rates for each program measure.

Table 89. 2020 Appliance Recycling Program Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
Refrigerator	1,391	1,411	1,411	101%
Freezer	256	243	243	95%
Window Air Conditioner	56	58	58	104%
Total	**1,703**	**1,712**	**1,712**	**101%**

Table 90 shows historical in-service rates for each program measure. The change in in-service rate in 2020 was due to inconsistencies in the tracking database that were accounted for by Cadmus during the database review process.

Table 90. Appliance Recycling Program Historical In-Service Rates

Measure	In-Service Rate								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Refrigerator	100%	100%	100%	100%	100%	100%	100%	100%	101%
Freezer	100%	100%	100%	100%	100%	100%	100%	100%	95%
Window Air Conditioner	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	104%

Net-to-Gross Analysis

Cadmus calculated NTG for the 2020 Appliance Recycling Program using findings from a survey of 120 program participants. Cadmus stratified the survey by measure type—refrigerators and freezers. Table 91 presents the NTG results for the program. These findings are described in greater detail in *Appendix B. Net-to-Gross Detailed Findings.*

Cadmus did not stratify the survey sample for window air conditioner participants due to the low number of participants. Cadmus assumed a 100% NTG for window air conditioners because these participants must recycle a refrigerator or a freezer to have the window air conditioner recycled. This measure represents 1% of gross program population savings.

Table 91. 2020 Appliance Recycling Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Refrigerator	38%	0%	62%
Freezer	44%	0%	56%
Window Air Conditioner	0%	0%	100%
Total Program[1]	**38%**	**0%**	**62%**

[1] Program-level estimates are weighted by each measure's *ex post* gross evaluated population energy savings.

Table 92 lists historical measure-level NTG ratios by year. The main contributor to lower NTG in 2020 compared to 2019 is because fewer 2020 participants said they would have kept their refrigerators and freezers in the absence of the Appliance Recycling Program than in 2019. NTG results are completely reliant on self-reported responses and therefore can change considerably from one year to the next.

Table 92. Appliance Recycling Program Historical Net-to-Gross Ratios

Measure	2012	2013	2014	2015	2016	2017	2018	2019	2020
Refrigerator	59%	52%	55%	54%	70%	50%	68%	69%	62%
Freezer	72%	55%	57%	57%	73%	72%	62%	78%	56%
Window AC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100%
Total Program[1]	**61%**	**54%**	**55%**	**54%**	**71%**	**53%**	**67%**	**70%**	**62%**

[1]Program-level estimates are weighted by each measure's *ex post* gross evaluated population energy savings.

Freeridership and Spillover

In general, independent of program intervention, participants' 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 considered a participant a freerider only under Scenario 3 because the unit would have been removed from the grid and destroyed, even if it was not recycled through the Appliance Recycling Program. Therefore, Vectren cannot claim energy savings generated by recycling Scenario 3 appliances.

Table 93 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.[43] Secondary market impacts and freeridership are derived from Scenario 2 and Scenario 3, respectively, and are calculated from responses to the participant

[43] Secondary market impacts account for the purchasing decisions made by would-be acquirers of Vectren participating units now that the units are unavailable in the used marketplace.

survey. Refer to *Appendix B. Net-to-Gross Detailed Findings* for freeridership and secondary market impacts methodology and results.

Table 93. 2020 Appliance Recycling Program NTG by Measure Type

Measure	Gross Per-Unit Savings (kWh/Year)	Freeridership and Secondary Market Impacts (kWh)	Freeridership
Refrigerator	1,012	385	38%
Freezer	722	315	44%

As recommended in the UMP, Cadmus did not include spillover in program net savings estimates for 2020.[44] 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.

Evaluated Net Savings Adjustments

Table 94 and Table 95 list evaluated net savings for the Appliance Recycling Program. The program achieved net savings of 1,001,198 kWh and 158 coincident kW demand reduction.

Table 94. 2020 Appliance Recycling 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				
Refrigerator	1,524,536	1,546,456	1,546,456	1,427,932	94%	62%	885,318
Freezer	180,736	171,558	171,558	175,446	97%	56%	98,250
Window Air Conditioner	17,022	17,630	17,630	17,630	104%	100%	17,630
Total	**1,722,294**	**1,735,644**	**1,735,644**	**1,621,008**	**94%**	**62%**	**1,001,198**

Table 95. 2020 Appliance Recycling Program Demand Reduction (Coincident Peak kW)

Measure	*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	188	190	190	212	113%	62%	131
Freezer	35	33	33	26	75%	56%	15
Window Air Conditioner	8	8	8	12	157%	100%	12
Total[1]	**230**	**231**	**231**	**250**	**109%**	**63%**	**158**

[1] Totals may not add up to the sum of the column due to rounding.

[44] U.S. Department of Energy. October 2017. "Chapter 7: Refrigerator Recycling Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.energy.gov/eere/about-us/ump-protocols

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the Appliance Recycling 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

APPLIANCE RECYCLING PROGRAM

Market Actor	End-Use Customer | Residential Customers		
Market Barriers	• Lack of program awareness • Health/safety concerns with pick-up process due to COVID-19	• 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	• Multiple marketing channels • Cross-promotion through other Vectren DSM programs • Program information and eligibility requirements available on Vectren website, bill inserts, and in retail stores • Bonus incentive for pick-ups during COVID-19 shutdown (with contactless pickup)	• Incentives for removal of working appliances • Program enrollment/scheduling at point of purchase of new appliance and Enhanced scheduling process with multiple options (phone, online, through a redesigned user-friendly mobile, point of purchase) and additional resolution specialists to resolve issues	• Pick-up of appliances within two to three weeks of initial customer contact • Text alerts to notify customers that pick-up staff are on their way • Pick-up staff deliver appliances to recycling center • Contactless pickup option
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 • Reduced energy use	• Environmentally responsible disposal of waste materials from recycled appliances • Increased customer satisfaction with scheduling and pickup processess
Key Indicators	• Achievement of program participation and savings goals • Program satisfaction ratings • Appliance pick-up experience satisfaction rating	• Likelihood to recommend ratings • Saturation of used appliances on the secondary market • Ease of scheduling ratings	

Market Actor	Program Implementer | Appliance Pick-Up Staff		
Market Barriers		• Insufficient pick-up staff qualifications • COVID-19 creates health/safety concern for appliance pick-up staff	• Participant concerns about pick-up staff entering home
Intervention Strategies / Activities		• RFPs to attract qualified program implementer • Open communication with participants to address concerns • Option for contactless pick-up	• Checklist followed by pick-up staff upon arrival at every home • Addition of strict safety measures, sanitation procedures, and personal protective equipment in response to COVID-19
Outcomes	• Assurance of quality work • Increased program participation	• Increased customer satisfaction with pick-up experience • Continuation of program services during COVID-19 shutdown	• Fewer inefficient appliances in operation
Key Indicators	• Achievement of program participation and savings goals		• Appliance pick-up experience satisfaction ratings

Program Performance

Cadmus measured 2012 to 2020 program performance against the KPIs listed in Table 96.

Table 96. Appliance Recycling Program Key Performance Indicators and 2012-2020 Performance

Key Performance Indicator	Performance								
	2012[1]	2013[2]	2014	2015	2016	2017	2018	2019	2020
Achievement of program participation goals	Did not meet goal; 75%	N/A	Did not meet goal; 94%	Met goal; 120%	Met goal; 105%	Met goal; 122%	Met goal; 108%	Did not meet goal[3]; 96%	Met goal; 122%
Achievement of kWh savings goals	N/A	N/A	Did not meet; 93%	Met goal; 120%	Met goal; 105%	Met goal; 122%	Met goal; 109%	Did not meet goal[3]; 97%	Met goal; 127%
Likelihood to recommend ratings	94%	N/A	N/A	N/A	98%	98%	100%	100%	99%
Saturation of used appliances on the secondary market	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Track in future program years
Program satisfaction ratings	99%	N/A	N/A	96%	99%	98%	100%	100%	99%
Satisfaction with pick-up staff service	N/A	N/A	N/A	N/A	N/A	N/A	100%	99%	97%[4]
Satisfaction with pick-up staff professionalism	N/A	N/A	N/A	N/A	N/A	N/A	100%	98%	98%
Satisfaction with the time between appointment and pick-up	N/A	N/A	N/A	N/A	N/A	N/A	97%	93%	96%
Ease of scheduling ratings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	96%

[1] Market performance indicators were not complete for Appliance Recycling Program in 2012.

[2] Market performance indicators and a process evaluation were not completed for Appliance Recycling Program in 2013.

[3] Vectren increased kWh savings goal by 24% and increased program participation goal from 1,200 units to 1,500 units in 2019.

[4] Satisfaction with pick-up staff service is the average between ratings given by contact and contactless pick-up participants (two separate questions in the survey).

Smart Cycle Program

Through the Smart Cycle Program, Vectren direct installs smart thermostats in residential homes to call load control events during the summer peak season. The program targets demand reductions during peak summer hours but also achieves energy savings from the smart thermostats throughout the year.

Each year, Vectren recruits participants from the long-running Summer Cycler Program to transition to the Smart Cycle Program.[45] Summer Cycler Program participants receive complimentary removal of their load control switches, a Nest thermostat installed by a technician at no additional cost, and automatic enrollment in the Smart Cycle Program.

Vectren contracted with a local HVAC company, A+Derr, to schedule and remove the Summer Cycler load control switches and replace them with Nest thermostats. The evaluation of the 2020 Smart Cycle Program focused only on savings derived from normal use of the Nest thermostats that were directly installed during the 2020 program year. Cadmus did not evaluate the demand response impacts from the program's load control events during 2020.

Accomplishments

Table 97 shows the program's achievements against goals in 2020. The Smart Cycle Program did not achieve its savings and participation goals due to the COVID-19 pandemic. Vectren suspended in-home installations from April through September 2020 to protect the health and safety of its installation contractors and customers.

Table 97. 2020 Smart Cycle Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	31,321	364,200	9%
Gross kW Savings	95	1,100	9%
Participants (measures)	86	1,000	9%
Program Expenditures	$397,184	$582,627	68%

[1] Goals and achievements from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values.

Table 98 shows electric savings for the Smart Cycle Program.

Table 98. 2020 Smart Cycle Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	31,321	31,321	30,945	43,196	138%	94%	40,713
Total kW	95	95	93	0	0%	N/A	0

45 The Summer Cycler Program is one of the Vectren programs designed to reduce the electricity loads of residential and small commercial air conditioning and water heating during summer peak hours. Through this program, customers receive bill credits for allowing Vectren to use radio communication equipment and load control switches to cycle off selected appliances during the summer.

The kWh realization rate of 138% results from differences between *ex ante* and *ex post* assumptions of home heating fuel. Cadmus was unable to verify the exact assumptions, but comparison to the *ex ante* savings from 2019 indicates a low share of electric heating was assumed for 2020 *ex ante* savings. In 2020, no survey was conducted because the participant population was small, so Cadmus applied the 2019 survey results, which found that 18% of surveyed participants had heat pumps and 13% had electric furnaces.

The kW realization rate of 0% is because there are not enough data to support applying peak demand savings for Nest thermostats aside from the savings achieved through load control events. The 2015 Indiana TRM v2.2 assumes no coincident peak demand reduction for Nest thermostats,[46] and Cadmus could derive no consensus from researching 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.

Conclusions and Recommendations

Program Administration and Delivery

Vectren could not direct install thermostats, at the pace planned, because of the COVID-19 pandemic. Installations were suspended from April to September 2020 due to the pandemic. Prior to the suspension, the program was operating successfully and had installed 72 thermostats. When installations resumed in October, A+Derr, the subcontractor, contacted customers it had recruited earlier in the year but found it difficult to get these customers to recommit. In all, the program installed 86 thermostats in 2020, far fewer than the goal of 1,000 thermostats.

Peak Demand Savings for Smart Thermostats

There are not enough data to support applying peak demand savings for smart thermostats aside from savings achieved through load control events. The 2015 Indiana TRM v2.2 assumes no coincident peak demand reduction for smart thermostats, and Cadmus could derive no consensus from researching 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. There are conflicting approaches within the industry, so this topic warrants further discussion during the development of the updated Indiana TRM. The 2020 Smart Cycle evaluation focused only on savings from normal use of the smart thermostats; therefore, this conclusion does not speak to the demand response impacts from Smart Cycle load control events during 2020.

Recommendation: For planning purposes, assume no coincident peak demand savings for normal use of smart thermostats until the new Indiana TRM is released and provides updated guidance.

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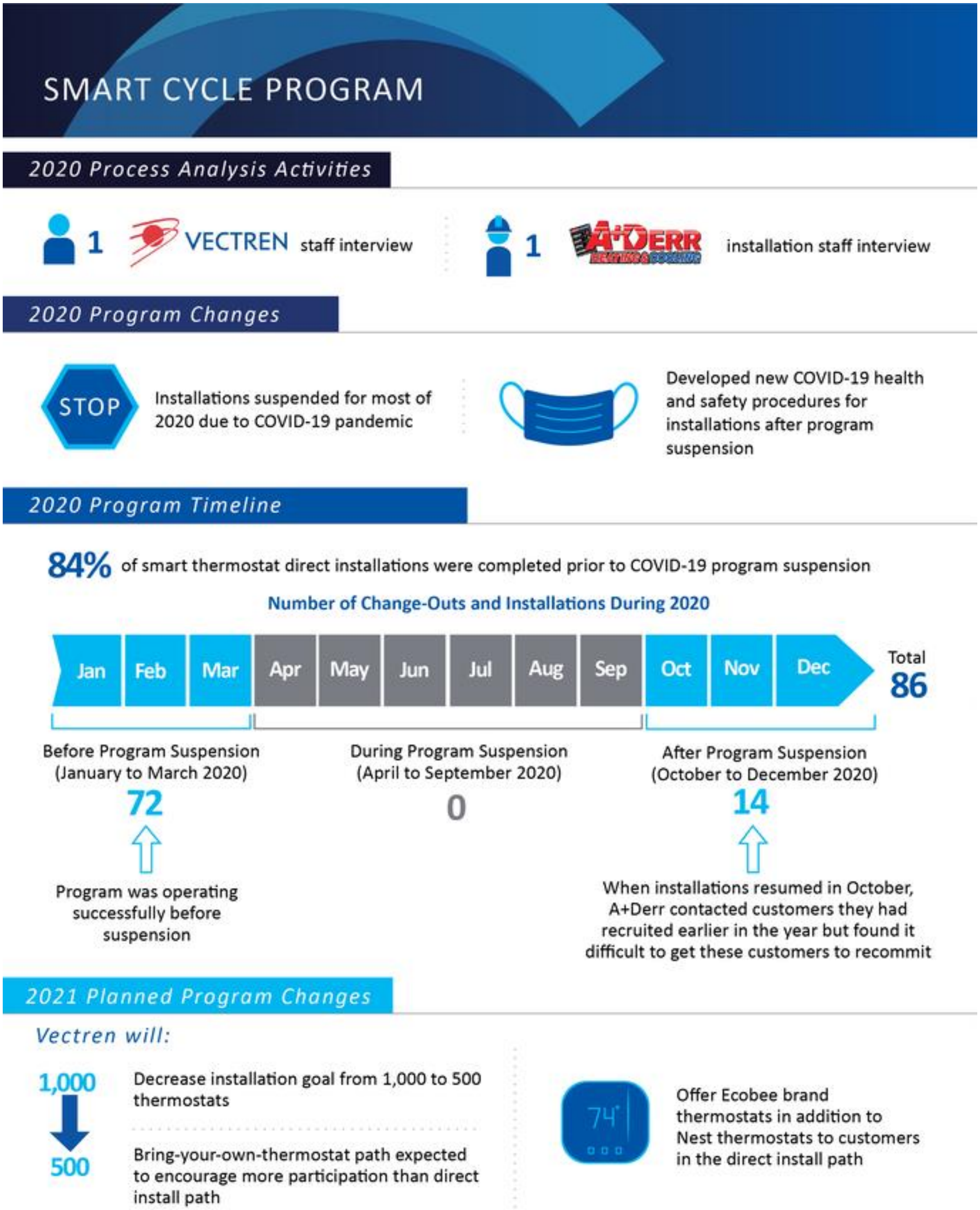
46 Cadmus, Opinion Dynamics, Integral Analytics, and Building Metrics. July 28, 2015. *Indiana Technical Reference Manual, Version 2.2.* Prepared for Indiana Demand Side Management Coordination Committee and EM&V Subcommittee.

Process Evaluation



Impact Evaluation

Impact Evaluation Methods and Findings

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

- Tracking database review
- Engineering desk review

Gross Savings Review

Table 99 provides per-unit annual gross savings for each program measure.

Table 99. 2020 Smart Cycle Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Smart Cycle Thermostat - Dual Fuel	364	305	1.1	0
Smart Cycle Thermostat - Electric		974		0

The difference between reported and evaluated kWh savings is probably due to differences in *ex ante* and *ex post* assumptions of home heating fuel. Cadmus was unable to verify the exact assumptions, but comparison to the *ex ante* savings from 2019 indicates a low share of electric heating was assumed for 2020 *ex ante* savings. In the 2019 evaluation, 18% of surveyed participants had heat pumps and 13% had electric furnaces. No survey was conducted in 2020 because the participant population was small, so Cadmus applied these 2019 survey results for home heating fuel to the 2020 evaluation.

The 2015 Indiana TRM v2.2 does not assign coincident peak demand savings for smart thermostats, shown as 0 kW evaluated savings in Table 99. Additional details for measure-level savings can be found in *Appendix A. Impact Evaluation Methodology.*

Table 100 lists historical evaluated gross per-unit energy savings for the smart thermostats since 2018, the Smart Cycle Program's inaugural year.

Table 100. Smart Cycle Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)		
	2018[1]	2019	2020
Smart Cycle Thermostat - Dual Fuel	283	298	305
Smart Cycle Thermostat - Electric	703	907	974

[1] The Smart Cycle Program launched in 2018.

The difference in electric savings between 2019 and 2020 is mainly driven by the assumed heating capacity of a home's HVAC system, which is derived from the average capacity of heat pumps installed in the 2020 Residential Prescriptive Program. This capacity increased to approximately 33,500 BTUH in 2020 from approximately 32,500 BTUH in 2019. 'Correct use rates' for thermostats used to evaluate savings for the Smart Cycle Program are based on the participant survey conducted for the 2020

Residential Prescriptive Program.[47] These correct use rates for thermostats decreased from 2019 to 2020, which contributed to the increase in energy savings.

Measure Verification

Cadmus calculated verified savings for the Smart Cycle thermostats by applying an in-service rate, as shown in Table 101. The in-service rate is based on results of the 2019 survey that asked participating customers if they had removed the smart thermostat after it was installed. Due to the small participation population in 2020, Cadmus did not field a customer survey and instead applied 2019 survey results for in-service rates.

Table 101. 2020 Smart Cycle Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited[1]	Verified	
Smart Cycle Thermostat - Dual Fuel	86	60	59	99%
Smart Cycle Thermostat - Electric		26	26	99%
Total	**86**	**86**	**85**	**99%**

[1] Vectren's 2020 Electric DSM Scorecard does not break out Smart Cycle thermostat installations by fuel type. Cadmus applied fuel and equipment type saturations determined from 2019 Smart Cycle survey data to distribute the total installations across these two thermostat fuel types.

Table 102 shows historical in-service rates for the Smart Cycle Program. In 2018, Vectren's reported installations accounted only for thermostats installed in time for summer load control events; however, the 2018 evaluation verified a higher number of installed thermostats contributed to year-round energy savings. The 2019 and 2020 in-service rate results are both derived from the 2019 Smart Cycle participant survey.

Table 102. Smart Cycle Historical In-Service Rates

Measure	In-Service Rate		
	2018	2019	2020
Smart Cycle Thermostat - Dual Fuel	107%	99%	99%
Smart Cycle Thermostat - Electric	107%	99%	99%

Net-to-Gross Analysis

Cadmus calculated net savings for the Smart Cycle Program by applying 2019 measure-specific NTG ratios calculated from 2019 survey results. The overall program NTG of 95% is weighted based on 2020 electric and gas gross evaluated program savings. However, the electric-specific NTG ratio of 94% is weighted specifically to 2020 electric savings. Table 103 presents the NTG results for the program.

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[47] Correct use rate is the percentage of homeowners who use their basic programmable or non-learning Wi-Fi thermostat in an energy-saving manner (i.e., by turning the setpoint down in the winter or up in the summer).

Table 103. 2020 Smart Cycle Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio	Total Program *Ex Post* MMBTU Savings
Total Program	9%[1]	4%[1]	95%[1]	474
Electric-Specific NTG			**94%**	**146**
Gas-Specific NTG			**96%**	**328**

[1] Weighted by 2020 evaluated *ex post* program MMBtu savings

Table 104 shows the 2019 measure-specific NTG ratio results that were applied to 2020 gross program savings.

Table 104. 2019 Smart Cycle Program Net-to-Gross Ratio Results

Measure	Freeridership	Spillover	NTG Ratio
Smart Cycle Thermostat - Dual Fuel	9%	5%	96%
Smart Cycle Thermostat - Electric	8%	1%	93%

Evaluated Net Savings Adjustments

Table 105 and Table 106 list evaluated net savings for the Smart Cycle Program. The program achieved net savings of 40,713 kWh and 0 coincident kW demand reduction.

Table 105. 2020 Smart Cycle 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				
Smart Cycle Thermostat - Dual Fuel	21,794	21,794	21,533	18,024	83%	96%	17,303
Smart Cycle Thermostat - Electric	9,527	9,527	9,413	25,172	264%	93%	23,410
Total[1]	**31,321**	**31,321**	**30,945**	**43,196**	**138%**	**94%**	**40,713**

[1] Totals may not add up to the sum of the column due to rounding.

Table 106. 2020 Smart Cycle Demand Reduction (Coincident Peak kW)

Measure	*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				
Smart Cycle Thermostat - Dual Fuel	65.83	65.83	65.04	0	0%	96%	0
Smart Cycle Thermostat - Electric	28.77	28.77	28.43	0	0%	93%	0
Total	**94.60**	**94.60**	**93.46[1]**	**0**	**0%**	**N/A**	**0**

[1] Totals may not add up to the sum of the column due to rounding.

Food Bank Initiative

Through the Food Bank Initiative (formerly referred to as the Food Bank LED Distribution Program and the Community-Based LED Distribution Program), Vectren partners with 19 food banks and four trustee offices in its territory to distribute one 4-pack of general purpose, 9-watt LED bulbs at no cost to qualifying food bank patrons.[48] 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 and trustee office staff receive and distribute the program bulbs.

In 2020, the program distributed LEDs in two waves. The first wave took place in May and the second wave in November. With each box of bulbs, Vectren included educational content and cross-promotional information for the recipient to review along with a brief postcard survey to assess installation rates and customer satisfaction. Bulb recipients were asked to complete the postcards and, in 2020, mail them directly to Vectren. In previous years, recipients could return the postcard to a box stationed in each partnering food bank and trustee office. However, COVID-19 social distancing protocols prevented food banks and trustee office patrons from being able to utilize these drop-off boxes. To encourage the return of the postcards, Vectren offered recipients the chance to win one of four $25 Walmart gift cards.

Accomplishments

Table 107 shows program achievements against goals in 2020. The Food Bank Initiative met all of its goals, distributing a total of 50,496 bulbs to food bank patrons.

Table 107. 2020 Food Bank Initiative Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	1,488,420	1,488,420	100%
Gross kW Savings	207	207	100%
Participants (bulbs)	50,496	50,496	100%
Program Expenditures	$136,445	$136,868	100%

[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values.

Table 108 lists the evaluated savings summary for the Food Bank Initiative. The realization rate is below 100% because Cadmus applied an 84% in-service rate and 4% leakage rate to program savings.

[48] Trustee offices, run by elected officials (trustees), are typically the first stop for someone who needs income assistance. Trustee offices provide services, such as food vouchers and assistance with rent, medical, and utility bills, to income-qualified residents of their communities.

Table 108. 2020 Food Bank Initiative Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	1,488,420	1,488,420	1,200,623	1,206,151	81%	100%	1,206,151
Total kW	207	207	167	166	80%	100%	166

Conclusions and Recommendations

Program Delivery

Despite COVID-19 impacts, the Food Bank Initiative was able to successfully meet its participation and savings goals. The program successfully delivered LED bulbs to participating food banks and trustee offices through contactless drop-offs. To continue to serve customers, food banks and trustee offices took precautionary steps, such as contactless pick-up and services, and all bulbs were delivered through Vectren's partners.

Contactless pick-up and services may have impeded postcard return rates. This year, the program had a postcard return rate of 1%, probably due to changes in how customers were able to obtain items from food banks and receive trustee services. In previous years, customers could place completed postcards in drop-off boxes at food banks and offices, and return rates were between 3% and 6%. In 2020, customers could only mail back the postcards themselves. Cadmus received 178 postcard records, but after removing duplicates, records without valid phone numbers, and individuals who asked to not be contacted, there were only 109 valid records for its survey sample. The phone survey achieved a 10% response rate with 11 responses, but this was insufficient data for the 2020 impact evaluation, so Cadmus relied on 2019 survey data instead.

Recommendation: If contactless options remain in place during the 2021 LED bulb distributions, consider mechanisms such as outdoor drop-off boxes, an online response option, and/or a higher incentive to increase the postcard response rate.

Customer Satisfaction

Customers are highly satisfied with the LED bulbs. The program design successfully incorporated the food banks and trustee offices as trusted partners in helping Vectren target the hard-to-reach low-income segment, as evidenced by high customer satisfaction and achievement of 100% program participation. All 11 surveyed recipients said they were satisfied with their bulbs.

Market Transition

Vectren will phase out general service LEDs from its portfolio in 2021. Vectren is exploring opportunities to distribute specialty LEDs through the Food Bank Initiative. Since the program launched in 2016, Cadmus has established the program's baseline using the Uniform Methods Project approach. This approach aligns with the baseline assumptions for all residential lighting measures in Vectren's portfolio. However, as Vectren transitions to distribute new products in 2021 and beyond, it may want to consider collecting supplemental baseline data to better understand how its market is transitioning over time. There are fewer options for specialty bulb replacements than general service bulbs.

Recommendation: Collect baseline data for the types of bulbs replaced by program bulbs in income-qualified customer homes to better understand customers' baseline conditions during halogen phase-out periods. These data can be collected through the postcard surveys or evaluation surveys (evaluation surveys are preferred since the postcard survey response rate is historically low).

Process Evaluation

FOOD BANK INITIATIVE

2020 Process Analysis Activities

1 VECTREN staff interview

1 CLEAResult® staff interview

11 phone surveys with bulb recipients (10% of postcard response)

2020 Program Changes

VECTREN enacted temporary delivery changes in response to COVID-19:

- Contactless drop-off of LEDs to food banks
- LED packages distributed to customers via contactless or drive-through pick-up

2021 Planned Program Changes

General service LED bulbs will no longer be distributed through the program; Vectren is exploring specialty bulb options for distribution

Continue COVID-19 delivery precautions, as needed

6'

Key Process Evaluation Findings

Bulb Recipient Survey Results:

11/11	satisfied with LEDs
9/11	were renters
6/11	had **not** installed LEDs in their home prior to the program
5/11	were aware Vectren sponsored the program
3/11	participated in another Vectren program as a result of the bulb giveaway: • Income Qualified Weatherization (n=2) • Residential Lighting (n=1)

Bulb Recipient Housing (n=11)

Single-Family Home	Multifamily Home
7	4

Bulb Recipient Age (n=10)

18 - 35	36 - 59	60 +
3	4	3

10/11	satisfied with variety of programs offered by Vectren
9/11	found Vectren's suggestions to reduce energy usage useful
8/10	satisfied with Vectren's efforts to help them manage their monthly usage

Impact Evaluation

Impact Evaluation Methods and Findings

The Food Bank Initiative impact evaluation included two evaluation tasks:

- Analysis of tracking database to review the number of LED bulbs distributed
- Engineering analysis to determine energy and demand savings based on the 2015 Indiana TRM v2.2 and the Residential Lighting Evaluation Protocol of the Uniform Methods Project (UMP)

Gross Savings Review

Table 109 provides per-unit annual gross savings for the program LEDs (these savings do not include adjustments for leakage and in-service rate). Additional details for measure-level savings can be found in *Appendix A. Impact Evaluation Methodology*.

Table 109. 2020 Food Bank Initiative Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
9-Watt LED	29	30	0.0041	0.0041

The small difference between reported and evaluated per-unit gross savings was because Cadmus used weighted average waste heat factors of electric space heating and cooling equipment by city, which changes from year to year based on where bulb recipients live. Cadmus used the default heating and cooling equipment from the 2015 Indiana TRM v2.2 and 2019 survey data to identify the city in which bulbs were distributed.[49]

Table 110 lists the evaluated gross per-unit energy savings for each program measure by year.

Table 110. Food Bank Initiative Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)[1]				
	2016	2017	2018	2019	2020
9-Watt LED	25	N/A[2]	29	30	30

[1] Evaluated savings vary because the distribution of waste heat factors by city changes from year-to-year based on survey results.
[2] Vectren did not offer the program in 2017.

[49] Cadmus conducted phone surveys with 11 bulb recipients (10% of available population sample data). Because of the low response rate in 2020, Cadmus used 2019 survey data (n=70) for all impact evaluation analysis.

Measure Verification

Cadmus verified measure installations in 2020 by using the estimated in-service rate (ISR) and leakage from the 2019 participant survey, which Cadmus designed to follow the Residential Lighting Evaluation Protocol in the UMP.[50] Due to COVID-19 and contactless bulb distribution in 2020, Vectren received fewer than 120 postcards with survey responses, which are needed to collect contact data for the evaluation survey.

Cadmus conducted a phone survey with 2020 bulb recipients and received 11 completes (a 10% response rate). Due to the small survey sample, the results did not achieve 90% confidence with 10% precision; therefore, Cadmus used the 2019 survey results for its impact evaluation assumptions.

Table 111 shows the overall measure verification of the Food Bank Initiative. The adjustments for in-service rate (84%) and leakage (4%) are derived from the number of bulbs currently installed in Vectren's service territory, as extrapolated from 2019 survey results. Cadmus estimated that 96% of the installed bulbs stayed in Vectren territory in 2020. For a more detailed explanation of the 2019 in-service and leakage rates, see the 2019 Vectren Indiana Evaluation.[51]

Table 111. 2020 Food Bank Initiative Measure Verification Results – In-Service Rates

Measure	Installations[1]				Adjustments		
	Reported	Audited	Verified (ISR)	Verified (ISR and Leakage)	In-Service Rate	Leakage[2]	Total (ISR and Leakage)[3]
9-Watt LED	50,496	50,496	42,217	40,732	84%	4%	81%

[1] When applying in-service rate and leakage, total installations may not sum due to rounding.
[2] The percentage of bulbs that stayed in the service territory is 96%.
.[3] Total adjustment rate equals ISR multiplied by (1-leakage rate).

Table 112 shows historical in-service rates for each program measure. In-service rates vary by the number of bulbs respondents put into storage each year (reported via survey results).

Table 112. Food Bank Initiative Historical In-Service Rates

Measure	In-Service Rate				
	2016	2017	2018	2019	2020
9-Watt LED	86%	N/A	88%	84%	84%

[50] Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68562.pdf

[51] Cadmus. June 5, 2020. *2019 Vectren Demand-Side Management Portfolio Process and Electric Impacts Evaluation*.

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 net-to-gross (NTG) ratio is assumed to be 100%.

Evaluated Net Savings Adjustments

Table 113 and Table 114 list evaluated net savings for the Food Bank Initiative. The program achieved net savings of 1,206,151 kWh and 166 coincident kW demand reduction.

Table 113. 2020 Food Bank Initiative 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				
9-Watt LED	1,488,420	1,488,420	1,200,623	1,206,151	81%	100%	1,206,151
Total	**1,488,420**	**1,488,420**	**1,200,623**	**1,206,151**	**81%**	**100%**	**1,206,151**

Table 114. 2020 Food Bank Initiative Demand Reduction (Coincident Peak kW)

Measure	*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				
9-Watt LED	207	207	167	166	80%	100%	166
Total	**207**	**207**	**167**	**166**	**80%**	**100%**	**166**

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and key performance indicators (KPIs) for the Food Bank Initiative. 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 INITIATIVE

Market Actor	End-Use Customer	Food Bank and Trustee Office Patrons	
Market Barriers		• Lack of program awareness • Higher cost of efficient light bulbs • Lack of energy efficiency education	• Skepticism of true energy savings • Negative associations with energy-efficient lighting • COVID-19 creates concern about social distancing when receiving bulbs
Intervention Strategies / Activities	• LED bulbs offered to customers at no cost • Program signage prominent in food banks and trustee offices	• Income-Qualified Weatherization Program information on bulb box • ENERGY STAR-certified bulbs to ensure quality	• Contactless option for bulb pickup
Outcomes	• Increased participation • Increased customer satisfaction • Increased awareness	• Increased energy savings • Improved customer perception of efficient lighting technologies • Continuation of program services	• Increased saturation of efficient lighting technologies • Increased awareness of Vectren energy efficiency programs
Key Indicators	• Achievement of program participation and savings goals • Installation rate • Persistence of measures		• Efficient lighting saturation in Vectren's territory • Conversion to other Vectren energy efficiency programs • Bulb satisfaction ratings

Market Actor	Trade Allies	Food Bank and Trustee Office Staff	
Market Barriers	• Lack of program understanding • COVID-19 creates health/safety concern for distribution staff	• Inability to encourage postcard return	• Lack of understanding of benefits of efficient lighting
Intervention Strategies / Activities	• Program implementer trains food bank and trustee office staff how to deliver program • Contactless option for bulb pickup		• Incentive for returned postcards • Program signage prominent in food banks and trustee offices
Outcomes	• Bulbs effectively distributed to food bank and trustee office patrons • Ability to contact bulb recipients to confirm installation of products	• Increased saturation of energy efficient lighting • Continuation of program services	• Increased program understanding
Key Indicators	• Achievement of program participation and savings goals • Number of bulbs distributed • Installation rate	• Efficient lighting saturation in Vectren's territory • Postcard response rate	

Program Performance

Cadmus measured 2016, 2018, 2019, and 2020 program performance against the KPIs listed in Table 115. Vectren did not deliver the program in 2017.

Table 115. Food Bank Initiative KPI and 2016 and 2018-2020 Performance

Key Performance Indicator	Performance			
	2016	2018	2019	2020
Achievement of Program Participation Goals	100%	100%	150%	100%
Achievement of Gross kWh Savings Goals	100%	100%	150%	100%
Achievement of Gross kW Savings Goals	100%	100%	150%	100%
Number of Bulbs Distributed	24,288	50,496	74,744	50,496
Installation Rate (after Initial Receipt of Bulbs)	86%	94%	90%	90%
In-Service Rate (Persistence of LED Bulbs)[1]	N/A	88%	84%	84%
Bulb Satisfaction Rate	88%[2]	100%	97%	100%[3]
Efficient Lighting Saturation in Vectren's Territory	N/A	43%[4]	48%	45%
Conversion to other Vectren Energy Efficiency Programs	N/A	9%	10%	30%[5]
Postcard Response Rate[6]	3%	6%	5%	1%[7]

[1] This percentage is based on final-year installation rates.
[2] The 2016 results are derived from the postcard survey using a different scale than used in the 2018 through 2020 participant surveys 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 through 2020 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.
[3] n=11, which is much smaller than previous years
[4] This percentage refers to market penetration based on survey results for the question: "Before receiving these bulbs, had you used an LED light bulb in your home?" Track efficient lighting saturation in future program years.
[5] n=10, which is much smaller than previous years.
[6] These are the evaluated response rates, after checking for duplicate responses.
[7] The impacts of COVID-19 probably lowered the postcard response rate because many food bank patrons may not have had access to postcard drop-off boxes as in the past. Most recipients in 2020 received bulbs through contactless distribution.

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 businesses. Vectren offers financial incentives to offset the higher purchase costs of high-efficiency upgrades for lighting, refrigeration, commercial kitchen, and HVAC equipment. The program implementer, Nexant, processes program paperwork and, with the help of trade allies, promotes the program to Vectren customers.

Accomplishments

Table 116 shows the program's achievements against goals in 2020. The C&I Prescriptive Program achieved 80% of its energy savings and 87% of its demand reduction goal. During interviews, Vectren said the C&I Custom Program, which is jointly marketed to prospective participants with the C&I Prescriptive Program, captured a larger portion of the pipelined C&I projects than Vectren initially expected.[52]

Table 116. 2020 C&I Prescriptive Program Goals and Achievements[1]

Unit	2020 Actual	2020 Planning Goal	Percentage of Goal
Gross kWh Savings	10,440,016	13,100,000	80%
Gross kW Savings	2,197	2,513	87%
Participants (measures)	34,998	30,672	114%

[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values. Program expenditures are tracked at the commercial sector level rather than by program.

Table 117 lists the evaluated savings summary for the C&I Prescriptive Program. The program realization rate was 96% for energy and 100% for demand. Like previous years, differences in reported and evaluated savings were primarily because Cadmus incorporated early replacement savings (which increased measure savings) and updated baseline standards (which decreased measure savings for refrigeration equipment) and because participant-specific survey results vary from year to year.

Table 117. 2020 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	10,440,016	10,440,016	10,434,950	10,025,648	96%	86%	8,649,572
Total kW	2,197	2,197	2,196	2,205	100%	86%	1,902

[52] The C&I Custom Program achieved 100% of its electric energy savings and 38% of its demand reduction goals. According to program staff, it is common for nonresidential projects and savings to shift year to year between the custom and prescriptive programs.

Conclusions and Recommendations

Customer Satisfaction

C&I Prescriptive Program participants are highly satisfied. Most surveyed participants were very satisfied with the program overall (87%, n=69) and are very likely to recommend the program to another business (84%, n=70).

Marketing and Outreach

The implementer developed a trade ally engagement strategy to enable future program success. In 2020, the implementer developed tools and resources to engage trade allies in Vectren's C&I Custom, Prescriptive, and Small Business Energy Services programs. Trade allies can enroll in the network at varying levels to gain access to an online portal stocked with resources, program listing via the Find a Trade Ally search engine, Vectren logo for use in marketing, a Mobile Assessment Tool equipped for on-site assessments, online rebate application submittal, and direct deposit rebate payments. Due to outreach restrictions stemming from the COVID-19 pandemic, the implementer was unable to adequately market the portal and plans to promote it in 2021 with updated, CenterPoint Energy-branded materials. The implementer has set a goal to have 150 contractors enrolled across Vectren's three C&I programs. Participating trade allies declined to 128 in 2020, so this effort should help bolster trade ally participation and maintain the proportion of continuing trade allies (in 2020, 59% had participated over multiple years).

Lighting

Lighting remains the program's dominant measure category, but upcoming changes in federal standards may diminish savings over time. Of the 2020 lighting measures, 49% of evaluated electric savings come from linear fluorescent replacements with LEDs, 20% from high bay LEDs, and 9% from single socket LEDs. Seventy-nine percent of linear fluorescent baselines were T8s, 4% were T12s, and for 16% of the projects with fluorescents to LEDs the specific baseline equipment could not be determined.[53] The current federal standard is for T8s, but T12s are still manufactured. [54] If the federal standard is enforced, it could affect future savings.

Based on 2020 data, savings for at least 4%, and possibly as much as 22%, of the fluorescents to LEDs could drop in upcoming years (assuming all replacements with unknown baseline equipment are T12s). An update to the baseline federal standard for high bay LEDs could become effective in 2023, which would lower the savings.

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53 The data do not report the equipment type. The tracking data only report the baseline wattage.

54 Reference to the availability of T12s (section 4.5.3, page 439). Illinois Energy Efficiency Stakeholder Advisory Group. October 17, 2019; effective January 1, 2020. *2020 Illinois Statewide Technical Reference Manual Version 8.0.* https://www.ilsag.info/technical-reference-manual/il_trm_version_8/

Recommendation: Track baseline equipment assumptions for all LED measures, especially fluorescent to LED replacements. For fluorescent to LED replacements, the tracking database reports all baselines as "T12 or T8." Specify actual equipment data to assess savings more accurately, even as federal standards shift.

For lighting measures, the implementer currently reports the values for all needed inputs—wattage, hours of use, interaction effects, etc. However, Cadmus had difficulty recreating reported savings using the reported inputs. The issue appears to be that waste heat factors and coincidence factors are not reported in the tracking database and that the data provided to Cadmus differed from factors used to calculate reported savings.

Recommendation: The implementer should include waste heat factors and coincidence factors in the tracking database and, if this is not possible, provide Cadmus the factor assumptions used for its reported savings.

Process Evaluation

C&I PRESCRIPTIVE PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 Nexant staff interview

70 phone surveys with participating customers

2020 Program Changes

Vectren revised its **midstream incentive offering, discontinuing HVAC measures and adding food service measures**, incenting 7 measures through one of the three enrolled commercial kitchen equipment distributors

In August, Vectren launched rebates for **advanced rooftop controls**

Nexant hosted a training for HVAC contractors to promote the initiative

Nexant developed a **trade ally engagement strategy** with partnership levels and exclusive benefits. Energy Savings Partners receive:

- **Find a Trade Ally** customer search engine listing
- **Trade Ally Connect** online portal for key program materials and updates
- **Vectren logo use** and cobranding options
- **Direct deposit** for rebates
- **Mobile Assessment Tool**, which provides an assessment report and resources simplifying the application process, including online rebate application submittal

2021 Planned Program Changes

Vectren will:

- Offer a **compressed air leak study incentive**, covering the cost of the study when participants commit to fixing a percentage of leaks found
- Decrease **lighting** incentives to account for evolving market conditions
- Revise incentives for boiler tune ups from a flat $200 rebate to $0.20 per MBtu up to $1,000 to encourage larger **boiler tune up** projects

Nexant will promote trade ally portal

Goal to enroll 150 contractors across Vectren's three C&I programs

Key Process Evaluation Findings

87% (n=69) of participants were **very satisfied** with the **program overall**

63% (n=67) of participants learn about rebates from **contractors**

76% (n=70) of participants worked with a contractor on their project

Of those (n=52), 90% were **very satisfied** with their **contractor**

67% (n=70) of participants visited **Vectren.com** for energy efficiency program information

68% (n=47) of those who visited the website found it **very user friendly** and 91% encountered no issues navigating

Impact Evaluation

Impact Evaluation Methods and Findings

The C&I Prescriptive Program impact evaluation included multiple data collection efforts and analysis tasks:

- Audit program tracking database for alignment with 2020 Electric 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 v2.2 or, for measures not present, the Illinois TRM V8.0,[55] with occasional adjustments from the Wisconsin Focus on Energy 2020 TRM[56]
- Incorporate site-specific findings, including in-service rate, spillover, and freeridership into evaluated savings via telephone surveys with participants (n=70)
- Incorporate early replacement savings for air conditioning, heat pump, lighting measures identified as retrofit projects

Gross Savings Review

Figure 3 shows the total *ex post* savings for all measure categories and measures. Lighting upgrades, chiller tune-ups, and thermostats comprised 97% of the program's evaluated electric impacts. Lighting upgrades alone comprised 88% of program savings.

The 2020 program tracking data contained 58 unique measure names, so Cadmus presents its impact evaluation findings at the measure category-level. These measure categories are listed here and shown as the right bar in Figure 3:

- Chillers
- Compressed air systems
- HVAC
- Kitchen equipment
- Lighting
- Refrigeration
- Thermostats
- VFDs/motors

55 Illinois Energy Efficiency Stakeholder Advisory Group. October 17, 2020. *2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0—Volume 2: Commercial and Industrial Measures*. https://ilsag.s3.amazonaws.com/IL-TRM_Effective_0-10-120_v8.0_Vol_2_C_and_I_10-17-19_Final.pdf

56 Wisconsin Focus on Energy. *2020 Technical Reference Manual*. https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf.

Figure 3. 2020 C&I Prescriptive Program Total *Ex Post* Electric Impacts by Measure Category and Measure

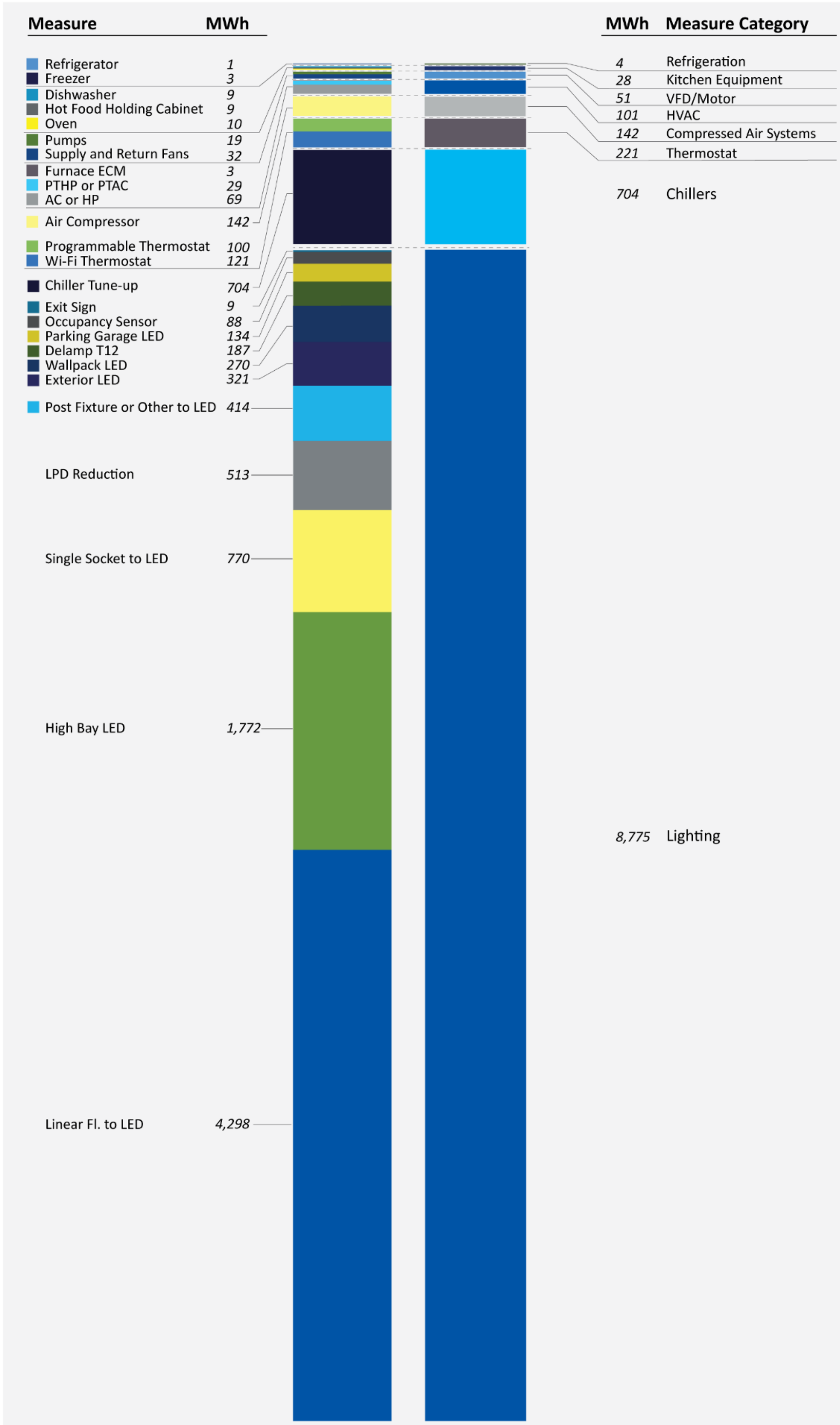

Table 118 lists the annual per-unit gross savings (total savings divided by installed units) for each measure category. Additional details for measure-level savings can be found in *Appendix A. Impact Evaluation Methodology*.

Table 118. 2020 C&I Prescriptive Program Per-Unit Gross Savings

Measure Category	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Chillers	15,661	16,017	14.21	14.53
Compressed Air Systems	71,243	71,094	7.39	7.37
HVAC	643	478	0.22	0.13
Kitchen Equipment	4,956	4,056	0.69	0.72
Lighting	264	253	0.04	0.04
Refrigeration	2,031	401	0.23	0.05
Thermostat	2,427	2,427	0.00	0.00
VFD/Motor	17,464	25,518	2.40	2.40

Table 119 summarizes the primary sources of differences in reported and evaluated per-unit savings for all measure categories. For the HVAC, kitchen equipment, refrigeration, and VFD/motor measure categories, reported per-unit savings differed from evaluated per-unit savings by more than 10%. For all other measure categories, reported and evaluated per-unit savings were within 5%.

Table 119. Summary of Differences in Per-Unit Savings

Measure Category	Updated Federal Baseline Standards	Updates for Early Replacement Baseline	Corrected Algorithm Inputs	Tracking Database Error	No Difference in Reported/ Evaluated Savings
Chillers				✓	
Compressed Air Systems			✓		
HVAC	✓	✓			
Kitchen Equipment			✓		
Lighting		✓	✓		
Refrigeration	✓		✓		
Thermostat					✓
VFD/Motor			✓		

Refrigeration measures had the largest difference—a decrease of 406% between reported and evaluated per-unit savings. The primary reason was that reported savings did not use the most recent federal standard as the baseline.[57] Another reason was that one commercial refrigeration unit met current federal standards, but not the current ENERGY STAR standards, and therefore received no

57 Code of Federal Regulations. Minimum Efficiency Standards for PTAC and PTHP. 10 CFR §431.62. "Energy conservation standards and their effective dates." https://www.ecfr.gov/cgi-bin/text-idx?SID=fb844b4072b6666f2a4aa4b3bb738eb5&mc=true&node=pt10.3.431&rgn=div5#sg10.3.431_164.sg5

savings. Differences in VFD/motor savings were due to a mistake in reported savings for one VFD measure. Cadmus corrected this mistake, which increased the evaluated energy savings.[58]

Table 120 lists evaluated gross per-unit energy savings for each measure category by year. The main driver of differences in savings over the years is due to variation in the type and number of measures installed within each measure category. For example, chillers in 2015, 2018, and 2019 consisted mostly of equipment upgrades, but in 2016, 2017, and 2020, these were mostly tune-ups, which produced lower per-installation savings.

Table 120. C&I Prescriptive Program Historical Per-Unit Savings

Measure Category	Evaluated Annual Gross Savings (kWh)					
	2015	2016	2017	2018	2019	2020
Chillers	54,296	11,111	18,420	88,781	80,420	16,017
Compressed Air Systems	N/A	N/A	81,021	73,533	66,674	71,094
HVAC	440	5,745	1,107	1,094	1,734	478
Kitchen Equipment	8,503	1,487	6,747	3,397	7,048	4,056
Lighting	332	453	372	408	344	253
Refrigeration	843	955	851	427	1,900	401
Thermostat	N/A	N/A	5,281	5,062	2,722	2,427
VFD/Motor	69,053	35,192	67,785	23,744	30,776	25,518

Measure Verification

Table 123 lists in-service rates for each program measure category. Cadmus used self-report survey data from 2020 program participants to determine measure persistence since initial installation. Cadmus' survey samples at the program-level, not the measure-level, so the program's in-service rate is calculated as all currently installed measures divided by all reportedly installed measures. In 2020, the C&I Prescriptive Program in-service rate was 99.95%.

The survey found that one thermostat, of 2,061 total reported measure installations, failed and was not yet replaced. Also, during Cadmus' audit of the tracking database, there was one extra reported chiller tune-up, but total reported savings matched evaluated savings because the total chiller tons were the same between the *ex ante* data and in the tracking database. Tons are the more appropriate "unit" to determine savings, but installations are based on the number of physical units. Table 123 shows this discrepancy, but Cadmus did not apply an additional change. Historical ISRs have been 100% (or within .10% of 100%) since 2015.

[58] Cadmus found the issue with the VFD/motor measure only for the energy savings. The peak demand savings followed the Illinois TRM V8.0 correctly.

Table 121. 2020 C&I Prescriptive Program Measure Verification Results – In-Service Rates

Measure Category	Installations			In-Service Rate[1]
	Reported	Audited	Verified	
Chillers	45[2]	44	44	100%
Compressed Air Systems	2	2	2	100%
HVAC	211	211	211	100%
Kitchen Equipment	7	7	7	100%
Lighting	34,633	34,633	34,616	100%
Refrigeration	9	9	9	100%
Thermostat	91	91	91	100%
VFD/Motor	2	2	2	100%
Total	**35,000**	**34,999**	**34,982**	100%

[1] All in-service rates are 99.95% but rounded to 100% in this table.
[2] For the C&I Prescriptive Program, Cadmus typically examines number of physical units installed. For chiller tune-ups, the number of installations refers to the number of chillers reported to have had a tune-up. However, the more appropriate unit to measure savings from chiller tune-ups is tons. Cadmus found that reported tons matched audited tons (reported savings also matched). However, one extra chiller tune-up was reported, but because tons were the same, savings were the same.

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.[59] The program resulted in an 86% NTG ratio. Table 122 presents the NTG results for the program. These findings are described in greater detail in *Appendix B. Net-to-Gross Detailed Findings.*

Table 122. 2020 C&I Prescriptive Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Total Program	15%[1]	1%	86%

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

Table 123 lists historical program-level NTG ratios by year. NTG results have remained consistent throughout the program years.

[59] NTG values are not calculated separately by fuel type. Electric and gas savings are combined and standardized using MMBtu and the overall NTG ratio is applied to both fuel types.

Table 123. 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%
2019	17%	0%	83%
2020	15%	1%	86%

Freeridership and Spillover

Cadmus estimated freeridership by combining the standard self-report intention method and the intention/influence method.[60] Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate the final program freeridership of 15%, as shown in Table 124.

Table 124. 2020 C&I Prescriptive Program Freeridership Estimate

Freeridership Metric	Estimate
Intention Score	21%[1]
Influence Score	10%[1]
Final Freeridership Score	**15%**

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

Three participants reported installing a total of three 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 used *ex post* savings for the 2020 C&I Prescriptive Program evaluation to estimate savings for all spillover measures attributed to the program, as shown in Table 125.

Table 125. C&I Prescriptive Spillover Estimates by Measure Category

Measure	Survey Sample Spillover MMBtu Savings	Survey Sample Program MMBtu Savings	Percentage Spillover Estimate
Total Program	25.6	2,006.1	1%

Evaluated Net Savings Adjustments

Table 126 and Table 127 list evaluated net savings for the C&I Prescriptive Program. The program achieved net savings of 8,649,572 kWh and 1,902 coincident kW demand reduction.

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

Table 126. 2020 C&I Prescriptive Program Electric Savings (kWh)

Measure Category	*Ex Ante* Savings (kWh)			Evaluated *Ex Post* Savings (kWh)	Realization Rates (kWh)	NTG Ratio	Evaluated Net Savings (kWh)
	Reported	Audited	Verified				
Chillers	704,761	704,761[1]	704,419	704,419	100%	86%	607,734
Compressed Air Systems	142,485	142,485	142,416	142,120	100%	86%	122,613
HVAC	135,713	135,713	135,647	100,854	74%	86%	87,011
Kitchen Equipment	34,690	34,690	34,674	28,381	82%	86%	24,485
Lighting	9,148,309	9,148,309	9,143,870	8,774,510	96%	86%	7,570,159
Refrigeration	18,276	18,276	18,267	3,608	20%	86%	3,113
Thermostat	220,853	220,853	220,746	220,746	100%	86%	190,447
VFD/Motor	34,928	34,928	34,911	51,011	146%	86%	44,009
Total[2]	**10,440,016**	**10,440,016**	**10,434,950**	**10,025,648**	**96%**	**86%**	**8,649,572**

[1] Even though reported quantities for chillers did not match evaluation quantities, total savings did match.
[2] Totals may not add up to the sum of the column due to rounding.

Table 127. 2020 C&I Prescriptive Program Demand Reduction (Coincident Peak kW)

Measure Category	*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				
Chillers	639	639[1]	639	639	100%	86%	551
Compressed Air Systems	15	15	15	15	100%	86%	13
HVAC	47	47	47	27	58%	86%	23
Kitchen Equipment	5	5	5	5	104%	86%	4
Lighting	1,485	1,485	1,484	1,513	102%	86%	1,306
Refrigeration	2	2	2	0	20%	86%	0
Thermostat	0	0	0	0	N/A	86%	0
VFD/Motor	5	5	5	5	100%	86%	4
Total[2]	**2,197**	**2,197**	**2,196**	**2,205**	**100%**	**86%**	**1,902**

[1] Even though reported quantities for chillers did not match evaluation quantities, total savings did match.
[2] Totals may not add up to the sum of the column due to rounding.

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and key performance indicators (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		• Program incentives for efficient technologies to offset initial upfront cost • Participating trade ally base to make installation timely and convenient
Outcomes	• Increased program awareness and participation • Improved customer perception of energy efficiency programs	• Increased market saturation of energy-efficient measures • Increased energy savings	
Key Indicators		• Likelihood to recommend ratings • Achievement of program participation and savings goals	• Participant satisfaction with the program

Market Actor	Trade Allies: Installation Contractors		
Market Barriers		• Administrative burden such as program eligibility and paperwork requirements	• Lack of program awareness
Intervention Strategies / Activities	• Program outreach staff train and communicate with trade allies about program offerings • Trade ally portal simplifies access to marketing materials to promote program to customers	• Program outreach staff cross-promote prescriptive and custom programs to deliver project assistance through a single procedure	• Provide project-level assistance to encourage trade ally engagement and adoption
Outcomes	• Increased contractor awareness of 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 • Achievement of program participation and savings goals	• Number of contractors participating in multiple years • Number of actively participating contractors • Average number of projects per contractor	

Program Performance

Cadmus measured 2015 to 2020 program performance against the KPIs listed in Table 128.

Table 128. C&I Prescriptive Program KPI and 2015-2020 Performance

KPI	Performance					
	2015	2016	2017	2018	2019	2020
Achievement of program participation goals	267%	133%	357%	170%	54%	114%
Achievement of gross kWh savings goals	100%	129%	197%	243%	75%	80%
Number of actively participating contractors (completed one or more projects)	N/A	N/A	195	157	160	128
Average number of projects per contractor	N/A	N/A	N/A	4	4	6
Number of contractors that participated in multiple C&I programs	N/A	N/A	16 of 195 (8%)	11 of 157 (7%)	14 of 160 (9%)	8 of 128 (6%)
Number of contractors participating for multiple years	N/A	N/A	N/A	66 of 157 (42%)	82 of 160 (51%)	76 of 128 (59%)
Participant satisfaction with the program (very satisfied)	74%	86%	84%	84%	84%	87%
Participant likelihood to recommend the program (very likely)	N/A	N/A	94%	90%	83%	84%
Contractor satisfaction with the program (very satisfied)	70%	N/A	N/A	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 enables business customers to implement energy-efficient projects that are not available through Vectren's other DSM programs. Projects are typically unique to the participant's business and require individual engineering analyses to determine savings. Vectren calculates program incentive levels on a basis of estimated first-year, amount-of-energy saved ($0.10 per kWh saved and $1.00 per therm saved). Incentives cannot exceed 50% of total project costs and have a maximum of up to $100,000 for qualified projects. Projects achieving a simple payback of one year or less do not qualify for the program.

The C&I Custom Program includes four subcomponents, as described in Figure 4.

Figure 4. 2020 C&I Custom Program Subcomponents

Vectren administers the program. Nexant, as program implementer, is responsible for program operations, managing day-to-day tasks, marketing (which it shares with Vectren), and confirming that all *ex ante* engineering calculations accurately represent installed measures for each project. The program implementer also subcontracted with Willdan to engage design teams to incorporate C&I Custom Program offerings into new construction building designs and sales practices. Trade allies, including design firms and installation contractors, promote the C&I Custom Program to customers and execute custom energy efficiency measures.

Accomplishments

During interviews, Vectren said the program implementer manages the commercial sector project pipeline at the sector level, rather than the program level. Because the implementer conducts outreach to commercial customers, project applications may fluctuate from year to year between the C&I Custom and C&I Prescriptive programs, depending on the needs of customers.

Table 129 shows the program's achievements against goals in 2020. The C&I Custom Program achieved 100% of its energy savings and increased its *ex ante* reported savings by over 900,000 kWh compared to

2019. However, the program achieved only 38% of its demand reduction goal. The low percentage, relative to savings achieved, was due to two main factors:

- In previous years, more than half the demand savings came from process updates and chiller replacements, but there were no such projects in 2020.
- 26% of the 2020 kWh savings were from exterior lighting projects, which do not contribute to reducing demand (kW).

Table 129. 2020 C&I Custom Program Goals and Achievements[1]

Unit	2020 Actual	2020 Planning Goal	Percentage of Goal
Gross kWh Savings	5,416,874	5,400,000	100%
Gross kW Savings	250	651	38%
Participants	39	56	70%

[1] Goals and achievements from Vectren's Electric 2020 DSM Scorecard. Actuals represent *ex ante* reported values. Program expenditures are tracked at the commercial sector level rather than by program.

Although Vectren does not set specific savings or participation targets for each program subcomponent, the following describes how each C&I Custom Program subcomponent performed in 2020 (*ex ante* reported achievements):

- **Custom incentives.** This made up the majority of the program's 2020 gross electric savings at 97%, compared to 83% in 2019 and 83% in 2018.
- **Commercial new construction.** The number of projects increased from 2019 to 2020, but most of the activity resulted in natural gas savings.[61] New construction projects accounted for less than 1% of 2020 gross electric savings achievement, a decrease compared to 14% in 2019 and 13.6% in 2018.
- **Building tune-up.** This subcomponent had a minor impact on program savings, with 3% of gross electric savings in 2020, same as the 3% in 2019.
- **Strategic energy management (SEM).** This subcomponent was introduced in 2019. To date, the implementer has recruited one customer to participate in an 18-month SEM training. Savings from this subcomponent will probably not be realized until 2021.

Table 130 lists the evaluated savings summary for the C&I Custom Program. Most applications exhibited reasonable savings estimates and calculation methodologies. Two application IDs required *ex post* adjustments, which resulted in a program realization rate of 97% for energy (kwh) and 101.7% for demand (kW).

[61] Natural gas results are presented in the *2020 Vectren DSM Portfolio Process and Natural Gas Impacts Evaluation.*

Table 130. 2020 C&I Custom 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	5,416,874	5,416,874	5,416,874	5,242,176	97%	96%	5,032,489
Total kW	250	250	250	254	102%	96%	244

Conclusions and Recommendations

Customer Satisfaction

Participants were satisfied with the C&I Custom Program. Nine of the 10 survey respondents reported being satisfied with the program and were very likely to recommend participation to another business.

Program Administration and Delivery

The C&I Custom Program reached its electric savings goal but not its demand reduction goal. The program achieved 100% of its electric savings goal, with 97% of the program’s savings achieved through its custom incentive component. Although *ex ante* reported savings for the program overall increased by over 900,000 kWh compared to 2019, demand savings were much lower than expected due to the mix of program measures.

Recommendation: If achieving demand reduction is important in the future, consider targeting projects that include process electric heating, chiller upgrades, or demand limiting through building management systems. Process heating and chiller upgrades contributed to a significant reduction in demand in previous program years.

Process Evaluation

C&I CUSTOM PROGRAM

2020 Process Analysis Activities

- 1 VECTREN staff interview
- 1 Nexant staff interview

10 phone surveys with participating customers

2020 Program Changes

In August, Vectren launched rebates for **advanced rooftop controls** and Nexant hosted a training for HVAC contractors to promote the initiative

Nexant developed a **trade ally engagement strategy** with partnership levels and exclusive benefits

2021 Planned Program Changes

Vectren will offer a **compressed air leak study incentive**, covering the cost of the study when participants commit to fixing a percentage of leaks found

Nexant will promote trade ally portal

Goal to enroll 150 contractors across Vectren's three C&I programs

150

Key Process Evaluation Findings

4/10

of surveyed participants visited Vectren.com for **energy efficiency program information**

9/10

surveyed participants **learned about rebates from contractors**. The remaining respondent learned through a Vectren account manager

3/4

of those who visited the website found it very or somewhat **user friendly** and all 4 encountered **no issues navigating**

9/10

surveyed participants were **satisfied with the program** & are **very likely to recommend** the program to other organizations

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
- Adjust the *ex post* savings estimations based on the desk review, where applicable.

Gross Savings Review

In 2020, 39 electric energy-saving measures were installed at 14 buildings under 15 application identifiers (IDs) through the C&I Custom Program: [62,63]

- 11 lighting or lighting control upgrades
- 3 variable frequency drive upgrades
- 2 building envelope upgrades
- 22 HVAC control-related installations or upgrades
- 1 refrigeration controls upgrade

Overall, evaluated savings closely aligned with Vectren's reported savings. Table 131 lists the reported and evaluated savings results for each electric application ID in the program. Several application IDs reported and were evaluated to have zero coincident peak demand savings. The reasons for this are either there was no reduction in demand or the reduction in demand occurred outside of the peak demand hours (e.g. exterior lighting where the demand reduction is at night). Additional details for application ID savings can be found in *Appendix A. Impact Evaluation Methodology*.

[62] An application ID is associated with an organization and may include one or multiple unique measure IDs.

[63] 2020 natural gas energy-saving projects are evaluated in the *2020 Vectren Demand-Side Management Portfolio Natural Gas Impacts Evaluation*.

Table 131. 2020 C&I Custom Program Per-Unit Gross Savings by Application ID

Application ID	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
1003214	9,376	9,376	2.7	2.7
1003286	397,302	397,302	129.1	129.1
1003333	715,589	578,232	31.6	35.8
1003335	663	663	1.0	1.0
1003484	33,475	33,475	-	-
1003660	12,424	12,424	-	-
1003702	532,111	532,111	-	-
1003703	529,314	529,314	-	-
1003704	1,315,270	1,315,270	-	-
1003705	310,652	310,652	-	-
1003706	568,551	568,551	-	-
1003797	152,008	114,668	4.0	4.0
1003803	323,460	323,460	-	-
1003846	484,379	484,379	63.1	63.1
1004011	32,301	32,301	18.6	18.6

In its review of electric applications, Cadmus performed desk reviews on 24 of the 39 measures under the 15 application IDs. These 24 measures made up 99.7% of the *ex ante* energy savings. For the remaining measures, 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. Cadmus adjusted savings for only two of the 15 electric application IDs, and these savings adjustments are summarized in Table 132.

Table 132. 2020 C&I Custom Program Savings Adjustments Summary

Application ID	Realization Rate	Adjustment to Reported kWh	Measure Type	Reason for Adjustment
1003333	81%	(137,357)	Control system optimization	Reported savings calculations did not account for interactivity of multiple measures implemented at the same time. Cadmus adjusted for interactivity between control measures.
1003797	75%	(37,340)	Control system optimization	Reported savings calculations used an incorrect baseline pump calculator setting, proposed pump enable setpoint, and chiller enable setpoint. Cadmus adjusted the calculator inputs to the correct values.

Table 133 lists the reported and evaluated savings results by measure end use. The control system optimization adjustments described above explain the differences in reported and evaluated savings for fans and pumps.

Table 133. 2020 C&I Custom Program Per-Unit Gross Savings by End Use

Measure End Use	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Cooling Chillers	582,333	585,082	-	-
Fans	228,828	91,506	15.18	15.18
HVAC	499,011	498,976	15.97	20.14
Insulation	950.2	950.2	1.41	1.41
Lighting	3,680,619	3,680,619	213.49	213.49
Pumps	101,673	61,584	4.0	4.0
Refrigeration	323,460	323,460	-	-

As shown in Table 134, the 2020 C&I Custom Program had a similar realization rate to previous program years.

Table 134. C&I Custom Program Historical Savings

Program Year	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%
2019	4,522,326	4,557,477	101%
2020	5,416,874	5,242,176	97%

Measure Verification

During the audit phase for the electric project applications, Cadmus determined that the savings and installations reported in the program tracking database correctly matched the 2020 Electric DSM Scorecard (39 measures installed under 15 application IDs). Cadmus asked survey respondents if they had removed any measures or installed additional equipment and if the equipment still worked properly. All 10 respondents said equipment installed through the program remained operational and no equipment had not been removed. Cadmus applied a 100% in-service rate for 2020, consistent with previous years

Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the C&I Custom Program as a whole using findings from surveys conducted with 10 program participants. As shown in Table 135, C&I Custom Program respondents exhibited an overall savings-weighted freeridership average of 4%, and the resulting NTG for the program is 96%.These findings are described in greater detail in *Appendix B. Net-to-Gross Detailed Findings*.

Table 135. 2020 C&I Custom Program Net-to-Gross Ratio

Program	Freeridership	Spillover	NTG Ratio
Total Program	4%[1]	0%	96%

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

Table 136 lists historical program-level NTG ratios by year. NTG results rely completely on self-reported responses and therefore can change from one year to the next, especially when sample sizes are small, as has been the case for the C&I Custom Program. In 2020, two respondents had a 0% freeridership estimate and accounted for 82% of the program energy savings in the analysis sample, so program-level freeridership in 2020 is lower than in preceding years.

Table 136. C&I Custom Program Historical Net-to-Gross Ratios

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%
2019	8%	0%	92%
2020	4%	0%	96%

[1] Program years 2012 to 2017 used the standard self-report intention freeridership method. Since 2018, the evaluation combined the intention questions from the standard self-report intention freeridership method and influence questions from the Intention/Influence method for a more comprehensive freeridership score.

Freeridership and Spillover

Cadmus estimated program freeridership by combining the standard self-report intention method and the intention/influence method.[64] Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate program freeridership of 4% (Table 137).

64 *Intention* and *influence* freeridership scores both have a maximum of 100%.

Table 137. 2020 C&I Custom Program Freeridership Estimate

Freeridership Metric	Estimate
Intention Score	6%[1]
Influence Score	2%[1]
Final Freeridership Score	**4%**

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

None of the surveyed customers 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, Cadmus did not attribute any spillover to the program.

Evaluated Net Savings Adjustments

Reported *ex ante* savings, evaluated *ex post* savings, realization rates, and evaluated net savings for each electric application ID in the C&I Custom Program are shown in Table 138 (electric savings) and Table 139 (demand reduction). In 2020, the C&I Custom Program achieved net savings of 5,032,489 kWh and 244 coincident kW demand reduction.

Table 138. 2020 C&I Custom Program Electric Savings (kWh)

Application ID	*Ex Ante* Savings (kWh)			Evaluated *Ex Post* Savings (kWh)	Realization Rates (kWh)	NTG Ratio	Evaluated Net Savings (kWh)
	Reported	Audited	Verified				
1003214	9,376	9,376	9,376	9,376	100%	96%	9,000
1003286	397,302	397,302	397,302	397,302	100%	96%	381,410
1003333	715,589	715,589	715,589	578,232	81%	96%	555,103
1003335	663	663	663	663	100%	96%	637
1003484	33,475	33,475	33,475	33,475	100%	96%	32,136
1003660	12,424	12,424	12,424	12,424	100%	96%	11,927
1003702	532,111	532,111	532,111	532,111	100%	96%	510,827
1003703	529,314	529,314	529,314	529,314	100%	96%	508,142
1003704	1,315,270	1,315,270	1,315,270	1,315,270	100%	96%	1,262,659
1003705	310,652	310,652	310,652	310,652	100%	96%	298,225
1003706	568,551	568,551	568,551	568,551	100%	96%	545,809
1003797	152,008	152,008	152,008	114,668	75%	96%	110,081
1003803	323,460	323,460	323,460	323,460	100%	96%	310,522
1003846	484,379	484,379	484,379	484,379	100%	96%	465,004
1004011	32,301	32,301	32,301	32,301	100%	96%	31,009
Total[1]	**5,416,874**	**5,416,874**	**5,416,874**	**5,242,176**	**97%**	**96%**	**5,032,489**

[1] Totals may not add up to the sum of the column due to rounding.

Table 139. 2020 C&I Custom Program Demand Reduction (Coincident Peak kW)

Application ID	*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				
1003214	3	3	3	3	100%	96%	3
1003286	129	129	129	129	100%	96%	124
1003333	32	32	32	36	113%	96%	34
1003335	1	1	1	1	100%	96%	1
1003484	-	-	-	-	N/A	96%	-
1003660	-	-	-	-	N/A	96%	-
1003702	-	-	-	-	N/A	96%	-
1003703	-	-	-	-	N/A	96%	-
1003704	-	-	-	-	N/A	96%	-
1003705	-	-	-	-	N/A	96%	-
1003706	-	-	-	-	N/A	96%	-
1003797	4	4	4	4	100%	96%	4
1003803	-	-	-	-	N/A	96%	-
1003846	63	63	63	63	100%	96%	61
1004011	19	19	19	19	100%	96%	18
Total	**250**	**250**	**250**	**254**	**102%**	**96%**	**244**

Market Performance Indicators

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 • Lack of knowledge of energy conservation benefits • Lack of knowledge of energy audit benefits	• Large out-of-pocket expenses • Perception that project is not cost-effective for business or that business does not need improvements	• Lack of knowledge about project eligibility • 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 up to 50% of qualified project cost • Explanation of total amount customer responsible for and calculation of payback period	• Participating trade ally base to make installation timely and convenient • Provide savings values, sample applications, and rebate process charts
Outcomes	• Increased program awareness • Increased participation • Incentive contribution allows energy efficiency customization to be viable option to C&I customers	• Increased market saturation of energy-efficient measures • Increased energy savings • Improved customer perception of energy efficiency programs	
Key Indicators		• Program satisfaction ratings • Average kWh per project	• Likelihood to recommend ratings • Achievement of participation and savings goals

Market Actor	Trade Allies: Installation Contractors		
Market Barriers	• Lack of program awareness • Inability to communicate directly with decision-maker	• Lack of customer awareness • Perception that design team engagement will slow down new construction project schedule	• Perception that time spent promoting program and helping customer with application is burdensome
Intervention Strategies / Activities	• Advertisement through trade associations and events • Facilitate trade ally relationships with decision-maker through account managers and energy manager • Partner with reputable firm to support new construction projects at the design stage		• Group and individual training sessions detailing program operations and requirements, application forms, and invoicing requirements • Trade ally portal simplifies access to marketing materials to promote program to customers
Outcomes	• Increased program awareness • Increased energy savings • Increased engagement with new construction design firms and architects	• Streamlined project communication and implementation • 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 • Number of actively participating contractors	• Number of new construction projects • Application processing time • Contractor satisfaction ratings	

Program Performance

Cadmus measured 2012 to 2020 program performance against the KPIs listed in Table 140.

Table 140. C&I Custom Program KPI and 2012-2020 Performance

KPI	Performance								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Achievement of Program Participation Goals	Achieved	Not achieved	103%	118%	80%	42%	48%	52%	70%
Achievement of Gross kWh Savings Goals	300%	246%	76%	167%	178%	108%	40%	129%	100%
Average kWh per Project/Measure[1]	124,763	163,938	94,844	142,577	381,956	256,753	62,801	74,136	115,053
Number of New Construction Projects	N/A	N/A	N/A	N/A	N/A	13	17	20	34
Participant Satisfaction with the Program (*very satisfied*)[2]	92%	100%	93%	80%	87%	88%	90%	80%	80%
Participant Likelihood to Recommend the Program (*very likely*)[3]	N/A	N/A	N/A	N/A	100%	88%	100%	100%	90%
Number of Contractors Participating in Multiple Years	N/A	N/A	N/A	N/A	N/A	3	8	10	12
Number of Actively Participating Contractors	26	34	39	20	19	23	28	30	25
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	72 days	49 days
Contractor Satisfaction with the Program (*very satisfied*)[2]	83%	72%	64%	N/A	40%	78%	N/A	73%	N/A
Contractor Satisfaction with the Application Process (*very satisfied*)[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60%	N/A

[1] The KPI changed from the average kWh per project used in 2012 through 2017 to average kWh per measure in 2018 through 2020. Prior to 2018, more of the multi-measure projects were combined into a single "project" in the implementer's tracked savings. Thus, the average savings decreased in years subsequent to 2017.

[2] N/A indicates that the metric was not tracked in the year noted.

[3] Small sample sizes have a greater influence on results from year to year.

Small Business Energy Solutions Program

The Small Business Energy Solutions (SBES) Program helps qualifying businesses identify energy-saving opportunities. To participate, a 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.[65]

Upon preapproval of customer eligibility through a program application, the SBES 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 LEDs (screw-in or pin-based lamps), vending machine sensors, Wi-Fi-enabled or programmable thermostats, pre-rinse sprayers, and faucet aerators, which the trade ally is encouraged to install 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 small business customers for the following electric-saving measures (referred to as low-cost measures):

- Interior and exterior energy-efficient lighting and occupancy sensors
- LED refrigerated case lighting
- LED exit signs
- Linear fluorescent delamping
- Anti-sweat heater controls
- Electronically commutated motors (ECMs) for refrigerated cases

The SBES Program is an integrated dual fuel program for Vectren. Eligible measures primarily contribute electric and demand savings to Vectren's nonresidential portfolio.

Accomplishments

The SBES Program far exceeded its 2020 savings and participation goals, as shown in Table 141. The program implementer attributed the program's success to highly engaged contractors. The two top-performing trade allies delivered 60% of the program's reported gross kWh savings. One of these

65 Nonprofits and multifamily property owners are eligible to participate in the program regardless of their facility's peak electric load.

trade allies more than doubled its performance over 2019, pulling into second place by generating over 500,000 kWh more in projects than the long-standing top two trade allies.

Fifteen trade allies generated projects for the program in 2020, compared to 14 in 2019, 10 in 2018, and eight in 2017. The average number of customers per trade ally rose to 18.2 in 2020, compared to 17.6 in 2019, 11.6 in 2018, and 9.5 in 2017.

Table 141. 2020 Small Business Energy Solutions Program Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Gross kWh Savings	10,869,170	3,600,000	302%
Gross kW Savings	2,342	358	654%
Participants	315	78	404%

[1] Goals and achievements are from Vectren's 2020 Electric DSM Scorecard. Actuals represent *ex ante* reported values. Program expenditures are tracked at the commercial-sector level rather than by program.

Table 142 lists the evaluated savings summary for the SBES Program. Overall, the program achieved a 100% realization rate for energy and a 99% realization rate for demand savings.

Table 142. 2020 Small Business Energy Solutions 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	10,869,170	10,869,170	10,869,170	10,841,359	100%	93%	10,047,846
Total kW	2,342	2,342	2,342	2,314	99%	93%	2,144

Conclusions and Recommendations

Program Administration and Delivery

Trade allies are highly engaged and are delivering substantial savings to the SBES Program. The implementer continues to expand its trade ally network, doubling the number of participating contractors since 2017. Top-performing trade allies continue to deliver the majority of savings. This year, three trade allies each contributed over a million kWh of the program's *ex ante* electric savings, an achievement held by only two trade allies in previous years. The implementer's new engagement strategy, which includes an online platform with tools and resources for trade allies and the new Mobile Assessment Tool that simplifies the rebate application process, will support additional increases in trade ally participation. The implementer plans to promote its new platform and tools to trade allies through emails and direct recruitment.

Customer Satisfaction

Participating customers are satisfied with the program and encourage Vectren to further engage with eligible small business customers. Participating customers remain highly satisfied with the program and its components. Many recommended that Vectren do more to increase the awareness of other eligible customers by sending incentive summaries and mailers and following up on leads.

Program Data

Tracking data does not delineate between exterior and interior lighting measures. There is no flag in the tracking database that explicitly identifies lighting measures as interior or exterior installations. Cadmus reviews various fields and descriptions in the tracking data to assess if a measure is an exterior lighting measure. This is an imperfect process and results in some differences between the savings inputs used to calculate *ex ante* and *ex post* savings. Because trade allies are using the Mobile Assessment Tool to provide rebate application inputs, it is understood they may be incorrectly assigning a measure name.

Thermostat projects require proper documentation to ensure accurate estimation of savings. The thermostat savings methodology agreed upon by Cadmus, Nexant, and Vectren caps savings at 25% of the facility's annual energy consumption, but annual energy consumption does not appear to be tracked in the program data. Facility annual energy use—kWh and therms—are used to cap thermostat savings at 25% of facility consumption to ensure that savings for any given project are reasonable compared to actual whole-building consumption. Additionally, it appears thermostat quantity is not always correctly accounted for in *ex ante* savings. One project in 2020 rebated six thermostats but savings were claimed for only a single thermostat. Though small in the relation to the overall program, correctly accounting for thermostat quantity would have increased energy savings for this thermostat project by 10% in 2020.

***Ex ante* demand savings do not reflect the true coincidence factor and in-service rates for exit signs.** *Ex ante* savings use a facility-specific coincidence factor to establish savings (varies project to project, with an average coincidence factor of 68% for the program). Exit signs operate continuously, so their operation coincides 100% with the utility peak period. In addition, the implementer noted that an in-service rate of 98%—stipulated in the 2015 Indiana TRM V2.2—was applied to some records. Cadmus assumed a 100% in-service rate because the program is direct install and survey results corroborate this assumption.

Inaccurate assignment of building type impacts savings estimates. Cadmus identified several lighting records that resulted in the installation of new, efficient equipment in religious schools. The program tracking data identified these projects as installed in a "Religious" building rather than a "School" building. Hours of operation, waste heat factors, and coincidence factors differ across these two building types and result in an inaccurate estimation of savings.

Recommendation: Cadmus suggests the following incremental enhancements to the Mobile Assessment Tool and tracking system:

- Update the tracking system to clearly delineate which lighting measures are interior and which are exterior. Because trade allies input the site conditions via the Mobile Assessment Tool and online application submissions, the implementer should review if a measure's use or location reflects an interior or exterior application and adjust the measure name as needed.
- Update the program tracking data to capture all information required for assessing thermostat energy savings, including the facility's annual energy consumption. Energy consumption

information may be difficult to collect during the site visit, and Vectren may be able to provide support for the implementation team.

- Update the thermostat savings calculation to account for multiple thermostat installations.
- Update *ex ante* savings for exit signs to use a coincidence factor of 100% and an in-service rate of 100%.
- Update the data collection tool or provide additional guidance to participating contractors about assigning the correct building type. In some cases, it may also be appropriate to have different building types within a single site to distinguish multibuilding facilities such as schools, hospitals, or other “campus” buildings.

The implementer should review submitted projects and, as necessary, follow up with trade allies on any discrepancies to help ensure they are correctly capturing important program savings input.

Process Evaluation

SMALL BUSINESS ENERGY SOLUTIONS PROGRAM

2020 Process Analysis Activities

1 VECTREN staff interview

1 Nexant staff interview

70 phone surveys with participating customers

2020 Program Changes

Vectren lifted the maximum **400 kW** eligibility criteria for nonprofit facilities, allowing any nonprofit organization to participate regardless of peak demand load

1 nonprofit participated in 2020 as a result of this change

Nexant developed a **trade ally engagement strategy** with partnership levels and exclusive benefits including:

- **Online portal** for program materials and updates
- **Mobile Assessment Tool**, which provides an assessment report and resources simplifying the application process, including online rebate application submittal

2021 Planned Program Changes

Nexant will promote trade ally portal

Goal to enroll 150 contractors across Vectren's three C&I programs

Vectren will decrease lighting incentives to account for evolving market conditions

Removed incentives for LEDs ≥100W

Key Process Evaluation Findings

Customer Survey Results:

99%	(n=69)	**Satisfied with program** overall
98%	(n=59)	**Satisfied with assessment report**
97%	(n=69)	**Very satisfied with contractor**
96%	(n=70)	**Very likely** to recommend program
66%	(n=65)	Learn about program from **contractors**

Survey respondents' recommended program improvements (n=23, multiple responses allowed)

78%	Provide more information, such as catalog or summary of incentive options, mailers, and follow up
17%	Simplify/expedite application process
9%	Include additional measures (exterior/interior signage, solar)
4%	Allow out-of-network contractors
4%	Increase rebate levels

Due to budget constraints, Nexant did not move forward a geotargeted marketing campaign in 2020, but the program's 2019 campaign continued to produce savings into 2020:

- 29 assessments, compared to 46 in 2019 and 7 in 2018 and 2017
- 4% of program's *ex ante* kWh were in the Newburgh zip code

15 trade allies delivered projects for the program, compared to 14 in 2019 and 10 in 2018

The two top-performing trade allies generated 60% of the program's *ex ante* kWh savings

Impact Evaluation

Impact Evaluation Methods and Findings

The SBES 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 70 program participants to gather measure verification, freeridership, and spillover data

Gross Savings Review

Table 143 provides per-unit annual gross savings for each program measure category. The impact evaluation included only those measures that were installed or rebated in the 2020 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 or included in the program dataset (such as faucet aerators and pre-rinse sprayers). Additional details for measure-level savings can be found in *Appendix A. Impact Evaluation Methodology*.

Table 143. 2020 Small Business Energy Solutions Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
ECM for Walk-in Freezer/Refrigerator	528	409	0.056	0.034
Lighting - Controls	210	211	0.040	0.041
Lighting - Exit Signs	87	85	0.008	0.011
Lighting - Exterior	763	753	0.012	0.000
Lighting - Interior	280	280	0.077	0.078
Lighting - Refrigerated Cases	220	220	0.033	0.033
Wi-Fi and Programmable Thermostats	1,956	2,241	0.000	0.000
Vending Machine Occupancy Sensors	1,612	1,612	0.000	0.000

Most minor differences between reported and evaluated savings are due to differences in input values based on installation location or type of facility for lighting measures, which led to differences in the applied *ex post* waste heat factors and coincidence factors. Four measures had larger deviations between reported and evaluated savings (albeit still minor):

- **ECM for walk-in freezer/refrigerator.** The measure is evaluated using deemed savings based on type of use (Grocery, Restaurant, or Reach-In Coolers and Freezers). Only one project was completed in 2020 and was recorded in the tracking data as a grocery application. Cadmus' review found that the facility appears to be a hunting lodge and events venue, which is unlikely to have energy consumption patterns similar to a grocery store. Cadmus determined savings for "Reach-In Coolers and Freezers" was more appropriate for this project.

- **Exit signs.** The exit sign measure has the largest realization rate deviations (from 100%) of any measure in the 2020 program. The realization rates are driven by a few factors:
  - Vectren's reported savings used a facility-specific coincidence factor (varies project to project, with an average in-service rate of 0.68 for the program). Exit signs operate continuously, so their operation coincides 100% with the utility peak period. Evaluated savings use a coincidence factor of 100%.
  - The implementer noted that an in-service rate of 98%—stipulated in the 2015 Indiana TRM V2.2—was applied to some of exit sign records. Cadmus assumed an in-service rate of 100% because the program is direct install and survey results corroborate this assumption.
  - Cadmus identified several lighting records that resulted in installations of new, efficient equipment in religious schools. The program tracking data identified these projects as installed in a "Religious" building rather than a "School" building. The hours of operation, waste heat factors, and coincidence factors differ across these two building types and result in realization rates that deviate from 100%.
  - **Exterior lighting.** The tracking database does not explicitly identify lighting measures as interior or exterior installations. Cadmus reviews various fields and descriptions in the tracking data to assess if a measure is for interior or exterior lighting. However, Cadmus may treat the same record differently than the implementation team, resulting in different savings.
- **Thermostats.** The difference in reported and evaluated savings is largely attributed to two large projects that installed multiple thermostats. In one project, the *ex ante* savings did not account for thermostat quantity (six were installed, not one). The second project was for a variety of spaces: two thermostats were installed in offices with air conditioning and gas heating, a third thermostat was installed in a warehouse space with gas heating only. Nexant manually adjusted savings for the warehouse thermostat because its legacy data collection tool could specify only a single heating and cooling type for a given facility. (In March 2020, Nexant launched a new mobile assessment tool, which should correct this issue going forward.) Cadmus allocated savings for this warehouse installation using the same eQuest model outputs that it and the implementer have used for the last several years; this allocation capped savings at 25% of the facility's annual consumption.

Table 144 lists the evaluated gross per-unit energy savings for each program measure by year. Savings vary within each measure category because of differences in measure quantity and mix each year, with some minor differences in installed space type and the number of controlled lamps (for occupancy sensors) and controlled equipment (for ECMs). Savings for the thermostat measure vary from year to year, primarily because of variations in square footage and the HVAC systems identified on site.

Table 144. Small Business Energy Solutions Program Historical Per-Unit Savings

Measure	Evaluated Annual Gross Savings (kWh)[1]							
	2013	2014	2015	2016	2017	2018	2019	2020
ECM for Walk-in Freezer/Refrigerator	-	354	325	402	-	398	458	409
Lighting - Controls	177	549	327	328	250	136	248	211
Lighting - Exit Signs	88	90	89	88	87	83	88	85
Lighting - Exterior	635	828	757	1,008	1,165	1,584	682	753
Lighting - Interior	218	288	241	230	219	194	300	280
Lighting - Refrigerated Cases	-	1,638	280	611	235	230	219	220
Wi-Fi and Programmable Thermostats	50	290	92	137	2,592	1,976	2,174	2,241
Vending Machine Occupancy Sensors	1,612	1,612	1,612	1,612	-	1,612	1,612	1,612

[1] Cells with no values represent years where no measures were rebated or installed through the program.

Measure Verification

All surveyed participants said measures installed through the SBES Program were still installed, resulting in a 100% in-service rate for all measures. Cadmus was unable to complete telephone surveys with participants who installed refrigerated case lighting, lighting controls, and ECMs for walk-in freezers or refrigerators. Therefore, Cadmus assigned these measures a 100% in-service rate, using their historical in-service rates and accounting for the difficulty and low probability of removing the measure after installation. Table 145 lists a 100% in-service rate for each program measure in 2020, consistent with previous program years (100% for all measures since 2017).

Table 145. 2020 Small Business Energy Solutions Program Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported[1]	Audited	Verified	
ECM for Walk-in Freezer/Refrigerator	1	1	1	100%
Lighting - Controls	582	582	582	100%
Lighting - Exit Signs	192	192	192	100%
Lighting - Exterior	3,009	3,009	3,009	100%
Lighting - Interior	29,475	29,475	29,475	100%
Lighting - Refrigerated Cases	26	26	26	100%
Wi-Fi and Programmable Thermostats	54	54	54	100%
Vending Machine Occupancy Sensors	39	39	39	100%
Total	**33,378**	**33,378**	**33,378**	**100%**

[1] The 2020 Electric DSM Scorecard tracked participation by number of small businesses served (n=315). The reported installations shown here are representative of the measure quantities reported in the 2020 program tracking database.

Net-to-Gross Analysis

Cadmus calculated freeridership and spillover for the SBES Program using findings from a survey conducted with 62 program participants.[66,67] Table 146 shows the program resulted in a 93% NTG. These findings are described in greater detail in *Appendix B. Net-to-Gross Detailed Findings*.

Table 146. 2020 Small Business Energy Solutions Program Net-to-Gross Ratio

Measure	Freeridership[1]	Spillover	NTG Ratio
Total Program	7%	0%	93%

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

Table 147 lists historical program-level NTG ratios by year.[68] The SBES Program NTG has remained relatively consistent in recent years despite smaller sample sizes of survey respondents.

Table 147. Small Business Energy Solutions 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%
2019	36	4%	0%	96%
2020	62	7%	0%	93%

Freeridership and Spillover

Cadmus estimated freeridership by combining two methods used in prior evaluations—the standard self-report intention method and the intention/influence method.[69] Cadmus calculated the arithmetic mean of the *intention* and *influence* freeridership components to estimate the final program freeridership of 7%, as shown in Table 148.

66 NTG ratios 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.

67 Sixty-two of the 70 survey respondents completed the questions relating to freeridership. Eight survey respondents were associated with no-cost measures and freeridership data were not collected.

68 The 2013 and 2014 analyses used the standard self-report intention freeridership method. The 2015, 2016, and 2017 analyses used two different freeridership methods: the standard self-report intention freeridership method and the Intention/Influence freeridership method. The 2018, 2019, and 2020 analyses are 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.

69 *Intention* and *influence* freeridership scores both have a maximum of 100%.

Table 148. 2020 Small Business Energy Solutions Program Freeridership Estimate

Freeridership Metric	Estimate
Intention Score	12%
Influence Score	2%
Final Freeridership Score[1]	**7%**

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

No viable spillover activity was reported by 2020 survey participants, resulting in zero spillover savings.

Evaluated Net Savings Adjustments

Table 149 and Table 150 list evaluated net savings for the SBES Program. The program achieved net savings of 10,047,846 kWh and 2,144.43 coincident kW demand reduction.

Table 149. 2020 Small Business Energy Solutions 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				
ECM for Walk-in Freezer/Refrigerator	528	528	528	409	77%	93%	379
Lighting - Controls	122,196	122,196	122,196	123,039	101%	93%	114,033
Lighting - Exit Signs	16,726	16,726	16,726	16,415	98%	93%	15,214
Lighting - Exterior	2,295,077	2,295,077	2,295,077	2,266,590	99%	93%	2,100,691
Lighting - Interior	8,260,453	8,260,453	8,260,453	8,245,321	100%	93%	7,641,820
Lighting - Refrigerated Cases	5,721	5,721	5,721	5,721	100%	93%	5,302
Wi-Fi and Programmable Thermostats	105,607	105,607	105,607	121,003	115%	93%	112,146
Vending Machine Occupancy Sensors	62,862	62,862	62,862	62,862	100%	93%	58,261
Total[1]	**10,869,170**	**10,869,170**	**10,869,170**	**10,841,359**	**100%**	**93%**	**10,047,846**

[1] Totals may not add up to the sum of the column due to rounding.

Table 150. 2020 Small Business Energy Solutions Program Demand Reduction (Coincident Peak kW)

Measure	*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				
ECM for Walk-in Freezer/Refrigerator	0.056	0.056	0.056	0.034	61%	93%	0.032
Lighting - Controls	23	23	23	24	101%	93%	22
Lighting - Exit Signs	1	1	1	2	143%	93%	2
Lighting - Exterior	36	36	36	0	0%	93%	0
Lighting - Interior	2,280	2,280	2,280	2,287	100%	93%	2,120
Lighting - Refrigerated Cases	1	1	1	1	100%	93%	1
Wi-Fi and Programmable Thermostats	0	0	0	0	--	93%	0
Vending Machine Occupancy Sensors	0	0	0	0	--	93%	0
Total[1]	**2,342**	**2,342**	**2,342**	**2,314**	**99%**	**93%**	**2,144**

[1] Totals may not add up to the sum of the column due to rounding.

Market Performance Indicators

After reviewing program materials and interviewing program stakeholders, Cadmus updated the logic model and KPIs for the SBES 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 ENERGY SOLUTIONS 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 of benefits of program-recommended energy-efficient products
Intervention Strategies / Activities	• Information on Vectren website • Product discounts for lighting, refrigeration, thermostats, and water-saving devices		• Efficient product discounts at point of purchase • Trade ally network promoting benefits of energy-efficient products through energy assessments
Outcomes	• Increased awareness • Increased participation • Increased customer satisfaction	• Improved customer perception of efficient products • Increased energy savings	• Increased penetration of efficient technologies
Key Indicators	• Achievement of program participation and savings goals • Number of participating small businesses	• Measure satisfaction ratings	

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 • Online trade ally portal provides program resources and simplifies program adoption
Outcomes	• Increased program awareness • Increased participation • Deeper savings per project	• 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 project		• Trade ally reported impact of program on sales • Conversion rate of energy assessments to low-cost measure installations • Program satisfaction ratings

Program Performance

Cadmus measured 2013 to 2020 program performance against the KPIs listed in Table 151.

Table 151. Small Business Energy Solutions Program KPI and 2013-2020 Performance

KPI	Performance							
	2013	2014	2015	2016	2017	2018	2019	2020
Achievement of Program Participation Goals	47%	18%	13%	41%	36%	243%	350%	404%
Achievement of Gross kWh Savings Goals	100%	194%	58%	61%	38%	347%	240%	302%
Average kWh per Project	12,710	25,360	24,257	33,487	19,763	32,907	34,204	39,960
Number of Participating Small Businesses[1]	146	163	143	121	76	116	246	273
Number of Participating Trade Allies	11	11	10	12	8	10	14	15
Participant Satisfaction with the Program (*very satisfied* or *somewhat satisfied*)	100%	100%	98%	98%	100%	100%	100%	99%
Participant Satisfaction with the Measures Installed (*very satisfied* or *somewhat satisfied*)	100%	100%	N/A	100%	100%	100%	98%	99%
Average Number of Recruited Participants per Trade Ally	13.2	14.9	10.3	10.2	9.5	11.6	17.6	18.2
Trade Ally Satisfaction (*very satisfied* or *somewhat satisfied*)	8 of 8	6 of 6	N/A	8 of 10	5 of 5	N/A	8 of 8	N/A
Impact of Program on Trade Ally Sales (% increase)	20%	12%	N/A	5%	5%	N/A	21%	N/A
Conversion Rate of Energy Assessments to Low-Cost Measure Installations[2]	N/A	N/A	N/A	N/A	44%	60%	62%	68%

[1] Unique phone number for participants who have completed one or more projects.

[2] Assessments completed from the fourth quarter of 2019 through the third quarter of 2020, compared to 2020 participating businesses.

Conservation Voltage Reduction

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 delivered voltage remains above the allowable minimum voltage of 114 V (allowable maximum is 126 V) set by the American National Standards Institute (ANSI). The CVR Program reduces end-user energy consumption without the end user having to alter behavior or equipment—that is, savings are generated without a noticeable impact on customers. In 2020, Vectren implemented the CVR Program at its East Side substation in Evansville, Indiana, by installing voltage monitors and automated control systems on the electric distribution system. Vectren had previously implemented the CVR Program at its Buckwood substation in 2017 and 2018 but did not continue at this substation in 2019.

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 changing transformers (LTCs) at the East Side substation.[70] Each LTC controls voltage on two distribution feeders (total of four feeders) that serve a mix of residential and commercial electric customers.

Accomplishments

By implementing CVR at the East Side substation, Vectren expanded the program beyond the initial installation at the Buckwood substation in 2017. The CVR Program at the East Side substation also expanded on the previous protocols used at the Buckwood substation by using three-day on/off cycling instead of one-day or varying cycling. This allowed better isolation of peak demand savings and more accurate baseline consumption modeling by controlling for many of the naturally occurring changes in consumption between July 1 and September 30, 2020.

Table 152 shows Vectren's *ex ante* claimed savings from CVR and implementation costs for 2020.

Table 152. 2020 Conservation Voltage Reduction Goals and Achievements

Unit	2020 Actual[1]	2020 Planning Goal[1]	Percentage of Goal
Residential Sector			
Gross kWh Savings	967,966	967,966	100%
Gross kW Savings	290	290	100%
Participants (meters affected)	5,418	5,418	100%
Program Expenditures	$205,896	$205,918	100%
Commercial and Industrial Sector			
Gross kWh Savings	603,603	603,603	100%
Gross kW Savings	181	181	100%
Participants (meters affected)	524	524	100%
Program Expenditures	$197,628	$197,628	100%

[1] Goals and achievements from Vectren's 2020 DSM Scorecard. Actuals represent *ex ante* reported values.

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[70] Load tap changers regulate voltage by discretely changing the "tap" position of a transformer.

Table 153 lists the evaluation savings summary for the CVR Program. The program achieved annual energy savings of 1,370,455 kWh and demand savings of 430 kW. These savings represent realization rates of 87% and 91%, respectively, due to unexpected periods of turning off CVR at each of the feeders, which led to a total CVR operating time of only 86% of planned.

Table 153. 2020 Conservation Voltage Reduction Electric Savings

Energy Savings Unit	*Ex Ante* Savings			Evaluated *Ex Post* Savings	Realization Rates	NTG Ratio	Evaluated Net Savings
	Reported	Audited	Verified				
Total kWh	1,571,569	1,571,569	1,571,569	1,370,455	87%	N/A	1,370,455
Total kW	471	471	471	430	91%	N/A	430

Conclusions and Recommendations

Program Planning

Vectren can claim savings for the CVR Program for at least three years. Though there is not yet consensus on how long grid efficiency measures should be credited for energy savings,[71] the Bonneville Power Administration protocol establishes the precedent of a three-year monitoring and documentation period following the implementation of volt/var optimization (VVO) or CVR operations.[72] During this period, monthly and annual reports are compiled by the utility to establish that voltage control settings are maintained and power factor levels are as expected.

Recommendation: Vectren should monitor and claim CVR energy savings for the East Side substation for three years. Though Vectren first intended the East Side CVR Program to claim first-year savings in the same fashion as the Buckwood CVR Program, Vectren can go beyond claiming only first-year savings and continue to claim annual savings for a three-year period, subject to monthly and annual evaluation.

Peak Period Consumption

Consumption during summer peak periods decreased significantly due to CVR. When comparing average consumption of each feeder, overall usage during the summer peak period was significantly lower (over 4%) with CVR on than with CVR off. CVR is an effective tool for managing demand during peak summer periods and should be implemented at other viable substations.

Recommendation: Identify additional substations viable for CVR to generate greater portfolio savings.

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71 U.S. Environmental Protection Agency. January 19, 2017. *Conservation Voltage Reduction/Volt VAR Optimization EM&V Practices*.

72 Bonneville Power Administration. "Simplified Voltage Optimization (VO) Measurement and Verification Protocol." https://www.bpa.gov/EE/Sectors/Industrial/Documents/Final_Draft_VO_MV_Protocol_4-27-10.pdf

Process Evaluation

CONSERVATION VOLTAGE REDUCTION PROGRAM

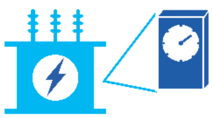
2020 Process Analysis Activities

1 VECTREN staff interview

1 Utilidata staff interview

2020 Program Operations

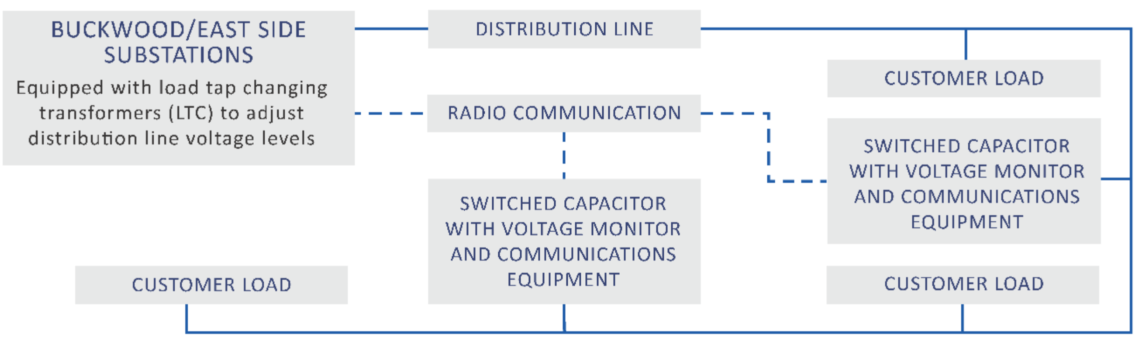
At the substation, monitoring and control equipment reduces voltage on electric distribution systems



Vectren launched CVR at its Buckwood substation in July 2017 and expanded to East Side substation in 2020

Residential and commercial customers use less energy without equipment or behavior modifications

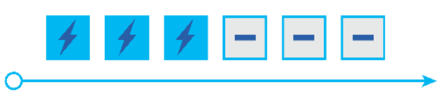
How CVR Implementation Works



Program Changes

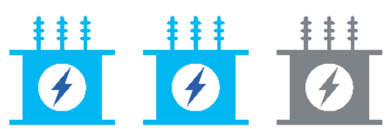
2020 Change

Vectren initiated a 3-day on/off cycling protocol as recommended in the 2018 evaluation



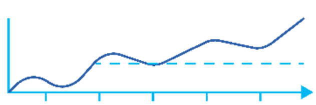
Planned Change

Vectren is planning to launch CVR at an additional substation in 2023



Key Process Evaluation Findings

Consistent with the Buckwood substation launch, Vectren will only claim first-year savings for CVR at the East Side substation, assuming that the baseline shifts after the first year of implementation



Even with COVID-related delays and shutdowns, planning and launch of CVR on the East Side substation was completed on-schedule

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.

Gross Savings Review

Vectren claimed almost 1,572 MWh savings for the CVR Program for 2020 for the East Side substation. Cadmus estimated savings of 1,370 MWh and peak coincident demand savings of 430 kW. Table 154 provides per-unit annual gross savings for the East Side substation. Savings were measured at the feeder level but evaluated on a substation basis because Cadmus did not receive site-specific data for residential or commercial and industrial (C&I) customers.

Table 154. 2020 Conservation Voltage Reduction Per-Unit Gross Savings

Program	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
East Side Substation CVR	1,571,569	1,370,455	471	430

From July 1 to September 30, 2020, CVR was active for 3,890 hours total across the four feeders at the Eastside substation (approximately 11% of the year), with 1,136 of these hours during peak coincident times (12 p.m. – 7 p.m.). Individual durations are shown in Table 155. Energy and demand savings are achieved only during periods when CVR is active.

Table 155. Feeder Annual Hours of Operation

Feeder	Annual Hours of Operation	Annual Hours of Operation (Peak Coincident)
LD188	1,037	305
LD288	1,126	329
LD388	614	174
LD488	1,113	328
Total	**3,890**	**1,136**

Ideally, CVR should have operated for 1,128 hours (329 peak coincident hours) at each of the four feeders, for a total of 4,512 hours of operation. The 3,890 hours achieved represent 86.2% of the desired operating time and was due to unexpected periods at each of the four separately operated feeders when CVR was turned off.

Vectren's CVR system achieved approximately 2.7% energy savings and approximately 4.1% demand savings while active during the 2020 program year. Savings are reported in Table 156 by specific feeder. CVR savings vary greatly from feeder to feeder due to the type of end uses associated with that feeder. For example, constant-resistance loads (e.g., refrigerator, lighting) will reduce demand more with CVR than constant-power loads (e.g., computer, TV). Certain constant-resistance loads, like space heaters, will experience demand reduction but not necessarily energy savings, as they operate at lower power with CVR on but operate for longer periods to accomplish the heating goal.

Table 156. 2020 Conservation Voltage Reduction Energy Savings by Feeder

Feeder	Energy Savings (kWh)	Percentage of Energy Savings	Demand Savings (kW)	Percentage of Demand Savings
LD188	508,450	2.6%	123	2.9%
LD288	184,982	2.4%	41	2.8%
LD388	626,654	5.0%	255	6.2%
LD488	50,369	0.4%	11	3.0%
Total	**1,370,455**	**2.7%**	**430**	**4.1%**

Table 157 lists CVR savings by program year. Savings have been relatively consistent over time, and 2020 savings for the East Side substation are comparable to prior savings for the Buckwood substation.

Table 157. Conservation Voltage Reduction Historical Percentage of Energy Savings

Measure	Evaluated Percentage of Energy Savings (kWh)			
	2017	2018	2019	2020
Total Program CVR	3%[1]	2.2%[1]	N/A[2]	2.7%[3]

[1] Buckwood substation.
[2] Vectren did not implement CVR in 2019.
[3] East Side substation.

Measure Verification

CVR was implemented at the East Side substation in 2020. This single substation had an in-service rate of 100% (Table 158), but Cadmus used program data to confirm that CVR functioned for only 86.2% of the intended time. In 2017 and 2018, the CVR Program had a 100% in-service rate (for the Buckwood substation).

Table 158. 2020 Conservation Voltage Reduction Measure Verification Results – In-Service Rates

Measure	Installations			In-Service Rate
	Reported	Audited	Verified	
East Side Substation CVR	1	1	1	100%
Total	**1**	**1**	**1**	**100%**

Net-to-Gross Analysis

CVR does not experience freeridership because reducing line voltage can be done only by Vectren and would not be achieved 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.

Evaluated Net Savings Adjustments

Table 159 and Table 160 list evaluated net savings for the CVR. The program achieved net savings of 1,370,455 kWh and 430 coincident kW demand reduction.

Table 159. 2020 Conservation Voltage Reduction 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				
East Side Substation CVR	1,571,569	1,571,569	1,571,569	1,370,455	87%	N/A	1,370,455
Total	**1,571,569**	**1,571,569**	**1,571,569**	**1,370,455**	**87%**	**N/A**	**1,370,455**

Table 160. 2020 Conservation Voltage Reduction 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				
East Side Substation CVR	471	471	471	430	91%	N/A	430
Total	**471**	**471**	**471**	**430**	**91%**	**N/A**	**430**

Appendix A. Impact Evaluation Methodology

A.1 Residential Lighting Program

Table A-1 provides per-unit annual gross savings for each program measure category (lamp type). Each measure category includes a range of wattages.

Table A-1. 2020 Residential Lighting Program Per-Unit Gross Savings

Measure Category	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
LED Fixture	48	35	0.006	0.005
LED General Service	30	31	0.003	0.004
LED Reflector	48	49	0.006	0.007
LED Specialty	35	29	0.006	0.004

A.1.1 LED Lighting

To determine the program's *ex post* gross savings, Cadmus applied the deemed values in the 2015 Indiana TRM v2.2 for hours of use (HOU), waste heat factor (WHF), and coincidence factor (CF) to each lamp in the program tracking database. The 2015 Indiana TRM v2.2 uses the following equations for determining energy savings and demand reductions for residential lighting:

$$\Delta kWh = \left(\frac{watts_{BASE} - watts_{EFF}}{1000}\right) * ISR * HOURS * (1 + WHF_E)$$

$$\Delta kW = \left(\frac{watts_{BASE} - watts_{EFF}}{1000}\right) * CF * HOURS * (1 + WHF_D)$$

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.[73] After carefully reviewing the delta watts multiplier approach recommended by the 2015 Indiana TRM v2.2, Cadmus determined that the specific values in the delta watts multiplier approach were out of date.

When the delta watts multiplier for LEDs was generated for the 2015 Indiana TRM v2.2, LEDs produced, on average, around 50 lumens per watt. For 2020 data, the average LED produced closer to 87 lumens per watt.

The U.S. Energy Information Agency (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.[74] This, in turn,

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73 Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* "Chapter 6: Residential Lighting Evaluation Protocol." https://www.nrel.gov/docs/fy17osti/68562.pdf

74 U.S. Energy Information Administration. March 19, 2014. "LED bulb efficiency expected to continue improving as cost declines." https://www.eia.gov/todayinenergy/detail.php?id=15471

means that as the technology improves, the continued use of the current TRM multiplier will probably significantly understate the savings potential of LED bulbs.

Cadmus used specified values for hours of use, waste heat factor for energy and demand, and coincidence factor for demand from the 2015 Indiana TRM v2.2. These values are listed in Table A-2.

Table A-2. 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

[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 2015 Illinois TRM, Version 4.0.

[2] 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. 2015 Indiana TRM v2.2, Version 2.2.

A.2 Residential Prescriptive Program

Cadmus' impact evaluation of the Residential Prescriptive Program included measures with attributable electric savings, including these:

HVAC measures:

- Air conditioner and heat pump tune-ups
- Air source heat pumps
- Central air conditioners
- Ductless heat pumps
- ECM HVAC motors

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

Table A-3 provides per-unit annual gross savings for each program measure. For each measure, Cadmus calculated savings for each unit using tracking data then averaged savings across all installations.

Table A-3. Residential Prescriptive Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
HVAC				
AC Tune-Up	111	89	0.12	0.15
Air Source HP 16 SEER	881	825	0.46	0.45
Air Source HP 18 SEER	1,590	1,457	0.53	0.25
CAC 16 SEER	435	377	0.54	0.47
CAC 18 SEER	666	695	0.58	0.59
Dual Fuel Air Source HP 16 SEER	695	609	0.33	0.37
Dual Fuel Air Source HP 18 SEER	992	956	0.32	0.55
Ductless HP 17 SEER 9.5 HSPF	3,804	3,316	0.41	0.14
Ductless HP 19 SEER 9.5 HSPF	3,067	2,911	0.38	0.34
Ductless HP 21 SEER 10 HSPF	2,932	3,301	0.37	0.39
Ductless HP 23 SEER 10 HSPF	4,306	2,614	0.71	0.36
ECM HVAC Motor	303	294	0.05	0.05
HP Tune-Up	285	289	-	0.14
Thermostats				
Smart Programmable Thermostat (Dual Fuel)	299	282	-	-
Smart Programmable Thermostat (Electric)	740	888	-	-
Wi-Fi Thermostat (Dual Fuel)	295	282	-	-
Wi-Fi Thermostat (Electric)	295	444	-	-
Weatherization				
Attic Insulation (All Electric)	3,019	4,041	0.10	0.43
Attic Insulation (Dual Fuel)	304	451	0.46	0.38
Duct Sealing Electric Resistive Furnace	1,359	1,366	0.38	0.37
Duct Sealing Gas Heating with AC	218	210	0.38	0.37
Wall Insulation (All Electric)	801	869	0.02	0.07
Wall Insulation (Dual Fuel)	29	94	0.26	0.09
Other				
Air Purifier	681	681	0.08	0.08
Heat Pump Water Heater	2,557	2,505	0.35	0.34
Pool Heater	1,267	1,234	-	-
Variable Speed Pool Pump	1,173	1,173	1.72	1.72

A.2.1 HVAC Measures

Air Conditioner and Heat Pump Tune-Up

Cadmus started with the 2015 Indiana TRM v2.2 methodology, which used this formula to calculate savings per air conditioner and heat pump tune-up:

$$\Delta kWh_{CAC} = EFLH_{Cool} * Btuh_{Cool} * \frac{1}{SEER_{CAC} * 1{,}000} * MF_E$$

$$\Delta kWh_{ASHP} = \left(EFLH_{Cool} * Btuh_{Cool} * \left(\frac{1}{SEER_{ASHP}}\right) + EFLH_{Heat} * Btuh_{Heat} * \left(\frac{1}{HSPF_{ASHP}}\right)\right) * \frac{MF_E}{1{,}000}$$

$$\Delta kW = Btuh_{Cool} * \frac{1}{EER * 1{,}000} * MF_D * CF$$

Where:

$EFLH_{Cool}$	=	Equivalent full load cooling hours
$BTUH_{Cool}$	=	Cooling capacity of equipment in BTUH
$SEER_{CAc}$	=	SEER efficiency of existing central air conditioning unit receiving maintenance
MF_E	=	Maintenance energy savings factor
$SEER_{ASHP}$	=	SEER efficiency of existing air-source heat pump unit receiving maintenance
$EFLH_{Heat}$	=	Equivalent full load heating hours
$BTUH_{Heat}$	=	Heating capacity of equipment in BTUH
HSPFBase	=	Heating season performance factor of existing air-source heat pump unit receiving maintenance
EER	=	EER efficiency of existing unit receiving maintenance
MFD	=	Maintenance demand reduction factor
CF	=	Summer peak coincidence factor

To determine effective full-load hours (EFLH), each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location's zip code. The FLH associated with that reference city was then used in the savings calculation for the installation. Table A-4 shows the other variables used in this evaluation.

Table A-4. Residential Prescriptive Program Air Conditioner and Heat Pump Tune-Up Calculation Variables

Variable	Value	Units	Source
$BTUH_{Cool}$	AC 33,243 HP 34,198	BTUH	2020 Residential Prescriptive Program tracking data
$SEER_{CAC}$	11.2	BTUH/Watt-hr	2015 Indiana TRM v2.2
MF_E	5%	%	2015 Indiana TRM v2.2
$SEER_{ASHP}$	13.3	BTUH/Watt-hr	2020 program tracking data
$BTUH_{Heat}$	33,476	BTUH	2020 program tracking data
$HSPF_{Base}$	7.9	BTUH/Watt-hr	2020 program tracking data
EER	AC 10 HP 10.7	BTUH/Watt-hr	Used 2015 Indiana TRM v2.2 calculation to determine EER from SEER (EER=SEER * 0.9) for air conditioners. 2020 program tracking data for heat pump

Variable	Value	Units	Source
MF_D	5%	%	2015 Indiana TRM v2.2
CF	88%	%	2015 Indiana TRM v2.2
Conversion	1,000	BTUH/ therm	Constant

Air Source Heat Pump, Dual Fuel Heat Pump, and Central Air Conditioner

Cadmus used these equations to calculate savings per heat pump installed (excluding ISR):[75]

$$Annual\ kWh\ Savings = [((FLHcool \times BTUH \times (1/SEERbase - 1/SEERnew)))/1000 + ((FLHheat \times BTUH \times (1/HSPFbase - 1/HSPFnew)))/1000]$$

$$Demand\ kW\ Savings = [BTUH \times (1/EERbase - 1/EERnew))/1000 \times CF]$$

Cadmus calculated central air conditioner savings using the following equation:

$$Annual\ kWh\ Savings = [(FLHcool \times BTUH \times (1/SEERbase - 1/SEERnew))/1000]$$

$$Demand\ kW\ Savings = [BTUH \times (1/EERbase - 1/EERnew))/1000 \times CF]$$

To determine FLH, each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location's zip code. The FLH associated with that reference city was then used in the savings calculation for the installation. Table A-5 shows the other inputs Cadmus used to evaluate impacts for these measures.

Table A-5. Residential Prescriptive Program Heat Pump and Central Air Conditioner Inputs Variables

Variable	Value	Units	Source
$SEERbase$	14 ASHP 13 CAC	Btu/Watt-hr	Federal standard for ASHPs and CACs
$EERbase$	11 Replacement	Btu/Watt-hr	Federal standard for ASHPs and CACs.
$HSPFbase$	8.2 Replacement	Btu/Watt-hr	Federal standard for ASHPs.
CF	0.88	decimal	2015 Indiana TRM v2.2
$FLHheat$	627	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 air source 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

75 These equations are referenced in the 2015 Indiana TRM v2.2.

cooling savings while dual fuel heat pumps received all cooling savings and partial electric heating savings. To calculate heating savings for dual fuel air source heat pumps, Cadmus ran a bin analysis to adjust the FLH in the 2015 Indiana TRM v2.2 from 982 to 627 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. Therefore, Cadmus determined an early replacement proportion using installation data across all air source heat pump and central air conditioner measures. Cadmus further vetted these data by including only installations with data entries for “existing unit age” and “condition of existing unit.” Cadmus considered any installation in this final group with an equipment age less than 18 years for central air conditioners and 15 years for ASHPs and an operable condition to be an early replacement installation. Using this approach, in 2020, 21% of air source heat pump and central air conditioner installations qualified as early replacement.

Efficiency metrics of baseline equipment in early replacement cases were based on appropriate federal standard values for HSPF and SEER. These values are shown in Table A-6.

Table A-6. Mechanical System Efficiency by Age

<table>
<tr><th>Mechanical Systems</th><th>Units</th><th>1993-2006</th><th>2006-2015</th><th>2015-present</th></tr>
<tr><td>Air Source Heat Pump</td><td>HSPF</td><td>6.8</td><td>7.7</td><td>8.2</td></tr>
<tr><td>Air Source Heat Pump</td><td>SEER</td><td rowspan="2">10</td><td rowspan="2">13</td><td>14</td></tr>
<tr><td>Central Air Conditioner</td><td>SEER</td><td>13</td></tr>
</table>

Using the table above in conjunction with equipment age information from installation data, Cadmus determined the baseline SEER and HSPF values. For installations missing input in this data field, Cadmus applied the average equipment age of the other installations for which the equipment age was less than the EUL of the measure. To determine baseline EER values for early replacement cases, the following equation was used according to the 2015 Indiana TRM v2.2:

$$EERbase = 0.9 * SEERbase$$

Ductless Heat Pump

Ductless heat pump 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 v2.2 does not include ductless heat pumps. For the 2020 evaluation, Cadmus used the Illinois TRM V8.0 method. Cadmus calculated ductless heat pump savings for all four efficiency bins using these equations (excluding in-service rate):

$$Annual\ \text{kWh Savings} = \Delta\text{kWh}_{\text{HEATING}} + \Delta\text{kWh}_{\text{COOLING}}$$

$$\Delta kWh_{HEATING} = Elec_{Heat} * Capacity_{Heat} * FLH_{Heat} * DHP_{HeatFLH_{Adjustment}} * (1/(HSPF\_base\ ) - 1/(HSPF\_ee\ ))$$

$$\Delta kWh_{Cooling} = Capacity_{cool} * FLH_{Cool} * DHP_{CoolFLH_{Adjustment}} * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right)$$

$$Demand\ kW\ Savings = Capacity_{Cool} \times \frac{\left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right)}{1000} \times CF$$

To determine FLH, each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location's zip code. The FLH associated with that reference city was then used in the savings calculation for the installation. Table A-7 shows other inputs Cadmus used to evaluate impacts for this measure. Cadmus used output capacity ($Capacity_{cool}$ and $Capacity_{heat}$), SEER (SEERee), EER (EERee), and HSPF (HSPFee) values of installed equipment from the program data on a per-installation basis.

Table A-7. Residential Prescriptive Program Ductless Heat Pump Input Variables

Variable	Value	Units	Source
$Elec_{Heat}$	1	-	Illinois TRM V9.0
$DHP_{HeatFLH_{Adjustment}}$	0.77	-	This adjustment is necessary to accurately calculate the savings for DHP measures using Indiana 2015 Indiana TRM v2.2 FLHs. The Illinois TRM V9.0 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 V9.0. Cadmus applied this factor to the Indiana FLHs to get Indiana DHP FLHs.
$DHP_{CoolFLH_{Adjustment}}$	0.61	-	This adjustment is necessary to accurately calculate the savings for DHP measures using 2015 Indiana TRM v2.2 FLHs. The Illinois TRM V8.0 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 V9.0. Cadmus applied this factor to the Indiana FLHs to get Indiana DHP FLHs.
Factor of 3.412	3.412	kBtu/kWh	Illinois TRM V9.0
HSPFbase	3.412	Btu/Watt-hr	Assume electric baseboard heat as baseline
SEERbase	11.3	Btu/Watt-hr	2016 Pennsylvania TRM
EERbase	9.8	Btu/Watt-hr	2016 Pennsylvania TRM
CF	0.88	-	2015 Indiana TRM v2.2

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 v2.2 and found that the TRM did not differentiate savings derived from heating/cooling or continuous circulation.

Like past evaluation years, for 2020 Cadmus applied a methodology from its evaluation of Wisconsin Focus on Energy's deemed savings changes,[76] 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): [77]

$$Annual\ kWh\ Savings = Cooling\ kWh + \ Heating\ kWh + \ Circulation\ kWh$$

$$Cooling\ kWh = FLHcool\ \times\ kBTUH\ \times\ \left(\frac{1}{SEERbase} - \frac{1}{SEERnew}\right) \times \%AC$$

$$Heating\ kWh = HOURSheat\ \times\ \Delta kW_{heat}$$

$$Circulation\ kWh = HOURScirc\ \times\ \Delta kWcirc$$

$$Cooling\ kW = FLHcool\ \times\ \text{kBTUH}\ \times\ \left(\frac{1}{EERbase} - \frac{1}{EERnew}\right) \times CF \times \%AC$$

Table A-8 shows the inputs Cadmus used to evaluate impacts for this measure. Cadmus used inputs from the 2015 Indiana TRM v2.2 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-8. Residential Prescriptive Program ECM Motor Input Variables

Variable	Value	Units	Source
$kBTUH$	33.243	kBTUH	2020 program tracking data
$FLHcool$	600	Hours	2015 Indiana TRM v2.2; 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 v2.2 calculation to determine EER from SEER (EER=SEER * 0.9)
EERnew	11.0	Btu/W-hr	Federal standard
CF	88%	%	2015 Indiana TRM v2.2
%AC	96%	%	2020 Residential Prescriptive Program participant survey
$HOURSheat$	713	Hours	Focus on Energy Evaluated Deemed Savings Changes, Nov 2014. Adjusted using HDD ratio between Evansville, Indiana, and Wisconsin.
ΔkW_{heat}	0.116	kW	Focus on Energy Evaluated Deemed Savings Changes, Nov 2014.

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76 Cadmus. November 14, 2014. *Focus on Energy Evaluated Deemed Savings Changes*. https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

77 These equations are referenced in the 2015 Indiana TRM v2.2.

Variable	Value	Units	Source
$HOURScirc$	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.
$Cooling\ kWh$	123	kWh	Calculated
$Heating\ kWh$	83	kWh	Calculated
$Circulation\ kWh$	211	kWh	Calculated

The 2020 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 federal standard requiring manufacturers to include ECMs in new central air systems came into effect on July 3, 2019. As a result, Vectren has discontinued offering the ECM HVAC motor measure. Savings for ECMs persisted through the end of 2019 because retailers had to sell through their inventory of models manufactured before July 3, 2019. The two installations of ECMs for this program year were installed in December 2018 and therefore qualify for savings (they were included in 2020 program tracking data because of rebate payment timing).

A.2.2 Thermostat Measures

Smart Programmable (Learning) and Wi-Fi Thermostats (Non-Learning)

Vectren's Residential Prescriptive Program has two types of thermostat measures:

- Smart thermostats (mostly learning) [78]
- Wi-Fi thermostats (mostly non-learning)

[78] Examples of learning thermostats are all Nest thermostats and ecobee3, 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 calculated smart and Wi-Fi thermostat savings using the following equations (excluding ISR).

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{\%_{HEAT\ PUMP}}{\eta_{HEAT\ PUMP} * 3412} + \frac{\%_{ER}}{\eta_{ER} * 3412}\right) * TStat\_Type_{Adjustment}$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline} * TStat_{Type_{COOLING_{DiscountRate}}} * \%AC$$

Cadmus used the same savings methodology for both categories of thermostats, though savings differ significantly because of differences in the proportion of learning and non-learning thermostats in each category.[79] Table A-9 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-9. 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 v2.2. To determine EFLH, each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location's zip code. The FLH associated with that reference city was then used in the savings calculation for the installation.

79 Cadmus reviewed thermostat capabilities using model numbers to determine if the thermostat was learning or non-learning.

Table A-9. Residential Prescriptive Program Thermostat Input Variables

Variable	Value	Units	Source
$\eta_{HEAT\ PUMP}$	2.40	-	Federal standard
η_{ER}	1.0	-	2015 Indiana TRM v2.2
$BTUH_{HEAT}$	34,198	BTUH	Average of 2020 Vectren Residential Prescriptive heat pump tracking data capacities
$\%_{HEAT\ PUMP}$	2%	%	2020 Residential Prescriptive Program participant survey
$\%_{GAS}$	93%	%	2020 Residential Prescriptive Program participant survey
$\%_{ER}$	5%	%	2020 Residential Prescriptive Program participant survey
Manual thermostat saturation	18%	%	2020 Residential Prescriptive Program participant survey
Programmable thermostat saturation	82%	%	2020 Residential Prescriptive Program participant survey
$TStat\_\text{Type}_{\text{DiscountRate}}$	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.
$TStat\_Type_{COOLING\ DiscountRate}$	100%	%	No cooling savings adjustment can be directly derived from the comparative study of 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.
$ESF_{AdjustedBaseline_{HEAT}}$	10.1%	%	Calculated, example below
$\%AC$	96%	%	2020 Residential Prescriptive Program participant survey
$\Delta Cooling_{AdjustedBaseline}$	265	kWh	Calculated, example below

2013-2014 Thermostat Evaluation and Adjusted Baseline

Cadmus' analysis of smart thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren South territory.[80] 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 2020 Residential Prescriptive Program participant survey indicated that the saturation was 18% for manual thermostats and 82% for programmable thermostats.

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2013-2014 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.

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

Cadmus used the following equations:[81]

$$\Delta Cooling_{AdjustedBaseline} = [18\% * 429 + 82\% * (429 - 186.9)] * 96\% = 265\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 18\% * 12.5\% + 82\% * (12.5\% - 2.97\%) = 10.1\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 186.9 represents the cooling savings (332 kWh multiplied by 56% correct use factor) for programmable thermostats.[82] 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

The 2014 thermostat evaluation concerned Nest Wi-Fi thermostats only. In 2020, the Residential Prescriptive Program's tracking data recorded many more models of smart and Wi-Fi-enabled thermostats. According to a later (2015) Cadmus study conducted for a Midwest utility thermostat program,[83] 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 (meaning non-learning thermostats save 31% as much heating energy as learning thermostats). The results of Cadmus' evaluation of the 2016 Vectren Smart Thermostat Pilot supported this conclusion.[84] However, no cooling savings adjustment can be directly derived from the comparative study conducted for a Midwest utility (2015) because the result was not statistically different than 0%.

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 2020 evaluation, Cadmus applied the 31% discount rate to the heating savings of all non-learning thermostat installations.

Vectren's thermostat offerings for 2020 align with this evaluation approach by segmenting Wi-Fi-enabled thermostats into two separate thermostat measures: smart and Wi-Fi thermostats. Cadmus found that thermostats rebated through the smart 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

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

82 The correct use rate is the percent of homeowners that use their basic programmable or non-learning Wi-Fi thermostat in an energy-saving manner (i.e. by turning the setpoint down in the winter or up in the summer).

83 Cadmus conducted an evaluation of thermostats for a Midwest utility, but the report is not publicly available.

84 Cadmus. August 8, 2017. *Vectren Residential Smart Thermostat Program 2016 Energy Savings Analysis.*

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 due to the proportion of learning thermostats in each thermostat measure.

A.2.3 Weatherization Measures

Attic and Wall Insulation

This algorithm from the 2015 Indiana TRM v2.2 served as the basis to calculate and verify energy saving (excluding in-service rate):

$$Annual\ (Energy\ or\ Demand)\ Savings = kSF\ x\ \frac{(Energy\ or\ Demand)\ Savings}{kSF}$$

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 v2.2. Table A-10 shows savings scenarios by measure and equipment type.

Table A-10. Residential Prescriptive Program Equipment Scenarios by Measure

Measure	Equipment Scenarios
Attic Insulation (All Electric)	Heat Pump
	Electric Heat with AC
	Electric Heat without AC
Attic Insulation (Dual Fuel)	Gas furnace with AC
Wall Insulation (All Electric)	Heat Pump
	Electric Heat with AC
	Electric Heat without AC
Wall Insulation (Dual Fuel)	Gas furnace with AC

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 v2.2 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. 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 v2.2.

Table A-11 lists the void factor based on the calculated R_{ratio}. Cadmus used 2% as a conservative assumption since this information was unknown.

Table A-11. 2015 Indiana TRM v2.2: Insulation Void Factors

Rratio	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 2015 Indiana TRM v2.2 Tables

Cadmus used the pre- and post-installation adjusted R-values from step two to interpolate energy and demand for every 2020 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 2020 Residential Prescriptive Program participant survey, which found that the saturation of central cooling equipment was 96%, of heat pumps was 34%, of electric furnaces was 62%, and of electric baseboard was 4%.[85] Cadmus adjusted the ducted savings by a duct efficiency of 76% for electric resistance furnaces because the TRM savings are representative of electric baseboard heating, which has no duct losses. Cadmus also calculated demand savings using a 0.88 coincidence factor from the 2015 Indiana TRM v2.2 for central air conditioners and cooling heat pumps.

Duct Sealing

Vectren's Residential Prescriptive Program has two types of duct sealing measures:

- Duct sealing electric resistive furnace
- Duct sealing gas heating with air conditioner

[85] 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 measures 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 v2.2 to determine the $\mathrm{DEPK_{BEFORE}}$ and $\mathrm{DEPK_{AFTER}}$values for the appropriate DE_{before} and DE_{after} values.

Cadmus used program data to determine average heating and cooling system capacities. To determine EFLH, each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location’s zip code. The full load hours associated with that reference city was then used in the savings calculation for the installation. Table A-12 shows the other inputs Cadmus used to evaluate impacts for this measure.

Table A-12. Residential Prescriptive Program Duct Sealing Input Variables

Variable	Value	Units	Source
$\mathrm{DE_{AFTER}}$	87%	%	Used the following reference (listed in the 2015 Indiana TRM v2.2): 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 after dealing sealing
$\mathrm{DE_{BEFORE}}$	76%	%	Used the following reference (listed in the 2015 Indiana TRM v2.2): 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.” Distribution efficiency of ductwork before dealing sealing
$\mathrm{DEPK_{AFTER}}$	85%	%	2015 Indiana TRM v2.2, DE for use in peak demand savings
$\mathrm{DEPK_{BEFORE}}$	73%	%	2015 Indiana TRM v2.2, DE for use in peak demand savings
$\mathrm{Btuh_{COOL}}$	AC 33,243 EF 32,000	BTUH	AC: 2020 program tracking data EF: 2016 Pennsylvania TRM
SEER	AC 12	BTUH/Watt-hr	Conservative CAC SEER baseline efficiency from the 2012 Indiana Residential Baseline Report
EER	AC 10.8	BTUH/Watt-hr	Used 2015 Indiana TRM v2.2 calculation to determine EER from SEER (EER=SEER * 0.9)

A.2.4 Other Measures

Air Purifier

Cadmus calculated air purifier savings using the following equations (excluding ISR): [86]

$$Annual\ kWh\ Savings = kWh_{BASE} - kWh_{ESTAR}$$

$$Demand\ kW\ Savings = \frac{Annual\ kWh\ Savings}{Hours} * CF$$

Table A-13 shows the inputs Cadmus used to evaluate impacts for this measure.

Table A-13. Residential Prescriptive Program Air Purifier Input Variables

Variable	Value	Units	Source
CF	66.7%	-	2018 Iowa TRM[1]
Hours	5,844	Hours	2018 Iowa TRM[1]

[1] Iowa Utilities Board. January 1, 2018. *Technical Reference Manual Version 2.* https://iub.iowa.gov/technical-reference-manual-version-2-effective-01-01-2018

The Indiana 2015 TRM v2.2 does not have an air purifier measure, so Cadmus used the 2018 Iowa TRM.[87] This method uses the ENERGY STAR air purifier calculator to determine kWh_BASE and kWh_ESTAR for different clean air delivery rate (CADR). The tracking data did not include equipment CADR, so Cadmus researched CADR values for each installation based on the installations reported equipment model number. These values were then applied to the savings algorithm used in the ENERGY STAR Air Cleaner Savings Calculator to determine the savings for each installation.[88]

Heat Pump Water Heater

Cadmus calculated heat pump water heater (HPWH) savings using the following equations (excluding ISR): [89]

$$Annual\ kWh\ Savings = kWh_{BASE} * \frac{COP_{NEW} - COP_{Base}}{COP_{New}} + (kWh_{COOLING} - kWh_{HEATING}) * \%\_Units\_In\_Conditioned\_Space$$

$$kWh_{HEATING} = kWh_{ER} * Saturation_{ER} + kWh_{HP} * Saturation_{HP} + kWh_{GAS} * Saturation_{GAS}$$

86 These equations are referenced in the 2018 Iowa TRM. State of Iowa. July 12, 2017. *Iowa Energy Efficiency Statewide Technical Reference Manual Version 2.0*. https://efs.iowa.gov/cs/idcplg?IdcService=GET_FILE&dDocName=1645801&allowInterrupt=1&noSaveAs=1&RevisionSelectionMethod=LatestReleased

87 Ibid.

88 This calculator is no longer available online; Cadmus used a version downloaded prior to its removal. The savings algorithm is still up to date.

89 These equations are referenced in the 2015 Indiana TRM v2.2

$$Demand\ kW\ Savings = \frac{Annual\ kWh\ Savings}{Hours} * CF$$

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 v2.2
COP_BASE	0.945	-	Federal standard
kWh_COOLING	180	kWh	2015 Indiana TRM v2.2
CF	34.6%	-	2015 Indiana TRM v2.2
Hours	2,533	Hours	2015 Indiana TRM v2.2
kWh_ER	1,577	kWh	2015 Indiana TRM v2.2
kWh_HP	779	kWh	2015 Indiana TRM v2.2
kWh_GAS	0	kWh	2015 Indiana TRM v2.2
Saturation_HP	2%	%	2020 Residential Prescriptive participant survey
Saturation_GAS	93%	%	2020 Residential Prescriptive participant survey
Saturation_ER	5%	%	2020 Residential Prescriptive participant survey
%_Units_In_Conditioned_Space	25%	%	2020 Residential Prescriptive participant survey
kWh_HEATING	91	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 v2.2 for all values except $\mathrm{COP_{NEW}}$ and $\mathrm{kWh_{HEATING}}$. Cadmus used HPWH model specifications for $\mathrm{COP_{NEW}}$ provided in program data and a weighted average of heating equipment saturations and deemed kWh savings to determine $\mathrm{kWh_{HEATING}}$ using the 2015 Indiana TRM v2.2.

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 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.

Additionally, Cadmus did not consider early replacement for HPWHs. Due to the low number of installations for this measure, Cadmus was unable to gather sufficient data to support a breakout between replace-on-burnout and early replacement for this measure.

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-15 shows the inputs Cadmus used to evaluate impacts for this measure.

Table A-15. 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
COP_ee	Varies	unitless	Based on model number research for each install
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.[90] 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[91]) that the outside air temperature is below 80°F in Evansville compared to Chicago.[92] 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.

[90] 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

[91] The 2015 Indiana TRM v2.2 assumes pool operation from Memorial Day to Labor Day.

[92] TMY3 bin data for Chicago, Illinois, and Evansville, Indiana.

Variable Speed Pool Pump

Cadmus used these equations to calculate savings per variable speed pool pump installed (excluding in-service rate):[93]

$$Annual\ kWh\ Savings = HP * LF * \frac{0.746}{\eta Pump} * \frac{Hrs}{day} * \frac{Days}{yr} * ESF$$

$$Annual\ kW\ Savings = HP * LF * \frac{0.746}{\eta Pump} * CF * DSF$$

Table A-16 shows the inputs Cadmus used to evaluate impacts for this measure.

Table A-16. 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 v2.2
LF – Load factor	0.66	Decimal	2015 Indiana TRM v2.2; First Energy, Residential Swimming Pool Pumps memo
ηPump	0.325	Decimal	2015 Indiana TRM v2.2; First Energy; Residential Swimming Pool Pumps memo
Hrs/day	6	Hrs/day	2015 Indiana TRM v2.2; Consortium for Energy Efficiency; Pool Pump Exploration Memo, June 2009
Days/yr	100	Days/yr	2015 Indiana TRM v2.2. Assumes pool operation from Memorial Day to Labor Day
ESF (energy savings factor)	86%	%	2015 Indiana TRM v2.2; First Energy; Residential Swimming Pool Pumps memo
CF	83%	%	2015 Indiana TRM v2.2; 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 v2.2; First Energy, Residential Swimming Pool Pumps memo

The 2020 program tracking data included pool pump operating hours, as Cadmus had recommended in previous evaluations; however, the data appeared to be unreliable as the hours estimates were unrealistic. Cadmus attributed this to the fact that the rebate form directly asks how many hours the pool pump operates. Many customers will not have a good sense of pool operating time in hours, so their best guess may be unreliable. As a result, Cadmus did not use pool pump operating hour data from the tracking database in 2020.

A federal standard requiring pool pumps to be variable speed is expected to come into effect July 18, 2021. Savings for variable speed pool pumps will likely persist throughout 2021 as vendors sell through their stock of models manufactured before the standard takes effect.

93 These equations are referenced in the 2015 Indiana TRM v2.2.

A.3 Residential New Construction Program

Table A-17 provides per-unit annual gross savings for each measure with attributable electric savings in the Residential New Construction (RNC) Program.

Table A-17. Residential New Construction Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
New Construction Homes				
Gold Star (Electric Only)	3,900	4,598	0.43	0.40
Gold Star (Dual Fuel)	1,033	1,218	0.43	0.40
Platinum Star (Electric Only)	N/A	N/A	N/A	N/A
Platinum Star (Dual Fuel)	1,144	1,349	0.43	0.40
Platinum Star Plus (Dual Fuel)	1,445	1,703	0.43	0.40
Habitat for Humanity Kits				
Habitat for Humanity Kit (Electric Only)	2,393	878	0.01	0.05
Habitat for Humanity Kit (Dual Fuel)	718	585	0.00	0.05

A.3.1 New Construction Homes

Cadmus evaluated gross savings for RNC Program homes by drawing a random sample of builder applications from 2020 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 software 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 V16.0 to evaluate the electric savings of the homes built under program requirements and found that savings were higher than the *ex ante* savings (derived from evaluated savings from 2019).[94]

Program homes had an average HERS score of 58—five points better than the program requirement of 63—which builders achieved through high-efficiency furnaces and air conditioners, tight building envelopes, improved wall insulation, sealed duct systems, and efficient windows.[95] Measures found in program homes in 2020 were very similar to previous program years.

94 REM/Rate V16.0 was released in December 2020.

95 The lower the HERS score, the higher the efficiency of the home.

Cadmus reviewed 152 random REM/Rate and Ekotrope-generated HERS reports across the dual fuel program populations.[96] For the electric population, Cadmus took a random sample of 39 homes.[97] Cadmus compiled the homes' characteristics, such as insulation levels and square footage, into a database for energy modeling. Table A-18 shows the sample of the 2020 homes.

Table A-18. 2020 Residential New Construction Program Homes Sample

Measure	2020 Participants	Sample
Gold Star (Electric Only)	2	0
Gold Star (Dual Fuel)	99	16
Platinum Star (Electric Only)	0	0
Platinum Star (Dual Fuel)	73	17
Platinum Star Plus (Dual Fuel)	71	6

Table A-19 presents the average home characteristics from 2015 to 2020, as well as sample sizes and precision estimates. Though there is year-on-year variance, since 2015 the typical characteristics of program homes have become more energy-efficient. Trends indicate that high-efficiency lighting has shown the greatest improvement, while the efficiency of ceiling insulation has had the greatest drop. Other home energy efficiency characteristics have shown minimal fluctuations over the past five years.

Table A-19. 2016-2020 Residential New Construction Program Home Characteristics

Home Characteristic	Program Year[1]						Changes in Program Home Characteristics from 2019
	2015	2016	2017	2018	2019	2020	
Sample Size	30	30	46	52	62	39	Smaller
Participants	124	128	171	145	194	245	Larger
Precision at 90% Confidence[2]	14%	13%	11%	10%	9%	12%	Lower precision
Home Size	2,431	3,191	2,279	2,268	2,236	2,226	Lower
Ceiling R Value	38	40	39	38	39	37.5	Lower
Walls R Value	15	15	15.3	14.8	14.9	14.8	Lower
Basement Wall R Value	10	11	N/A	10.2	13.1	10.2	Lower
Crawlspace Wall R Value	11	11	12	11	11	11.1	Higher
Windows U Factor[3]	0.302	0.302	0.302	0.295	0.299	0.3	Higher
Home Tightness ACH50[3]	3.92	3.42	3.13	3.04	3.50	3.4	Lower
Duct Tightness CFM25/100 sq. ft.[3]	3.42	2.82	2.27	2.69	3.81	3.4	Lower
Furnace AFUE	94	93	94	94	93.8	94.1	Higher
Air Conditioner SEER	14.3	13.5	14.4	14.4	14.3	14.3	Same

96 Home energy raters used either the Ekotrope and REM/Rate software to generate HERS scores. Cadmus requested 45 HERS certificates but six 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.

97 A greater proportion of the HERs certificates Cadmus reviewed for the 2020 impact evaluation were for the gas program. Natural gas impacts are evaluated in the *2020 Vectren Demand-Side Management Portfolio Natural Gas Impacts Evaluation*.

Home Characteristic	Program Year[1]						Changes in Program Home Characteristics from 2019
	2015	2016	2017	2018	2019	2020	
Percentage High-Efficiency Lighting	69%	81%	76%	86%	100%	99%	Lower
Gas Water Heat Energy Factor	0.9	0.87	0.85	0.88	0.92	0.92	Same
Electric Water Heat Energy Factor	N/A	0.95	0.95	N/A[4]	0.93	0.93	Same

[1] All values rounded.
[2] 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.
[3] Lower value represents higher efficiency.

To evaluate electric savings for the participating homes, Cadmus developed seven prototype energy models,[98] 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	Weather Location
Conditioned Basement	Gas Tankless	Evansville
Conditioned Basement	Gas Tank	Evansville
Slab on Grade	Electric Tank	Evansville
Slab on Grade	Gas Tankless	Evansville
Conditioned Crawl Space	Electric Tank	Evansville
Conditioned Crawl Space	Gas Tankless	Evansville
Conditioned Crawl Space	Gas Tank	Evansville

Cadmus calculated electric energy and demand savings as the savings between the baseline energy code model and the modeled home for each of the seven 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 118%, and the realization for demand reduction was 93%, as shown in Table A-21. Cadmus applied the realization rates to reported savings for Gold Star, Platinum Star, and Platinum Star Plus homes.

Table A-21. 2020 Residential New Construction Program Modeled Prototypes Realization Rates

Annual Gross Savings Type	Reported Sample (n=39)	Evaluated Sample (n=39)	Realization Rate
kWh	41,328	48,725	118%
Coincident Peak kW	19	18	93%

[98] Prototype energy models represent simulated program homes. Because the sample had no homes with heat pumps, the prototypes did not include heating and cooling system iterations.

A.3.2 Habitat for Humanity Kits

Vectren offered two types of kits to Habitat for Humanity builders. One kit contained gas and electric measures, the other kit contained only electric measures. The primary difference was the type of water heater—gas or electric—on which water flow measures, such as kitchen and bathroom aerators and energy-efficient showerheads, were installed.

Though each kit contained multiple individual measures, Vectren provided *ex ante* savings at the kit level. To establish a realization rate for each kit, Cadmus calculated the energy savings for each kit measure and multiplied these savings by the number of measures in the kit. To calculate per-measure savings, Cadmus applied engineering algorithms from the 2015 Indiana TRM v2.2.

Table A-22 shows the evaluated kWh and kW savings for each electric-only kit measure, the number of measures in the kit, the *ex ante* kit savings, and the overall realization rate for the kit.

Table A-22. Electric Only Kit Analysis

Measure	Quantity per Kit	Evaluated Per Unit kWh	Evaluated Per Unit kW
9W LED	5	27	0.004
LED 5W Globe	3	27	0.004
LED R30 Dimmable	1	31	0.004
5W Candelabra	3	27	0.004
Bathroom Aerator 1 GPM: Electric Water Heater	1	3	0.000
Kitchen Aerator 1.5 GPM: Electric Water Heater	1	17	0.001
Energy-Efficient Showerhead: Electric Water Heater	1	43	0.002
Smart Thermostat	1	484	-
	Measure Quantity	**Total Kit kWh**	**Total Kit kW**
Total Kit Savings	16	878	0.05
		***Ex Ante* Kit kWh**	***Ex Ante* Kit kW**
		2,393	0.01
		Kit kWh Realization Rate	**Kit kW Realization Rate**
		37%	651%

Table A-23 shows the evaluated kWh and kW savings for each gas and electric kit measure, the number of measures in the kit, the *ex ante* kit savings, and the overall realization rate for the kit.

Table A-23. Gas and Electric Kit Analysis

Measure	Measure Quantity per Kit	Per Measure (kWh)	Per Measure (kW)
9W LED	5	27	0.004
LED 5W Globe	3	27	0.004
LED R30 Dimmable	1	31	0.004
5W Candelabra	3	27	0.004
Bathroom Aerator 1 gpm – Gas Water Heater	1	3	0.000
Kitchen Aerator 1.5 gpm – Gas Water Heater	1	17	0.001
Energy-Efficient Showerhead – Gas Water Heater	1	64	0.003
Smart Thermostat	1	169	0
	Total Kit Measures	**Total Kit kWh**	**Total Kit kW**
Total Kit kWh Measures and Savings	16	585	0.05
		***Ex Ante* Kit kWh**	***Ex Ante* Kit kW**
Total Kit kW Savings		718	0.002
		Kit kWh Realization Rate	**Kit kW Realization Rate**
Kit Realization Rate		81%	2,794%

LED Light Bulbs

Cadmus used these equations to calculate savings for each of the LED light bulbs in the Habitat for Humanity Kits:

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * ISR * HOURS\right) * (1 + WHF_E)$$

$$kW\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * ISR * HOURS\right) * (1 + WHF_D) * CF$$

Some of the inputs, including in-service rate (ISR) and baseline efficiency ($watts_{BASE}$) varied by bulb type, whereas others, including hours and waste heat factors (WHF) did not. In-service rates were based on 2019 surveys conducted for the Vectren Energy Efficient Schools program or benchmarked to a recent Wisconsin study.[99] To estimate baseline wattages, Cadmus estimated the median lumen for each LED bulb then used the lumens to identify corresponding baseline wattages according to the Uniform Methods Protocol.[100]

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[99] Cadmus. May 2020. *Focus on Energy Calendar Year 2018 Evaluation Report Volume II.* P. 98. https://focusonenergy.com/sites/default/files/WI_FOE_CY_2018_Volume_II.pdf

[100] 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.* The 2015 Indiana TRM v2.2 LED bulb assumptions do not account for bulb location.

Cadmus used the 2015 Indiana TRM 2.2 assumption of 902 hours of use per year for each bulb.[101] 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 -0.059 WHF for electricity savings and a 0.057 WHF for demand as indicated in the 2015 Indiana TRM for statewide locations in Indiana. Table A-24 shows the inputs used to calculate the savings of various LED bulbs distributed in Habitat for Humanity kits.

Table A-24. LED Savings Inputs

Input	9W LED	5W Globe	LED R30 Dimmable	5 W Candelabra	Source
ISR	95%	91.5%	91.5%	91.5%	9W LED: 2019 Vectren Energy Efficient School Survey data 5W Globe and Candelabra, R30 Dimmable: Wisconsin benchmark
Baseline Wattage	43	40	50	40	DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol (program data provided by Vectren)[1]
Hours of Use per Year	902	902	902	902	2015 Indiana TRM v2.2
Summer Peak Coincidence Factor	0.11	0.11	0.11	0.11	2015 Indiana TRM v2.2
Waste Heat Factor for Energy	-0.059	-0.059	-0.059	-0.059	2015 Indiana TRM v2.2 statewide value
Waste Heat Factor for Demand	0.057	0.057	0.057	0.057	2015 Indiana TRM v2.2 Evansville value

[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

Kitchen and Bathroom Aerators

Cadmus used these equations to calculate savings per kitchen faucet aerator installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{FH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * DR * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

Cadmus calculated savings for kitchen and bathroom faucet aerators distributed through the Habitat for Humanity kits using values from the 2015 Indiana TRM v2.2 and data from the student household survey for the 2019 Energy Efficient Schools Program, as shown in Table A-25.

[101] 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.* The 2015 Indiana TRM v2.2 LED bulb assumptions do not account for bulb location.

Table A-25. Kitchen and Bathroom Faucet Aerator Savings Inputs

Input	Kitchen Faucet Assumption	Bathroom Faucet Assumption	Source
MPD (Minutes/Day/Person)	4.5	1.6	2015 Indiana TRM v2.2
FH, Number of Faucets per Home	1	2	2015 Indiana TRM v2.2 (single-family)
PH, Average Household Size (Number of People)	2.64	2.64	2015 Indiana TRM v2.2 (single-family)
Tin, Input Water Temperature to House (°F)	58.9	58.9	2015 Indiana TRM v2.2 Statewide average
Tmix, Temperature of Water at Faucet (°F)	93	86	2015 Indiana TRM v2.2
DR, Percent of Water Flowing Down Drain	50%	70%	2015 Indiana TRM v2.2
GPMbase, Gallons per Minute of Baseline Faucet Aerator	2.44	1.9	2015 Indiana TRM v2.2
GPMlow, Gallons per Minute of Energy-Efficient Faucet Aerator	1.5	1.0	Provided by Vectren
RE, Recovery Efficiency of Electric Hot Water Heater	0.98	0.98	2015 Indiana TRM v2.2
CF, Summertime Peak Coincidence Factor	0.0033	0.0012	2015 Indiana TRM v2.2
ISR	43%	36%	2019 School Kits Analysis
%Fuel (Electric)	100%	40%	Provided by Vectren

[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

Energy-Efficient Showerheads

Cadmus used these equations to calculate savings per energy-efficient showerhead installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

To inform the energy-savings estimate, Cadmus used the 2015 Indiana TRM v2.2 and in-service rates collected through a student household survey for the 2019 Energy Efficient Schools Program. Table A-26 shows these inputs.

Table A-26. Energy-Efficient Showerhead Inputs

Input	Assumption	Source
MS, Average Shower Length (Minutes)	7.8	2015 Indiana TRM v2.2
PH, Average Household Size (Number of People)	2.64	2015 Indiana TRM v2.2 (single-family homes)
SH, Number of Showerheads per Home	1.6	2015 Indiana TRM v2.2
SPD, Number of Showers per Day per Person	0.6	2015 Indiana TRM v2.2
Tin, Input Water Temperature to House (°F)	58.9	2015 Indiana TRM v2.2 statewide average.
Tmix, Water Temperature at Showerhead (°F)	101	2015 Indiana TRM v2.2
GPMbase, Gallons per Minute of Baseline Showerhead	2.63	2015 Indiana TRM v2.2
GPMlow, Gallons per Minute of Energy-Efficient Showerhead	1.50	Provided by Vectren
RE, Recovery Efficiency of Electric Hot Water Heater	0.98	2015 Indiana TRM v2.2
CF, Summer Peak Coincidence Factor	0.0023	2015 Indiana TRM v2.2
ISR	43%	2019 School Kits Analysis
% Fuel (Electric)	100%	Provided by Vectren

[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

Smart Thermostats

Cadmus calculated smart thermostat savings using the following equations.

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{\%_{HEAT\ PUMP}}{\eta_{HEAT\ PUMP} * 3412} + \frac{\%_{ER}}{\eta_{ER} * 3412}\right) * TStat_{Type_{Adjustment}} * ISR$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline} * TStat_{Type_{COOLING_{DiscountRate}}} * \%AC * ISR$$

This methodology allows for the savings to differ significantly depending on whether or not the thermostat is considered to be a learning thermostat. Cadmus assumed all savings from smart thermostats in the RNC Program came from devices categorized as learning thermostats. Cadmus selected the reference cities for each builder based on proximity, enabling EFLH values to be determined from the given values in the 2015 Indiana TRM v2.2 associated with these reference cities.

Table A-27 shows the other inputs Cadmus used to evaluate impacts for this measure. To inform other inputs for the savings calculations, Cadmus interviewed Habitat for Humanity builders who received each kit type. Their responses provided inputs for heating equipment type, saturations, and air conditioner saturation. These interviews revealed a difference in evaluated savings between the two types of thermostats. The electric-only thermostats were placed in homes with 100% electric space heat, while the dual fuel thermostats were installed only in homes with gas furnaces. However, both types of thermostats were installed in homes with a central air conditioning system, making the cooling electric savings for the two types the same.

Table A-27. Smart Programmable Thermostats Input Variables

Variable	Value	Units	Source
$\eta_{HEAT\ PUMP}$	2.49	-	Vectren Residential Efficient Products (REP) Program data (weighted average of adjusted baseline SEER to HSPF ratio of ASHP measures) and 2020 RNC Interview Results
η_{ER}	1.0	-	2015 Indiana TRM v2.2
$BTUH_{HEAT}$	28,994	BTUH	2015 Indiana TRM v2.2
$TStat\_Type_{COOLING\ DiscountRate}$	100%	%	The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not.
$ESF_{AdjustedBaseline_{HEAT}}$	9.42%	%	No cooling savings adjustment can be directly derived from the comparative of study smart Wi-Fi thermostats. Cadmus cannot discount 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.
Electric-Only $\Delta Cooling_{AdjustedBaseline}$	178	kWh	Vectren Programmable and Smart Thermostat Program evaluation (see adjustment explanation below)
Dual Fuel $\Delta Cooling_{AdjustedBaseline}$	173	kWh	Vectren Programmable and Smart Thermostat Program evaluation (see adjustment explanation below)
Electric-Only $\%_{HEAT\ PUMP}$	100%	%	2020 RNC Program Interview Results
Dual Fuel $\%_{HEAT\ PUMP}$	0%	%	2020 RNC Program Interview Results
$\%_{ER}$	0%	%	2020 RNC Program Interview Results
$\%AC$	100%	%	2020 RNC Interview Results
In Service Rate (ISR)	98%	%	2018 Focus on Energy Evaluation Report[1]
$HP\ SEER_{old}$	11.6	Btu/Watt-hr	Vectren REP Program data (weighted average of adjusted baseline SEER of ASHP measures)
$HP\ SEER_{new}$	15	Btu/Watt-hr	2020 RNC Interview Results
$CAC\ SEER_{old}$	11.2	Btu/Watt-hr	Vectren REP Program data (weighted average of adjusted baseline SEER of CAC measures)
$CAC\ SEER_{new}$	15	Btu/Watt-hr	2020 RNC Interview Results
In-service rate (ISR)	98%	%	Wisconsin benchmark (Simple Energy Efficiency Program)

[1] Cadmus. May 17, 2019. *Focus on Energy Calendar Year 2018 Evaluation Report*. https://focusonenergy.com/sites/default/files/WI_FOE_CY_2018_Volume_II.pdf

2013–2014 Thermostat Evaluation and Adjusted Baseline

Cadmus' analysis of smart thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren's Indiana South territory.[102] 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 thermostats.

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

The 2013-2014 thermostat evaluation used a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2020 Residential New Construction Program has a 100% programmable thermostat baseline as state code requires programmable thermostats in new homes.

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2013-2014 thermostat evaluation and adjusted the savings for Nest thermostats from a manual thermostat baseline to a programmable thermostat baseline. The savings were also adjusted to account for the difference in equipment age. The 2013-2014 thermostat evaluation was based on homes with existing HVAC equipment, while the homes in the 2020 Residential New Construction Program had new HVAC equipment. A SEER adjustment was applied to account for this difference, as seen in the equations. Cadmus used these equations for the electric-only kits:[103]

$$\Delta Cooling_{AdjustedBaseline} = [0\% * 429 + 100\% * (429 - 199.2)] * 100\% * \frac{HP\ SEER_{old}}{HP\ SEER_{new}} = 178\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 0\% * 12.5\% + 100\% * (12.5\% - 3.077\%) = 9.42\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 199.2 represents the cooling savings from the 2013-2014 thermostat evaluation adjusted to account for the percentage of people who use their programmable thermostat in an energy-saving manner (332 kWh multiplied by 60% correct use factor). 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.

Cadmus used these equations for the dual fuel kits:[104]

$$\Delta Cooling_{AdjustedBaseline} = [0\% * 429 + 100\% * (429 - 199.2)] * 100\% * \frac{CAC\ SEER_{old}}{CAC\ SEER_{new}} = 173\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 0\% * 12.5\% + 100\% * (12.5\% - 3.077\%) = 9.42\%$$

103 Cadmus. January 29, 2015. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program*.

104 Ibid.

A.4 Home Energy Assessment 2.0

Cadmus' impact evaluation of the 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 0.3W nightlight

Plug load reduction

- Smart power strips

HVAC and water-heating measures

- Filter whistle
- Pipe wrap
- Water heater temperature setback
- Smart thermostat
- Insulation Referral

Water-saving devices

- Bathroom aerator
- Kitchen aerator
- Efficient showerhead

Table A-28 provides per-unit annual gross savings for each program measure.

Table A-28. HEA 2.0 Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported *Ex Ante*[1]	Evaluated *Ex Post*	Reported *Ex Ante*[2]	Evaluated *Ex Post*
Audit Education				
Audit Fee (Electric)	61	85	N/A	0.0033
Lighting				
LED 6W Globe	10	21	N/A	0.0028
LED 8W Bulb	53	54	N/A	0.0070
LED 9W Bulb	32	31	N/A	0.0041
LED 9W Bulb (Exterior)	92	84	N/A	0.0000
LED Candelabra	41	22	N/A	0.0029
LED Downlight Retrofit	35	39	N/A	0.0051
LED Nightlight	14	13	N/A	0.0000
Plug Load Reduction				
Smart Strips	103	25	N/A	0.0019
HVAC and Water Heating Measures				
Filter Whistle (Dual Fuel, Gas Heat with CAC)	0	56	N/A	0.0904
Filter Whistle (Electric)	61	120	N/A	0.1956
Insulation Referral[3]	304	451	N/A	0.3800
Pipe Wrap (Electric)	65	91	N/A	0.0104
Smart Thermostat (Dual Fuel, Gas Heat with CAC)	0	351	N/A	0.0000
Smart Thermostat (Electric)	370	1,402	N/A	0.0000

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported *Ex Ante*[1]	Evaluated *Ex Post*	Reported *Ex Ante*[2]	Evaluated *Ex Post*
Water Heater Setback (Electric)	87	82	N/A	0.0093
Water-Saving Devices				
Bathroom Aerator (Electric)	9	19	N/A	0.0026
Kitchen Aerator (Electric)	115	143	N/A	0.0070
Showerhead (Electric)	206	225	N/A	0.0148

[1] The 2020 Electric DSM Scorecard did not include per-unit electric savings. These are the audited per-unit electric savings from the 2020 program tracking data.
[2] Vectren did not provide demand savings at the measure level. The only source of demand savings was the 2020 Electric DSM Scorecard for the program overall.
[3] Two customers were referred for attic insulation at the end of their assessment and received a $450 rebate for installed insulation. These savings are not double counted in another program.

A.4.1 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.

Cadmus conducted a survey with 2020 HEA 2.0 Program participants but achieved a small number of completed surveys due to the small program population. Therefore, Cadmus applied 2019 HEA 2.0 Program survey data to the 2020 impact analysis. The 2019 HEA participant survey collected data from 89 participants. Of these, 69% 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-29 shows household percentages for recommended measures that HEA 2.0 Program participants reportedly engaged in after receiving a program audit. *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.

Table A-29. 2020 HEA 2.0 Program Percentages per Recommended Action

Recommendation	Percentage of Households that Reportedly Took Action
Behavioral Measures	
Turn off lights when not in use	65%
Take shorter showers	38%
Program thermostat with efficient settings (excludes recipients of smart thermostats through program)	58%
Unplug appliances when not in use	39%
Installation Measures	
Air sealing/weather-stripping	5%

A.4.2 Lighting

Cadmus used the following equations from the 2015 Indiana TRM v2.2 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, 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-30 and are based on bulb.

Cadmus used the 2015 Indiana TRM v2.2 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 2015 Indiana TRM v2.2 for the city of Evansville, Indiana, and were dependent on the heating and cooling type at each home.

The 2015 Indiana TRM v2.2 assumption of 902 hours of use applied only to lighting installed indoors; therefore, Cadmus used 2,475 hours from the Illinois TRM V8.0, which specifically applies to exterior bulbs. Exterior bulbs also did not have a waste heat factor applied to them because there are no interactive effects on bulbs installed outdoors. Table A-30 shows the savings inputs Cadmus used for its *ex post* calculations.

Table A-30. HEA 2.0 Program 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 450 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 (BR30 Dimmable LED) (WattsBase)	65	PA TRM for 650 lumen BR30 bulb. Reflectors are EISA exempt and lumen bins are not available in the DOE Uniform Methods Project for reflector bulbs
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	29	DOE Uniform Methods Project, Chapter 21 Residential Lighting Evaluation Protocol for EISA-exempt 325 lumen LED candelabra
Hours of use per year (HOURS)	902 (interior) 2,475 (exterior)	2015 Indiana TRM v2.2 (interior) Illinois TRM V8.0 (exterior)
Summer peak coincidence factor (CF)	0.11	2015 Indiana TRM v2.2
Waste heat factor for energy (WHFe)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 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 v2.2 appendix with 2018 heating and cooling for each lighting participant

LED Nightlights

Cadmus used the following 2015 Indiana TRM v2.2 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 v2.2 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-31.

Table A-31. HEA 2.0 Program LED Nightlight Savings Inputs

Input	Assumption	Source
Baseline wattage for equivalent incandescent nightlight (WattsBase)	5.00	2015 Indiana TRM v2.2
Wattage of LED night light (WattsEff)	0.3	Provided by Vectren
Hours of use per year (Hours)	2,920	2015 Indiana TRM v2.2

A.4.3 Plug Load Reduction

Tier 1 Advanced Power Strips (Smart Strips)

Cadmus used deemed savings from the 2015 Indiana TRM v2.2 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 v2.2 where 50% are installed with TV systems and 50% are installed with computer systems. The heating and cooling factors were taken from the 2015 Indiana TRM v2.2 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-32**.**

Table A-32. HEA 2.0 Program 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 v2.2
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 v2.2
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 v2.2
Number of hours per year peripherals are controlled (computers) (H)	7,474	2015 Indiana TRM v2.2
Number of hours per year peripherals are controlled (televisions) (H)	6,784	2015 Indiana TRM v2.2
Coincident factor (CF)	0.50	2015 Indiana TRM v2.2
Waste heat factor for energy (WHFe)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each participant
Waste heat factor for demand (WHFd)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each participant

A.4.4 HVAC and Water Heating Measures

Furnace Filter Whistle

Cadmus used the following analysis equations from a Quantec study to calculate savings per filter whistle,[105] in combination with 2015 Indiana TRM v2.2 assumptions (excludes ISR):

$$kWh\ Savings_{CAC} = FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} * EF_{elec}$$

$$kWh\ Savings_{HP} = \left(FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} + FLH_{heat} * BtuH_{HP} * \frac{\frac{1}{HSPF}}{1000} \right) * EF_{elec}$$

$$kW\ Savings_{CAC} = BtuH_{CAC} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

$$kW\ Savings_{HP} = BtuH_{HP} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * \ CF$$

- The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-33.

Table A-33. HEA 2.0 Program 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	2020 HEA 2.0 participant tracking data
Energy efficiency ratio (EER)	Varies by customer	2020 HEA 2.0 participant tracking data, SEER * .9
Size of central AC units (BtuHCAC)	Varies by customer	2020 HEA 2.0 participant tracking data
Heating season performance factor (HSPF)	Varies by customer	2020 HEA 2.0 participant tracking data
Size of heat pump (BtuHHP)	Varies by customer	2020 HEA 2.0 participant tracking data
Summer peak coincidence factor for heat pump/central AC (CF)	0.88	2015 Indiana TRM v2.2: Summer peak coincidence factor is deemed at 0.88 per Duke Energy load shape
Full load cooling hours (FLHcool)	600	2015 Indiana TRM v2.2: Evansville
Full load heating hours (FLHheat)	982	2015 Indiana TRM v2.2: Evansville

[105] 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 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 2015 Indiana TRM v2.2 methodology because it 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.[106] The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-34.

Table A-34. HEA 2.0 Program 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 2.47 average home size from 2019 HEA 2.0 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 v2.2
Water heater temperature setpoint (°F, Tsetpoint)	135 / 120	Illinois TRM V8.0 default value, or 120 if the home received a water heater setback
Input water temperature to house (°F, Tin)	62.8	2015 Indiana TRM v2.2 for Evansville; 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 v2.2
Hours in a year (Hours)	8760	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	1	2015 Indiana TRM v2.2

Smart Thermostats

Cadmus calculated smart thermostat savings using the following equations (excluding ISR):

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{1}{\eta_{HEAT} * 3412}\right)$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline}$$

[106] 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.*

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-35.

Table A-35. HEA 2.0 Program Smart Thermostat Savings Inputs

Variable	Value	Units	Source
FLH_{HEAT}	982	Hours	2015 Indiana TRM v2.2; Evansville, Indiana
$BTUH_{HEAT}$	32,000	BTUH	2016 Pennsylvania TRM
η_{HEAT}	Varies	-	2015 Indiana TRM v2.2 – 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	96%	%	2020 HEA 2.0 Tracking Data
Programmable thermostat saturation	4%	%	2020 HEA 2.0 Tracking Data
$ESF_{AdjustedBaseline_{HEAT}}$	10.92%	%	Calculated, example below
$\Delta Cooling_{AdjustedBaseline}$	328	kWh	Calculated, example below

2013–2014 Thermostat Evaluation and Adjusted Baseline

Cadmus' analysis of smart thermostat savings used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren South territory.[107] 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.

The 2014 Cadmus thermostat study uses a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2020 HEA 2.0 tracking data indicated that the saturation was 96% for manual thermostats and 4% 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 smart thermostats from a manual thermostat baseline to a mixed manual and programmable thermostat baseline.

Cadmus used these equations:[108]

$$\Delta Cooling_{AdjustedBaseline} = [96\% * 429 + 4\% * (429 - 197)] = 421\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline_{HEAT}}} = 96\% * 12.5\% + 4\% * (12.5\% - 3.1\%) = 12.38\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 197 represents the cooling savings (332 kWh multiplied by 59% 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

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

[108] Ibid.

homes with gas heating, so Cadmus assumed that the percentage of gas savings from that evaluation apply to electric heat as well.

A correct usage factor was not applied to this evaluation because the program installed only smart, 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.

Water Heater Temperature Setback

Cadmus used the following Illinois TRM V8.0 equations (measure not available in the 2015 Indiana TRM v2.2) 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-36.

Table A-36. HEA 2.0 Program Water Heater Temperature Setback Savings Inputs

Input	Assumption	Source
Heat transfer coefficient of tank (U)	0.083	Illinois TRM V8.0 default value
Surface area of tank (A)	24.99	Illinois TRM V8.0 default value
Water heater temperature before setback (Tpre)	135	Illinois TRM V8.0 default value
Water heater temperature before setback (Tpost)	120	Implementer tracking data
Hours in a year (Hours)	8760	2015 Indiana TRM v2.2
Electric water heater recovery efficiency (Reelectric)	98%	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	1	Illinois TRM V8.0 default value
Conversion from Btu to kWh	3412	Conversion factor

Insulation Referrals

This measure is an instant rebate for insulation installation. Vectren did not collect measure-level data on this measure. Both insulation referrals resulted in attic insulation installations. To evaluate savings, Cadmus used the 2020 Residential Prescriptive Program average attic insulation savings.

Table A-37. HEA 2.0 Program Insulation Referral Inputs

Cadmus Assumptions	Inputs	Units	Source
kWh Savings	450.8	kWh	2020 Residential Prescriptive Program average attic insulation savings
kW Savings	0.38	kW	2020 Residential Prescriptive Program average attic insulation savings

A.4.5 Water-Saving Devices

Faucet Aerators

Cadmus used the following 2015 Indiana TRM v2.2 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-38.

Table A-38. HEA 2.0 Program Faucet Aerator Savings Inputs

Input	Assumption		Source
	Kitchen Faucet	Bathroom Faucet	
Faucet usage (minutes/day/person) (MPD)	4.5	1.6	2015 Indiana TRM v2.2
Number of faucets per home (FH)	1	2.69	2019 HEA 2.0 participant survey data for bathroom; 2015 Indiana TRM v2.2 for kitchen
Average household size (PH)	2.47	2.47	2019 HEA 2.0 participant survey data
Input water temperature to house (°F) (°F, Tin)	62.8	62.8	2015 Indiana TRM v2.2 for Evansville; cold water temperature entering the DWH system
Temperature of water at faucet (°F) (°F, Tmix)	93	86	2015 Indiana TRM v2.2
Percent of water flowing down drain (DR)	0.5	0.7	2015 Indiana TRM v2.2
Gallons per minute of baseline faucet aerator (GPMbase)	2.44	1.9	2015 Indiana TRM v2.2
Gallons per minute of energy-efficient faucet aerator (GPMlow)	1.5	1.0	2020 program tracking data
Electric water heater recovery efficiency (RE)	0.98	0.98	2015 Indiana TRM v2.2
Summertime peak coincidence factor (CF)	0.0033	0.0033	2015 Indiana TRM v2.2

Efficient Showerhead

Cadmus used the following 2015 Indiana TRM v2.2 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-39.

Table A-39. HEA 2.0 Program Efficient Showerhead Savings Inputs

Input	Assumption	Source
Average shower length (MS)	7.8	2015 Indiana TRM v2.2
Average household size (participants/household, PH)	2.47	2019 HEA 2.0 Participant survey data
Number of showerheads per home (SH)	2.01	2019 HEA 2.0 Participant survey data
Number of showers per day per person (SPD)	0.6	2015 Indiana TRM v2.2
Input water temperature to house (°F, Tin)	62.8	2015 Indiana TRM v2.2 for Evansville; cold water temperature entering the DWH system
Water temperature at showerhead (°F, Tmix)	101	2015 Indiana TRM v2.2, average mixed temperature of water used for shower
Gallons per minute of baseline showerhead (GPMbase)	2.63	2015 Indiana TRM v2.2
Gallons per minute of energy-efficient showerhead (GPMlow)	1.50	2020 HEA 2.0 Program tracking data
Electric recovery efficiency of hot water heater (RE)	0.98	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	0.0023	2015 Indiana TRM v2.2

A.5 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

Lighting

- Exterior LED lamp
- LED 5W globe
- LED 5W candelabra
- 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

- AC tune-up
- Central air conditioner
- Filter whistle
- Pipe wrap
- Smart thermostat

Weatherization measures

- Air sealing
- Attic insulation
- Duct sealing
- Wall Insulation
- Whole Home IQW

Table A-40 provides per-unit annual gross savings for each program measure. Some measures are broken out by fuel type (dual fuel or electric only) and building type (single-family or multifamily). The following sections provide details on the equations and assumptions Cadmus used to calculate evaluated gross savings by measure type.

Table A-40. Income-Qualified Weatherization Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Audited[1]	Evaluated
Audit Education				
Audit Fee (Multifamily, Dual Fuel)	37	20	0.0017	0.0093
Audit Fee (Multifamily, Electric)	46	54	0.0000	0.0096
Audit Fee (Single-Family, Dual Fuel)	83	81	0.0038	0.0199
Audit Fee (Single-Family, Electric)	102	114	0.0033	0.0208
Lighting				
Exterior LED Lamps	99	92	0.0000	0.0000
LED 5W Bulb (Multifamily)	20	19	0.0024	0.0024
LED 5W Bulb (Single-Family)	20	18	0.0024	0.0024
LED 5W Candelabra	10	23	0.0014	0.0030
LED 9W Bulb (Multifamily)	33	28	0.0040	0.0041
LED 9W Bulb (Single-Family)	33	32	0.0041	0.0041
LED R30 Bulb (Multifamily)	32	55	0.0040	0.0070
LED R30 Bulb (Single-Family)	33	54	0.0040	0.0069
LED Nightlight	14	13	0.0000	0.0000
Water-Saving Devices				
Bathroom Aerator (Multifamily, Electric)	29	27	0.0026	0.0026
Bathroom Aerator (Single-Family, Electric)	35	27	0.0026	0.0026
Energy-Efficient Kitchen Aerator (Multifamily, Electric)	97	132	0.0070	0.0070
Energy-Efficient Kitchen Aerator (Single-Family, Electric)	146	117	0.0070	0.0070
Energy-Efficient Showerhead (Multifamily, Electric)	267	257	0.0148	0.0148
Energy-Efficient Showerhead (Single-Family, Electric)	343	293	0.0148	0.0148
HVAC and Water Heating Measures				
AC Tune-Up	155	70	0.1973	0.1146
Central Air Conditioner 16 SEER	587	228	1.0465	0.3259
Filter Whistle (Single-Family)	46	46	0.0760	0.0746
Furnace Tune-Up (Electric)	155	0	0.1973	0.0000
Pipe Wrap (Single-Family, Electric)	99	89	0.0113	0.0102
Smart Thermostat (Multifamily, Dual Fuel)	720	225	0.0000	0.0000
Smart Thermostat (Single-Family, Dual Fuel)	429	377	0.0000	0.0000
Smart Thermostat (Single-Family, Electric)	1,580	1,364	0.0000	0.0000
Appliance and Plug Load Reduction				
Refrigerator Replacement	360	735	0.0529	0.1079
Smart Power Strips	26	25	0.0019	0.0018

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Audited[1]	Evaluated
Weatherization Measures				
Air Sealing 20% Infil. Reduction (Dual Fuel)	125	213	0.1622	0.3120
Attic Insulation (Dual Fuel)	367	446	0.3620	0.4201
Duct 10% leakage Reduction (Dual Fuel)	155	165	0.2688	0.2694
Wall Insulation (Dual Fuel)	58	78	0.0416	0.0840
IQW Whole Home (Dual Fuel)	1,316	910	0.0000	0.3832

A.5.1 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 57 IQW Program participants. Of these respondents, 75% said they had implemented one or more recommendations from the home audit report. Home audit reports had two types of recommended measures:

- **Behavioral measures** that 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
- **Installation measures** that required purchases and installations of equipment

Table A-41 shows household percentages for each recommended action that IQW Program participants reported engaging in after receiving an on-site energy assessment.

Table A-41. 20120 IQW Household Percentages and Average Savings per Recommended Measure

Recommendation	Percentage of Households that Reportedly Took Action	Average Per-unit Evaluated Savings for Action (kWh)
Behavioral Measures		
Turn off lights when not in use	61%	9
Unplug appliances when not in use	46%	10
Take shorter showers	46%	14
Program thermostat with efficient settings (excludes recipients of smart thermostats through program)	51%	82
Installation Measures		
Air sealing/weather-stripping	12%	7

Table A-42 shows the assumptions that went into the evaluated savings for each component. For all energy-saving actions, Cadmus adjusted savings 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-42. 2020 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 judgment
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 judgment

A.5.2 Lighting

LED Bulbs

Cadmus used the following equations from the 2015 Indiana TRM v2.2 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 Uniform Methods Project, which specifies baseline wattages based on lumen output and style of the installed bulbs.

Cadmus used the 2015 Indiana TRM v2.2 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 v2.2 for the city of Evansville, Indiana, and were dependent on the heating and cooling type of each different site.

The assumption of 902 hours of use applied only to lighting installed indoors, so Cadmus used 2,475 hours from the Illinois TRM V8.0, which specifically applies to exterior bulbs. Exterior bulbs also did not have a waste heat factor 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-43.

Table A-43. Lighting Savings Inputs

Input	Assumption	Source
Baseline wattage for equivalent incandescent bulb (5W 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 (9W 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)	65	2016 Pennsylvania TRM[1]
Baseline wattage for equivalent incandescent bulb (exterior bulb 13W 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) 2,475 (exterior)	2015 Indiana TRM v2.2 (interior) Illinois TRM V8.0 (exterior)
Summer peak coincidence factor (CF)	0.11	2015 Indiana TRM v2.2
Waste heat factor for energy (WHFe)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each lighting participant
Waste heat factor for demand (WHFd)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each lighting participant

[1] The Uniform Methods Project does not include lumen bins for reflector bulbs. Since these bulbs are exempt from current EISA regulations, Cadmus used lumen bins for reflector bulbs in the 2016 Pennsylvania TRM. This TRM closely follows the Uniform Methods Project approach but has additional lumen bins for non-exempt bulbs like reflectors.

LED Night Lights

Cadmus used the following 2015 Indiana TRM v2.2 equation to calculate gross savings per night light installed (excluding ISR):

$$kWh\ Savings = \left(\frac{watts_{BASE} - watts_{EFF}}{1{,}000} * HOURS\right)$$

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-44.

Table A-44. LED Night Light Savings Inputs

Input	Assumption	Source
Baseline wattage for equivalent incandescent night light (WattsBase)	5.00	2015 Indiana TRM v2.2
Wattage of LED night light (WattsEff)	0.5	Provided by Vectren
Hours of use per year (Hours)	2,920	2015 Indiana TRM v2.2

A.5.3 Water-Saving Devices

Faucet Aerators

Cadmus used the following 2015 Indiana TRM v2.2 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-45.

Table A-45. Faucet Aerator Savings Inputs

Input	Assumption		Source
	Kitchen Faucet	Bathroom Faucet	
Faucet usage (minutes/day/person) (MPD)	4.5	1.6	2015 Indiana TRM v2.2
Number of faucets per home (FH) – Single-Family	1	1.60	2020 IQW Participant survey data for bathroom. 2015 Indiana TRM v2.2 for kitchen
Number of faucets per home (FH) – Multi Family	1	1.80	2020 MFDI Participant survey data,[1] 2015 Indiana TRM v2.2 for kitchen
Average household size (participants/household, PH) – Single-Family	2.01	2.01	2020 IQW participant survey
Average household size (participants/household, PH) – Multifamily	2.28	2.28	2020 MFDI Participant survey[1]
Input water temperature to house (°F) (°F, Tin)	62.8	62.8	2015 Indiana TRM v2.2 for Evansville, IN, cold water temperature entering the DWH system
Temperature of water at faucet (°F) (°F, Tmix)	93	86	2015 Indiana TRM v2.2
Percent of water flowing down drain (DR)	0.5	0.7	2015 Indiana TRM v2.2
Gallons per minute of baseline faucet aerator (GPMbase)	2.44	1.9	2015 Indiana TRM v2.2
Gallons per minute of energy-efficient faucet aerator (GPMlow)	1.5	1.0	2020 program tracking data
Electric water heater recovery efficiency (RE)	0.98	0.98	2015 Indiana TRM v2.2
Summertime peak coincidence factor (CF)	0.0033	0.0033	2015 Indiana TRM v2.2

[1] Cadmus used MFDI survey data because there were no multifamily specific responses in the IQW survey data

Efficient Showerhead

Cadmus used the following 2015 Indiana TRM v2.2 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-46.

Table A-46. Efficient Showerhead Savings Inputs

Input	Assumption	Source
Average shower length in minutes (MS)	7.8	2015 Indiana TRM v2.2
Average household size (participants/household, PH) – Single-Family	2.01	2020 IQW participant survey data
Average household size (participants/household, PH) – Multifamily	2.28	2020 MFDI participant survey data[1]
Number of showerheads per home (SH) – Single-Family	1.26	2020 IQW participant survey data
Number of showerheads per home (SH) – Multifamily	1.62	2020 MFDI participant survey data[1]
Number of showers per day per person (SPD)	0.6	2015 Indiana TRM v2.2
Input water temperature to house (°F, Tin)	62.8	2015 Indiana TRM v2.2 for Evansville cold water temperature entering the DWH system
Water temperature at showerhead (°F, Tmix)	101	2015 Indiana TRM v2.2, average mixed temperature of water used for shower
Gallons per minute of baseline showerhead (GPMbase)	2.63	2015 Indiana TRM v2.2
Gallons per minute of energy-efficient showerhead (GPMlow)	1.50	2020 program tracking data
Electric recovery efficiency of hot water heater (RE)	0.98	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	0.0023	2015 Indiana TRM v2.2
[1] Cadmus used MFDI survey data because there were no multifamily specific responses in the IQW survey data		

A.5.4 HVAC and Water Heating Measures

AC Tune-Up

Cadmus used these equations to calculate savings per AC tune-up (excluding ISR):

$$\Delta kWh_{CAC} = EFLH_{Cool} * Btuh_{Cool} * \frac{1}{SEER_{CAC} * 1{,}000} * MF_E$$

$$\Delta kW = Btuh_{Cool} * \frac{1}{EER * 1{,}000} * MF_D * CF$$

Where:

$EFLH_{Cool}$ = Equivalent full load cooling hours

$Btuh_{Cool}$ = Cooling capacity of equipment in Btuh

$SEER_{CAc}$ = SEER efficiency of existing central air conditioning unit receiving maintenance

MF_E = Maintenance energy savings factor

EER = EER efficiency of existing unit receiving maintenance

MF_D = Maintenance demand reduction factor

CF = Summer peak coincidence factor

Cadmus calculated savings for air conditioner tune-ups implemented through the IQW Program using the savings inputs used for its *ex post* calculations are shown in Table A-47.

Table A-47. IQW Program AC Tune-Up Savings Inputs

Variable	Value	Units	Source
$Btuh_{Cool}$	26,146	Btuh	2020 IQW Central Air Conditioner tracking data
$SEER_{CAc}$	11.2	Btuh/Watt-hr	2015 Indiana TRM v2.2
MF_E	5%	%	2015 Indiana TRM v2.2
EER	10	Btuh/Watt-hr	Used 2015 Indiana TRM v2.2 calculation to determine EER from SEER (EER=SEER * 0.9) for AC.
MF_D	5%	%	2015 Indiana TRM v2.2
CF	88%	%	2015 Indiana TRM v2.2

Central Air Conditioner

Cadmus used these equations to calculate savings per air conditioner replacement (excluding ISR):

$$Annual\ kWh\ Savings = FLH_{COOL} * Btuh * \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{Eff}}\right) * \frac{1}{1000}$$

$$Demand\ kW\ Savings = Btuh * \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{Eff}}\right) * \frac{1}{1000} * CF$$

Savings inputs Cadmus used its *ex post* calculations are shown in Table A-48.

Table A-48. IQW Program Central Air Conditioner Savings Inputs

Description	Assumption	Source
Efficient SEER	Varies	2020 program tracking data
Efficient EER	Varies	2020 program tracking data
Baseline SEER	13	Federal Standard SEER Rating, 2015 Indiana TRM v2.2
Baseline EER	11	Federal Standard EER Rating, 2015 Indiana TRM v2.2
CAC Btuh	Varies	2020 program tracking data
FLHcool – Evansville	600	2015 Indiana TRM v2.2
CF	88%	2015 Indiana TRM v2.2

Furnace Filter Whistle

Cadmus used the following analysis equations from a Quantec study to calculate savings per filter whistle,[109] as in previous program years, in combination with 2015 Indiana TRM v2.2 assumptions (excluding ISR):

$$kWh\ Savings_{CAC} = FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} * EF_{elec} * SqFt_{Adjust}$$

$$kWh\ Savings_{HP} = \left(FLH_{cool} * BtuH_{CAC} * \frac{\frac{1}{SEER}}{1000} + FLH_{heat} * BtuH_{HP} * \frac{\frac{1}{HSPF}}{1000} \right) * EF_{elec} * SqFt_{Adjust}$$

$$kW\ Savings_{CAC} = BtuH_{CAC} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * CF * SqFt_{Adjust}$$

$$kW\ Savings_{HP} = BtuH_{HP} * \frac{\frac{1}{EER}}{1000} * EF_{elec} * CF * SqFt_{Adjust}$$

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-49. To account for savings differences by home type, Cadmus applied a square footage adjustment due to reduced heating and cooling load for multifamily homes compared to single-family homes.

Table A-49. Furnace Whistle Savings Inputs

Input	Assumption	Source
Efficiency savings for heat pump/air conditioner (Efelec)	0.0350	Quantec analysis: Engineering Review and Savings Estimates for the “Filtertone” Filter Restriction Alarm
Seasonal energy efficiency ratio (SEER)	13	2015 Indiana TRM v2.2: 13 SEER reflects new federal efficiency standard for baseline equipment
Energy efficiency ratio (EER)	11	2015 Indiana TRM v2.2: 11 EER reflects new federal efficiency standard for baseline equipment
Size of central AC units (BtuHCAC)	26,147	2020 IQW CAC Installation Data
Heating season performance factor (HSPF)	8.2	2015 Indiana TRM v2.2: 8.2 HSPF reflects new federal efficiency standard for baseline equipment
Size of heat pump (BtuHHP)	26,147	2020 program tracking data, for CAC installations
Summer peak coincidence factor for heat pump/central AC (CF)	0.88	2015 Indiana TRM v2.2: Summer peak coincidence factor is deemed at 0.88 per Duke Energy load shape
Full load cooling hours (FLHcool)	600	2015 Indiana TRM v2.2: Evansville
Full load heating hours (FLHheat)	982	2015 Indiana TRM v2.2: Evansville
Square Footage Adjustment for MF	45%	2009 RECS square footage by building type

[109] 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.

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 v2.2 methodology because the TRM assumed the average temperature difference between water supplied by the water heater 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 the TRM likely 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.[110] The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-50.

Table A-50. 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)	45.8 (SF)/50.1 (MF)	Calculated using people per home from 2020 IQW survey data for single-family and 2020 MFDI survey data for multifamily to interpolate daily usage, based on relationship between gallons of water per day, per household vs. number of people. 2015 Indiana TRM v2.2
Water heater temperature setpoint (°F, Tsetpoint)	135/120	Illinois TRM V8.0 default value or 120 if the customer received a water heater setback
Input water temperature to house (°F, Tin)	62.8	2015 Indiana TRM v2.2 for Evansville, 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 v2.2
Hours in a year (Hours)	8760	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	1	2015 Indiana TRM v2.2

Smart Thermostats

Cadmus calculated smart thermostat savings using the following equation (excluding ISR).

$$Annual\ kWh\ Savings = (\Delta kWh_{HEATING} + \Delta kWh_{COOLING}) * \ SqFt_{Adjust}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{1}{\eta_{HEAT} \ * 3412}\right)$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline}$$

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

The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-51. These inputs were primarily derived from results of a 2013-2014 evaluation of programmable and smart thermostats in Vectren South territory.[111] Because smart thermostats have a learning function, it was assumed that 100% were auto-adjusting temperature appropriately.

Table A-51. Smart Thermostat Savings Inputs

Variable	Value	Units	Source
FLH_{HEAT}	982	Hours	2015 Indiana TRM v2.2; Evansville, Indiana
$BTUH_{HEAT}$	32,000	BTUH	2016 Pennsylvania TRM
η_{HEAT}	2.0/1.0	-	2015 Indiana TRM v2.2 – 2.0 used for Heat Pumps. 1.0 used for Electric Resistance Heat
Manual thermostat saturation	47%	%	2020 IQW Program participant survey
Programmable thermostat saturation	53%	%	2020 IQW Program participant survey
$ESF_{AdjustedBaseline_{HEAT}}$	10.71%	%	Calculated, example below. Based on Evaluation of the 2013-2014 Programmable and Smart Thermostat Program
$\Delta Cooling_{AdjustedBaseline}$	377	kWh	Calculated, example below. Based on Evaluation of the 2013-2014 Programmable and Smart Thermostat Program
Square Footage Adjustment for MF	45%	%	2009 RECS square footage by building type

In 2020, smart thermostats were installed in homes with gas heating and central air conditioning as well as homes with electric furnaces and central air conditioning. Cadmus calculated electric heating savings for all thermostats installed in electrically heated homes.

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 South territory.[112] 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 2020 IQW Program participant survey indicated that the saturation was 47% for manual thermostats and 53% for programmable thermostats (n=17).

Cadmus used the reported household cooling and heating savings for programmable thermostats from the 2013-2014 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.

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

112 Ibid.

Cadmus used these equations:[113]

$$\Delta Cooling_{AdjustedBaseline} = [47\% * 429 + 53\% * (429 - 224)] = 377\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 47\% * 12.5\% + 53\% * (12.5\% - 3.3\%) = 10.71\%$$

In the $\Delta Cooling_{AdjustedBaseline}$ calculation, the 224 represents the cooling savings (332 kWh multiplied by 67% correct use factor) for replaced 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.

Home Type Adjustment

The 2013-2014 thermostat evaluation from which savings are derived was based on single-family homes. To account for savings differences by home type due to reduced heating and cooling load for multifamily homes compared to single-family homes, Cadmus applied a square footage adjustment to attempt to account for differences in savings by home type.

A.5.5 Appliance and Plug Load Reduction

Refrigerator Replacement

Cadmus used the following equation from the 2015 Indiana TRM v2.2 to calculate savings for replaced refrigerators (excludes ISR). The regression coefficients were updated with the coefficient findings for the 2020 Appliance Recycling Program.

$$kWh\ Savings = [(UEC_{RETIRED} * F_{RUNTIME}) - UEC_{NEW}] * \left(\frac{RUL_{RECYCLED}}{EUL_{NEW}}\right) + [(UEC_{STANDARD} - UEC_{NEW}) * (\frac{(EUL_{new} - RUL_{RECYCLED})}{EUL_{NEW}})]$$

$$UEC_{existing} = 365.25 * [0.81 + (0.02 * Age) + (1.04 * F_{before1990}) + (0.06 * Size) + (-1.75 * F_{singledoor}) + (1.12 * F_{side-by-side}) + (0.56 * F_{primary}) + (-0.04 * HDD * F_{outdoor}) + (0.03 * CDD * F_{outdoor})]$$

$$kW\ Savings = \frac{\Delta kWh}{8{,}760} * TAF * LSAF$$

Cadmus calculated savings for each refrigerator replaced using the following sources:

- 2015 Indiana TRM v2.2 methodology for refrigerator recycling to establish the unit energy consumption (UEC) of the retired refrigerators, using updated algorithm coefficients from the 2020 Appliance Recycling Program evaluation results

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

- ENERGY STAR database to determine the UEC of the new refrigerator units based on make and model numbers
- 2020 program 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 v2.2:

- 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=$EUL_{new\ refrigerator} - RUL_{recycled\ unit}$)

Savings inputs are shown in Table A-52.

Table A-52. IQW Program Refrigerator Replacement Savings Inputs

Description	Assumption	Source
UEC_new (kWh)	404	2020 program tracking data, ENERGY STAR database
UEC_retired (kWh)	1,965	2020 program tracking data, appliance recycling program coefficients
UEC_standard baseline (kWh)	404	2015 Indiana TRM v2.2, averaged by program data configuration
F_run time	1.000	2015 Indiana TRM v2.2
TAF	1.21	2015 Indiana TRM v2.2
LSAF_old	1.063	2015 Indiana TRM v2.2, refrigerator recycling
LSAF_new	1.124	2015 Indiana TRM v2.2, time-of-sale refrigerator
Remaining useful life of old unit (years)	8	2015 Indiana TRM v2.2
EUL of new refrigerator (years)	17	2015 Indiana TRM v2.2

Smart Strips

Cadmus used deemed savings from the 2015 Indiana TRM v2.2 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 v2.2 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 v2.2 for the city of Evansville and were dependent on the heating and cooling type of each participant home. The savings inputs Cadmus used for its *ex post* calculations are shown in Table A-53.

Table A-53. 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 v2.2 Smart Power Strip section	2015 Indiana TRM v2.2
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 v2.2 Smart Power Strip section	2015 Indiana TRM v2.2
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 v2.2 Smart Power Strip section	2015 Indiana TRM v2.2
Number of hours per year peripherals are controlled (computers) (H)	7,474	2015 Indiana TRM v2.2
Number of hours per year peripherals are controlled (televisions) (H)	6,784	2015 Indiana TRM v2.2
Coincident factor (CF)	0.50	2015 Indiana TRM v2.2
Waste heat factor for energy (WHFe)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each lighting participant
Waste heat factor for demand (WHFd)	Dependent on heating and cooling type	2015 Indiana TRM v2.2 appendix with 2020 heating and cooling for each lighting participant

A.5.6 Weatherization Measures

Air Sealing/Infiltration Reduction

Cadmus used these equations from the 2015 Indiana TRM v2.2 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-54.

Table A-54. IQW Program Air Sealing Savings Inputs

Description	Assumption	Source
Leakage rate before installation (CFM50_exist)	Actual	2020 program tracking data
Leakage rate after installation (CFM50_new)	Actual	2020 program tracking data
N-Factor	16.3	2015 Indiana TRM v2.2
Summer peak coincidence factor (CF)	0.88	2015 Indiana TRM v2.2
kWh/CFM – Electric, CAC (kWh/CFM)	40.30	2015 Indiana TRM v2.2
kW/CFM – Electric, CAC (kW/CFM)	0.01	2015 Indiana TRM v2.2
kWh/CFM – Heat Pump (kWh/CFM)	20.50	2015 Indiana TRM v2.2
kW/CFM – Heat Pump (kW/CFM)	0.01	2015 Indiana TRM v2.2
kWh/CFM – Electric, NO AC (kWh/CFM)	36.90	2015 Indiana TRM v2.2
kW/CFM – Electric, NO AC (kW/CFM)	0.00	2015 Indiana TRM v2.2
kWh/CFM – Gas Furnace, CAC (kWh/CFM)	3.00	2015 Indiana TRM v2.2
kW/CFM – Gas Furnace, CAC (kW/CFM)	0.01	2015 Indiana TRM v2.2

Insulation (Attic and Wall)

Cadmus applied this algorithm from the 2015 Indiana TRM v2.2 to calculate and verify energy saving (excludes ISR):

$$Annual\ (Energy\ or\ Demand)\ Savings = kSF\ x\ \frac{(Energy\ or\ Demand)\ Savings}{kSF}$$

Table A-55. IQW Program Attic Insultation Savings Inputs

Description	Assumption	Source
Area of installed insulation (kSF)	Actual	2020 program tracking data
Energy Savings	Dependent on recorded pre and post R-values	2020 program tracking 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 v2.2. 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 v2.2 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-56.

Table A-56. Attic Insulation Compression, Rratio, and Void Factors

Description	Assumption	Source
Actual pre- and post-R-values per manufacturing specifications (Rnominal)	Actual	2020 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 (Rframing and air space)	5	2015 Indiana TRM v2.2
Area of installed insulation in thousand square feet (kSF)	Varies by participant	2020 program tracking data for heating/cooling combination for each participant

Table A-57 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-57. Indiana TRM v2.2: 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 v2.2 Tables

Cadmus used the pre- and post-adjusted R-values from step two to interpolate energy and demand for every 2019 installation based on the reported heating and cooling types. Appendix C of the 2015 Indiana TRM v2.2 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-58.

Table A-58. 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 v2.2): 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 v2.2): 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 v2.2
DE for use in peak demand savings ($DEPK_{BEFORE}$)	73%	2015 Indiana TRM v2.2
Full-load heating hours ($EFLH_{HEAT}$)	1,341; 982	2015 Indiana TRM v2.2 for Indianapolis and Evansville
Full-load cooling hours ($EFLH_{COOL}$)	600	2015 Indiana TRM v2.2 for Evansville

Description	Assumption	Source
Heating system capacity – electric furnace ($Btuh_{HEAT}$)	32,000 BTUH	2016 Pennsylvania TRM[114]
Cooling system capacity ($Btuh_{COOL}$)	26,146 BTUH	2020 IQW CAC Installation Data
Efficiency of heating system – electric furnace (η_{HEAT})	HSPF=3.412	2015 Indiana TRM v2.2
Efficiency of cooling system (SEER)	13	2015 Indiana TRM v2.2: 13 SEER reflects new federal efficiency standard for baseline equipment
Efficiency of cooling system (EER)	11	2015 Indiana TRM v2.2: 11 EER reflects new federal efficiency standard for baseline equipment

Whole Home IQW

Vectren provided descriptions of the three Whole Home IQW measures. Of the three projects, two were air and duct sealing measures without accompanying values for blower door tests. For these two measures, Cadmus applied the program average air and duct sealing savings. The third measure was an electric water heater replacing an electric water heater for health and safety purposes, for which there is no basis for savings.

A.6 Energy Efficient Schools Program

Cadmus' impact evaluation of the Energy Efficient Schools Program included measures with attributable electric savings, including these:

Electric measures

- One 15-watt LED
- Two 11-watt LEDs
- LED nightlight

Dual fuel measures

- Kitchen faucet aerator (1.5 gpm)
- Two bathroom faucet aerators (1.0 gpm)
- Energy-efficient showerhead (1.5 gpm)
- Furnace filter whistle

Table A-59 provides per-unit annual gross savings for each program measure. These savings include adjustments for in-service rate and water heater fuel saturation.

[114] Electric heating system capacity assumptions were not available in the Indiana TRM v2.2.

Table A-59. 2020 Energy Efficient Schools Program Per-Unit Gross Savings

Measure	Annual Gross Savings[1] (kWh)		Annual Gross Savings[1] (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
11W LED (one unit only)[2]	31.2	38.0	0.0034	0.0042
15W LED	42.3	59.2	0.0046	0.0065
Energy-Efficient Bathroom Aerator (one unit only)[2]	8.9	6.4	0.0004	0.0004
Energy-Efficient Kitchen Aerator	45.4	49.4	0.0012	0.0013
Energy-Efficient Showerhead	109.9	80.0	0.0029	0.0027
Furnace Filter Whistle	12.3	16.5	0.0153	0.0251
LED Nightlight	6.6	3.8	0.0000	0.0000

[1] Reported and evaluated savings include in-service rates

[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 assumption of 1,135 hours of use per year from the 2015 Indiana TRM v2.2.[115] 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 v2.2 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-60.

[115] The 2015 Indiana TRM v2.2 LED bulb assumptions do not account for bulb location.

Table A-60. 2020 Energy Efficient Schools Program LED Savings Inputs

Input	Assumption	Source
Baseline Wattage for Equivalent Incandescent Bulb (11-watt LED)	53	Residential Lighting Evaluation Protocol for post-EISA 1100 lumen LED (program data provided by Vectren) [1]
Baseline Wattage for Equivalent Incandescent Bulb (15-watt LED)	72	Residential Lighting Evaluation Protocol for post-EISA 1600 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
In-Service Rate for 11W LED	82.4%	2019 student household survey
In-Service Rate for 15W LED	94.7%	2019 student household survey

[1] Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68562.pdf

A.6.2 Energy-Efficient Faucet Aerators

Cadmus used these equations to calculate savings per faucet aerator installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MPD * \frac{PH}{SH} * DR * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * DR * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

To inform the energy-savings estimate, Cadmus used the 2015 Indiana TRM v2.2 and data collected from the 2019 student household survey and 2020 HEWs to determine household characteristics. Table A-61 shows these inputs.

Table A-61. 2020 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 v2.2
Number of Faucets per Home	1	2.36	2019 student household survey
Average Household Size (Number of People)	4.62	4.62	2020 HEW
Input Water Temperature to House (°F)	62.8	62.8	2015 Indiana TRM v2.2 for Evansville, Indiana, cold water temperature entering the DHW system
Temperature of Water at Faucet (°F)	93	86	2015 Indiana TRM v2.2
Percent of Water Flowing Down Drain	50%	70%	2015 Indiana TRM v2.2
Gallons per Minute of Baseline Faucet Aerator	2.44	1.9	2015 Indiana TRM v2.2
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 v2.2
Summertime Peak Coincidence Factor	0.0033	0.0012	2015 Indiana TRM v2.2
In-Service Rate	43%	36%	2019 student household survey
%Fuel	43%	43%	2020 HEW

A.6.3 Energy-Efficient Showerhead

Cadmus used these equations to calculate savings per energy-efficient showerhead installed:

$$kWh\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * MS * SPD * \frac{PH}{SH} * 8.3 * (T_{MIX} - T_{IN}) * \frac{365}{RE * 3{,}412}$$

$$kW\ Savings = ISR * \%Fuel * (GPM_{BASE} - GPM_{LOW}) * 60 * 8.3 * \frac{(T_{MIX} - T_{IN})}{RE * 3{,}412} * CF$$

To inform the energy-savings estimate, Cadmus used the 2015 Indiana TRM v2.2 and data collected from the 2019 student household survey and 2020 HEWs to determine household characteristics. Table A-62 shows these inputs.

Table A-62. 2020 Energy Efficient Schools Program Showerhead Savings Inputs

Input	Assumption	Source
Average Shower Length (Minutes)	7.8	2015 Indiana TRM v2.2
Average Household Size (Number of People)	4.62	2020 HEW
Number of Showerheads per Home	1.95	2019 student household survey
Number of Showers per Day per Person	0.6	2015 Indiana TRM v2.2
Input Water Temperature to House (°F)	62.8	2015 Indiana TRM v2.2 for Evansville, Indiana, cold water temperature entering the DHW system
Water Temperature at Showerhead (°F)	101	2015 Indiana TRM v2.2, average mixed temperature of water used for shower
Gallons per Minute of Baseline Showerhead	2.63	2015 Indiana TRM v2.2
Gallons per Minute of Energy-Efficient Showerhead	1.50	Provided by Vectren
Recovery Efficiency of Electric Hot Water Heater	0.98	2015 Indiana TRM v2.2
Summer Peak Coincidence Factor	0.0023	2015 Indiana TRM v2.2
In-Service Rate	43%	2019 student household survey
%Fuel	43%	2020 HEW

A.6.4 LED Nightlight

Cadmus used this equation to calculate savings per LED nightlight installed:

$$kWh\ Savings = \frac{watts_{BASE} - watts_{LED}}{1{,}000} * ISR * HOURS * IRF$$

Cadmus calculated savings for LED nightlights using values from the 2015 Indiana TRM v2.2 for hours of use and baseline wattages. The lighting evaluation protocol from the Uniform Methods Project was used for standard LEDs, but this protocol does not provide guidance for nightlights. For the incandescent replacement factor (IRF), or the percentage of LED nightlights that replaced incandescent nightlights, Cadmus used 2019 student household survey data. The assumptions used in these savings calculations are shown in Table A-63. According to the 2015 Indiana TRM v2.2, no peak demand reduction is associated with nightlights.

Table A-63. 2020 Energy Efficient Schools Program LED Nightlight Savings Inputs

Input	Assumption	Source
Baseline Wattage for Incandescent Nightlight	5	2015 Indiana TRM v2.2
LED Nightlight Wattage	0.5	Provided by Vectren
Hours of Use per Year	2,920	2015 Indiana TRM v2.2
Incandescent Replacement Factor	41%	2019 student household survey
In-Service Rate	71%	2019 student household survey

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-64, Cadmus calculated savings for the furnace filter whistles installed through the program using values from the 2015 Indiana TRM v2.2, 2019 student household survey data, the 2012 Indiana residential baseline study, and an engineering review conducted by Quantec detailing algorithms for the measure.[116]

Table A-64. 2020 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 v2.2: when unknown use 11.15 (minimum federal standard)
Energy Efficiency Ratio	10.04	2015 Indiana TRM v2.2: EER=SEER*0.9
Multiplier for Energy Efficiency Ratio	0.90	2015 Indiana TRM v2.2: EER=SEER*0.9
Heating Season Performance Factor	6.8	2015 Indiana TRM v2.2: 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 v2.2: CAC early replacement default existing unit cooling capacity
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 v2.2
Full Load Cooling Hours	600	2015 Indiana TRM v2.2 for Evansville
Full Load Heating Hours (Gas and Electric)	982	2015 Indiana TRM v2.2 for Evansville
In-Service Rate	28%	2019 student household survey
%CAC	97%	2019 student household survey
%HP	3%	2019 student household survey

[116] 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.

A.7 Residential Behavioral Savings Program

Cadmus' impact evaluation of the Residential Behavioral Savings (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:

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

A.7.1 Data Collection, Review, and Preparation

Vectren provided data from monthly utility bills for electric only and dual fuel homes for treatment and control group customers between January 2011 and January 2021 (approximately 13 months of bills prior to the beginning of the RBS Program in 2012 and 108 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 and launch date/wave)
- Assignment to treatment or control groups
- First report date
- 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 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 2020 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 worked with Vectren and the program implementer to acquire the data necessary for the RBS Program evaluation in 2020. Major data preparation steps included cleaning and compiling the program tracking data, billing consumption and weather data, and testing for significant differences in annual pretreatment consumption between treatment and control customers, by customer segment. This section describes the steps Cadmus took to process the data and verify customers in the tracking and billing data.

Program Tracking Data

Cadmus received RBS Program tracking data from the program implementer at the close of 2020. These data included treatment group customers who received home energy reports in the current or a previous year and control group customers tracked since the program's inception. Because the RBS Program was implemented as a randomized control trial, Cadmus included all of the possible customers in its evaluation, adopting a "once in, always in" policy for customers originally randomized into either the treatment or control group prior to the launch of the home energy reports.

Table A-65 shows customer attrition through 2020, by treatment and control groups, by customer segment, and as originally randomized and active at the beginning of treatment in 2020. The attrition process captures customers whose accounts closed (became inactive) since the launch of the program.

Table A-65. 2020 RBS Program Customer Attrition

Customer Segment	Originally Randomized		Active at the Beginning of Treatment in 2020	
	Treatment	Control	Treatment	Control
Wave 1 Electric Only (2012)	25,746	6,098	11,414	2,747
Wave 1 Dual Fuel (2013)	51,496	5,590	27,480	3,053
Wave 2 Dual Fuel (2020)	13,001	9,468	13,001	9,468
Program Total	**90,243**	**21,156**	**51,895**	**15,268**

Billing Data

Cadmus collected customer billing data for each customer segment from the program implementer. To clean the billing data, Cadmus followed these steps:

1. Drop customers whose accounts went inactive before the delivery of the first energy reports
2. Clean and calendarize bills, which included dropping bills that covered more than 100 days (about three months), dropping bills with negative consumption, dropping bills earlier than one year prior to the delivery of the first energy reports, and truing up bills with estimated reads
3. Drop customers with less than six months of pretreatment bills (six months of pretreatment bills was used as a cutoff to preserve sample sizes and be consistent across waves)

Table A-66 provides the attrition in the 2020 analysis sample from data cleaning steps. The final modeling sample included customers in Cadmus' final tracking data who were not dropped during the billing data cleaning process and were included in the billing analysis. These customers were not necessarily active at the beginning of treatment in 2020.

Table A-66. 2020 RBS Program Analysis Sample

Step in Attrition	Wave 1 Electric Only[1]		Wave 1 Dual Fuel[1]		Wave 2 Dual Fuel	
	Treatment	Control	Treatment	Control	Treatment	Control
Originally Randomized Customers	25,746 (100%)	6,098 (100%)	51,496 (100%)	5,590 (100%)	13,001 (100%)	9,468 (100%)
Included in Billing Data	25,673 (100%)	6,082 (100%)	51,380 (100%)	5,578 (100%)	13,001 (100%)	9,468 (100%)
Active at Program Launch	25,167 (98%)	5,963 (98%)	50,809 (99%)	5,528 (99%)	13,001 (100%)	9,468 (100%)
Less than 6 Months of Pretreatment Data	23,708 (92%)	5,593 (92%)	49,619 (96%)	5,388 (96%)	12,628 (97%)	9,168 (97%)
Final Modeling Sample	**23,708 (92%)**	**5,593 (92%)**	**49,619 (96%)**	**5,388 (96%)**	**12,628 (97%)**	**9,168 (97%)**

[1] The billing data analysis sample includes customers who were randomized into the program and active when treatment began in 2012. These customers were not necessarily active in 2020. All Wave 2 customers were active in 22

Weather Data

Cadmus collected weather data from the weather station closest to each home and estimated the heating degree days (HDDs) and cooling degree days (CDDs) for each customer billing cycle. After merging the weather and billing data, Cadmus allocated the billing cycle electricity consumption, HDDs, and CDDs to calendar months.

Verification of Balanced Treatment and Control Groups

Cadmus verified that subjects in the treatment and control groups in the final analysis sample were equivalent in their annual pretreatment energy consumption. Cadmus verified the equivalence of waves using the cleaned billing data, comparing preprogram average annual consumption from before the launch of the program.

Table A-67 provides the 2020 results of the tests for significant differences in treatment and control group pretreatment consumption. Cadmus found that all waves were balanced. No statistically significant differences existed between the pretreatment consumption of treatment and control groups in any customer segment.

Table A-67. 2020 RBS Program Analysis Sample

Customer Segment	Average Annual Electricity Use per Customer (kWh/yr)			p-value[1]
	Treatment Group	Control Group	Difference	
Wave 1 Electric Only (2012)	14,769	14,645	-124	0.29
Wave 1 Dual Fuel (2013)	12,022	11,937	-85	0.31
Wave 2 Dual Fuel (2020)	11,849	11,864	15	0.85

[1] A p-value >0.05 indicates an insignificant difference at the 5% significance level.

A.7.2 Regression Analysis

Cadmus used regression analyses of monthly billing data from customers in the treatment and control groups to estimate the RBS Program's energy savings. The billing analysis conformed to IPMVP Option C, whole facility,[117] and the approach described in the Uniform Methods Project.[118,119]

More specifically, Cadmus used a multivariate regression to analyze the energy use of customers who had been randomly assigned to treatment and control groups. Cadmus tested and compared two general model specifications to check the robustness of savings results:

- The ***post-only*** model regresses customer average daily consumption on a treatment indicator variable and includes as regressors customers' pretreatment energy use, month-by-year fixed effects and weather.[120] The model is estimated only with posttreatment customer bills.
- The ***difference-in-differences (D-in-D) fixed effects*** model regresses average daily consumption on a treatment indicator variable, month-by-year fixed effects, customer fixed effects, and weather. The model is estimated with pretreatment and posttreatment customer bills.

Both models yielded savings estimates that were within each other's confidence intervals, meaning that their results were not statistically different. In 2020, Cadmus reported the results of the post-only model, consistent with previous program years.

The error terms of the post-only model and D-in-D fixed effects model should be uncorrelated with program participation ($PART_i$) and other observable variables because of the random assignment of homes to treatment and control groups, and therefore Ordinary Least Squares (OLS) regression should result in an unbiased estimate of the average daily savings per customer. Cadmus clustered the standard errors on customers to account for arbitrary correlation in customer consumption over the analysis period.

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[117] Efficiency Valuation Organization. January 2012. *International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume 1.* Page 25. (EVO 10000 – 1:2012) http://www.evo-world.org/

[118] Agnew, K., and M. Goldberg. April 2013. "Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* National Renewable Energy Laboratory. (NREL/SR-7A30-53827) http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

[119] Stewart, J., and A. Todd. August 2014. "Chapter 17: Residential Behavior Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* National Renewable Energy Laboratory. (NREL/SR-7A40-62497) http://www1.eere.energy.gov/office_eere/de_ump_protocols.html

[120] Allcott, H., and T. Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review* 104 (10), 3003-3037.

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:

$$ADC_{it} = \sum_{t=1}^{T} \beta_{1t} PART_i * PY_t + \beta_2 Pre\text{–}ADC_{im} \times M_m + W'\gamma + \tau_t + \varepsilon_{it}$$

Where:

β_1	=	Coefficient representing the conditional average treatment effect of the program on electricity consumption (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).
β_2	=	Coefficient representing the conditional average effect of pre-treatment electricity consumption on post-treatment average daily consumption (kWh per customer per day).
$Pre\text{–}ADC_{im}$	=	Mean household energy consumption of customer 'i' in month 'm' in the pre-treatment period.
M_m	=	Variable indicating the month of the calendar year for months $m = 1,2, \ldots ,12$.
W	=	Vector using both HDD and CDD variables to control for weather impacts on energy use.
γ	=	Vector of coefficients representing the average impact of weather variables on energy use.
τ_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.
ε_{it}	=	Error term for customer 'i' in month 't.'

D-in-D 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:

β_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.
γ	=	Vector of coefficients representing the average impact of weather variables on energy use.
α_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.
τ_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.
ϵ_{it}	=	Error term for customer 'i' in month 't'

Regression Analysis Estimates

Cadmus estimated separate treatment effects for each customer segment and program year. Table A-68 shows both the post-only and D-in-D fixed effects model estimates of average daily savings per customer, by segment and program year. All of the models were estimated by OLS, and Huber-White robust clustered standard errors were adjusted for correlation over time in a customer's consumption. The post-only and D-in-D fixed effects models produce statistically indistinguishable results each year, showing that estimated treatment effects are robust.

Table A-68. RBS Program Historical Model Comparison of Savings

Treatment Year	Wave 1 Electric Only[1]		Wave 1 Dual Fuel[1]		Wave 2 Dual Fuel[1]	
	Post-Only (Standard Error)	D-in-D Fixed Effects (Standard Error)	Post-Only (Standard Error)	D-in-D Fixed Effects (Standard Error)	Post-Only (Standard Error)	D-in-D Fixed Effects (Standard Error)
2012	-0.422 (0.092) ***	-0.354 (0.092) ***	-0.201 (0.083) **	-0.156 (0.073) **	N/A	N/A
2013	-0.646 (0.139) ***	-0.614 (0.126) ***	-0.318 (0.099) ***	-0.293 (0.096) ***	N/A	N/A
2014	-0.735 (0.174) ***	-0.676 (0.162) ***	-0.436 (0.118) ***	-0.425 (0.117) ***	N/A	N/A
2015	-0.694 (0.174) ***	-0.627 (0.171) ***	-0.471 (0.127) ***	-0.453 (0.128) ***	N/A	N/A
2016	-0.674 (0.188) ***	-0.648 (0.189) ***	-0.446 (0.144) ***	-0.423 (0.146) ***	N/A	N/A
2017	-0.747 (0.198) ***	-0.68 (0.204) ***	-0.41 (0.15) ***	-0.422 (0.156) ***	N/A	N/A
2018	-0.815 (0.244) ***	-0.743 (0.236) ***	-0.308 (0.171) *	-0.347 (0.172) *	N/A	N/A
2019	-0.67 (0.251) ***	-0.58 (0.249) **	-0.482 (0.181) ***	-0.482 (0.185) ***	N/A	N/A
2020	-0.819 (0.265) ***	-0.71 (0.267) ***	-0.585 (0.188) ***	-0.586 (0.193) ***	-0.179 (0.098) *	0.192 (0.083) **

[1]Standard errors clustered on customers are presented below the estimated treatment effect in parentheses (*** Significant at 1%; ** Significant at 5%; * Significant at 10%). The treatment effects represent the average daily savings per treatment group customer.

A.7.3 Program Total Savings Estimation

Cadmus estimated program savings in 2020 for each wave's population of treated customers as the product of average daily savings per participant and the number of days these customers were treated in 2020, shown below. Cadmus assumed that the program implementer intended to treat all eligible customers at least once in 2020 and included treatment days for customers who should have received treatment in 2020 (i.e., those who were still active and randomized as a treatment customer), even when customers were not explicitly flagged as receiving 2020 treatment.

$$Savings_h = -\hat{\beta}_{1,h} * \sum_{i=1}^{N} Treatment\ Days_{i,h}$$

Where:

$\hat{\beta}_{1,h}$	=	Average daily savings (kWh) per treatment group customer in wave 'h', estimated from the post-only regression model.
$Treatment\ Days_{i,h}$	=	The number of days customer 'i' in wave 'h'was treated in 2020.

Cadmus estimated realization rates for each wave as the ratio of verified program savings to reported program savings (estimated by the program implementor).

A.7.4 Energy Efficiency Program Channel (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 the DSM 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
- Income Qualified Weatherization (IQW) Program
- Home Energy Assessment 2.0 (HEA 2.0) Program
- Residential Prescriptive Program
- Smart Cycle 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 rather than the customer level.

The Residential New Construction Program targeted builders of new homes, which the RBS Program did not target. 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 2020, matching the data to RBS Program treatment and control homes, and applied a simple differences analysis to each customer segment. 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 2020 efficiency program data, Cadmus excluded measures installed after an account became inactive or measures installed before the start of the evaluation year. 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 prorated 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 2020.

Let ρ_m be the participation rate (defined as the number of participants to the number of potential participants) in a program in 2020 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 2020, 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:

$$\textit{Net savings per home from participation uplift} = \sigma_1 - \sigma_0$$[121]

Multiplying net savings per home by the number of program homes yielded an estimate for a customer segment of total RBS net savings counted in Vectren's other efficiency programs.

121 Cadmus obtained net savings by multiplying measure-verified gross savings by the estimated measure NTG ratio.

A.7.5 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. This methodology is a reasonable approach for programs that evaluate savings using billing analysis, in the absence of an hourly analysis of treatment and control AMI data. These approaches and validities are further outlined in the Uniform Methods Project.[122] Reported demand savings were based on per-household estimates that do not take into account year-to-year differences in energy savings.

The Calibrated DSMore Load-Shape Differences (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 each customer segment.

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 *A.7.2 Regression 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.[123]
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 active treatment customers 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.

[122] Stern, F., and J. Spencer. October 2017. "Chapter 10: Peak Demand and Time-Differentiated Energy Savings Cross-Cutting Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68566.pdf

[123] 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.8 Appliance Recycling Program

Cadmus' impact evaluation of the Appliance Recycling Program included measures with attributable electric savings—recycled refrigerators, freezers, and window air conditioners. Table A-69 provides per-unit annual gross savings for each program measure.

Table A-69. 2019 Appliance Recycling Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Refrigerator	1,096	1,012	0.14	0.15
Freezer	706	722	0.14	0.11
Window Air Conditioner	304	304	0.14	0.21

A.8.1 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.[124] Because the UMP does not have specifications for freezers, Cadmus created an analogous freezer model from an aggregated dataset of freezers metered by Cadmus in Wisconsin and Michigan. The coefficient for each independent variable indicated the influence of that variable on daily consumption. Holding all other variables constant, a positive coefficient indicated an upward influence on consumption, and a negative coefficient indicated a downward effect on consumption.

Table A-70 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.

[124] 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

Table A-70. Refrigerator UEC Regression Model Estimates

(Dependent Variable=Average Daily kWh, R2=0.30)

Independent Variables	Coefficient	p-Value
Intercept	0.81	0.13
Age (years)	0.021	0.04
Dummy: Unit manufactured pre 1990s	1.04	<.0001
Size (cu. Ft.)	0.06	0.02
Dummy: Single Door	-1.75	<.0001
Dummy: Side-by-Side	1.12	<.0001
Dummy: Primary	0.56	0.003
Interaction: Unconditioned Space x HDDs[1]	-0.04	<.0001
Interaction: Unconditioned Space x CDDs[2]	0.03	0.19

[1] Heating degree day

[2] Cooling degree day

Table A-71 shows the final model specifications Cadmus used to estimate annual energy consumption of participating freezers and their estimated parameters.

Table A-71. Freezer UEC Regression Model Estimates

(Dependent Variable=Average Daily kWh, R2=0.45)

Independent Variables	Coefficient	p-Value
Intercept	-0.96	0.54
Age (years)	0.045	0.12
Dummy: Unit Manufactured Pre-1990	0.54	0.24
Size (cu. Ft.)	0.12	0.09
Dummy: Chest Freezer	0.30	0.07
Interaction: Unconditioned Space x HDDs[1]	-0.03	0.54
Interaction: Unconditioned Space x CDDs[1]	0.08	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, the program implementer, in the 2020 program tracking database). Table A-72 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.[125]

[125] TMY3 used median daily values for a variety of weather data collected from 1991 to 2005.

Table A-72. 2020 Appliance Recycling Program Participant Mean Explanatory Variables and Model Coefficients

Measure	Independent Variables	2020 Mean Value	2020 Model Coefficient
Refrigerator	Intercept	1.00	0.81
	Age (years)	19.36	0.021
	Dummy: Manufactured pre 1990s	0.09	1.04
	Size (cu. Ft.)	19.96	0.06
	Dummy: Single Door	0.03	-1.75
	Dummy: Side-by-Side	0.32	1.12
	Dummy: Primary	0.50	0.56
	Interaction: Unconditioned Space x HDDs[1]	4.71	-0.04
	Interaction: Unconditioned Space x CDDs[1]	1.42	0.03
Freezer	Intercept	1.00	-0.96
	Age (years)	23.01	0.045
	Dummy: Unit Manufactured Pre-1990	0.23	0.54
	Size (cu. Ft.)	15.54	0.12
	Dummy: Chest Freezer	0.41	0.30
	Interaction: Unconditioned Space x HDDs[1]	6.60	-0.03
	Interaction: Unconditioned Space x CDDs[1]	1.98	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 2020 Appliance Recycling Program 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 2020 rather than on a secondary data source.

Table A-73 shows the average per-unit UEC for refrigerators and freezers recycled during 2020 and 2019 (for comparison). In 2020, refrigerators and freezers had a lower UEC than in 2019. Note that the average per-unit UEC shown in the table does not include the part-use adjustment factor.

Table A-73. 2020 and 2019 Appliance Recycling Program – Refrigerator and Freezer Average UEC

Measure	2019 Average Unit Energy Consumption (kWh/Year)	2020 Average Unit Energy Consumption (kWh/Year)	2020 Relative Precision (90% Confidence)
Refrigerator	1,151	1,077	11%
Freezer	875	785	26%

Using values from Table A-72 above, Cadmus calculated the estimated annual UEC for 2020 freezers using the following equation:

$$\text{2020 Freezer UEC} = 365.25\ days * (-0.96 + 0.045 * [23.01\ years\ old] + 0.54 * [23\%\ units\ manufactured\ pre-1990] + 0.12 * [15.54\ ft.^3\ ] + 0.30 * [41\%\ units\ that\ are\ chest\ freezers] + 0.08 * [1.98\ Unconditioned\ CDDs] - 0.03 * [6.60\ Unconditioned\ HDDs]) = 785\ kWh/year$$

The change in the refrigerator UEC is because of an 18% decrease in the percentage of recycled refrigerators manufactured before 1990 and a 12% decrease in the average age of recycled refrigerators compared to 2019. The independent variables for units manufactured before 1990 and unit age 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 of a 23% decrease in the percentage of recycled freezers that were manufactured before 1990 and a 12% decrease in the average age of recycled freezers compared to 2019.

Table A-74 shows a direct comparison of average values for 2020 and 2019 for all model variables.

Table A-74. Appliance Recycling Program Participant Mean Explanatory Variables 2020 and 2019 Comparison

Measure	Independent Variables	2020 Mean Value	2019 Mean Value
Refrigerator	Age (years)	19.36	21.90
	Dummy: Manufactured pre 1990s	0.09	0.27
	Size (cubic feet)	19.96	19.73
	Dummy: Single Door	0.03	0.03
	Dummy: Side-by-Side	0.32	0.31
	Dummy: Primary	0.50	0.49
	Interaction: Unconditioned Space x HDDs[1]	4.71	4.88
	Interaction: Unconditioned Space x CDDs[1]	1.42	1.47
Freezer	Age (years)	23.01	26.07
	Dummy: Unit Manufactured Pre-1990	0.23	0.46
	Size (cubic feet)	15.54	15.55
	Dummy: Chest Freezer	0.41	0.41
	Interaction: Unconditioned Space x HDDs[1]	6.60	9.22
	Interaction: Unconditioned Space x CDDs[1]	1.98	2.77

[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.

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. The UEC itself is not equal to the gross savings 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 2020 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, respondents estimated the total number of months that the appliance was plugged in. (In 2020, responses from this participant subset resulted in secondary refrigerators operating an average of 7.3 months and secondary freezers operating an average of 1.0 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 2020, the average secondary refrigerator had a part-use factor of 0.61, and the average secondary freezer had a part-use factor of 0.08.)
- 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 (0.91 for refrigerators and 0.92 for freezers, as shown in Table A-75).

- If participants said they would have discarded their appliance independent of the Appliance Recycling Program, 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, as shown in Table A-75) 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-75 lists the resulting part-use factor results by category.

Table A-75. 2020 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=34			N/A		
Not in Use	6%	0.00	-			
Used Part-Time	9%	0.61	658			
Used Full-Time	85%	1.00	1,077			
Weighted Average	**100%**	**0.91**	**977**			
All Units (Primary and Secondary)	n=69			n=47		
Not in Use	3%	0.00	-	6%	0.00	-
Used Part-Time	4%	0.61	658	2%	0.08	65
Used Full-Time	93%	1.00	1,077	91%	1.00	785
Weighted Average	**100%**	**0.95**	**1,028**	**100%[1]**	**0.92**	**720**

[1] Percentages may not sum to 100% due to rounding.
[2] All freezer units are considered to be secondary.

Combining the part-use factors in Table A-75 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-76. This table shows that the weighted average of these future scenarios produces final part-use factor for refrigerators of 0.94 for the 2020 Appliance Recycling Program. The final part-use estimate of 0.92 for freezers comes from Table A-75, as all freezer units are considered secondary units and no additional weighting is needed.

Table A-76. 2020 Appliance Recycling Program Refrigerator Weighted Average Part-Use

Use Prior to Recycling	Likely Use Independent of Recycling	Refrigerators	
		Part-Use Factor	Percentage of Participants
Secondary	Kept	0.91	19%
	Discarded	0.95	32%
Primary	Kept (as primary unit)	1.00	6%
	Kept (as secondary unit)	0.91	12%
	Discarded	0.95	32%
Overall		**0.94**	**100%**[1]

[1] Percentages may not sum to 100% due to rounding.

In 2020, the part-use factor for refrigerators increased from 0.89 in 2019 to 0.94 in 2020, while freezers increased from 0.81 in 2019 to 0.92 in 2020. Table A-77 compares Vectren's part-use factors to previous evaluation years. Part-use factors can vary every year because they are based on survey results.

Table A-77. 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
2019	0.89	0.81
2020	**0.94**	**0.92**

A.8.2 Window Air Conditioner

Cadmus used the following equations from the 2015 Indiana TRM v2.2 to calculate *ex post,* per-measure energy savings and demand reduction for recycled window air conditioners:

$$kWh\ savings = \frac{EFLH_{clg} * \text{BTUh}}{1{,}000} * \left(\frac{1}{EER_{exist}} - \frac{\%_{replaced}}{EER_{new}}\right)$$

$$kW\ reduction = \frac{BTUh * CF}{1{,}000} * \left(\frac{1}{EER_{exist}} - \frac{\%_{replaced}}{EER_{new}}\right)$$

Where:

$EFLH_{clg}$ = Equivalent full-load hours to satisfy the cooling requirements for residents in Evansville, Indiana

BTUh = Actual size of the recycled window air conditioner in BTUh units (where 1 ton = 12,000 BTUh)

EER_{exist} = Energy efficiency rating of the recycled window air conditioner

% Replaced = Average percentage of recycled window air conditioners replaced with a new window air conditioner

EER_{new} = Energy efficiency rating of the newly installed window air conditioner

CF = Coincidence factor, a number between 0 and 1 indicating how many window air conditioners are expected to be in use and saving energy during the peak summer demand period

Table A-78 summarizes the recycled window air conditioners' savings assumptions and identifies each assumption's source.

Table A-78. Appliance Recycling Program Variable Assumptions for Recycled Window Air Conditioners

Variable	Window Air Conditioner Value	Source
Equivalent Full-Load Hours (EFLHclg)	445	2015 Indiana TRM v2.2
BTUh	11,357	
Energy Efficiency Rating-Existing(EERexist)	7.7	
% Replaced	76%	
Energy Efficiency Rating-New (EERnew)	10.9	
Coincidence Factor (CF)	0.30	

A.9 Smart Cycle (Direct Load Control Change Out)

Cadmus' impact evaluation of the Smart Cycle Program focused on smart thermostats with attributable electric savings. Table A-79 provides per-unit annual gross savings. The 2015 Indiana TRM v2.2 does not assign coincident peak demand savings for smart thermostats, so Cadmus assigned 0 kW from normal use of the smart thermostats.

Table A-79. 2020 Smart Cycle Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Smart Cycle Thermostat - Dual Fuel	364	305	1.1	0
Smart Cycle Thermostat - Electric		974		0

A.9.1 Smart Thermostats

Using the same savings methodology used to calculate smart thermostat savings in the 2020 Residential Prescriptive Program, Cadmus calculated Nest thermostat savings using the following equations (excluding in-service rate):

$$Annual\ kWh\ Savings = \Delta kWh_{HEATING} + \Delta kWh_{COOLING}$$

$$\Delta kWh_{HEATING} = FLH_{HEAT} * BTUH_{HEAT} * ESF_{AdjustedBaseline_{HEAT}} * \left(\frac{1}{\eta_{HEAT\ PUMP} * 3412}\right) * TStat\_Type_{DiscountRate}$$

$$\Delta kWh_{Cooling} = \Delta Cooling_{AdjustedBaseline} * TStat_{Type_{COOLING_{DiscountRate}}} * \%AC$$

Table A-80 shows the inputs Cadmus used to evaluate impacts for the smart (learning) thermostats. The Smart Cycle Program tracking data does not have information on home heating equipment capacity, so Cadmus used the average heat pump capacity from the 2020 Residential Prescriptive Program tracking database for the BTUH capacity in the electric heating savings calculation.

Table A-80. 2020 Smart Cycle Per-Unit Savings Inputs

Variable	Value	Units	Source
$\eta_{HEAT\ PUMP}$	2.40	N/A	Federal standard (COP)
η_{ER}	1.0	N/A	2015 Indiana TRM v2.2 (COP)
$BTUH_{HEAT}$	33,476	BTUH	Average of 2020 Residential Prescriptive Program heat pump tracking data capacities
$\%_{HEAT\ PUMP}$	18% for program; 59% for electric only	%	2019 participant survey
$\%_{GAS}$	68% for program; 98% for dual fuel	%	2019 participant survey
$\%_{PROPANE}$	1% for program; 2% for dual fuel	%	2019 participant survey
$\%_{ELECTRIC\ FURNACE}$	13% for program; 41% for electric only	%	2019 participant survey
Manual thermostat saturation	38%	%	2019 participant survey
Programmable thermostat saturation	62%	%	2019 participant survey
$TStat\_Type_{DiscountRate}$	31% non-learning 100% learning	%	The 2013–2014 Programmable and Smart Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology (learning vs. non-learning) 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%	%	The 2013–2014 Thermostat Evaluation indicates that heating savings are highly dependent on thermostat technology and that cooling savings are not. No cooling savings adjustment can be directly derived from the comparative study of smart Wi-Fi thermostats to programmable thermostats.
$ESF_{AdjustedBaseline_{HEAT}}$	10.6%	%	Calculated, example below
$\%AC$	100%	%	Program design assumption; all Smart Cycle participants much have central air conditioning to participate in the program
$\Delta Cooling_{AdjustedBaselin}$	307	kWh	Calculated, example below

Cadmus used a heat pump efficiency of 2.40 coefficient of performance (COP) based on the federal standard. To determine full load hours (FLH), each installation was matched to its nearest 2015 Indiana TRM v2.2 reference city using the installation location's zip code. The full load hours associated with that reference city was then used in the savings calculation for the installation. Cadmus applied additional assumptions from the 2019 participant survey. Cadmus did not conduct a participant survey for the 2020 Smart Cycle Program due to the small population size.

2013–2014 Thermostat Evaluation and Adjusted Baseline

Cadmus' analysis of the thermostat savings for the 2020 Smart Cycle Program used the results of a separate Cadmus evaluation of programmable and Nest Wi-Fi thermostats in Vectren's Indiana South territory in 2013 and 2014.[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 used a 100% manual thermostat baseline for both programmable and Nest Wi-Fi thermostats. However, the 2020 Smart Cycle Program includes participants regardless of their existing thermostat type. Therefore, Cadmus used results from the 2019 Smart Cycle Program participant survey to inform methodology inputs. Survey data indicated a saturation of 38% for manual thermostats and 62% for programmable thermostats.

Cadmus used the reported household cooling and heating savings for programmable thermostats from its thermostat study for the 2013-2014 program and a weighted average to adjust the savings for learning thermostats from a manual thermostat baseline to a mixed manual and programmable thermostat baseline. Cadmus used these equations:[127,128]

$$\Delta Cooling_{AdjustedBaseline} = [38\% * 429 + 62\% * (429 - 186.9)] * 100\% = 314\ kWh$$

$$\mathrm{ESF}_{\mathrm{AdjustedBaseline}_{\mathrm{HEAT}}} = 38\% * 12.5\% + 62\% * (12.5\% - 2.97\%) = 10.7\%$$

Cadmus performed equivalent calculations to obtain adjusted baseline values for the heating energy saving factor. 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 heating as well.

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126 Cadmus. January 29, 2015. *Evaluation of the 2013–2014 Programmable and Smart Thermostat Program.*

127 Ibid.

128 In the ΔCooling_AdjustedBaseline calculation, the 186.9 represents the cooling savings (332 kWh multiplied by 56% correct use factor) for programmable thermostats. The 56% cooling correct use factor is from the 2020 Residential Prescriptive Program participant survey, which asks homeowners with programmable thermostats about their thermostat usage habits related to cooling.

A.10 Food Bank Initiative

The Food Bank Initiative provided participants with one 4-pack of general purpose, 9-watt LED bulbs. Table A-81 provides the per-unit annual gross savings for this program measure.

Table A-81. Food Bank Initiative Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
9W LED	29	30	0.0041	0.0041

A.10.1 9-Watt LEDs

Cadmus applied the savings algorithm in the Residential ENERGY STAR Lighting (CFL and LED) section of the 2015 Indiana TRM v2.2. Cadmus used the lumen equivalence method to determine the baseline bulb wattage. 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 v2.2. Table A-82 shows the input values and the source for each value.

Table A-82. 2020 9-Watt LED Inputs

Cadmus Assumptions	Inputs	Source
HOURS – Hours of use per year	902	2015 Indiana TRM v2.2[1]
$Watts_{BASE}$ – Equivalent baseline wattage of program bulb	43	Uniform Methods Project, Chapter 6 Residential Lighting[2]
$Watts_{EFF}$ – Wattage of program bulbs	9	Spec sheets of program bulb
WHF_E – Waste heat factor to account for cooling and heating savings	-0.034	2015 Indiana TRM v2.2—weighted average of weighted average heating types. Cities were Evansville (98%) and Indianapolis (2%), based on 2019 survey data.[3]
WHF_D – waste heat factor for demand to account for cooling kW	0.091	
WHF_G – Waste heat factor to account for gas impacts	-0.002	
CF – Coincidence factor	0.11	2015 Indiana TRM v2.2

[1] Cadmus et al. July 28, 2015. *Indiana Technical Reference Manual, Version 2.2.*

[2] Dimetrosky, S., K. Parkinson, and N. Lieb. October 2017. "Chapter 6: Residential Lighting Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68562.pdf

[3] 2020 survey sample was too small to generate adequate precision. Cadmus used 2019 survey results for 2020 impact evaluation assumptions.

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. Because of the small sample size available for surveys in 2020, Cadmus used 2019 survey results to estimate leakage. Table A-83 lists the electric utility, number of program bulbs installed, and number of survey respondents (included for context).

Table A-83. 2020 LED Distribution Leakage Summary (Based on 2019 Survey Results)

Utility/Co-op	Bulbs Installed	Survey Respondents
	2019 Survey Results	
Vectren Indiana	192	55
NIPSCO	3	1
Southern Indiana Power	4	1
Indianapolis Power and Light (IPL)	-	-
Duke Energy	-	-
Indiana Michigan	-	-
Total[1]	**199**	**57**
Percentage Outside of Vectren's Electric Territory	**4%**	**4%**

[1] Participants who did not know their utility, how many bulbs they installed, or installed zero bulbs were excluded from the totals.

Note that leakage is calculated from the number of bulbs installed, not the number of recipients. Of 70 bulb recipients in Cadmus' 2019 survey, 57 knew their electric utility provider *and* how many bulbs they did or did not install, a total of 199 bulbs. Cadmus was unable to determine from which distribution sites the "leaked" bulbs came. These data were not collected in the 2019 program's postcard survey. However, these data were collected in 2020.

In 2020, as in 2019, Cadmus found that all distribution locations were in Vectren's electric service territory. Of the 11 responses in 2020, Cadmus found no leakage. However, it should be noted that the 11 responses were not enough to draw meaningful conclusions. Nevertheless, though based on limited results in 2020, Vectren has apparently continued to decrease the amount of leakage in LED bulb distribution since 2018 when leakage was 29%.

A.11 Commercial and Industrial Prescriptive Program

Cadmus' impact evaluation of the C&I Prescriptive Program included measures with attributable electric savings, including these:

- Chillers
- Compressed air systems
- HVAC
- Kitchen equipment
- Lighting
- Refrigeration
- Thermostats
- VFDs/motors

Table A-84 provides per-unit annual gross savings for each program measure.

Table A-84. C&I Prescriptive Program Per-Unit Gross Savings

Measure Category	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
Chillers	15,661	16,017	14.21	14.53
Compressed Air Systems	71,243	71,094	7.39	7.37
HVAC	643	478	0.22	0.13
Kitchen Equipment	4,956	4,056	0.69	0.72
Lighting	264	253	0.04	0.04
Refrigeration	2,031	401	0.23	0.05
Thermostat	2,427	2,427	0.00	0.00
VFD/Motor	17,464	25,518	2.40	2.40

A.11.1 Chillers

In 2020, the C&I Prescriptive Program only had chiller tune-ups and no chiller replacements. Cadmus used the 2015 Indiana TRM v2.2 algorithms for chiller tune-ups:

$$\Delta kWh = TONS \times \frac{3.516}{IPLV_{BASE}} \times EFLH \times ESF$$

$$\Delta kW = TONS \times \frac{3.516}{COP_{BASE}} \times DSF \times CF$$

Where, in the kWh equation:

TONS = Existing chiller’s size in tons

$IPLV_{BASE}$ = Assumed baseline IPLV that depends on the chiller type and size and is derived from the ASHRAE 90.1–2007 standard

3.516 = Conversion factor to IPLV in kW/ton

COP_{BASE} = Assumed baseline COP 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

ESF = Energy savings factor, 8%

The kW equation uses coefficient of performance (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%. The demand savings factor (DSF) is 8%.

A.11.2 Compressed Air Systems

Cadmus used the 2015 Indiana TRM v2.2 algorithms for the efficient air compressor project (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, η_{motor} is the motor efficiency, and ESF is the energy savings factor based on the load control type—10% for no load, 17% for variable displacement, and 26% for variable frequency drive.

A.11.3 HVAC

Air Conditioners and Heat Pumps

For unitary or split air conditioning units and heat pumps, Cadmus followed the algorithm in the 2015 Indiana TRM v2.2 for time-of-sale measures (or replace-on-burnout) and early replacement measures:

$$\Delta kWh = kBTU \times \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right) \times EFLH_{Cool} + kBTU \times \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right) \times EFLH_{Heat}$$

$$\Delta kW = kBTU \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times CF$$

Here, kBTU, $SEER_{ee}$, and EER_{ee} are the capacity and efficiency specifications of the installed cooling equipment or heat pump equipment. For heat pump systems, there is also $HSPF_{ee}$, which is the heating efficiency of the heat pump. The heating and cooling hours are denoted by $EFLH_{Cool}$ and $EFLH_{Heat}$, which come from the 2015 Indiana TRM v2.2. 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.

Packaged Terminal Heat Pumps (PTHPs) and Packaged Terminal Air Conditioners (PTACs)

Cadmus used the Illinois TRM V8.0 to calculate savings for PTHPs and PTACs.[129] The algorithm is:

$$\Delta kWh = kBTU \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times EFLH_{Cool} + \frac{kBTU}{3.412} \times \left(\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right) \times EFLH_{Heat}$$

$$\Delta kW = kBTU \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right) \times CF$$

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[129] Section 4.4.13. Illinois Commerce Commission. October 17, 2020. *2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0—Volume 2: Commercial and Industrial Measures*. https://ilsag.s3.amazonaws.com/IL-TRM_Effective_0-10-120_v8.0_Vol_2_C_and_I_10-17-19_Final.pdf

Like air conditioners and heat pumps, kBTU and EER_{ee} are the capacity and efficiency specifications of the installed PTHPs and PTACs. For PTHPs, there is also COP_{ee}, which is the heating efficiency of the heat pump. The heating and cooling hours are denoted by $EFLH_{Cool}$ and $EFLH_{Heat}$, which come from the 2015 Indiana TRM v2.2. Baseline efficiency terms are equal to the current federal baseline based on equipment size and location.[130]

Furnace ECMs

In previous years, natural gas furnaces had additional electric savings due to the installation of an ECM fan. However, residential-sized furnaces (or, furnaces with input capacities less than 225,000 Btuh[131]), which made up all the furnaces in the program, have a new federal standard fan requirement, which reduces ECM savings.[132] As such, Cadmus used the deemed savings for residential-sized furnaces installed in commercial applications—70kWh per furnace fan—from the Wisconsin Focus on Energy 2020 TRM.[133]

A.11.4 Kitchen Equipment

The kitchen equipment measure category contains a variety of commercial appliances including convection ovens, dishwashers, griddles, and ice machines, some of which are not included in the 2015 Indiana TRM v2.2.

Convection Ovens

For convection ovens, Cadmus used the following 2015 Indiana TRM v2.2 equations

$$\Delta kWh = kWh_{base} - kWh_{EFF}$$

$$kWh_{base} = \left(\frac{LB * E_{food}}{EFF_{Base}} + \frac{IDLE_{Base}}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC_{Base}} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY,B}\right) * DAYS$$

$$kWh_{EFF} = \left(\frac{LB * E_{food}}{EFF_{EFF}} + \frac{IDLE_{EFF}}{1{,}000} * \left(HOURS_{DAY} - \frac{LB}{PC_{EFF}} - \frac{PRE_{TIME}}{60}\right) + PRE_{ENERGY,EFF}\right) * DAYS$$

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130 Code of Federal Regulations. 10 CFR §431.97. Minimum Efficiency Standards for PTAC and PTHP. "Table 7. Minimum Efficiency Standards for PTAC and PTHP." https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=8de751f141aaa1c1c9833b36156faf67&mc=true&n=pt10.3.431&r=PART&ty=HTML#se10.3.431_197.

131 U.S. Department of Energy. "Appliance and Equipment Standards Rulemakings and Notices. Consumer Furnaces." https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=59&action=viewlive

132 Code of Federal Regulations. Residential Furnace Fans. Title 10, Chapter II, Subchapter D, 10 CFR §430.32. "Table 1. Energy Conservation Standards for Covered Residential Furnace Fans." https://www.ecfr.gov/cgi-bin/text-idx?SID=0423028877ce42bb0c3e0e2529ac80ba&mc=true&node=se10.3.430_132&rgn=div8.

133 Wisconsin Focus on Energy. *2020 Technical Reference Manual.* "Gas Furnaces, Business." Page 367-371. https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf.

Where:

LB	=	Pounds of food cooked per day (= 100 lb/day, per IN TRM)
E_{Food}	=	ASTM Energy to Food; the amount of energy absorbed by the food during cooking (= 0.00732 kWh/lb, per IN TRM)
Eff_{base}	=	Heavy load cooking energy efficiency of baseline oven (= 65%, per IN TRM)
Eff_{ES}	=	Heavy load cooking energy efficiency of ENERGY STAR oven (= 74%, per IN TRM)
$IDLE_{Base}$	=	Idle energy rate of baseline model (= 2 kW, per IN TRM)
$IDLE_{EFF}$	=	Idle energy rate of ENERGY STAR model (= 1.3 kW, per IN TRM)
$HOURS_{DAY}$	=	Daily operating hours (= 12, per IN TRM)
PC_{BASE}	=	Production capacity of baseline oven (= 70 lb/hr, per IN TRM)
PC_{EFF}	=	Production capacity of ENERGY STAR oven (= 80 lb/hr, per IN TRM)
PRE_{TIME}	=	Preheat time to reach operating temperature (= 15 min/day, per IN TRM)
$PRE_{ENERGY,B}$	=	Baseline preheat energy (= 1.5 kWh, per IN TRM)
$PRE_{ENERGY,EFF}$	=	ENERGY STAR preheat energy (= 1 kWh, per IN TRM)
DAYS	=	Operating days per year (= 365, per IN TRM)

Dishwashers

For dishwashers, Cadmus used the electric deemed savings provided in the Illinois TRM V8.0, as shown in Table A-85.

Table A-85. 2020 C&I Prescriptive Program Dishwasher Deemed Savings

Temperature	Dishwasher Type	Base kWh	ENERGY STAR kWh	ΔkWh
Electric Building and Electric Booster Water Heating				
Low Temp	Under Counter	10,972	8,431	2,541
Low Temp	Stationary Single Tank Door	39,306	23,142	16,164
Low Temp	Single Tank Conveyor	42,230	28,594	13,636
Low Temp	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	12,363	9,191	3,173
High Temp	Stationary Single Tank Door	39,852	27,981	11,871
High Temp	Single Tank Conveyor	45,593	36,375	9,218
High Temp	Multi Tank Conveyor	72,523	45,096	27,426
High Temp	Pot, Pan, and Utensil	21,079	17,766	3,313
Electric Building and Natural Gas Booster Water Heating				
Low Temp	Under Counter	10,972	8,431	2,541
Low Temp	Stationary Single Tank Door	39,306	23,142	16,164
Low Temp	Single Tank Conveyor	42,230	28,594	13,636
Low Temp	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	9,432	6,878	2,554

Temperature	Dishwasher Type	Base kWh	ENERGY STAR kWh	ΔkWh
High Temp	Stationary Single Tank Door	26,901	19,046	7,856
High Temp	Single Tank Conveyor	33,115	26,335	6,780
High Temp	Multi Tank Conveyor	51,655	33,479	18,176
High Temp	Pot, Pan, and Utensil	14,052	11,943	2,108
Natural Gas Building and Electric Booster Water Heating				
Low Temp	Under Counter	2,831	2,831	0
Low Temp	Stationary Single Tank Door	2,411	2,411	0
Low Temp	Single Tank Conveyor	9,350	8,766	584
Low Temp	Multi Tank Conveyor	10,958	10,958	0
High Temp	Under Counter	7,234	5,143	2,090
High Temp	Stationary Single Tank Door	17,188	12,344	4,844
High Temp	Single Tank Conveyor	23,757	18,806	4,951
High Temp	Multi Tank Conveyor	36,004	24,766	11,238
High Temp	Pot, Pan, and Utensil	8,781	7,576	1,205

Hot Food Holding Cabinets

For hot food holding cabinets, Cadmus used the algorithm from the 2015 Indiana TRM v2.2, with an adjustment for the building types that installed these measures. The algorithms are:

$$\Delta kWh = \frac{W_{FOOT\ BASE} - W_{FOOT\ EFF}}{1{,}000} \times V \times Hours$$

$$\Delta kW = \frac{W_{FOOT\ BASE} - W_{FOOT\ EFF}}{1{,}000} \times V \times CF$$

$W_{FOOT\ Base}$ and $W_{FOOT\ EE}$ refer to the electrical demand of baseline (from the 2015 Indiana TRM v2.2) and efficient units (actual installed). One thousand is a conversion factor, V is the actual volume of the cabinet, hours is the hours of use per year, and CF is the summer peak coincidence factor (0.84).

The 2015 Indiana TRM v2.2 assumes all cabinets are installed in restaurants and offers only one value for hours of use (15 hours per day for 365 days per year, or 5,475 hours per year). However, in the 2020 program, two units were installed in schools. Therefore, Cadmus used the hours of use for the building type “Schools/government”—10.5 hours per day for 282.5 days per year, or 2,966 hours per year—from the 2020 Wisconsin TRM.[134] This lowered the evaluated savings compared to the reported savings.

[134] Wisconsin Focus on Energy. *2020 Technical Reference Manual.* “Hot Food Holding Cabinets.” Page 184-187.

A.11.5 Lighting

Retrofits

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 v2.2 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

Program tracking data reported savings and new and replaced wattages for each lighting project. In accordance with the 2015 Indiana TRM v2.2, Cadmus used actual wattages (from the program tracking data) for $WATTS_{ee}$ and $WATTS_{base}$.

New Construction

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 v2.2:

$$\Delta kWh = (LPD_{BASE} - LPD_{EE}) \times AREA \times Hours \times \frac{(1 + WHF_E)}{1000}$$

$$\Delta kW = (LPD_{BASE} - LPD_{EE}) \times AREA \times CF \times \frac{(1 + WHF_D)}{1000}$$

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 a reduction in overall wattage.

Occupancy Sensors

Cadmus categorized occupancy sensors as a lighting measure for the purposes of the evaluation and used the 2015 Indiana TRM v2.2 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.11.6 Refrigeration

The predominant measure upgrade for refrigeration was upgrading commercial freezers and/or refrigerators to an ENERGY STAR model. Cadmus based evaluated savings on the 2015 Indiana TRM v2.2 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 v2.2 based on the size of the unit. Hours equal 8,760, and coincidence factor equals 1.

A.11.7 Thermostats

The program implementer currently uses an energy modeling tool to determine savings for Wi-Fi and programmable thermostat measures because the 2015 Indiana TRM v2.2 does not provide savings algorithms for thermostats in commercial applications. In 2020, as in the previous three program years, the implementer used energy savings intensity factors (which estimate energy savings per square foot of building served by the thermostat) based on an eQuest model of a 15,000-square-foot office building. The eQuest model simulates the heating, cooling, and ventilation savings for 360 different thermostat configurations for two different weather locations: Indianapolis and Evansville. Configurations vary by degree heating/cooling setback, hours of setback per day, and days the business was closed per week. Savings are assigned on a project-by-project basis according to the project's reported thermostat setback schedule and facility square footage.

Cadmus performed an in-depth review of the implementer's model as part of the 2017 and 2018 evaluations. Cadmus 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. Consistent with 2018 and 2019, 2020 reported thermostat savings equal evaluated savings.

A.11.8 VFD/Motors

Variable frequency drive (VFD) controls added to HVAC fans, pumps, and cooling towers were the predominant measure type in this measure category. Cadmus evaluated savings using the Illinois TRM V8.[135] The 2015 Indiana TRM v2.2 had limited building types.

Pumps and Cooling Tower Fans

Cadmus used the following equations to determine savings:

$$\Delta kWh = \frac{BHP}{Eff_i} * Hours * ESF$$

$$\Delta kW = \frac{BHP}{Eff_i} * DSF$$

Where:

BHP	=	System brake horsepower (= nominal motor HP * load factor [65%])
Eff_i	=	Motor efficiency installed (= 93%)
Hours	=	Operating hours, varies by building type and equipment type
ESF	=	Energy savings factor, varies by equipment type
DSF	=	Demand savings factor, varies by equipment type

Supply and Return Fans

Cadmus used the following equations to determine savings:

$$\Delta kWh = \Delta kWh_{fan} * \left(1 + IE_{Energy}\right)$$

$$\Delta kWh_{fan} = kWh_{base} - kWh_{retrofit}$$

$$kWh_{base} = \left(0.746 * HP * \frac{LF}{\eta_{motor}}\right) * RHRS_{base} * \sum_{0\%}^{100\%} (\%FF * PLR_{Base})$$

$$kWh_{Retrofit} = \left(0.746 * HP * \frac{LF}{\eta_{motor}}\right) * RHRS_{base} * \sum_{0\%}^{100\%} (\%FF * PLR_{Retrofit})$$

[135] Sections 4.4.17 for pumps and cooling tower fans and 4.4.26 for supply and return fans. October 17, 2020. *2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0—Volume 2: Commercial and Industrial Measures*. https://ilsag.s3.amazonaws.com/IL-TRM_Effective_0-10-120_v8.0_Vol_2_C_and_I_10-17-19_Final.pdf

$$\Delta kW = \Delta kW_{fan} * (1 + IE_{Demand})$$

$$\Delta kW_{fan} = kW_{base} - kW_{Retrofit}$$

$$kW_{base} = \left(0.746 * HP * \frac{LF}{\eta_{motor}}\right) * PLR_{base,FFpeak}$$

$$kW_{Retrofit} = \left(0.746 * HP * \frac{LF}{\eta_{motor}}\right) * PLR_{RF,FFpeak}$$

Where:

0.746	=	Conversion from HP to kWh
HP	=	Nominal horsepower of controlled motor (= actual)
LF	=	Load factor of motor (= 65%)
η_{motor}	=	Installed motor efficiency (= default NEMA premium efficiency , ODP, 4-pole, 1800 RPM fan motor at nominal horsepower)
$RHRS_{Base}$	=	Annual operating hours based on building type
%FF	=	Percentage of run-time spent within a given flow fraction
PLR_{Base}	=	Part load ratio for a given flow fraction range based on the baseline flow control type
$PLR_{Retrofit}$	=	Part load ratio for a given flow fraction range based on the retrofit flow control type
IE_{Energy}	=	HVAC interactive effects factor for energy (= 15.7%)
$PLR_{base,FFpeak}$	=	The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the baseline flow control type (default average flow fraction during peak period = 100%)
$PLR_{,RF,FFpeak}$	=	The part load ratio for the average flow fraction between the peak daytime hours during the weekday peak time period based on the retrofit flow control type (default average flow fraction during peak period = 90%)
IE_{Demand}	=	HVAC interactive effects factor for demand (= 15.7%)

A.12 C&I Custom Program

Cadmus' impact evaluation of the C&I Custom Program included 15 application IDs with attributable electric savings. Cadmus performed desk reviews of all available documentation for most of the individual measures under the 15 application IDs, which represented 99.7% of the program's electric savings. Table A-86 lists the results of the evaluation methodology.

Table A-86. 2019 Summary of C&I Custom Program Evaluation Methodology

Evaluation Methodology	Total Application IDs	Application IDs Requiring Update
Desk Review	15	2
Total	**15**	**2**

A.12.1 Desk Reviews

Each customer (or participating contractor) provided initial documentation of the project's energy savings 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 reviews (no on-site verification) on 15 C&I Custom Program electric application IDs for 2020. Cadmus determined that savings for the following applications required an adjustment:

- **Application ID 1003333.** Cadmus found that multiple control system measures were implemented on the same air handling units (AHUs) at the same time. Each measure was originally calculated as if it were implemented independently, and the calculations did not account for interactivity between measures. Specifically, a scheduling measure implemented by the installation contractor reduced the hours of operation of the AHUs from 8,760 to 3,484. For a second measure, fan speed reduction, the program implementer used 8,760 hours as its baseline, which had the effect of counting fan speed savings when the AHUs were already scheduled to be off (due to the scheduling change). Cadmus' adjustments to this application ID reduced reported savings by 137,357 kWh, resulting in a realization rate of 81% for electric energy savings. This project also included removal of an exhaust fan, but the program implementer did not credit this removal for a reduction in demand. Cadmus adjusted this calculation, which resulted in a reduction of reported demand savings by 4.17 kW and a corresponding realization rate of 113% for peak demand.
- **Application ID 1003797.** Cadmus found that the calculator used by the program implementer assumed the chilled water pump was always off below 55°F outside air temperature (OAT). However, the project documentation indicated the pump was off between 55°F and 35°F then back on for freeze protection below 35°F. Cadmus updated this assumption in the calculator,

which reduced reported savings. The revised reduction was consistent with the original measure description, which states that the savings would be approximately 40% less if the pump was allowed to run below 35°F rather than draining the chilled water coils and leaving the pump off below 35°F OAT. Cadmus also noted in the program documentation (from the programming screen shot in the M&V report) that the pump enable setpoint was 50°F rather than the 55°F used in the program implementer's calculator. Changing this value in the calculator further reduced the project's savings. Overall, this application ID had a realization rate of 75% and a 37,340 kWh reduction in reported savings.

A.13 Small Business Energy Solutions Program

Table A-87 provides per-unit annual gross savings for each Small Business Energy Solutions (SBES) Program measure with attributable electric savings.

Table A-87. Small Business Energy Solutions Program Per-Unit Gross Savings

Measure	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
ECM for Walk-in Freezer/Refrigerator	528	409	0.056	0.034
Lighting - Controls	210	211	0.040	0.041
Lighting - Exit Signs	87	85	0.008	0.011
Lighting - Exterior	763	753	0.012	0.000
Lighting - Interior	280	280	0.077	0.078
Lighting - Refrigerated Cases	220	220	0.033	0.033
Wi-Fi and Programmable Thermostats	1,956	2,241	0.000	0.000
Vending Machine Occupancy Sensors	1,612	1,612	0.000	0.000

A.13.1 Electronically Commutated Motors (ECMs) for Walk-In Coolers and Freezers

Cadmus used deemed values 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 v2.2.[136]

A.13.2 Lighting – Controls

Cadmus adhered to the 2015 Indiana TRM v2.2 guidelines for evaluating savings for occupancy sensors. Savings for this measure are largely a reflection of the total connected wattage controlled by each sensor. The evaluated savings align well with the tracking database with the exception of seven records (15.9% of lighting controls records). One record did not include controlled wattage in the initial dataset; Cadmus requested the missing information from the implementer and calculated *ex post* savings using that information. The remaining six records, representing installations at religious schools, used a

[136] Vectren. 2015. *Vectren Small Business Energy Solutions Technical Reference Manual*.

different energy waste heat factor than assigned by Cadmus. “Religious” building inputs (hours of use, waste heat factor, coincidence factor) were used to calculate *ex ante* savings, whereas Cadmus used a “School” building type to calculate *ex post* inputs.

A.13.3 Lighting – Exit Signs

Cadmus adhered to the 2015 Indiana TRM v2.2 guidelines for evaluating savings for LED exit signs, including a coincidence factor of 100%, which aligns with the annual operating hours of 8,760 hours annually. As in previous years, Cadmus used an in-service rate of 100% rather than the 98% in-service rate stipulated in the TRM because the program is direct install and survey results corroborate this assumption. Cadmus identified the following differences between *ex ante* and evaluated calculations:

- 54 records (100% of exit sign records) use a different coincidence factor than stated in the 2015 Indiana TRM v2.2. The coincidence factors tracked in the program data appear to be based on building type rather than using the 100% coincidence factor for this measure.
- 4 records (approximately 8.2% of exit sign records) use an in-service rate of 98% in the *ex ante* savings calculation. As just explained, the SBES Program should be claiming savings for equipment that is directly installed, so the in-service rate should be 100%.
- 8 records (approximately 16.3% of exit sign records) use a different waste heat factor than assigned by Cadmus because of differences in assignment of building type. The program tracking data identified these projects as installed in a “Religious” building rather than a “School” building. Hours of operation, waste heat factors, and coincidence factors differ for these two building types, causing realization rates to deviate from 100%.

A.13.4 Lighting – Exterior

The tracking database does not explicitly identify whether a measure is installed in a conditioned or unconditioned location. Cadmus uses a combination of the measure name, building type, and the “Location” field (a free-response text field) from the program tracking database to identify lighting measures installed in unconditioned locations. Some records that reported demand savings did not receive evaluated demand savings because Cadmus determined they were probably installed in unconditioned locations.

Cadmus used hours of use and baseline wattages as reported in the tracking database and a coincidence factor of 0%, as stated in the 2015 Indiana TRM v2.2. Lighting installed in unconditioned spaces does not have any interactive effects with HVAC equipment, so no waste heat factors were applied to the exterior lighting measures.

A.13.5 Lighting – Interior

Cadmus applied waste heat factors and coincidence factors in accordance with Appendix B of the 2015 Indiana TRM v2.2. For waste heat factors, Cadmus looked up waste heat factors based on the type of HVAC equipment serving the facility and the facility type. A similar task was performed for coincidence factors, though coincidence factor is based solely on building type.

Approximately 23.9% of records in the tracking database use a different waste heat factor than Cadmus assigned by looking up data in the 2015 Indiana TRM v2.2, and approximately 30.5% of records use a different coincidence factor. These include the following:

- 427 records (21.9% of interior lighting records) use a different coincidence factor in the *ex ante* and *ex post* calculations.
- 284 records (14.5% of interior lighting records) use a different energy waste heat factor in the *ex ante* and *ex post* calculations.
- 20 records (1.0% of interior lighting records) use a different demand waste heat factor in the *ex ante* and *ex post* calculations.

In numerous other instances, the evaluated and tracked values did not align. A primary driver for these discrepancies was that the building type and style recorded in the program tracking data did not align with the building types specified in the 2015 Indiana TRM v2.2. The implementer provided the mapping from the "Building Type" and "Building Style" fields in the tracking data to the TRM building types used to assign hours of use, waste heat factor, and coincidence factor. Cadmus adopted this mapping but made some small alterations for a significant number of records for which the *ex ante* and *ex post* savings used different inputs, probably resulting from using two different data collection tools for the 2020 program year.

Despite the large number of records with differences in savings inputs, the interior lighting measure achieved realization rates of 100.3% for energy and 99.8% for demand, indicating that the differences tend to balance out at the program level.

A.13.6 Lighting – Refrigerated Cases

Savings for LED case lighting are a result of the installed lamp length as well as the installation location. Cadmus evaluated savings in accordance with the 2015 Indiana TRM v2.2.

A.13.7 Wi-Fi and Programmable Thermostats

The program implementer currently uses an energy modeling tool for determining savings for thermostat measures because the 2015 Indiana TRM v2.2 does not provide savings algorithms for thermostats in commercial applications.[137] In 2020, as in the previous four program years, the implementer used energy savings intensity factors (which estimate energy savings per square foot of building served by the thermostat) based on an eQuest model of a 15,000-square-foot office building. The eQuest model simulates 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. Savings are assigned on a project-by-project basis according to the project's reported thermostat setback schedule and facility square footage.

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[137] The same eQuest model is used for both programmable and smart Wi-Fi thermostats. Approximately 47% of the thermostats rebated in 2019 were programmable and the balance (53%) were smart Wi-Fi thermostats.

During the 2020 evaluation, one project was capped at 25% of the facility's annual consumption. Information about the annual facility energy consumption was not included in the program tracking data, but Cadmus recommends this information be tracked for all thermostat projects going forward.

Thermostat Programming Verification

In 2020, as in prior evaluations, Cadmus asked survey respondents explicitly what type of thermostat they had used previously. All five respondents said their new thermostat had replaced a manual thermostat with no programming capability. Therefore, Cadmus applied thermostat savings as in previous years, because it was not necessary to adjust savings to reflect a different baseline.

Thermostat Savings

Thermostats installed in 2020 resulted in a kWh realization rate of 114.6%, which deviates from 100% largely due to the influence of two large projects that installed multiple thermostats. In one project, the *ex ante* savings did not account for thermostat quantity (six were installed, not one). Cadmus evaluated savings for each of the six thermostats. The second project was for a variety of spaces: two thermostats were installed in offices with air conditioning and gas heating, a third thermostat was installed in a warehouse space with gas heating only. Nexant manually adjusted reported savings for the warehouse thermostat because its legacy data collection tool could specify only a single heating and cooling type for a given facility. Cadmus allocated savings for this warehouse installation using the same eQuest model outputs that it and the implementer have used for the last several years; this allocation capped savings at 25% of the facility's annual consumption.

A.13.8 Vending Machine Occupancy Sensors

Cadmus relied on the 2015 Indiana TRM v2.2 to determine evaluated savings for vending machine occupancy sensors. The evaluated savings matched the per-unit deemed kWh savings as reported.

A.14 Conservation Voltage Reduction

Table A-88 lists the reported and evaluated savings for the 2020 Conservation Voltage Reduction (CVR) Program.

Table A-88. 2020 Conservation Voltage Reduction Per-Unit Gross Savings

Program	Annual Gross Savings (kWh)		Annual Gross Savings (Coincident Peak kW)	
	Reported	Evaluated	Reported	Evaluated
East Side Substation CVR	1,571,569	1,370,455	471	430

A.14.1 Data Sources

Cadmus analyzed feeder-level data for each of the four feeders at Vectren's East Side substation between July 1 and September 30, 2020. 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. Cadmus retrieved the data from Vectren's SFTP site. 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.14.2 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 select the data from 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 event periods, and savings estimates are reported for these hours. Figure A-1 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-2.

Figure A-1. Example Activation of Conservation Voltage Reduction for Single Feeder, One Week 2020

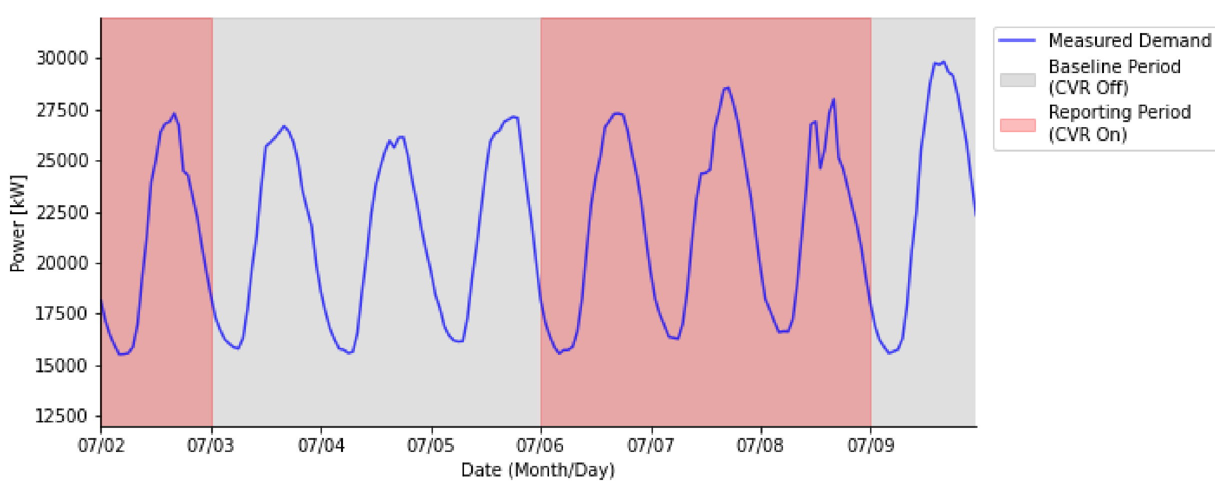
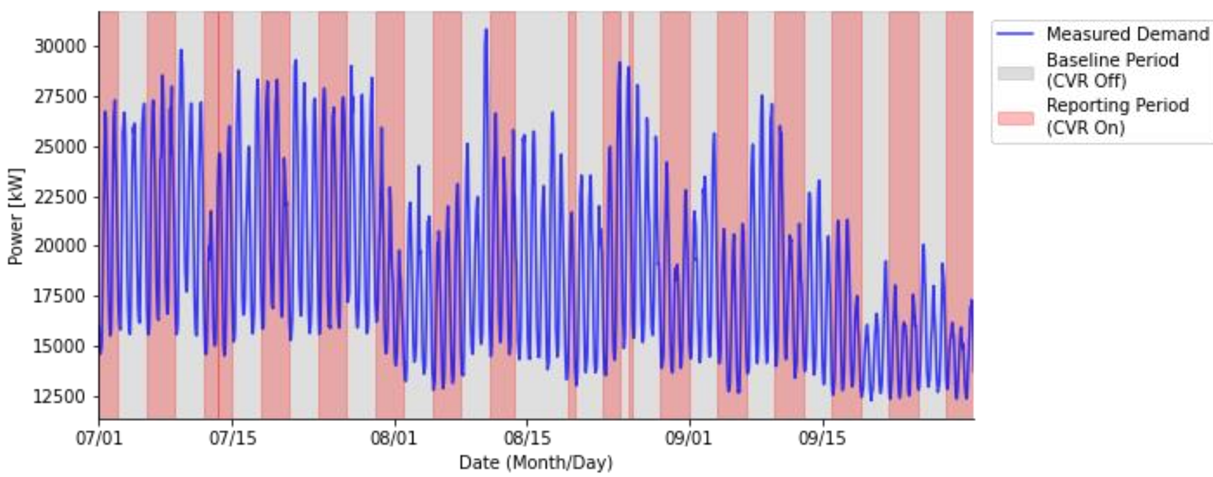
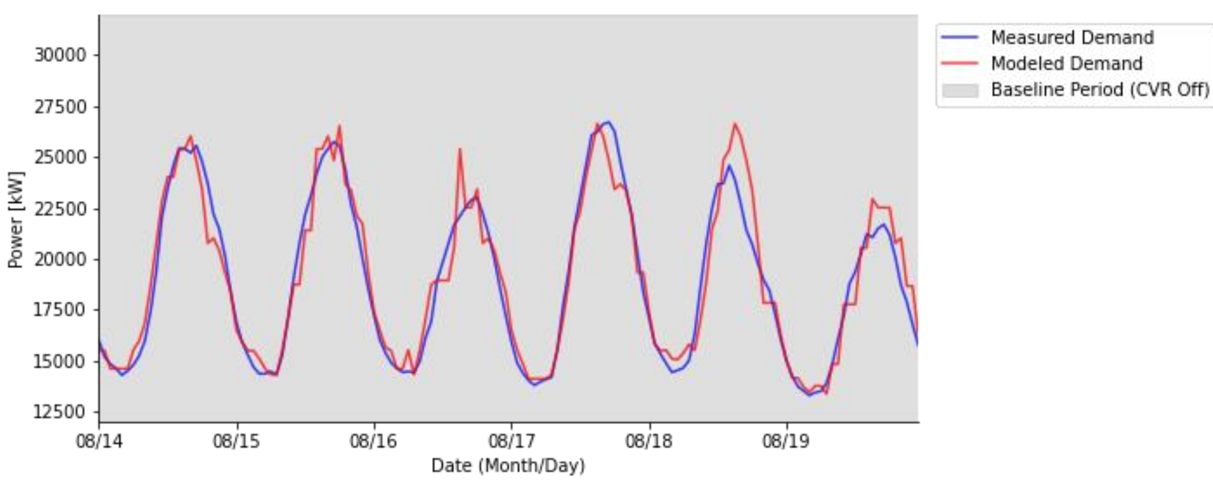


Figure A-2. Example Activation of Conservation Voltage Reduction for Single Feeder, July-September 2020



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.[138] A sample of predictions from a baseline model fit to a single feeder are shown in Figure A-3 along with the measured values used for model fitting. For three of the four feeders, the coefficient of determination of the baseline model exceeded 0.9, implying greater than 90% of the variability in demand during CVR off periods is explained by the model, while the fourth feeder had a coefficient of determination of 0.88. Thus, the predictions of what baseline consumption would be during CVR operating hours is assumed to be a highly accurate estimate against which to compare the actual consumption and determine savings.

Figure A-3. Example Baseline Modeling for Single Feeder



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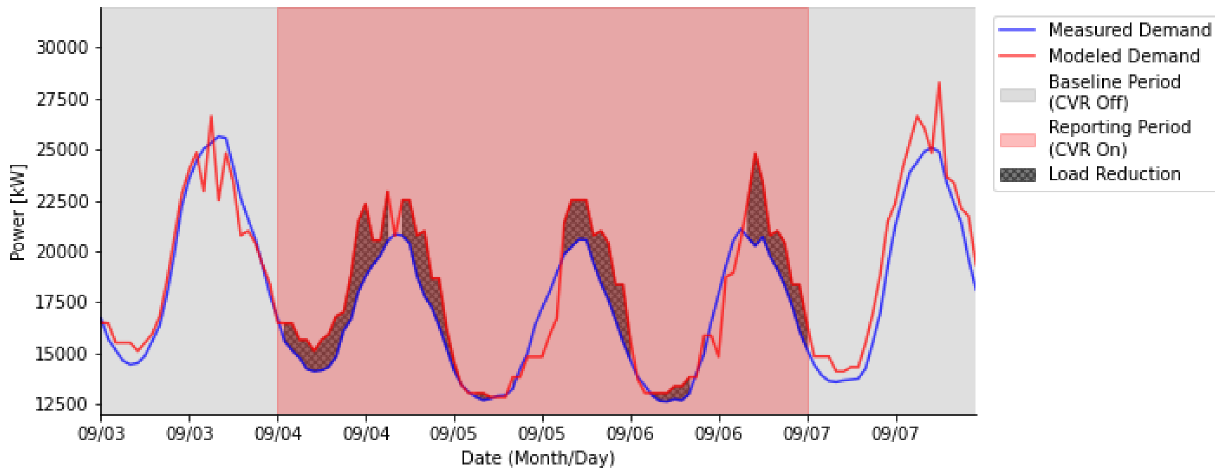
[138] Random forest regression is an ensemble machine learning method that fits many decision trees on subsamples of data.

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-4.

Figure A-4. Example Calculating Savings for Single Feeder



As Figure A-4 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,[139] it is important to average demand savings over the summer season and total energy savings over the program year.

139 Pacific Northwest National Laboratory. July 2010. *Evaluation of CVR on a National Level.* PNNL-19596.

Appendix B. Net-to-Gross Detailed Findings

B.1 Nonparticipant Spillover Survey

For the 2020 evaluation, Cadmus randomly selected and surveyed 350 customers from a sample of 10,000 randomly generated residential accounts provided by Vectren. To avoid possibly double-counting program savings and/or program-specific spillover, Cadmus referred to program tracking databases to remove from the sample any customers who had participated in Vectren's 2018 to 2020 DSM programs (including the Residential Behavioral Savings Program).

Cadmus limited the nonparticipant spillover analysis to the same efficiency measures rebated through Vectren programs (that is, "like" spillover). Examples included installing a high-efficiency central air conditioner or high-efficiency insulation that, for whatever reason, participants did not apply for or receive incentives. Cadmus excluded one notable category of like measures—lighting products—to preclude possibly double-counting savings from the spillover analysis that were already captured through upstream lighting incentives.

Using a 1 to 4 scale, with 1 meaning *not at all important* and 4 meaning *very important*, the survey asked customers to rate the importance of several factors on their decisions to install energy-efficient equipment without receiving an incentive from Vectren. This question determined whether Vectren's energy efficiency initiatives motivated energy-efficient purchases. The surveys asked respondents to address the following factors:

- Information about energy efficiency provided by Vectren
- Information from friends or family who installed energy-efficient equipment and received an incentive from Vectren
- Respondents' experiences with past Vectren incentive programs

Cadmus estimated nonparticipant spillover savings for respondents who rated any of these factors as *very important* for any energy-efficient actions or installations reported. Cadmus applied measure-level estimated gross savings from the 2020 Vectren residential evaluation activities for the reported measures used in the nonparticipant spillover analysis.

Using the variables shown in Table B-1, Cadmus determined total nonparticipant spillover generated by Vectren's marketing efforts. In 2020, Vectren conducted multiple mass media campaigns focused on its energy efficiency programs delivered through TV, radio, and online, including billboards, interviews on daytime talk programs. Vectren reported 17,571,211 impressions and confirmed views of these campaigns in 2020.

Table B-1. Nonparticipant Spillover Analysis Method

Variable	Metric	Source
A	Total "Like Spillover" Nonparticipant MMBtu Savings	2020 NPSO Survey response data
B	Total Nonparticipant Customers Surveyed	Survey disposition
C	MMBtu Measure Savings Per Customer Contacted	A ÷ B

Variable	Metric	Source
D	Total Residential Customer Population (Nonparticipants)	Based on Data Provided by Vectren and 2018-2020 Program Tracking Data
E	NPSO MMBtu Savings Applied to Population	C x D
F	Total Evaluated Gross MMBtu Savings	2020 Vectren Residential portfolio Evaluation
G	NPSO as a Percentage of Total Residential Portfolio Evaluated Gross MMBtu Savings	E ÷ F

B.1.1 Nonparticipant Spillover Approach Logic

The UMP offers explanations of spillover in sections 3.2.2 (Spillover), 4.3.2 (Surveys of Program Nonparticipants), and 4.3.4 (Case Studies for Estimating Net Savings Using Survey Approaches).[140] The UMP defines "spillover" as "additional reductions in energy consumption or demand that are due to program influences beyond those directly associated with program participation." The UMP defines "nonparticipant spillover" as: "The additional energy savings that are achieved when a nonparticipant implements energy efficiency measures or practices as a result of the program's influence (for example, through exposure to the program portfolio through promotion) but is not accounted for in program savings."

"Self-report surveys with nonparticipants are commonly used to triangulate participant self-report responses and collect data for calculating nonparticipant spillover or market effects. These surveys help evaluators understand what energy-efficient actions nonparticipants have taken and whether they took those actions because of program influences (nonparticipant spillover). Conducting surveys with nonparticipants poses its own unique challenges:

- There is no record of the equipment purchase and identifying a group of nonparticipants who have installed energy-efficient equipment on their own can be time consuming and costly.[141]
- Establishing causality entails estimating gross unit savings (often with limited evidence other than the consumer self-report) and establishing how the program may have influenced the consumer's decision. The consumer may not have been aware, for example, of the influence the program had on the equipment's availability or the market actor's stocking practices."

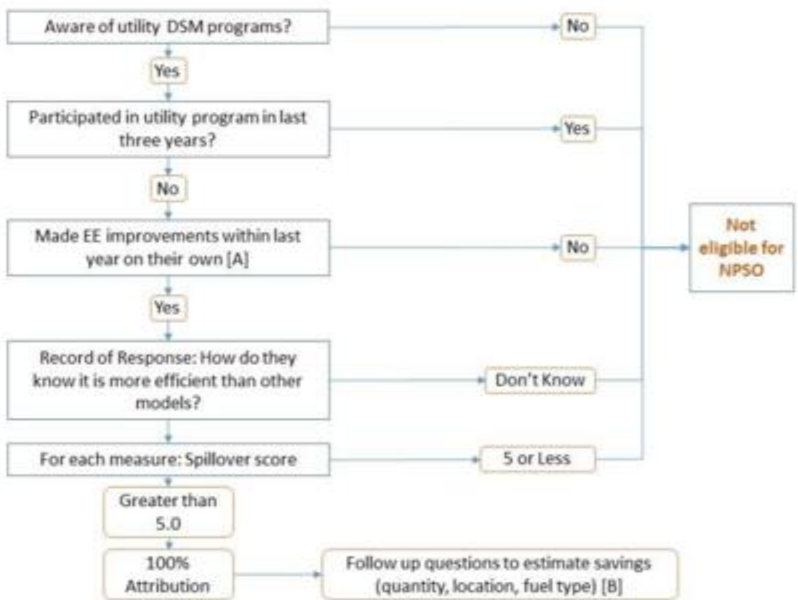
The NPSO analysis conducted for Vectren in 2020 and 2017 is outlined in the Illinois Technical Reference Manual (TRM): Cross Cutting Measures and Attachments 4.3.1 Nonparticipant Spillover Measured from

[140] National Renewable Energy Laboratory. October 2017. "Chapter 21: Estimating Net Savings – Common Practices" in *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* https://www.nrel.gov/docs/fy17osti/68578.pdf

[141] One approach to mitigating the efficiency and cost of this is to use one nonparticipant survey that asks about a variety of program-eligible measures and use the results across multiple programs.

Customers.[142] The Illinois NPSO analysis procedure is also referenced in the UMP. The Illinois TRM includes a residential cross-cutting NTG protocol as well as protocols for specific residential programs. It also provides specific questions and algorithms for measuring nonparticipant spillover (NPSO) from trade allies and customers, implying that they are to be included in the portfolio's NTG formula (methodology shown in Figure).

Figure B-1. NPSO Question Logic from IL TRM Version 8



| 2020 IL TRM v8.0 Vol. 4_October 17, 2019_FINAL   Page **55** of **136**

Table 4-3. Calculation of Total NPSO Generated

Variable	Description	Source/Calculation
F	Average kWh Energy Savings per Surveyed Customer	Survey data and Savings Calculation
J	Total Nonparticipating Residential Population	Customer database
K	NPSO MWh Energy Savings Extrapolated to Nonparticipating Population	[F × J] ÷ 1,000 kWh/MWh
S	Total Evaluated MWh Savings	Residential Portfolio Savings
G	NPSO Spillover Rate	K ÷ S

[142] State of Illinois. January 1, 2020. "Volume 4: Cross-Cutting Measures and Attachments" in *2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0.* https://ilsag.s3.amazonaws.com/IL-TRM_Effective_01-01-20_v8.0_Vol_4_X-Cutting_Measures_and_Attach_10-17-19_Final.pdf

B.1.2 Detailed Spillover Findings

Of 350 customers surveyed, two nonparticipant respondents reported installing energy efficient gas water heaters because of Vectren's influence. Table B-2 presents measures and gross evaluated MMBtu savings that Cadmus attributed to Vectren, generating total savings of 6.542 MMBtu.

Table B-2. NPSO Response Summary

Reported Spillover Measures	Quantity	Unit Energy Savings (MMBtu)	Total Savings (MMBtu)
Gas water heater	2	3.271	6.542
Total	**2**	**N/A**	**6.542**

Table B-3 shows the importance ratings from the two water heater NPSO respondents for each Vectren related influence factor.

Table B-3. Water Heater NPSO Respondents Importance Ratings of Vectren Related Factors

Water Heater NPSO Respondent	General information about energy efficiency provided by Vectren	Information from friends or family members who installed energy efficient equipment and received a rebate from Vectren	Your experience with a past Vectren rebate program
Respondent #1	Very Important	Very Important	Very Important
Respondent #2	Very Important	Very Important	Very Important

Table B-4 presents variables used to estimate overall nonparticipant spillover for the Vectren residential portfolio—a figure Cadmus estimates as 5% (rounded to the nearest whole percent) of Vectren's total residential portfolio evaluated savings (electric and gas combined).

Table B-4. NPSO Analysis Results

Variable	Metric	Value	Source
A	Total "Like Spillover" Nonparticipant MMBtu Savings	6.542	2020 NPSO Survey response data
B	Total Nonparticipant Customers Surveyed	350	Survey disposition
C	MMBtu Measure Savings Per Customer Contacted	0.019	A ÷ B
D	Total Residential Customer Population (Nonparticipants)	632,631	Based on Data Provided by Vectren and 2018-2020 Program Tracking Data
E	NPSO MMBtu Savings Applied to Population	11,825	C x D
F	Total Evaluated Gross MMBtu Savings	253,882	2020 Vectren Residential portfolio Evaluation
G	NPSO as a Percentage of Total Residential Portfolio Evaluated Gross MMBtu Savings	5%	E ÷ F

The estimated spillover activity equates to 11,825 MMBtu of nonparticipant spillover savings attributed to Vectren for the promotion of its programs and general energy-efficiency marketing campaigns. Cadmus applied the 5% NPSO to the overall 2020 Vectren residential portfolio. These results are consistent with NPSO found in the 2017 NPSO survey (5%) and Cadmus applied to the 2017-2019 Vectren residential portfolio savings.

The two high-efficiency gas water heaters' total gross savings of 6.542 MMBtu (A) translated to 0.019 gross MMBtu (C) measure savings per residential nonparticipant customer surveyed. The 0.019 MMBtu (C) is multiplied by the total Vectren residential nonparticipant population (D) to arrive at NPSO MMBtu savings extrapolated to Vectren's residential nonparticipant population (E). The NPSO MMBtu savings extrapolated to Vectren's residential nonparticipant population (E) is then divided by the total 2020 Vectren residential portfolio evaluated gross MMBtu savings (F) to arrive at the 5% Vectren utility-level residential portfolio nonparticipant estimate (G).

Statistical Sampling

As stated in Section 4.3.2 in Chapter 21 of the UMP, "identifying a group of nonparticipants who have installed energy-efficient equipment on their own can be time consuming and costly" and "one approach to mitigating the efficiency and cost of this is to use one nonparticipant survey that asks about a variety of program-eligible measures and use the results across multiple programs." As in the 2017 evaluation, in 2020, Cadmus used one residential nonparticipant survey that asks about a variety of program-eligible measures and applied the results across multiple programs (i.e., the residential portfolio).

Cadmus did not stratify the sample by electric and gas customers. Cadmus developed one residential nonparticipant sample by randomly selecting from a combination of two datasets:

- Vectren North Gas customer database
- Vectren South Electric & Gas customer database

The sampling approach was designed to estimate one NPSO estimate that is applied to both the residential electric and gas portfolios. When this approach was used in 2017, four measures were attributed to Vectren—two smart thermostats with estimated electric and gas savings, a central air conditioner with only estimated electric savings, and an insulation project with only estimated gas savings. Cadmus applied one NPSO estimate to both the residential electric and residential gas programs based on how Cadmus had designed the sampling approach of combining electric and gas customers into one sample frame. During the 2017 analysis process, this approach seemed reasonable given that three of four measures attributed to Vectren had estimated electric savings and three of four measures attributed had gas savings.

In 2020, using the exact same sampling and analysis approach as 2017, Cadmus estimated two gas water heating measures reported by Vectren North Gas customers as NPSO attributable to Vectren. Cadmus applied one NPSO estimate to both the 2020 residential electric and gas programs based on how Cadmus had designed the sampling approach of combining electric and gas customers into one sample frame. The survey sampling approach was not statistically designed to meet separate electric and gas nonparticipant customer respondent targets. The sample and survey quota was designed to extrapolate to Vectren's entire population of nonparticipant customers, based on 90% confidence with 10% precision.

B.2 Residential Lighting Program

In 2019, 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. Cadmus applied the 2019 NTG to its 2020 impact analysis. After weighting by savings, Cadmus estimated a 53% NTG ratio for the 2020 program overall.

Table B-5 lists the presents the NTG results for each measure category (lamp type).

Table B-5. 2020 Residential Lighting Program Net-to-Gross Ratio

Measure Category	Freeridership	Spillover	NTG Ratio
LED Fixture	61%	0%	39%
LED General Service	48%	0%	52%
LED Reflector	46%	0%	54%
LED Specialty	41%	0%	59%

B.2.1 Detailed Freeridership Findings

In 2019, 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.

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:

$$FR\ Ratio = \left(\frac{Predicted\ Savings\ without\ Program}{Predicted\ Savings\ with\ Program}\right)$$

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 stock keeping unit [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 86% of all LED sales from 2019. Outdoor fixtures were excluded from the model due to lack of price variation and low sales volume. Indoor fixtures were included as sales volume was significantly higher than outdoor fixtures and prices showed sufficient variation across retailers.

Merchandising Displays

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 (special promotions):

- Off-shelf placement of program SKUs
- Additional manufacturer point-of-sale discounts
- Manufacturer coupons with additional discounts

Cadmus assumed additional manufacturer discounts were dependent on program support, that is, such discounts would not have been applied absent the program. Therefore, net program sales include the additional increase in sales from the manufacturer discounts. The effect of special promotions was not significant in the 2019 model, but Cadmus included the special promotions as an explanatory variable due to its theoretical significance. Overall, freeridership was not sensitive to promotions, increasing by 0.2% when promotions were excluded from the model.

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*):

$$\ln(Q_{it}) = \sum_{\pi}\left(\beta_{\pi} ID_{\pi,\mathrm{i}}\right) + \sum_{\theta}(\beta_{\theta 1}[ln(P_{it}) * \ Retail\ Channel_{\delta}])$$
$$+ \sum_{\delta}(\beta_{\delta 1} SpecialPromo_{t} * Retail\ Channel_{\mathrm{i}}) + \varepsilon_{it}$$

Where:

$\ln$	=	Natural log
Q	=	Quantity of bulbs sold during the month
P	=	Per-bulb retail price (after markdown) in that month
Promo	=	Special promotion occurred in month *t* featuring product *i*
Retailer	=	Retail channel with each retailer categorized as club store retailer or Other
ε_{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)[143]
- Explanatory variable cross-correlation (minimizing where possible)
- Minimizing the number of coefficients signs (+/-) contrary to expectations and economic theory
- Model Akaike's Information Criteria (AIC) (minimizing between models)[144]
- Minimizing multicollinearity
- Optimizing model fit

Overall, the modeled sales were within 3% of actual 2019 sales.

Table B-6 shows the average elasticity estimate by retail channel. The model did not find any statistically significant differences in elasticities by measure category; demand for general service LEDs was no more or less sensitive to price than demand for reflector, fixtures, or specialty LEDs. However, demand for LEDs was more sensitive to price at club stores than other retailers.

Table B-6. Price Elasticity Parameter Estimates by Retail Channel

Retail Channel	Average Elasticity Coefficient	Standard Error	p-value
Club Stores	–1.955	0.145	0.0000
Other	–1.134	0.287	0.0001

Table B-7 shows the incentive as a share of the original retail price and the estimated freeridership ratio by measure category and retail channel. Typically, the proportional price reduction and the freeridership tend to correlate. In this case, within the same retail channel, differences in the relative markdown account for the differences in freeridership by measure category since elasticities did not differ by measure category.

Markdowns were very similar among club store retailers, between 51% and 54%, which resulted in similar estimates of freeridership across all measure categories. Markdowns varied more within retailer stores in the other category, 28% for indoor fixtures and as high as 45% for specialty LEDs.

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143 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.

144 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.

Table B-7. Incentive as Share of Original Retail Price and Estimated Freeridership

Retail Channel	Lamp Type	Original Price	Target Retail Price	Incentive	Manufacturer Contribution	Markdown Percent	Freeridership
Club	General Service	$2.48	$1.16	$1.32	$0.00	53%	24%
	Indoor Fixture	$7.50	$3.65	$3.85	$0.00	51%	28%
	Reflector	$3.20	$1.46	$1.73	$0.00	54%	24%
	Specialty	$2.88	$1.37	$1.51	$0.00	52%	25%
Other	General Service	$3.11	$1.88	$1.19	$0.03	39%	53%
	Indoor Fixture	$17.84	$12.91	$4.93	$0.00	28%	63%
	Reflector	$4.85	$2.85	$1.97	$0.03	41%	51%
	Specialty	$3.52	$1.92	$1.59	$0.00	45%	45%

B.3 Residential Prescriptive Program

Cadmus calculated freeridership for the Residential Prescriptive Program using findings from a quarterly freeridership surveys conducted with 1,165 program participants, of which 1,086 answered the freeridership questions. Cadmus calculated spillover for the Residential Prescriptive Program using findings from an annual survey conducted with 435 program participants, of which 417 answered the spillover questions. Table B-8 summarizes the freeridership, spillover, and NTG estimates by measure category. The overall program NTG ratio of 61% is weighted by the combination of electric and gas gross evaluated program population savings.

The electric-specific NTG ratio of 78% presented in Table B-8 is weighted specifically to electric savings due to the application of measure category level NTG estimates. The overall program NTG ratio is heavily weighted toward the gas-specific NTG estimate of 60% because *ex post* gross gas savings account for 94% of the total 2020 Residential Prescriptive Program energy savings.

Table B-8. 2020 Residential Prescriptive Program Net-to-Gross Ratio

Measure Category	Freeridership	Spillover	NTG Ratio	Total Program *Ex Post* MMBTU Savings
Furnace/Boiler (n=416 for FR, 128 for SO)	46%	1%	55%	108,922
Heat Pump/CAC (n=66 for FR, 15 for SO)	31%	14%	83%	5,095
Thermostat (n=411 for FR, 197 for SO)	25%	4%	79%	27,726
Weatherization (n=22 for FR, 8 for SO)	27%	0%	73%	970
Water Heater (n=136 for FR, 55 for SO)	35%	1%	66%	8,127
Other (n=35 for FR, 14 for SO)	40%	0%	60%	4,590
Total Program (n=1,503)2	**41%[1]**	**2%[1]**	**61%[1]**	**155,430**
Electric-Specific NTG			**78%**	**9,636**
Gas-Specific NTG			**60%**	**145,793**

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

[2] 1,086 respondents answered the freeridership questions through the quarterly freeridership surveys. 417 respondents answered the spillover questions through the annual spillover specific survey. Not all respondents surveyed answered the freeridership and spillover questions.

B.3.1 Detailed Freeridership Findings

Cadmus estimated freeridership by combining the standard self-report intention method and the intention/influence method.[145] Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership estimates,[146] 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 *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. Use of multiple questions also checks consistency.

Table B-9 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 decrements based on their responses to the questions.

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

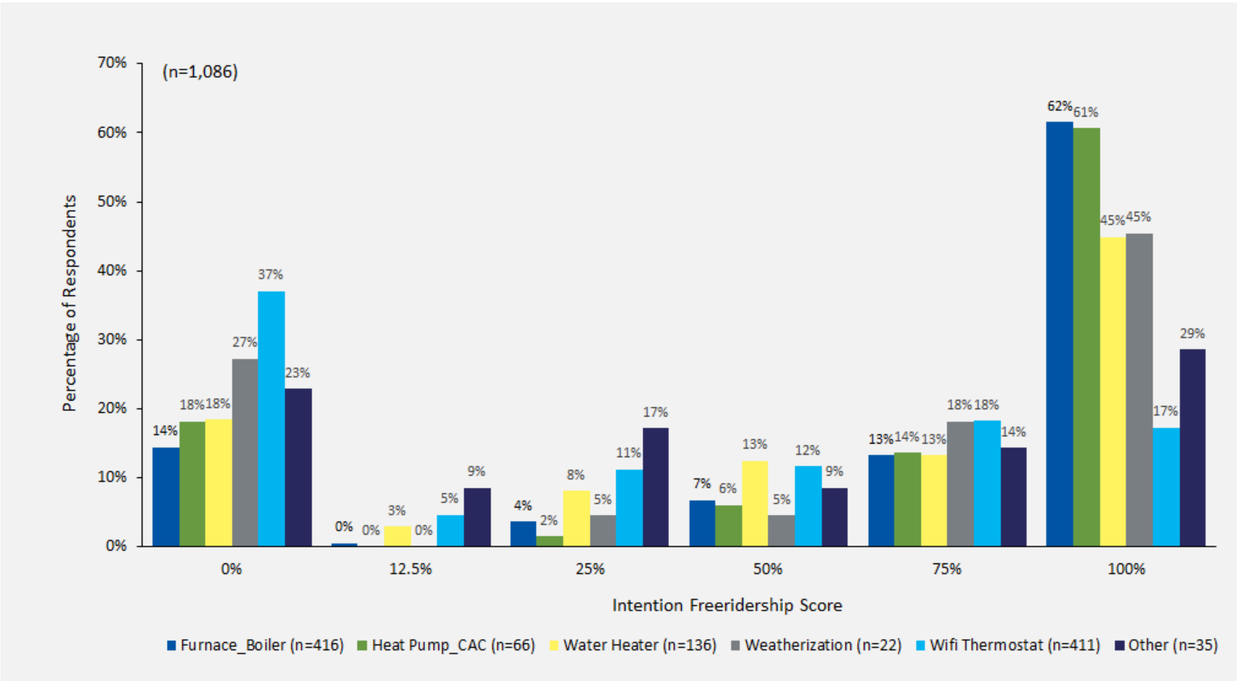
[146] *Ex post* gross program savings.

Table B-9. Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology Residential Prescriptive Program and Scoring

BEFORE you heard about the Vectren Residential Efficient Products Rebate Program, had you already PLANNED [If purchase: purchase the/if tune-up: schedule a tune-up or annual check-up of your] [MEASURE 1]?	Before you heard anything about the Vectren Residential Rebate program, had you already had you already [If purchase: purchased or installed/if tune-up: scheduled the tune-up or annual check-up of] [MEASURE 1]?	To confirm, you [If purchase: installed your new/if tune-up: scheduled a tune-up for your] [MEASURE 1] before you heard anything about the Vectren Residential Efficient Products Rebate Program, correct?	[If purchase] Would you have installed the same [MEASURE 1] without the rebate from Vectren? [If tune-up] Would you have scheduled a [MEASURE_1] tune-up without the rebate from Vectren?	[If purchase] Would you have installed a different type of [MEASURE_1] without the Vectren rebate or would you have decided not to purchase it?	[If purchase] Without the rebate from Vectren, would you have purchased and installed a [MEASURE_1] that was just as efficient, less efficient or more efficient than what you purchased?	Without the rebate from Vectren, what kind of thermostat would you have installed?	[If purchase] Would you have installed the same quantity of [MEASURE_1]s without the incentive from Vectren?	Thinking about timing, without the Vectren rebate, when would you have [If purchase: installed/if tune-up: scheduled a tune-up for] the [MEASURE_1]?...
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes, that is correct (Yes) [100% FR Assigned]	Yes (Yes) [-0%]	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-2 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

Figure B-2. Residential Prescriptive Program Self-Report *Intention* Freeridership Distribution by Estimate



Influence Freeridership Score

Table B-10 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." Cadmus assessed influence freeridership from participants' ratings to how important various program elements were in their decision to purchase energy-efficient products.

Table B-10. Residential Prescriptive Program Freeridership *Influence* Responses by Measure Category (n=1,086)

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/Boiler	Heat Pump/CAC	Thermostat	Weatherization	Water Heater	Other	Furnace/Boiler	Heat Pump/CAC	Thermostat	Weatherization	Water Heater	Other	Furnace/Boiler	Heat Pump/CAC	Thermostat	Weatherization	Water Heater	Other	Furnace/Boiler	Heat Pump/CAC	Thermostat	Weatherization	Water Heater	Other
1 - Not at all influential	100%	19	5	3	0	5	1	19	5	14	0	7	1	19	5	14	0	7	1	19	5	14	0	7	1
2 - Not too influential	75%	20	1	4	1	5	0	21	1	10	1	8	0	21	1	10	1	8	0	21	1	10	1	8	0
3 - Somewhat influential	25%	83	13	18	2	25	2	86	13	72	2	32	6	86	13	72	2	32	6	86	13	72	2	32	6
4 - Very influential	0%	278	43	97	19	67	22	279	45	305	19	87	28	279	45	305	19	87	28	279	45	305	19	87	28
Not Applicable	50%	8	1	3	0	0	0	8	1	3	0	0	0	8	1	3	0	0	0	8	1	3	0	0	0
Average Rating		**3.6**	**3.5**	**3.7**	**3.8**	**3.5**	**3.8**	**3.5**	**3.5**	**3.7**	**3.8**	**3.5**	**3.7**	**3.5**	**3.5**	**3.7**	**3.8**	**3.5**	**3.7**	**3.5**	**3.5**	**3.7**	**3.8**	**3.5**	**3.7**

Cadmus used the maximum rating given by each participant for any factor in Table B-10 to determine the participant's influence score, presented in Table B-11. 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-11. Residential Prescriptive Program Influence Freeridership Score (n=1,086)

Maximum Influence Rating	Influence Score	Furnace/Boiler	Heat Pump/CAC	Thermostat	Weatherization	Water Heater	Other
1 – Not at all influential	100%	19	5	14	0	7	1
2 – Not too influential	75%	21	1	10	1	8	0
3 – Somewhat influential	25%	86	13	72	2	32	6
4 – Very influential	0%	279	45	305	19	87	28
Not Applicable	50%	11	2	10	0	2	0
Average Maximum Influence Rating - Simple Average		**3.5**	**3.5**	**3.7**	**3.8**	**3.5**	**3.7**
Average Influence Score - Weighted by *Ex Post* Savings		**15%**	**11%**	**10%**	**7%**	**6%**	**16%**

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-12 summarizes the intention, influence, and overall freeridership scores for each measure category.

Table B-12. Residential Prescriptive Program Intention, Influence and Overall Freeridership Scores by Measure Category

Measure Category	n	Intention Score	Influence Score	Freeridership Score
Furnace/Boiler	416	76%	15%	46%
Heat Pump/CAC	66	51%	11%	31%
Thermostat	411	40%	10%	25%
Weatherization	22	47%	7%	27%
Water Heater	136	63%	6%	35%
Other	35	64%	16%	40%

B.3.2 Detailed Spillover Findings

Twelve participants reported installing a total of 16 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 a high-efficiency clothes washer, dishwashers, water heaters, duct sealing, a smart thermostat, and HVAC equipment.

Cadmus used *ex post* savings estimated for the 2020 Residential Prescriptive Program evaluation in combination with the 2015 Indiana TRM v2.2 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-13.

Table B-13. Residential Prescriptive Spillover Estimates by Measure Category

Measure Category	Survey Sample Spillover MMBtu Savings	Survey Sample Program MMBtu Savings	Percentage Spillover Estimate
Furnace/Boiler	14.3	1,666.7	1%
Heat Pump/CAC	4.5	31.9	14%
Thermostat	40.1	1,087.1	4%
Weatherization	0.0	150.0	0%
Water Heater	2.8	371.3	1%
Other	0.0	54.3	0%

B.4 Residential New Construction Program

Cadmus analyzed NTG for the 2020 Residential New Construction (RNC) Program through interviews with 10 participating builders. Cadmus estimated freeridership using the intention/influence freeridership method.[147] Cadmus applied 100% NTG to Habitat for Humanity Kit measures because they target low-income home recipients. Table B-14 presents the freeridership, spillover, and NTG results for the 2020 RNC Program.

Table B-14. 2020 Residential New Construction Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
New Construction Incentives	42%	0%	58%[1]
Habitat for Humanity Kit	N/A	N/A	100%

[1]Absolute precision at 90% confidence interval is ±9%.

B.4.1 Detailed Freeridership Findings

Intention Method

The initial intention freeridership questions and answers are shown in Table B-15. 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 respondent's respective

[147] The intention score and influence score each have maximum values of 50%. They are then added to arrive at the final freeridership score. Other programs use a maximum value of 100% for the intention score and influence score, which are then averaged to arrive at the final freeridership score.

verified gross program savings. 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 32%.

Table B-15. 2020 Residential New Construction Program Evaluated Net Savings

Intention Question / Response Options Thinking about the Vectren Residential New Construction Program homes you built in 2020, 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%	0	0	0
Some	25%	1	1,234	309
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%	0	0	0
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 for some homes within the last 12 months	25%	3	15,309	3,823
Yes, would have adopted 100% of New Construction Program standards for some homes within one to two years	25%	0	0	0
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%	5	6,045	3,023
No	0%	0	0	0
Total		**10**	**22,588**	**7,154**
Intention Score - Weighted by *Ex Post* MMBtu Savings (Intention Score MMBtu Savings Divided by Total Survey Sample *Ex Post* MMBtu Savings)	**32%**			

Influence Method

Table B-16 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 builders' ratings to determine how important various program elements were in their decision to build program qualifying homes. Table B-16 shows the program elements that participants rated for influence, along with a count and average rating for each factor.

Table B-16. 2020 Residential New Construction Program Freeridership Influence Responses (n=10)

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%	2	2	3	0	3
2 – Not too influential	37.5%	4	6	2	1	2
3 – Somewhat influential	12.5%	2	0	3	3	0
4 – Very influential	0%	2	2	1	6	0
Don't Know	25%	0	0	1	0	5
Average		**2.4**	**2.2**	**2.2**	**3.5**	**1.4**

Cadmus used the maximum rating given by each builder for any factor in Table B-16 to determine their influence score, which is presented in Table B-17. The counts refer to the number of responses for each factor/influence score response option. Cadmus weighted individuals' influence scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 10% for the RNC Program.

Table B-17. 2020 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%	0	0	0
3 – Somewhat influential	12.5%	4	18,673	2,334
4 – Very influential	0%	6	3,915	0
Average Maximum Influence Rating - Simple Average		**3.6**		
Average Influence Score - Weighted by Ex Post MMBtu Savings		**10%**		

Next, Cadmus summed the intention and influence components to estimate the total intention/ influence method freeridership of 42%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates.

B.4.2 Detailed Spillover Findings

The 2020 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.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 Appliance Recycling Program. The decision tree—populated by the responses of 120 surveyed 2020 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 been 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 NTG results for the program. Cadmus assumed NTG for window air conditioners was 100% because window air conditioner participants must recycle a refrigerator or freezer to have the window air conditioner recycled and the measure represented only 1% of gross program population savings.

Table B-18. 2020 Appliance Recycling Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Refrigerator	38%	0%	62%
Freezer	44%	0%	56%
Window Air Conditioner	0%	0%	100%
Total Program[1]	**38%**	**0%**	**62%**

[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.

Table B-19. 2020 Appliance Recycling Program NTG by Appliance Type

Measure	Gross Per-Unit Savings (kWh/Year)	Freeridership and Secondary Market Impacts (kWh)	Additional kWh Savings (Spillover)	Net kWh	NTG[1]	Absolute Precision (90% Confidence)
Refrigerator	1,012	385	0	627	62%	±10%
Freezer	722	315	0	407	56%	±12%

[1]Cadmus assumed 100% NTG for window air conditioners.

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, even if 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 which of the following would have occurred to the appliance had it not been recycled by Vectren:

- Sold it to someone directly
- Sold it to a used appliance dealer
- Given it away to someone for free
- Given it away to charity organization
- Left it on the curb with a free sign
- Had it removed by the dealer you got your new appliance
- Hauled it to the dump yourself [or with help from a friend or family member.
- Hauled it to a recycling center yourself [or with help from a friend or family member]
- 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 Appliance Recycling Program, Cadmus calculated the percentage of refrigerators and freezers that would have been kept or discarded. As shown in Table B-20, 59% of respondents would not have kept their refrigerator.

Of those disposing of the appliance, 42% would have discarded it through one of the following means:

- Had it removed by the dealer from which they purchased the new or replacement appliance
- Took it to a dump or recycling center themselves (or with help from a friend or family member)
- Had someone take it to a dump or recycling center (for example, a handyman or local waste management company)

Table B-20. 2019 Appliance Recycling Program Final Distribution of Kept and Discarded Appliances

Stated Action Absent Program	Indicative of Freeridership	Refrigerators (n=64)[1]	Freezers (n=49)[1]
Kept	No	41%	39%
Discarded	Varies by discard method	59%	61%
Total Program		**100%**	**100%**

[1] Does not include *don't know* responses and refusals.

As shown in Table B-21, fewer 2020 participants said they would have kept their refrigerators and freezers in the absence of the Appliance Recycling Program than in 2019. This decrease is the main factor contributing to a lower NTG estimate in 2020 than in 2019.

Table B-21. Vectren Historical Appliance Recycling Program 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%
2019	51%	62%
2020	**41%**	**39%**

Having the retailer pick up the appliance was not necessarily indicative of freeridership. Rather, this depended on the retailer's decision whether or not to resell the unit. Not all appliances would be viable for resale. Cadmus used age as a proxy for secondary market viability, assuming a retailer would be unlikely to resell appliances over 15 years old. Together, these actions resulted in a 25% reduction in gross savings due to refrigerator freeridership.[148]

[148] Reduction in gross savings due to refrigerator freeridership is calculated as 59% of respondents not keeping their appliance * 42% of respondents reporting one of the three actions leading to freeridership = 25% freeridership. For freezers, 61% * 50% = 31%.

Freeridership for freezer recyclers took a similar route. Of 61% of respondents who would not have kept their freezers, 50% would have taken one of the three actions listed above, leading to the appliance's removal from the grid, for a 31% freeridership for freezers.

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,[149] 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.

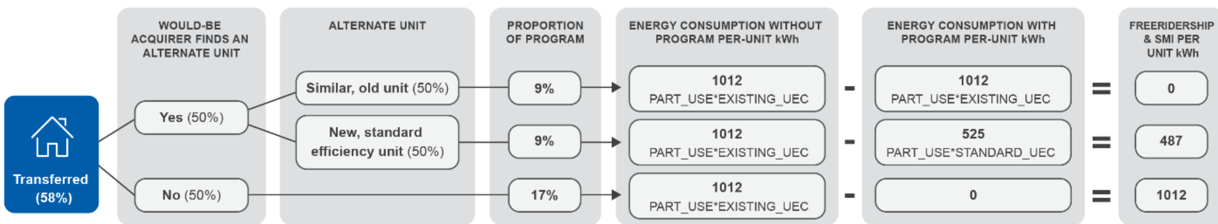
149 Thirty-four percent of refrigerator 2020 survey respondents and 31% of freezer 2020 survey respondents would have directly or indirectly transferred their unit to another customer on the grid.

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.[150]

Figure B-3 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)

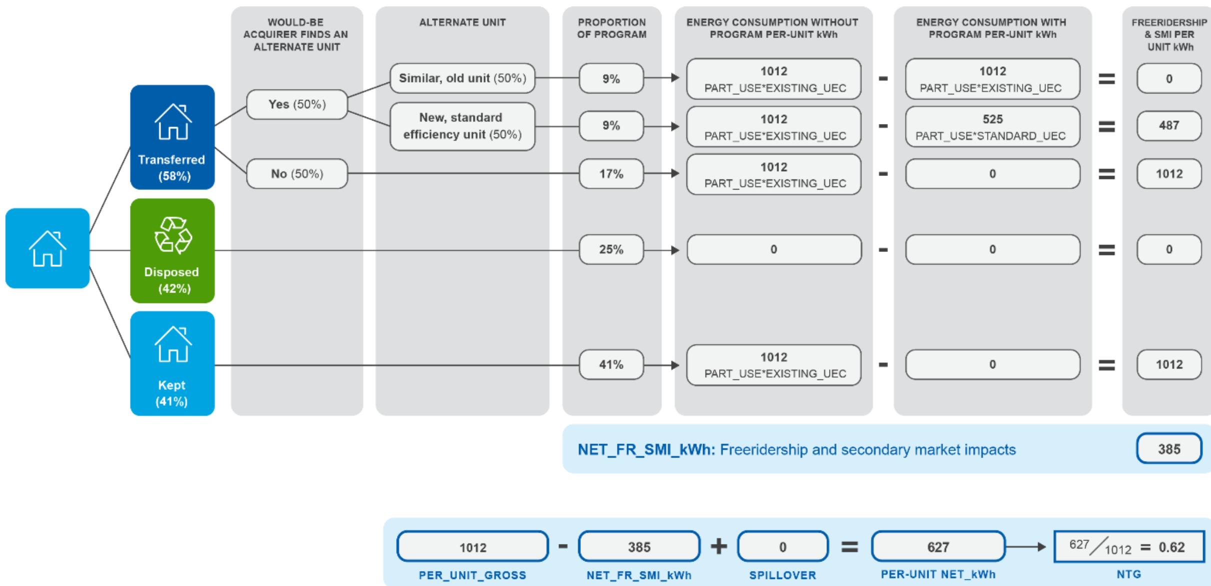
Figure B-3. Secondary Market Impacts—Refrigerators



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-4 shows how these values integrated into a combined savings estimate, net of freeridership and secondary market impacts.

[150] 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

Figure B-4. Savings Net of Freeridership and Secondary Market Impacts—Refrigerators



B.5.2 Detailed Spillover Findings

As recommended in the UMP, Cadmus did not include spillover in net savings estimates for the Appliance Recycling Program in 2020. 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 using findings from a survey conducted with 70 program participants. After including spillover, the program resulted in an 86% NTG ratio. Table B-22 lists the presents the NTG results for the program.

Table B-22. C&I Prescriptive Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Total Program	15%[1]	1%	86%

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

B.6.1 Detailed Freeridership Findings

Intention Freeridership Score

Cadmus estimated *intention* freeridership scores for all participants based on their responses to the *intention*-focused freeridership questions. 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.

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. 2020 C&I Prescriptive Program Self-Report *Intention* Freeridership Distribution by Estimate

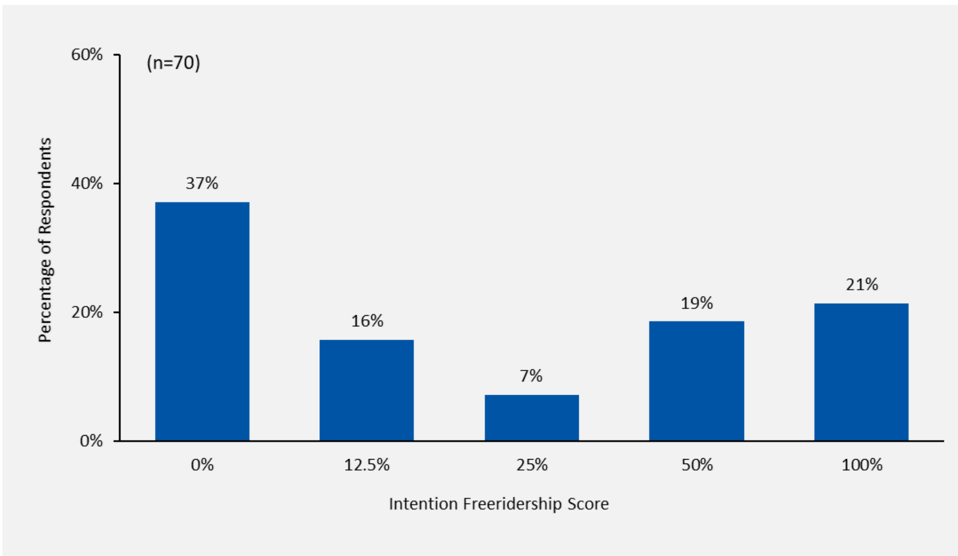


Table B-23. 2020 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology C&I Prescriptive Program and Scoring

FR1. First, did your organization have specific plans to install the [MEASURE] before learning about Vectren's Business Rebate Program?	FR2. Had you already purchased or installed the new [MEASURE] before you learned about the program?	FR3. Just to be clear, you installed the [MEASURE] before you heard anything about the Vectren program, correct?	FR4. Would you have installed a [MEASURE] that (was/were) just as energy-efficient without the Vectren program and rebates?	FR5. And would you have installed the same quantity of [MEASURE] in absence of the Vectren program and rebates?	FR6. Without the Vectren program and rebates, would you have installed the [MEASURE] …	FR7. Did the incentive help the [MEASURE] project receive implementation approval from your organization?	FR8. Prior to participating in the Business Rebate Program, was the purchase and installation of the [MEASURE] included in your organization's capital budget?
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes, that is correct (Yes) [100% FR Assigned]	Yes, just as energy-efficient (Yes) [-0%]	Yes, same quantity (Yes) [-0%]	Within the same year? (Yes) [-0%]	Yes (No) [-50%]	Yes (No) [-50%]
No (No) [-50%]	No (No) [-0%]	No, that's not correct (No) [-0%]	No, less energy efficient (No) [-50%]	No, I would have installed less (No) [-50%]	Within one to two years? (Partial) [-25%]	No (Yes) [-0%]	No (Yes) [-0%]
DK/RF (Partial) [-25%]	DK/RF (No) [-0%]	DK/RF (No) [-0%]	No, more energy efficient (Yes) [-0%]	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%]		

Influence Freeridership Score

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." Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions, as shown in Table B-24.

Table B-24. 2020 C&I Prescriptive Program Freeridership Influence Responses (n=70)

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%	40	10	14	13	17
2 – Not too important	75%	6	11	16	9	2
3 – Somewhat important	25%	11	13	18	12	11
4 - Very important	0%	11	35	20	30	12
Don't Know	50%	1	0	1	1	16
Not Applicable	50%	1	1	1	5	0
Average		**1.9**	**3.1**	**2.6**	**2.9**	**2.4**

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. 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 10% for C&I Prescriptive Program participants.

Table B-25. 2020 C&I Prescriptive Program Influence Freeridership Score (n=70)

Maximum Influence Rating	Influence Score	Count[1]	Total Survey Sample *Ex Post* MMBtu Savings	Influence Score MMBtu Savings
1 – Not at all important	100%	2	41	41
2 – Not too important	75%	5	253	190
3 – Somewhat important	25%	10	1,387	347
4 - Very important	0%	52	4,301	0
Not Applicable	0%	1	0	0
Average Maximum Influence Rating - Simple Average		**3.6**		
Average Influence Score - Weighted by *Ex Post* Savings		**10%**		

[1] Refers to the number of responses for each factor/influence score response option.

Final Freeridership Score

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-26 presents the intention, influence, and freeridership scores for the C&I Prescriptive Program.

Table B-26. 2020 C&I Prescriptive Program Intention/Influence Freeridership Score

n	Intention Score	Influence Score	Freeridership Score
70	21%	10%	15%

B.6.2 Detailed Spillover Findings

Three participants reported installing a total of three 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 LEDs and a combination oven. [151]

Cadmus used *ex post* savings estimated for the 2020 C&I Prescriptive Program evaluation 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 the measure category spillover estimates in Table B-27.

Table B-27. C&I Prescriptive Program Spillover Estimates by Measure Category

Measure	Survey Sample Spillover MMBtu Savings	Survey Sample Program MMBtu Savings	Percentage Spillover Estimate
Total Program	25.6	2,006.1	1%

B.7 C&I Custom Program

Cadmus calculated freeridership and spillover for the C&I Custom Program using findings from a survey conducted with 10 program participants. After including spillover, the program resulted in an 96% NTG ratio. Table B-28 lists the presents the NTG results for the program.

Table B-28. C&I Custom Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Total Program	4%[1]	0%	96%

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

[151] Program NTG calculations, including spillover, are calculated at the overall program level and are not fuel dependent.

B.7.1 Detailed Freeridership Findings

Intention Freeridership Score

Cadmus estimated *intention* freeridership scores for the program based on surveyed participants' responses to the *intention*-focused freeridership questions. Table B-29 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 decrements based on responses to the questions. After assigning an *intention* freeridership score to every survey respondent, Cadmus calculated a savings-weighted average *intention* freerider score of 6% for the program.

Figure B-6 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses using the pure intention-based freeridership method.

Figure B-6. 2020 C&I Custom Program Self-Report *Intention* Freeridership Distribution by Estimate

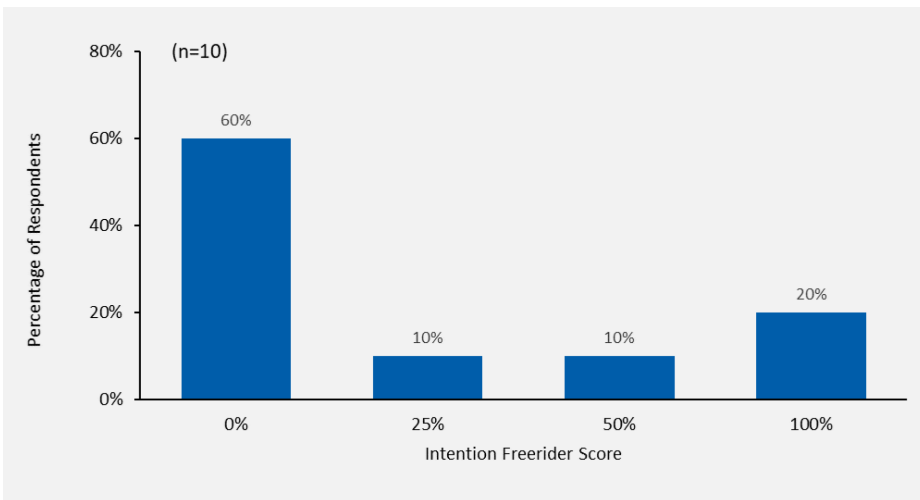


Table B-29. 2020 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology C&I Custom Program and Scoring

First, did your organization have specific plans to install the [MEASURE] BEFORE learning about Vectren's Commercial Custom Program rebate?	Had you already purchased or installed the new [MEASURE] before you learned about the program?	Just to be clear, you installed the [MEASURE] before you heard anything about the Vectren program, correct?	Would you have installed a [MEASURE] that (was/were) just as energy-efficient without the Vectren program and rebates? [READ LIST IF NECESSARY]	And would you have installed the same quantity of [MEASURE] in absence of the Vectren program and rebates? [READ LIST IF NECESSARY]	Without the Vectren program and rebates, would you have installed the [MEASURE] … [READ LIST]?	Did the incentive help the [MEASURE] project receive implementation approval from your organization?	Prior to participating in the Commercial Custom Program, was the purchase and installation of the [MEASURE] included in your organization's capital budget?
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes, that is correct (Yes) [100% freerider Assigned]	Yes, just as energy-efficient (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, less energy efficient (No) [-100%]	No, I would have installed less (No) [-50%]	Within one to two years? (Partial) [-25%]	No (Yes) [-0%]	No (No) [-50%]
DK/NA (Partial) [-25%]	DK/NA (No) [-0%]	DK/NA (No) [-0%]	No, more energy efficient (Yes) [-0%]	No, I would have installed more (Yes) [-0%]	Within three to five years? (No) [-100%]	DK/NA (Partial) [-25%]	DK/NA (Partial) [-25%]
			DK/NA (Partial) [-25%]	DK/NA (Partial) [-25%]	In more than five years? (No) [-100%]		
					DK/NA (Partial) [-25%]		

DK = don't know; RF = refused

Influence Freeridership Score

Table B-30 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." Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions, as shown in Table B-30.

Table B-30. 2020 C&I Custom Program Freeridership Influence Responses (n=10)

Question Response Options	Influence Score	Vectren or program implementer 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 influential	100%	5	2	3	2	4
2 – Not too influential	75%	1	0	3	2	0
3 – Somewhat influential	25%	0	2	1	2	1
4 - Very influential	0%	4	6	3	4	3
Don't Know	50%	0	0	0	0	0
Not Applicable	50%	0	0	0	0	2
Average		**2.3**	**3.2**	**2.4**	**2.8**	**1.9**

Cadmus used the maximum rating given by each participant for any factor in Table B-30 to determine the participant's influence score presented in Table B-31. Cadmus weighted individual influence scores by each participant's respective *ex post* gross savings associated with the total survey sample to arrive at a savings-weighted average influence score of 2% for C&I Custom Program participants.

Table B-31. 2020 C&I Custom Program Influence Freeridership Score (n=10)

Maximum Influence Rating	Influence Score	Count[1]	Total Survey Sample *Ex post* MMBtu Savings	Influence Score MMBtu Savings
1 – Not at all influential	100%	2	480	480
2 – Not too influential	75%	0	0	0
3 – Somewhat influential	25%	0	0	0
4 - Very influential	0%	8	21,325	0
Average Maximum Influence Rating - Simple Average		**3.4**		
Average Influence Score - Weighted by *Ex Post* Savings		**2%**		

[1] Refers to the number of responses for each factor/influence score response option.

Final Freeridership Score

Cadmus calculated the arithmetic mean of the intention and influence freeridership components to estimate a final freeridership value of 4%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-32 presents the intention, influence, and freeridership scores for the C&I Custom Program.

Table B-32. 2020 C&I Custom Program Intention/Influence Freeridership Score

n	Intention Score	Influence Score	Freeridership Score
10	6%	2%	4%

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 Small Business Energy Solutions Program

Cadmus calculated freeridership and spillover for the Small Business Energy Solutions (SBES) Program using findings from a survey conducted with 62 program participants.[152] Table B-33 lists the NTG results.

Table B-33. Small Business Energy Solutions Program Net-to-Gross Ratio

Measure	Freeridership	Spillover	NTG Ratio
Total Program	7%[1]	0%	93%

[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.[153] Cadmus calculated the arithmetic mean of the savings weighted *intention* and *influence* freeridership components to estimate measure category freeridership,[154] 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 *intention*-focused freeridership questions. Table B-34 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 decrements based on the participant's response to the questions.

152 Sixty-two of the 70 survey respondents completed the questions relating to freeridership. Eight survey respondents were associated with no-cost measures and freeridership data were not collected.

153 *Intention* and *influence* freeridership scores both have a maximum of 100%.

154 *Ex post* gross program savings.

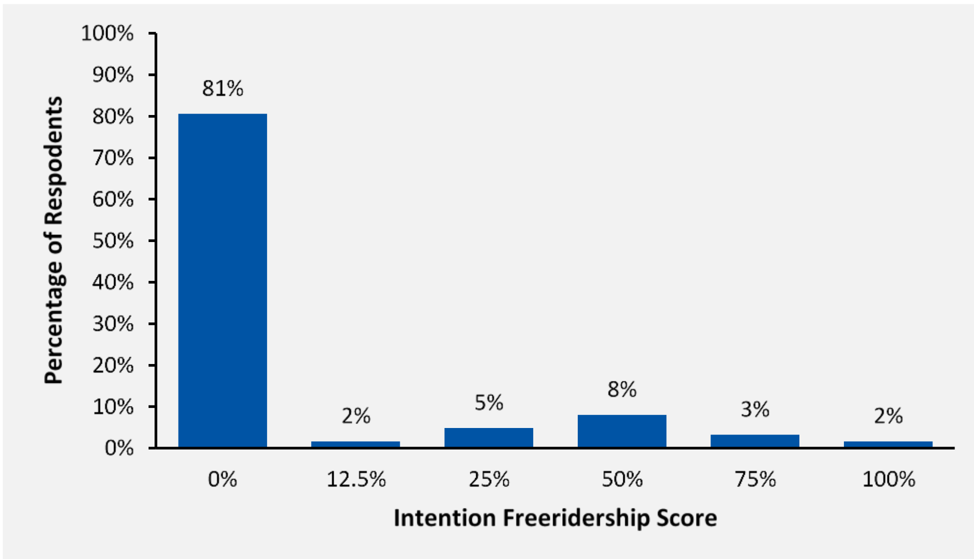
Table B-34. 2020 Raw Survey Responses Translation to *Intention* Freeridership Scoring Matrix Terminology Small Business Energy Solutions Program and Scoring

Did you have specific plans to install any additional energy-efficient equipment BEFORE learning about the program?	Would you have installed the same [MEASURE] if the equipment had not been recommended to you in the Small Business Energy Solutions assessment report?	Would you have installed the same [MEASURE] without the instant discount?	In absence of the program, would you have installed the equipment to at least the same level of efficiency? [READ LIST]	In absence of the program, would you have installed the same quantity of [MEASURE]?	In absence of the program, would you have installed the [MEASURE]…	Prior to participating in this program, was the purchase and installation of the [MEASURE] included in your organization's most recent capital budget?
Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes (Yes) [-0%]	Yes, just as energy efficient (Yes) [-0%]	Yes, same quantity (Yes) [-0%]	At the same time (No) [-0%]	Yes (Yes) [-0%]
No (No) [-50%]	No (No) [-25%]	No (No) [-25%]	No, less energy efficient (No) [-100%]	No, I would have installed less (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%]	No, more energy efficient (Yes) [-0%]	No, I would have installed more (Yes) [-0%]	Within one to two years (No) [-100%]	DK/RF (Partial) [-25%]
			DK/RF (Partial) [-25%]	DK/RF (Partial) [-25%]	Within three to five years (No) [-100%]	
					In more than five years (No) [-100%]	
					DK/RF (Partial) [-25%]	

DK = don't know; RF = refused

Figure B-7 shows the distribution of *intention* freeridership estimates Cadmus assigned to participant responses to the pure intention-based freeridership method.

Figure B-7. 2020 Small Business Energy Solutions Program Self-Report *Intention* Freeridership Distribution by Estimate



Influence Freeridership Score

Table B-35 shows the distribution of responses to the influence freeridership 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." Cadmus assessed influence freeridership from participants' ratings to the relative importance of various program elements in their purchasing decisions.

Table B-35. 2020 Small Business Energy Solutions Program Freeridership Influence Responses (n=62)

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%	5	4	7	4	10
2 – Not too influential	75%	5	0	8	2	2
3 – Somewhat influential	25%	6	1	12	7	11
4 – Very influential	0%	40	54	30	44	26
Don't Know	50%	3	1	4	1	4
Not Applicable	50%	3	2	1	4	9
Average		**3.7**	**3.4**	**3.8**	**3.1**	**3.6**

Cadmus used the maximum rating given by each participant for any factor in Table B-35 to determine their influence freeridership score presented in Table B-36. The counts refer to the number of responses for each factor/influence freeridership score response option. Cadmus weighted individual influence freeridership scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence freeridership score of 2% for SBES Program participants.

Table B-36. 2020 Small Business Energy Solutions Program Influence Freeridership Score (n=62)

Maximum Influence Rating	Influence Score	Count	Total Survey Sample *Ex Post* MMBtu Savings	Influence Score MMBtu Savings
1 – Not at all influential	100%	1	22	16
2 – Not too influential	75%	0	0	0
3 – Somewhat influential	25%	1	174	22
4 – Very influential	0%	60	2,579	165
Don't know	50%	0	0	0
Average Maximum Influence Rating - Simple Average	**3.9**			
Average Influence Score - Weighted by *Ex Post* Savings	**2%**			

Final Freeridership Score

Cadmus calculated the arithmetic mean of the intention and influence freeridership components to estimate a final freeridership value of 7%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table B-37 summarizes the intention, influence, and freeridership scores for the SBES Program.

Table B-37. 2020 Small Business Energy Solutions Program Intention/Influence Freeridership Score

n	Intention Score	Influence Score	Freeridership Score
62	12%	2%	7%

B.8.2 Detailed Spillover Findings

No viable spillover activity was reported by 2020 survey participants, resulting in zero spillover savings.