BEFORE THE
PUBLIC UTILITIES COMMISSION OF OHIO

In the matter of the Application of Vectren Energy Delivery of Ohio, Inc. for Approval of an Alternative Rate Plan.	))))	Case No. 18-49-GA-ALT
In the Matter of the Application of Vectren Energy Delivery of Ohio, Inc. for Approval of an Increase in Gas Rates.	))))	Case No. 18-0298-GA-AIR
In the Matter of the Application of Vectren Energy Delivery of Ohio, Inc., for Approval of an Alternative Rate Plan.	))))	Case No. 18-0299-GA-ALT

DIRECT TESTIMONY OF TAMARA DZUBAY ON BEHALF OF ENVIRONMENTAL LAW AND POLICY CENTER

Filed: November 7, 2018

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I. INTRODUCTION

My name is Tamara Dzubay, and I am presenting testimony on behalf of the Environmental Law & Policy Center. I am a Clean Energy Finance Specialist at the Environmental Law & Policy Center in Chicago. I hold a Bachelor of Business Administration degree from the University of Michigan's Ross School of Business with a concentration in finance. I also hold a Master of Business Administration degree from Northwestern University's Kellogg School of Management where I majored in finance. I've worked in financial roles for over seven years, half of that time focusing on the energy industry. I've provided expert testimony before the Illinois Pollution Control Board in *Amendments to 35 Illinois Administrative Code 225.233, Multi-Pollutant Standards*. For the past two years, I've represented ELPC in the Illinois Energy Efficiency Stakeholder Advisory Group and helped lead a collaborative process specifically dedicated to accelerating customer participation in a utility smart thermostat program run by ComEd and formerly Nicor Gas, Peoples Gas and Northshore Gas in Illinois. The collaborative meets regularly to refine marketing, messaging, and rebate strategies based on program results, market research studies, focus groups and survey data. I've guest lectured on Topics in Energy & Sustainability at the University of Illinois at Chicago, presented on energy issues at state conferences and submitted comments on behalf of the Environmental Law & Policy Center to numerous state agencies and regulatory authorities in the Midwest region.

II. QUESTIONS AND ANSWERS

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to respond to Staff's Report regarding Vectren Energy Delivery of Ohio's (VEDO) Energy Efficiency (EE) programs and provide recommendations regarding the collaborative process and the smart thermostat program.

Q. What are your recommendations regarding VEDO's collaborative process?

A. VEDO's current collaborative, which provides oversight in the administration of its EE Programs, includes the company, the Public Utilities Commission of Ohio ("PUCO"), the Office of the Ohio Consumers' Counsel ("OCC") and the Ohio Partnership for Affordable Energy ("OPAE"). The collaborative should be continued and the group should be expanded to include other interested stakeholders such as environmental nonprofits and public interest advocacy groups. This would be particularly valuable in facilitating information sharing across states to maximize program effectiveness. This would also enable a more open and transparent portfolio planning process.

Q. Please describe what a smart thermostat is and its benefits.

A. A smart thermostat is a Wifi-enabled device that connects with an app on a smartphone or tablet, allowing users to monitor and control their heating and cooling remotely, and has the capability to make automated adjustments to temperature based on occupant behavior. It can sense when a home is vacant and automatically adjusts the HVAC to save energy and money. It can also spot a user's proximity to home through geo-fencing and automatically adjusts the HVAC to maximize comfort and convenience. Smart thermostats can learn customer preferences over time to maximize comfort, convenience, control and savings. Some smart thermostats have additional features, such as virtual

assistants, weather information displays, demand response abilities, detailed reports on heating and cooling usage with energy saving tips, appliance maintenance alerts, and communication and control abilities for other energy-using devices, such as pool pumps, security systems, and appliances.

Q. What advantages do smart thermostats offer over other thermostats on the market?

A. The other thermostats on the market include manual, programmable and WiFi programmable (which is referred to as "WiFi Basic" in Vectren's current and proposed EE program). Manual thermostats require a user to change a setting on the thermostat every time they want their home temperature changed which results in wasted energy heating or cooling empty spaces. A programmable thermostat allows a user to designate specific temperature set points for specific times and days of the week. Unfortunately, in practice, they are often not programmed correctly as changes in weather and user schedules result in overrides which minimize the device's effectiveness.[1] This results in wasted energy heating or cooling empty spaces. This could be why EPA suspended the ENERGY STAR programmable thermostats specification effective December 31, 2009[2]. Wi-Fi-programmable thermostats are slightly more advanced than programmable thermostats and allow a user to remotely program the thermostat, through a phone or computer, rather than requiring programming directly on the device. A user must still change the temperature set points if their schedule or the seasons change, and the devices do not have sensing or geo-fencing capabilities which prevents maximum energy savings

[1] *See* Direct Testimony of John Paul Jewell on Behalf of Environmental Law & Policy Center, the Northwest Ohio Aggregation Coalition, and NOAC Communities, Case Nos. 16-1309-GA-UNC and 16-1310-GA-AAM, Exhibit C (September 13, 2016) ("Jewell Testimony").

[2] See Energy Star. "Programmable Thermostats." https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/thermostats/Spec_Suspension_Memo_May2009.pdf, Attached as Exhibit TD-1.

as highlighted in Cadmus' 2015 evaluation of gas demand-side management ("DSM") programs, which states "learning thermostats are likely to have higher energy savings as models self-adjust to energy saving modules based on occupant behavior."[3] This is also documented in Table 7-1 Residential Prescriptive Measures.[4]

Q. What is Witness Hariss' Table 7-1 Residential Prescriptive Measures showing?

A. It is showing the incentives available for higher efficiency products and the energy savings attributable to those higher efficiency products based on Cadmus' 2015 evaluation of gas DSM programs. Based on this evaluation, Cadmus found that on average wi-fi learning thermostats saved approximately 10 Ccf more than a basic Wifi thermostat.

Q. How does this translate to percent energy savings?

A. Cadmus' evaluation states that Wifi thermostat customers saved an average of 61 therms, or 7% of pre-participation consumption.[5] However, this fails to differentiate percentage savings between Wifi Basic thermostats and Wifi smart thermostats. Using this information, the evaluated Ccf information in Table 7-1 Residential Prescriptive Measures and an energy conversion calculator[6], a relative percent savings value for Wifi Basic thermostats and Wifi smart thermostats can be extrapolated. This calculation results in a savings value of 7.89% for Wifi smart thermostats and a savings value of 5.98% for Wifi basic thermostats.

[3] *See* ELPC 1-RPD-4 2015 PY VEDO Final Evaluation, page 41, Attached as Exhibit TD-2.
[4] *See* Direct Testimony of Rina H. Harris on Behalf of Vectren Energy Delivery of Ohio, Inc., Case Nos. 18-0298-GA-AIR and 18-0299-GA-ALT, Attachment A, page 93 (April, 13, 2018) ("Harris Testimony").
[5] *See* ELPC 1-RPD-4 2015 PY VEDO Final Evaluation, page 40, Attached as Exhibit TD-2.
[6] Abraxas. "Energy Conversion Calculator." https://www.abraxasenergy.com/energy-resources/toolbox/conversion-calculators/energy/

Q. Do you agree with the Wifi-Enabled thermostat savings values depicted in Ms. Harris' chart?

A. It should be noted that since this evaluation was conducted, ENERGY STAR certified a number of Wifi smart thermostat products as providing a minimum of 8% heating and 10% cooling energy savings through a robust stakeholder process that included exhaustive input and review from industry, regulators, national labs and other stakeholders. Products that have received the ENERGY STAR designation need to submit aggregate savings data and associated statistics to the US EPA every six months in accordance with the ENERGY STAR Method to Demonstrate Connected Thermostat Field Savings to maintain the certification. ENERGY STAR has not certified Wifi basic thermostats as providing a minimum savings value Therefore, the savings value attributed to Wifi Basic thermostats in the chart depicting Cadmus' 2015 evaluation results is inconsistent with ENERGY STAR's certification, which provides a minimum heating savings value of 8% for Wifi smart thermostats but no minimum savings value for Wifi basic thermostats.[7] It should also be noted that the 2015 Cadmus evaluation was conducted at a time when smart thermostat users were "innovators" and "early adopters."[8] These terms come from the diffusion of innovation theory which determines the point at which an innovation reaches critical mass. It is likely that innovators and early adopters would be more likely to program programmable thermostats correctly than

[7] ENERGY STAR. 2017. "Smart Thermostats Key Product Criteria." https://www.energystar.gov/products/heating_cooling/smart_thermostats/key_product_criteria

[8] Parks Associates. 2018. "13% of U.S. broadband households owned a smart thermostat at the end of 2017." http://www.parksassociates.com/blog/article/ses2018-pr6 and Newman, Daniel. 2016. "Why You Should Align Your Business Transformation To The Adoption Bell Curve." https://www.forbes.com/sites/danielnewman/2016/05/31/why-you-should-align-your-business-transformation-to-the-adoption-bell-curve/#5f4dc1121160

the vast majority of the population and that savings attributable to smart thermostats would be greater once the innovation has reached a critical mass.

Q. What are your recommendations regarding VEDO's smart thermostat program?

A. VEDO should not rebate Wifi "Basic" thermostats because doing so confuses customers, cannibalizes Wifi smart thermostat adoption, and prevents VEDO from achieving maximum energy savings. VEDO should only rebate Wifi smart thermostats, and VEDO's smart thermostat program should be simplified to include only ENERGY STAR certified smart thermostat products which have been demonstrated to provide a minimum of 8% heating savings. It is important to coordinate gas utility program design elements with electric to maximize joint program effectiveness. Dayton Power & Light ("DP&L") only rebates ENERGY STAR certified smart thermostat products,[9] and Vectren should do the same. This is especially important in light of the fact that DP&L's online marketplace now offers instant discounts for Vectren customers as well as DP&L customers.[10] Therefore, Vectren rebating different thermostat products beyond ENERGY STAR certified smart thermostats rebated by DP&L would confuse customers and could lead to unintended consequences such as misleading customers to believe that they could receive a DP&L rebate in addition to a Vectren rebate when in fact DP&L rebates are only available for ENERGY STAR certified smart thermostat products. In determining the proper rebate amount for Wifi smart thermostats, it is also important to coordinate gas utility programs with electric to ensure that the combined rebate for smart thermostats

[9] DP& L. 2018. "Rebate Application." https://www.dpandl.com/images/uploads/dpl-smart-thermostat-rebate-application_June-2018.pdf

[10] DP& L Marketplace. "Wi-Fi Thermostats." https://dplmarketplace.com/collections/wifi-thermostats?utm_source=DP%26L&utm_medium=website&utm_campaign=smart_thermostat_rebate

reduces the purchase price by at least 50% in order to maximize program participation and energy savings. Therefore, the rebate amount for the Wifi smart thermostats offered by Vectren should increase to $75. A $75 rebate offered by Vectren coupled with the $50 rebate offered by Dayton Power & Light would reduce the purchase price of all ENERGY STAR certified smart thermostats by at least 50%. It should also be noted that the Commission ordered a $75 rebate for Wifi smart thermostats in the Columbia Gas Order,[11] that Cadmus recommended a $75 rebate for Wifi Learning Thermostats[12] and that Vectren provides a $75 rebate for smart thermostats to its customers in Indiana.[13] Additionally, the program budget for smart thermostats should be increased to enable VEDO to reach at least 10% of its customers with an ENERGY STAR certified smart thermostat in the first three years of the plan, which amounts to roughly 10,000 units per year. This is in line with the DP&L stipulation which dedicates a $600,000 annual budget for smart thermostat rebates which would equate to 12,000 units per year not including non-incentive costs[14]. A well designed smart thermostat program will require non-incentive costs including marketing, back-end administration and rebate processing

[11] Opinion and Order of the Public Utilities Commission of Ohio In the Matter of the Application of Columbia Gas of Ohio, Inc. for Approval of Demand-Side Management Programs for Its Residential and Commercial Customers, Case No. 16-1309-GA-UNC, and In the Matter of the Application of Columbia Gas of Ohio, Inc. for Approval to Change Accounting Methods, Case No. 16-1310-GA-AAM December 21, 2016, page 37.

[12] *See* ELPC 1-RPD-4 2015 PY VEDO Final Evaluation, page 41, Attached as Exhibit TD-2.

[13] Vectren. 2018. "Thermostat Rebates." https://www.vectren.com/savings/in-home/rebates/thermostat

[14] Stipulation and Recommendation of the Dayton Power and Light Company, PUCO Staff, ELPC, the Kroger Co., Ohio Environmental Council and EDF, Ohio Manufacturers Association Energy Group, Ohio Hospital Association, Ohio Partners for Affordable Energy and People Working Cooperatively, Inc. in the Public Utilities Commission of Ohio, In the Matter of the Application of The Dayton Power and Light Company for Approval of Its Energy Efficiency and Peak Demand Reduction Program Portfolio Plan for 2018 through 2020, Case Nos. 17-1398-EL-POR and 17-1399-EL-WVR, Exhibit 1.

among others. On a per unit basis, many of these costs can be reduced through economies of scale which means that if program goals are too small, programs are designed to fail because non-incentive spending per unit and per Ccf saved will not be optimized to enable sufficient marketing efforts.

Q. How should VEDO fund this increased smart thermostat effort?

A. This can be accomplished by increasing the overall EE budget. This can also be accomplished by moving the budget for the Wifi "Basic" thermostats to the budget for the Wifi smart thermostats and reducing or eliminating the budget for Furnace 95. The Furnace 95 is the less efficient furnace option compared to the Furnace 97. Therefore, it does not maximize energy savings. It is also not predicted to be a residential top measure in 2023 based on market research and has a very low Net-To-Gross ratio of 33%.[15] This means that 67% of customers who purchase a Furnace AFUE .95 would have done so without the incentive offered by Vectren, and that the incentive offered by Vectren can only be attributed to 33% of the program participants' purchase decision. Given the minimal value from the Furnace 95, this money should be reallocated to programs that have much more impact on purchase decisions to drive market transformation where it otherwise wouldn't exist, such as smart thermostats, which have a much higher Net-To-Gross ratio of 79%.

Q. Do you have any other thoughts you'd like to share?

A. Yes. I'd like to point out that the Residential Prescriptive Rebate Program describes customer targeted marketing tactics and includes a potential mass education message of

[15] Harris Testimony, Attachment A, page 8 (MPSAP Residential Top Measures in 2023) and ELPC 1-RPD-2 (AppD-Program Level Measure Data Excel File Tab Table D1-Residential Programs), Attached as Exhibit TD-3.

"program your thermostat".[16] I do not think this is a good message for a few reasons. First, Vectren should be promoting smart thermostats and not programmable thermostats. Second, having sat through 12 hours of smart thermostat focus groups with ComEd customers, I've learned that customers do not respond well to unclear, vague messaging. A better mass education message would be the recommended smart thermostat set points to maximize savings but maintain comfort. The US Department of Energy recommends a set point of 68 degrees in the winter when home and a set point that is 7-13 degrees cooler when away. [17] This highlights the need for an inclusive stakeholder collaborative to refine program design elements based on learnings and best practices from other states.

III. CONCLUSION

All customers would benefit from Vectren having a more open stakeholder collaborative process. Additionally, Vectren should expand its smart thermostat program consistent with my testimony.

[16] Harris Testimony, Attachment A, page 51.
[17] *See* Rich Wallace, Maureen. 2018. "Get smart, save money with ENERGY STAR smart thermostat." https://newsroom.lowes.com/inside-lowes/get-smart-save-money-with-energy-star-smart-thermostat/

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

**OFFICE OF
AIR AND RADIATION**

May 4, 2009

Dear Programmable Thermostat Manufacturer or Other Interested Stakeholder:

The purpose of this letter is to notify programmable thermostat stakeholders of the U.S. Environmental Protection Agency's (EPA) intention to sunset the Version 1.2 ENERGY STAR® Programmable Thermostat specification as scheduled on December 31, 2009 and to outline EPA's next steps with programmable thermostats. EPA will also issue a letter later this month detailing the specific timeline associated with sunsetting the ENERGY STAR specification.

EPA recognizes the potential for programmable thermostats (PTs) to save significant amounts of energy. We remain committed to cooperating with industry and other experts to structure a program that works toward this end. At this point we see that the best next step is to proceed as outlined in a February 2008 decision letter on PTs to sunset the current specification while we continue to work to design and implement an improved program. This is for the following reasons:

- Significant questions have been raised as to the net energy savings and environmental benefits being achieved with the current set of ENERGY STAR qualifying PTs through a number of field studies as discussed in the February 2008 decision letter.

- EPA established December 31, 2009 as a sunset date for the ENERGY STAR PT specification: 1) in light of a January 2007 Gas Networks study that demonstrated savings from PTs under some circumstances; 2) to allow some ENERGY STAR partners to complete their programs which extended into 2009 and that incorporated ENERGY STAR PTs; and 3) to see if an enhanced educational effort on proper use could improve the effectiveness of the program.

- EPA has been unable to confirm any improvement in terms of the savings delivered by programmable thermostats and has no credible basis for continuing to extend the current ENERGY STAR specification.

- No new approach has been developed for differentiating thermostats that reliably and easily assist homeowners in saving energy (and one is not imminent) as EPA had outlined would need to be finalized by March, 2009 so as to avoid sunsetting the specification.

Despite sunsetting the specification, EPA plans to continue to advance energy efficiency through programmable thermostats in the following ways:

- Continue to work with industry to develop a new ENERGY STAR specification that differentiates products with demonstrated ease-of-use features so as to minimize the potential for user interface issues to reduce energy savings. EPA will be exploring the usability of PT products, functionalities that improve user savings, and functionalities that offer consumers further comfort, communication, and control of energy costs.

- Continue to educate homeowners about the energy savings associated with the proper use of these devices. Programmable thermostat education will be integrated into this year's *Change the World, Start with ENERGY STAR* campaign. EPA will continue to promote and provide the Agency's educational materials and tools at www.energystar.gov.

During the week of May 18, 2009, EPA plans to issue a letter to PT partners outlining the milestones associated with sunsetting the specification. If you are aware of new studies or other information demonstrating PT effectiveness in terms of energy savings, we would appreciate receiving it prior to this date.

EPA appreciates the efforts programmable thermostat partners have made to deliver ENERGY STAR qualified products to consumers and to educate consumers regarding their proper use. We look forward to continuing our work to hone the ENERGY STAR program for these products and to staying in touch with you on any progress. Please feel free to share your comments or concerns with me at 202-343-9120 or kaplan.katharine@epa.gov and Christina Chang, ICF International, at 202-862-1206 or cchang@icfi.com.

Sincerely,

Katharine Kaplan

Katharine Kaplan
US EPA, ENERGY STAR Product Development

Table D-1: Residential Programs

Measure	Program Name	Measure Life	Savings per unit (CCF)	Participation 2018
Behavioral Programs	Behavior	1	10	50,000
Crawlspace Wall Insulation SF EX	Home Insulation	25	61	50
Ducting - Repair and Sealing	Home Insulation	20	159	100
Insulation - Ducting SF EX	Home Insulation	20	62	50
Insulation - Infiltration Control SF EX	Home Insulation	15	102	400
Insulation - Ceiling SF EX	Home Insulation	25	129	450
Insulation - Wall SF EX	Home Insulation	25	231	200
Boiler	Residential Rebate	18	190	40
Furnace 95	Residential Rebate	15	121	2,500
Furnace 97	Residential Rebate	15	151	1,000
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	15	58	1,800
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	15	67	4,745
Water Heater - Faucet Aerators	Residential Rebate	10	23	2,037
Water Heater - Low-Flow Showerheads	Residential Rebate	10	23	2,037
Water Heater - Pipe Insulation	Residential Rebate	15	7	1,689
Water Heater - Shower Starters	Residential Rebate	10	6	115
School Kits	School Education	10	11	9,000
VWP I	Vectren Weatherization Program	15	260	160
VWP II	Vectren Weatherization Program	15	319	130

Table D-1: Residential Programs

Measure	Program Name	Participation 2019	Participation 2020	Participation 2021
Behavioral Programs	Behavior	50,000	50,000	50,000
Crawlspace Wall Insulation SF EX	Home Insulation	50	50	50
Ducting - Repair and Sealing	Home Insulation	100	100	100
Insulation - Ducting SF EX	Home Insulation	50	50	50
Insulation - Infiltration Control SF EX	Home Insulation	400	400	400
Insulation - Ceiling SF EX	Home Insulation	450	450	450
Insulation - Wall SF EX	Home Insulation	200	200	200
Boiler	Residential Rebate	40	40	40
Furnace 95	Residential Rebate	2,500	2,500	2,500
Furnace 97	Residential Rebate	1,000	1,000	1,000
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	1,800	1,800	1,800
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	4,745	4,745	4,745
Water Heater - Faucet Aerators	Residential Rebate	2,110	2,183	2,258
Water Heater - Low-Flow Showerheads	Residential Rebate	2,110	2,183	2,258
Water Heater - Pipe Insulation	Residential Rebate	1,740	1,792	1,843
Water Heater - Shower Starters	Residential Rebate	121	128	134
School Kits	School Education	9,000	9,000	9,000
VWP I	Vectren Weatherization Program	160	160	160
VWP II	Vectren Weatherization Program	130	130	130

Table D-1: Residential Programs

Measure	Program Name	Participation 2022	Participation 2023	Savings CCF 2018
Behavioral Programs	Behavior	50,000	50,000	521,242
Crawlspace Wall Insulation SF EX	Home Insulation	50	50	3,064
Ducting - Repair and Sealing	Home Insulation	100	100	15,867
Insulation - Ducting SF EX	Home Insulation	50	50	3,080
Insulation - Infiltration Control SF EX	Home Insulation	400	400	40,680
Insulation - Ceiling SF EX	Home Insulation	450	450	58,055
Insulation - Wall SF EX	Home Insulation	200	200	46,236
Boiler	Residential Rebate	40	40	7,615
Furnace 95	Residential Rebate	2,500	2,500	301,750
Furnace 97	Residential Rebate	1,000	1,000	151,240
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	1,800	1,800	103,662
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	4,745	4,745	319,718
Water Heater - Faucet Aerators	Residential Rebate	2,332	2,407	46,613
Water Heater - Low-Flow Showerheads	Residential Rebate	2,332	2,407	47,059
Water Heater - Pipe Insulation	Residential Rebate	1,894	1,945	11,662
Water Heater - Shower Starters	Residential Rebate	141	147	683
School Kits	School Education	9,000	9,000	99,180
VWP I	Vectren Weatherization Program	160	160	41,600
VWP II	Vectren Weatherization Program	130	130	41,470

Table D-1: Residential Programs

Measure	Program Name	Savings CCF 2019	Savings CCF 2020	Savings CCF 2021
Behavioral Programs	Behavior	521,242	521,242	521,242
Crawlspace Wall Insulation SF EX	Home Insulation	3,006	2,946	2,887
Ducting - Repair and Sealing	Home Insulation	15,593	15,314	15,039
Insulation - Ducting SF EX	Home Insulation	3,016	2,951	2,886
Insulation - Infiltration Control SF EX	Home Insulation	40,680	40,680	40,680
Insulation - Ceiling SF EX	Home Insulation	58,055	58,055	58,055
Insulation - Wall SF EX	Home Insulation	46,236	46,236	46,236
Boiler	Residential Rebate	7,615	7,615	7,615
Furnace 95	Residential Rebate	300,638	299,412	299,677
Furnace 97	Residential Rebate	150,683	150,068	150,201
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	101,700	99,703	97,715
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	314,168	308,534	302,944
Water Heater - Faucet Aerators	Residential Rebate	48,208	49,818	51,449
Water Heater - Low-Flow Showerheads	Residential Rebate	48,586	50,121	51,672
Water Heater - Pipe Insulation	Residential Rebate	11,967	12,266	12,560
Water Heater - Shower Starters	Residential Rebate	719	755	790
School Kits	School Education	99,180	99,180	99,180
VWP I	Vectren Weatherization Program	41,600	41,600	41,600
VWP II	Vectren Weatherization Program	41,470	41,470	41,470

Table D-1: Residential Programs

Measure	Program Name	Savings CCF 2022	Savings CCF 2023	NTG	Incentive Per Unit 2018
Behavioral Programs	Behavior	521,242	521,242	100%	$ -
Crawlspace Wall Insulation SF EX	Home Insulation	2,828	2,770	69%	$ 198
Ducting - Repair and Sealing	Home Insulation	14,770	14,508	69%	$ 137
Insulation - Ducting SF EX	Home Insulation	2,822	2,759	69%	$ 252
Insulation - Infiltration Control SF EX	Home Insulation	40,680	40,680	73%	$ 212
Insulation - Ceiling SF EX	Home Insulation	58,055	58,055	60%	$ 562
Insulation - Wall SF EX	Home Insulation	46,236	46,236	60%	$ 520
Boiler	Residential Rebate	7,615	7,615	50%	$ 500
Furnace 95	Residential Rebate	300,043	299,886	33%	$ 150
Furnace 97	Residential Rebate	150,384	150,306	55%	$ 400
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	95,756	93,734	79%	$ 30
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	297,465	292,132	79%	$ 50
Water Heater - Faucet Aerators	Residential Rebate	53,073	54,729	100%	$ 0
Water Heater - Low-Flow Showerheads	Residential Rebate	53,208	54,770	100%	$ 4
Water Heater - Pipe Insulation	Residential Rebate	12,848	13,133	100%	$ 24
Water Heater - Shower Starters	Residential Rebate	826	862	100%	$ 16
School Kits	School Education	99,180	99,180	100%	$ -
VWP I	Vectren Weatherization Program	41,600	41,600	100%	$ -
VWP II	Vectren Weatherization Program	41,470	41,470	100%	$ -

Table D-1: Residential Programs

Measure	Program Name	Incremental Cost Per Unit 2018	Total Incentives 2018-2023
Behavioral Programs	Behavior	$ -	$ -
Crawlspace Wall Insulation SF EX	Home Insulation	$ 380	$ 63,596
Ducting - Repair and Sealing	Home Insulation	$ 264	$ 88,354
Insulation - Ducting SF EX	Home Insulation	$ 484	$ 80,965
Insulation - Infiltration Control SF EX	Home Insulation	$ 408	$ 545,650
Insulation - Ceiling SF EX	Home Insulation	$ 754	$ 1,627,668
Insulation - Wall SF EX	Home Insulation	$ 943	$ 669,345
Boiler	Residential Rebate	$ 750	$ 128,720
Furnace 95	Residential Rebate	$ 689	$ 2,413,505
Furnace 97	Residential Rebate	$ 867	$ 2,574,405
Thermostat - Wi-Fi Enabled Basic EX	Residential Rebate	$ 103	$ 324,000
Thermostat - Wi-Fi Enabled Smart EX	Residential Rebate	$ 196	$ 1,423,500
Water Heater - Faucet Aerators	Residential Rebate	$ 1	$ 5,457
Water Heater - Low-Flow Showerheads	Residential Rebate	$ 7	$ 50,478
Water Heater - Pipe Insulation	Residential Rebate	$ 46	$ 278,320
Water Heater - Shower Starters	Residential Rebate	$ 31	$ 13,544
School Kits	School Education	$ -	$ -
VWP I	Vectren Weatherization Program	$ -	$ -
VWP II	Vectren Weatherization Program	$ -	$ -

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Vectren Energy Delivery of Ohio 2015 DSM Evaluation

July 2016

Vectren Energy Delivery of Ohio
One Vectren Square
Evansville, IN 47708

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CADMUS

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CADMUS

Introduction

Vectren Energy Delivery of Ohio (Vectren) tasked Cadmus with evaluating its 2015 (PY7) gas demand-side management (DSM) programs.[1] These programs and evaluation activities are summarized here.

Program Descriptions

- ***Residential Prescriptive Rebate Program:*** The program's design seeks to reduce gas consumption in single-family residential homes, or buildings with 12 or less dwelling units, by offering rebates to customers who purchase high-efficiency equipment. Cadmus' evaluation of the 2015 Residential Prescriptive Rebate Program focused on natural gas furnaces with 97% annual fuel utilization efficiency (AFUE) or greater, boilers with 95% AFUE or greater, programmable thermostats, and WiFi-enabled thermostats. Both existing and new construction applications were included in the analysis.
- ***Commercial Prescriptive Rebate Program:*** The program focuses on nonresidential customers who purchase high-efficiency equipment that reduces gas consumption. Cadmus' evaluation of the 2015 program focused solely on natural gas furnaces with 95% AFUE or greater.

Evaluation Activities

The study involved three types of evaluation activities:

- ***Impact evaluation:*** Review deemed savings values and assumptions, verify measure installation, and determine participants' freerider and spillover behaviors (net-to-gross ratio [NTG]).
- ***Process evaluation:*** Examine the program from the customer, trade ally, and utility perspectives to determine aspects that worked well and identify possible modifications to refine the program.
- ***Thermostat incentive research:*** Evaluate the incentive for thermostats by benchmarking to similar jurisdictions and natural gas utilities across the United States; develop questions for trade allies to examine the appropriateness of current incentive levels for programmable and WiFi-enabled thermostats.

Cadmus completed the impact and process evaluations and the incentive research for the Residential Prescriptive Rebate Program. Although the evaluation of the Commercial Prescriptive Rebate Program focused solely on impact, we conducted staff interviews and participant surveys and have included any insights on process gathered from these activities in this report.

[1] PY7 began on January 1, 2015, and ended on December 31, 2015.

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Report Organization

This report first describes the activities Cadmus used to conduct the evaluation:

- Goals for each interview/survey
- Description of the sampling plan
- Methods for calculating deemed savings, conducting measure verification, and determining freeridership and spillover

Although we completed similar tasks in evaluating both programs, our approaches varied. In each program section, we describe the approach used and present, where applicable, these:

- Process evaluation findings
- Impact evaluation findings
- Conclusions and recommendations

For the process evaluation findings, we have organized by topic, with information from each respondent group. The impact evaluation findings for each program present NTG, measure verification, and savings values by measure and program and also include comparisons between *ex ante* and *ex post* savings as well as realization rates.

Summary of Gas Savings

Table 1 shows reported *ex ante,* verified *ex ante* and *ex post* savings, realization rates, and evaluated net savings for measures evaluated in 2015 for Vectren.[2] Cadmus adjusted *ex post* savings after analyzing

[2] Reported *ex ante* savings (in 100 cubic feet, or CCF) can be defined as annual gross savings for the evaluation period, as reported by Vectren. *Ex post* savings (in CCF) can be defined as gross savings adjusted for the installation rate and from the deemed savings review. Net savings take into account the NTG ratio.

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installation rates and deemed savings. Evaluated net savings reflect an adjustment made for the estimated NTG ratio. Findings show a realization rate of 115% and evaluated net savings of 159,471 CCF.

Table 1. Summary-Level Evaluated Net Savings

Measure	Reported *Ex Ante* Savings (CCF)	Verified *Ex Ante* Savings (CCF)	Evaluated *Ex Post* Savings (CCF)	Realization Rate	NTG Ratio	Evaluated Net Savings (CCF)
97% AFUE Residential furnaces	60,768	61,766	74,863	123%	50%	37,432
95% Residential Boilers	2,473	2,473	4,381	177%	50%	2,190
Programmable Thermostats	28,580	29,603	29,572	100%	64%	18,926
WiFi-Enabled Thermostats - Residential	163,011	168,836	118,918	70%	79%	93,945
95% AFUE Commercial furnaces	10,531	10,531	12,031	114%	58%	6,978
Total	**265,363**	**273,209**	**239,765**	**88%**	**N/A**	**159,471**

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Methodology

Process Evaluation Methodology

The process evaluation documented how well the Residential Prescriptive Rebate Program works and identified the most important influences on its operations and achievements. The goals of the process evaluation were to assess the program's strengths, weaknesses, and areas for improvement and to gauge relevant stakeholders' perceptions of program effectiveness.

Cadmus interviewed Vectren program staff and trade allies (contractors) and conducted surveys with participant customers. Table 2 shows respondents by measure. Although we did not conduct a process evaluation for the Commercial Prescriptive Rebate Program, we interviewed program staff and conducted a survey with participating customers. We used these results primarily to establish NTG.

Table 2. Survey Respondent Groups by Measure

Respondent Group	Residential				Commercial
	>97% AFUE Furnaces	>95% AFUE Boilers	WiFi Thermostats	Programmable Thermostats	>95% AFUE Furnaces
Vectren Staff	✓	✓	✓	✓	✓
Trade Allies	15				N/A
Participant Customers	72	5	66	64	20

We designed the participant samples to meet the 90% confidence and 10% precision (90/10) threshold for general survey results at the measure level for the Residential Prescriptive Rebate Program.[3] We attempted a census for the Commercial Prescriptive Program and were able to speak to 20 participating customers who represented 58 of the 72 furnaces installed through the program.

Program Staff and Implementer Interviews

Cadmus interviewed Vectren program managers to gain an understanding of these components:

- Program design
- Program delivery
- Program administration
- Target audiences
- Marketing strategies
- Application and eligibility
- Reasons for customer participation
- Market barriers, implementation barriers, and participation barriers
- Quality control (QC)
- Communication and coordination with implementation/utility staff and trade allies

[3] Although the samples were designed with the goal of achieving 90/10 confidence/precision, precision estimates vary depending on the number of respondents who answered the individual questions and the distribution of their responses.

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- Proposed program changes

Trade Ally Surveys

Trade allies proved to be a key respondent group for the Residential Prescriptive Rebate Program process evaluation because they are the interface between Vectren and residential customers. Our interviews with participating trade allies focused on these research areas:

- Program awareness
- Program delivery and implementation
- Coordination with program staff
- Reasons for participation
- Marketing to customers
- Reasons for customer participation
- Market and participation barriers
- Satisfaction
- Training and education opportunities
- Program strengths and potential areas for improvements

Participant Surveys

We completed surveys with participating customers for the Residential Prescriptive Rebate Program to assess the following:

- How customers learned of the program
- Reasons for participation
- The program's value
- Program delivery
- Interaction with trade allies
- Satisfaction levels
- Freeridership and spillover
- Suggestions for program improvements

We also conducted surveys with customers participating in the Commercial Prescriptive Rebate Program, focusing on these topics:

- How they learned of the program
- Benefits of program participation
- Pre-program equipment characteristics
- Reasons for participation
- Freeridership and spillover

Impact Evaluation Methodology

The impact evaluation goals involved reviewing the engineering savings values, verifying measure installations, determining participants' freerider and spillover behaviors (NTG ratio), and estimating realized program savings. We used different approaches for each program, as shown in Table 3, and explain each of these below.

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Table 3. Impact Evaluation Task by Program

Program	Engineering Desk Review	Billing Analysis	Freeridership	Spillover
Residential Prescriptive	✓	✓	✓	✓
Commercial Prescriptive	✓		✓	✓

Engineering Desk Review and Billing Analysis

For both programs, Cadmus conducted an engineering desk review to assess Vectren's claimed measure savings (CCF), relying on these data:

- Utility program data
- Assumptions from technical reference manuals (TRMs) from Ohio, Indiana, and other states
- Industry studies and papers
- Engineering estimates

For the Residential Prescriptive Rebate Program, we performed a billing analysis for the programmable and WiFi thermostats. Billing analysis is a more accurate method to assess impacts from thermostats because savings primarily come from the behavior of thermostat users. We collected 12 months of pre-installation and up to 12 months of post-installation billing (monthly use) data from Vectren and assessed subsequent changes in thermostat use.

In the sections for each program, we explain the deemed savings review methodology and assumptions we used.

Net-to-Gross

An NTG ratio can be broken into two components: freeridership and spillover. Freeridership is equal to the percentage of savings that would have occurred in the program's absence because participants take the same actions (purchase the same measures) without the program's influence. Spillover occurs when participants purchase energy-efficient measures or adopt energy-efficient practices because of prior participation in a utility-sponsored program, but without currently participating in a utility-sponsored program. Cadmus estimated each program's NTG using this equation:

$$Program\ NTG = 1 - Freeridership + Spillover$$

We combined two methods—the pure intention (self-report) method and intention/influence method—to calculate NTG for the Residential Prescriptive Rebate Program and Commercial Prescriptive Rebate Program. We computed a savings weighted average of the NTG derived from each method to apply the overall NTG for both programs.

Pure Intention Method

To determine a freeridership score, Cadmus relied on pure intention (self-report) surveys in which participants were asked a series of questions about what their actions would have been in the absence

of the program. We used each unique set of responses to calculate a freeridership score for that individual then aggregated the scores and determined a total freeridership score for each program. To facilitate comparisons over program years, we used the same sets of NTG questions used in the evaluations of the 2012–2014 programs.

Spillover is measured by asking participants who purchased a particular measure if, as a result of the program, they decided to install another energy-efficient product or undertake some other activity to improve energy efficiency. Cadmus assessed spillover through pure intention surveys, in which interviewers read to respondents a list of energy-efficient products and asked if they had installed any of the products in their home or business since participating in the program. If respondents said they had purchased products or made energy-efficient improvements, interviewers asked how influential the program was on their purchasing decisions.

Cadmus used the 2015 Indiana TRM and deemed savings values, consistent with those used in calculating the gross program savings value, when applying savings to the relevant spillover measures for which participants said the program was very influential in their decision. The sum of these savings values, divided by the savings achieved through the program for each relevant measure, yielded spillover savings as a percentage of total savings, which we then extrapolated to the population of program participants.

Intention/Influence Method for Self-Reports

The intention/influence method assesses freeridership in two steps. Although questions are similar to those used in the pure intention method, they explore the participant's *intention* and the program's *influence* in more detail. These two parts of the survey are first scored separately, then combined with equal weight to determine one freeridership score for each survey respondent.

The total freeridership score is calculated as the sum of the intention (maximum score 0.5) and influence (maximum score 0.5) components, resulting in a value between 0 and 1, as shown in this equation:

$$Total\ Freeridership\ =\ Intention\ Score\ +\ Influence\ Score$$

The influence and intention scores contribute equally to the total freeridership score. The higher the total freeridership score, the greater the deduction of savings from the gross savings estimates.

Participant Spillover

Participant spillover refers to additional savings generated by program participants because of their program participation but that are not captured by program records. Spillover occurs when participants choose to purchase energy-efficient measures or adopt energy-efficient practices due to a program, but choose not to participate (or are otherwise unable to participate) in an incentive program. These customers' savings are not automatically credited to the program.

Cadmus used the pure intention surveys to assess participant spillover. The surveys asked participants about a list of energy-efficient products and if they installed these products in their home or business

since participating in the program. If respondents had made energy-efficient improvements and/or purchased products, the survey asked how influential the program proved to be on their purchasing decisions ("not at all," "not too," "somewhat," or "very influential").

Cadmus applied deemed savings values to measures for which participants said the program was "very influential" in their decision to purchase.[4] The spillover percentage for a measure is calculated by dividing the sum of additional spillover savings reported by participants across the whole program for a given measure by the total reported gross program savings achieved by program respondents for that measure (as reported in the customer survey), as shown in this equation:

$$Spillover\ \% = \frac{\sum \text{Spillover Measure Evaluated Gross kWh Savings for All Survey Respondents}}{\sum \text{Program Measure Evaluated Gross kWh Savings for All Survey Respondents}}$$

Measure Verification

Cadmus first reviewed the tracking data for each program to verify their accuracy and completeness. Additional measure verification followed through telephone surveys with participants to confirm participation status, the number and type of measures rebated through the program, and the persistence of installations. We then compared the total verified measure types and quantities to Vectren's reported measure types and quantities for the program population. We determined the program installation rate using this equation:

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

Evaluated Net Savings Adjustments

The impact evaluation used reported *ex ante* and evaluated *ex post* terminology for reporting gross savings and evaluated net savings for reporting net savings. These are the definitions for these terms:

- **Reported *ex ante* savings:** Annual gross savings for the evaluation period, as reported by Vectren in the 2015 scorecard
- **Verified savings:** Annual gross savings, adjusted for the installation rate
- **Evaluated *ex post* savings:** Verified gross savings with adjustments made for the deemed savings review
- **Realization rate:** The percentage of savings that the evaluation determined the program actually realized, calculated as in this equation:

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

[4] Deemed savings values are consistent with those we used to calculate the gross program savings and follow the 2015 Indiana TRM.

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

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Residential Prescriptive Rebate Program

Program Overview

Description

Vectren's Residential Prescriptive Rebate Program, designed to reduce natural gas consumption in residential homes in Vectren's service territory by offering rebates to customers who purchase high-efficiency furnaces, boilers, programmable thermostats, and WiFi-enabled thermostats. Vectren intends the rebates to transform the market by increasing customer demand for and encouraging trade allies to promote high-efficiency products.

Vectren offered rebates for two new measures in 2015: a $300 rebate to replace a furnace with 97% AFUE or greater and a $100 rebate for WiFi-enabled thermostats. Also in 2015, the boiler replacement (which continues to have a $500 rebate) was changed from 90% AFUE or greater to 95% AFUE or greater to reduce freeridership. Vectren continued to offer a $200 rebate to replace a furnace of 95% AFUE to 96.99% AFUE and a $20 rebate for programmable thermostats as in 2014.

Cadmus' evaluation of the 2015 Residential Prescriptive Rebate Program focused on this equipment:

- Furnace replacement—97% AFUE or greater
- Boiler replacement—95% AFUE or greater
- Programmable thermostats
- WiFi-enabled thermostats

To gain insight into program performance in 2015 and gather NTG data, Cadmus interviewed 15 trade allies and contracted with the Thoroughbred Research Group to conduct surveys with 207 participants.

Accomplishments

The Residential Prescriptive Rebate Program reported participation and fuel savings that exceeded its 2015 goals while staying within budgeted expenditures. Table 4 summarizes the program performance as reported in the 2015scorecard.

Table 4. Residential Prescriptive *Ex Ante* Summary

Measure	Participation Units)	Percentage of Goal Achieved (of Units)	CCF Savings	Percentage of CCF Savings Goal
97% AFUE furnaces	487	325%	60,768	325%
95% Boilers	22	88%	2,473	88%
Programmable Thermostats	892	58%	28,580	58%
WiFi-Enabled Thermostats	1,936	3872%	163,011	3872%
Total	**3,337**	**1086%**	**254,832**	**N/A**

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Process Evaluation Findings

Process Evaluation Methods

The purpose of the process evaluation was to assess how the program operates and recommend improvements. Cadmus interviewed program staff and trade allies and conducted surveys with program participants. These are the number of completed interviews and surveys:

- Vectren program staff and implementer interviews (n=2)
- Contractor interviews (n=15)
- Participant surveys WiFi thermostats (n=66)
- Participant surveys programmable thermostats (n=64)
- Participant surveys 97% AFUE furnaces (n=72)
- Participant surveys 95% AFUE boilers (n=5)

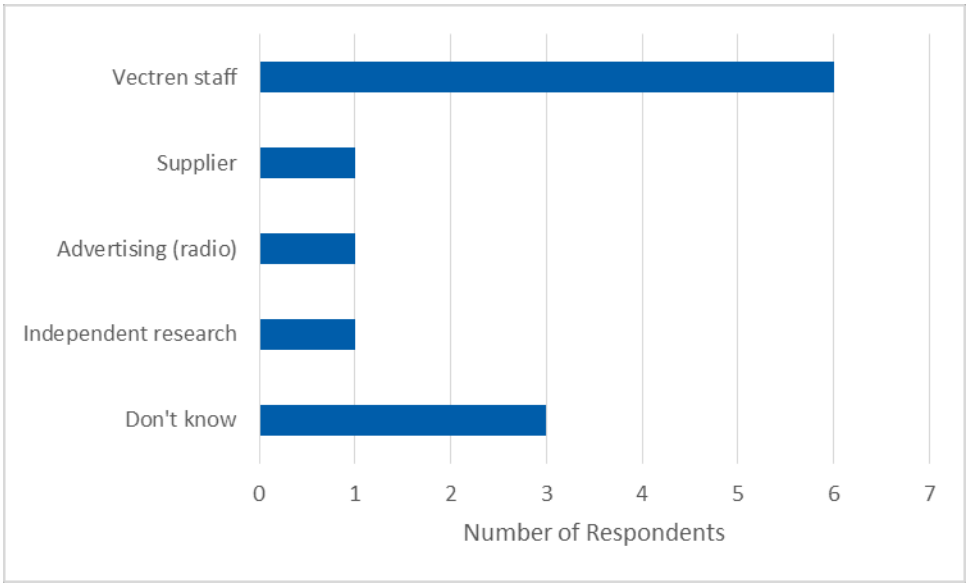
Cadmus originally proposed to complete 13 interviews with participants who installed boilers. However, with only 18 participants, the sample size was limited, making it difficult to achieve our proposed completes. However, even with few boiler data points, we could use the participant surveys to meet the 90% confidence and 10% precision threshold for processing data.

Program Awareness

Vectren markets the Residential Prescriptive Rebate Program through a combination of bill inserts and mass media outreach. It also reminds participating trade allies of the program and any changes through e-mails, mailings including program materials, and in-person meetings. Vectren believes customer outreach from trade allies was the most effective form or marketing for the program.

When asked how they first learned of the program, half (six out of 12) of the surveyed trade allies reported that they learned about the program through Vectren staff, as shown in Figure 1. Other ways were through a supplier, advertising, or independent research. Three trade allies responded “don’t know” because their company had already participated before they started working there.

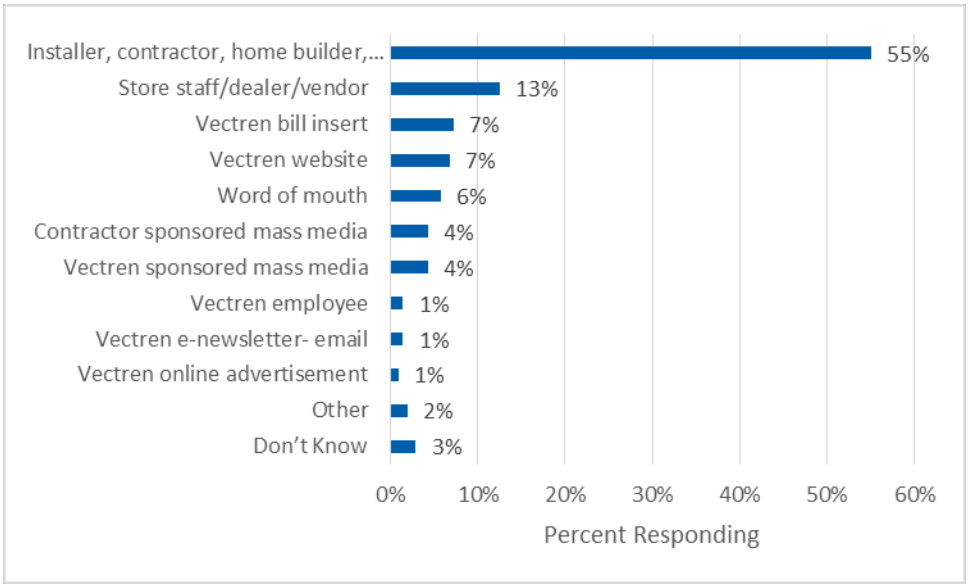
Figure 1. How Trade Allies Learned About Residential Prescriptive Rebate Program (n=12*)



* Three trade allies did not answer this question because of time constraints.

Figure 2 shows how customers first learned about the program. Participants most frequently reported their source was their contractor, installer, or builder (55%). Participant responses appear to confirm Vectren's belief that trade allies provided the most effective marketing for the program.

Figure 2. How Participants Learned About Residential Prescriptive Rebate Program (n=207; multiple responses allowed)



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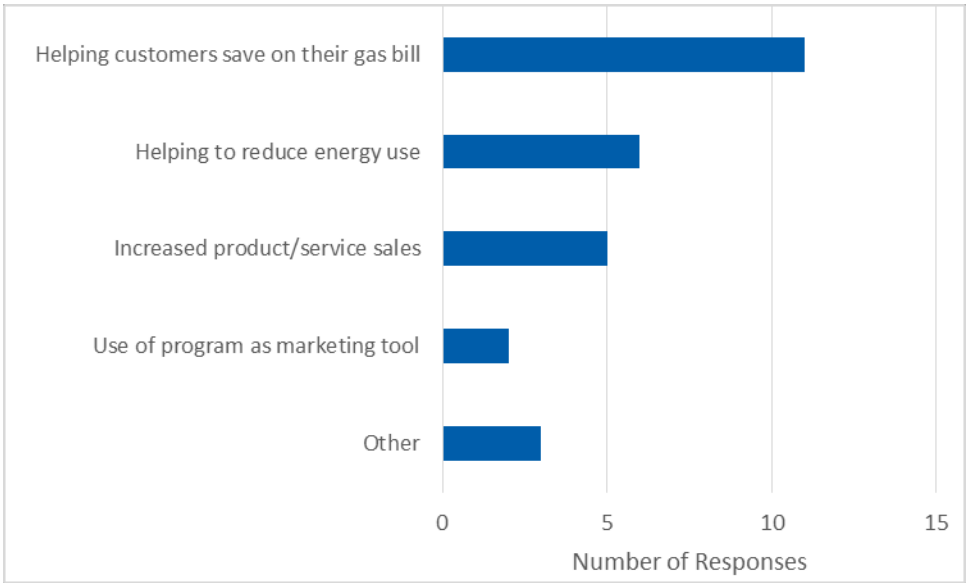
Participation and Decision Making

The typical participation process involved either the trade ally or customer filling out the application and submitting it with any accompanying invoice documentation to Vectren by mail or online. After verifying the completeness of the application and that it had followed guidelines for a rebate, Vectren mailed the rebate to the customer within six to eight weeks (though often sooner).

Cadmus asked the 15 surveyed trade allies about their reasons for participating as well as their customers' motivation for installing high-efficiency equipment in their homes. As shown in Figure 3, the most frequent (11 out of 15) reason for participating was to help their customers lower their gas bill.

Figure 3. Trade Ally Reasons for Participating in Program (n=15; multiple responses allowed)



* Three trade allies did not answer this question because of time constraints.

Table 5 shows trade allies' responses when asked about their customers' primary reason for purchasing and installing high-efficiency equipment. Similar to their own reasons, trade allies said their customers' primary reason for purchasing and installing high-efficiency equipment was to save on energy bills.

Table 5. Trade Ally Reasons Why their Customers Purchase High-Efficiency Equipment (n=15)

Response	Response Count
Cost Savings on Bill	8
Saving Energy	4
Rebate Amount	3

Participants were asked about their motivation for purchasing their new equipment. Participants' main reasons varied depending on what equipment they purchased. As shown in Table 6, the most frequent response (53 out of 76) from respondents who purchased new boilers or furnaces was that their old equipment did not work properly. As shown in Table 7, respondents who purchased a new

programmable or WiFi thermostat were most commonly motivated because of a recommendation from their contractor (32 out of 130) and the program rebate (32 out of 130).

Table 6. Motivations for Purchasing New Boilers/Furnaces (n=76; multiple responses allowed)

Category	Response Count
Old equipment didn't work	53
Wanted to save energy	11
Wanted to reduce energy costs	6
Comfort issues in home	3
The program rebate	1
Recommendation from contractor	1
Other	9

Table 7. Motivations for Purchasing New Thermostats (n=130; multiple responses allowed)

Category	Response Count
Recommendation from contractor	32
The program rebate	32
Old equipment didn't work	28
Wanted to save energy	19
Wanted to reduce energy costs	13
Comfort issues in home	4
Because of past experience with another Vectren program	3
Recommendation from friend, family member, colleague	3
Environmental concerns/global warming or climate change	2
Other	18

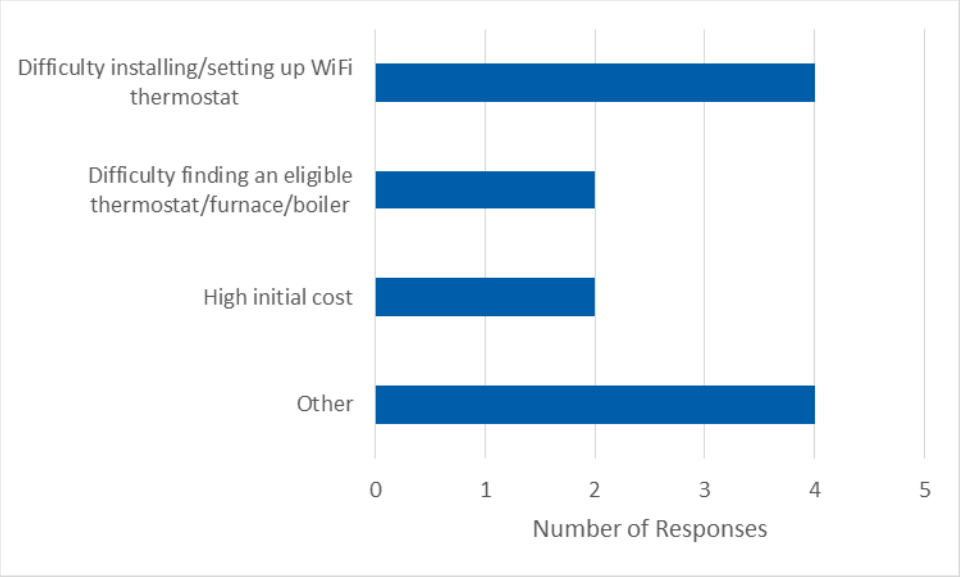
Measure Eligibility

We asked the 15 surveyed trade allies if there were any other measures they thought the program should make eligible for rebates. One trade ally suggested that water heaters should be eligible for rebates through the program, and one suggested including variable speed motors. The remaining 13 trade allies did not believe there were any additional measures that should be included in the program.

Surveyed participants were asked about challenges or barriers to purchasing or installing their new equipment and if they had any suggestions for improving the program. As explained in the satisfaction section below, four of the 201 respondents who answered the question about program improvement suggested adding more qualifying measures. Almost all (194 out of 206) reported they did not face any

barriers to purchasing or installing their new equipment. Twelve respondents identified challenges or barriers; the most common response (four out of 12) was difficulty installing or setting up the WiFi thermostat. These 12 responses are shown in Figure 4.

Figure 4. Participant Barriers to Purchasing/Installing New Equipment (n=206*)



*194 responses indicating "no barriers" are not represented in figure. One surveyed participant did not answer this question.

Satisfaction

During the interview, Vectren staff said CLEAResult processed program rebates in a timely manner (normally within two weeks), and there were only isolated cases for which customer issues needed to be addressed.

Cadmus asked the 15 surveyed trade allies to rate their overall satisfaction with the program. Thirteen described themselves as "very satisfied" with the program, and the remaining two were "somewhat satisfied." We also asked trade allies if they would recommend any changes to improve the program. Table 8 shows trade allies' recommendations. The most frequent recommendation was from five trade allies who wanted an online portal for rebate submittal and tracking. Vectren began allowing online rebate submissions for the Residential Prescriptive Rebate Program in 2015. Six trade allies had no recommendations for improvement.

Table 8. Trade Ally Recommendations for Improving Program (n=15)

Recommendation	Response Count
No recommended changes	6
Online portal for submitting and tracking rebates	5
Provide a rebate for contractor	2
Increased program marketing	1
Less paperwork	1

Surveyed participants were asked about their satisfaction with several program elements, including the application and enrollment process, installed equipment, and overall experience with the program. As Table 9 shows, the majority (85% or more) of participants reported that they were "very satisfied" with the specified elements of the program. Out of the 207 participants surveyed, only 10 responded "not too satisfied" or "not satisfied at all" to any of the program elements.

Table 9. Participant Satisfaction with Various Program Elements

Element	Proportion of Respondents Very Satisfied	Total Respondents*
Application and Enrollment Process	89%	200
Equipment	85%	204
Overall Program	88%	204

*Some respondents declined to answer certain questions.

Surveyed participants were asked for suggestions on how the program could be improved. Over 80% (166 out of 200) said they had no suggestions for improvement. Of the 35 respondents who provided suggestions for improvement, the most common was to increase awareness and marketing of the program. Table 10 lists participants' suggestions for improving the program.

Table 10. Participant Suggestions for Program Improvement

Suggestion	Response Count
Increase program awareness/marketing	22
Increase rebate amount	8
Allow more qualifying measures	4
Ease paperwork process	1

Impact Evaluation Findings

Engineering Desk Review 97% AFUE Furnaces

This section presents detailed findings from Cadmus' assessment of energy savings for early retirement and existing building gas furnaces and a discussion of the engineering assumptions informing its calculations. Table 11 presents the Residential Prescriptive Rebate Program's per-unit annual gross savings for each furnace category.

Table 11. Residential Furnaces per-Unit Savings Comparison

Measure	Annual Gross Therm Savings	
	Reported	Evaluated
Furnace Replacement>97% AFUE: Retrofit	124.78	149.73
Furnace Replacement>97% AFUE: Early Retirement		166.33

Cadmus used the Uniform Methods Project (UMP) equation 1,[5] shown here, to calculate savings per furnace installed, based on provided participant data:

$$\text{MMBtu Savings} = \text{EFLH x BTUH} * \left(\frac{\text{AFUEeff}}{\text{AFUEbase}} - 1\right) / \text{Conversion}$$

Table 12. Furnace Calculation Variables

Description	Value	Unit	Source
AFUEeff - Efficiency of efficient furnace	Varies	%	Tracking database; verified with AHRI database
BTUH - Furnace capacity	Varies	BTUH	Tracking database; verified with AHRI database
AFUEbase - Baseline unit efficiency for units replaced on failure	80%	%	Federal standard
AFUEbase - Baseline unit efficiency for early replacements	78%	%	RESNET*
EFLH - Equivalent full load hours	927	hours	Indiana 2015 TRM v2.2 EFLH values for Indianapolis with an HDD adjustment to Dayton, Ohio
Conversion	100,000	BTUH/ therm	Constant
%Existing - Percent of furnace installations replaced on failure	91%	%	2015 Evaluation Survey Results
%ER - Percentage of furnaces replaced early (before failure)	9%	%	2015 Evaluation Survey Results

* Mortgage Industry National Home Energy Rating Systems Standards; Table 303.8.1(3): Default Values for Mechanical System Efficiency (Age-Based). Available online: http://www.resnet.us/standards/RESNET_Mortgage_Industry_National_HERS_Standards.pdf

Replace on Failure and Early Replacement Units

The program tracking data did not distinguish between replacement on failure and early replacement. Therefore, we used participant information and survey data to assign each unit to one of these two categories. We used participant survey results to determine the percentage of customers who had furnaces that qualified for early retirement—units were in working order and were less than 20 years old—and found that 9% of all units were early retirement and 91% were replaced on failure.

We used the federal standard of 80% AFUE as the baseline for units replaced upon failure.[6]

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[5] Jacobson, David. "Chapter 5: Residential Furnaces and Boilers Evaluation Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* April 2013. Available online: http://energy.gov/sites/prod/files/2013/11/f5/53827-5.pdf

[6] U.S. Department of Energy. "*Water and Energy Conservation Standards and their Effective Dates.*" 10 CFR Ch. II (1–1–12 Edition) § 430.32. Available online: https://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

We relied on secondary sources to determine the baseline for early replacement units. Gas furnaces manufactured in the late 1990s showed typical efficiencies between 78% and 80% AFUE.[7] After reviewing applicable TRMs, Cadmus used an $AFUE_{base}$ of 78% for early retirement savings calculations. This value is based on furnace models and default, age-based values developed by the Residential Energy Services Network (RESNET) for the Mortgage Industry National Home Energy Rating Systems Standards,[8] as shown in Table 13.

Table 13. RESNET Default Values for Mechanical System Efficiency by Age

Mechanical System	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992-2015
Gas Furnace	AFUE	0.72	0.72	0.72	0.72	0.72	0.76	0.78

Equivalent Full Load Hours

The value for equivalent full load hours (EFLH) used in this evaluation represents a departure from the method used in the previous evaluation. The *ex ante* calculation used the Ohio 2010 TRM value of 712 hours for furnaces. Cadmus used a value of 927 hours for furnaces, which updates the EFLH value to a more recent source—the 2015 Indiana TRM v2.2 value for Indianapolis.[9] We also adjusted this value using heating degree days (HDD) 65 from ASHRAE handbook.[10]

The 2015 Indiana TRM developed the values for FLH_{HEAT} using a modeling tool that assumed baseline furnaces were exactly sized to meet peak heating demand. Residential furnaces are sized in 15,000 Btu to 20,000 Btu increments, so furnaces are typically oversized in residential applications to assure that the unit can supply enough heat to meet a household's peak heating demand. The more oversized a furnace is compared to the heat load of the house, the fewer hours it will run.

Additionally, much of the time, an older standard-efficiency furnace is replaced with a more efficient unit with the same input capacity. Thus, the combination of full load hours defined by the perfectly sized furnace and the traditional oversizing of furnaces in actual installations has meant savings are overestimated when using the 2015 Indiana TRM v2.2 assumptions.

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7 Preston Marketing Group. *Preston's Guide: 1965 – 2005 Edition*. December 2008.

8 RESNET. Mortgage Industry National Home Energy Rating Systems Standards; Table 303.8.1(3): Default Values for Mechanical System Efficiency (Age-Based). Available online at: http://www.resnet.us/standards/RESNET_Mortgage_Industry_National_HERS_Standards.pdf

9 State of Indiana. *2015 Indiana Technical Reference Manual v2.2*. 2015.

10 ASHRAE. *2013 ASHAE Handbook—Fundamentals.* 2013. Information available online: https://www.ashrae.org/resources--publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals

To correct for this, we developed and applied a 120% oversizing factor to the 2015 Indiana TRM v2.2 full load hours for both furnaces and boilers. We applied 20% oversizing factor of the baseline furnace to the savings equation, as oversizing is common in residential furnace installation, ensuring occupant comfort. Additionally, we applied an oversizing factor to the efficient furnace that was proportional to the efficiencies of the installed unit and the baseline unit.

$$Efficient\ Unit\ Oversizing\ Factor\ = 120\% \times AFUE_{Eff}/AFUE_{Base}$$

Where:

120% = Oversizing factor of baseline unit

The following equation shows the relationship between the 2015 Indiana TRM v2.2 full load hours ($TRM\ FLH_{Heat}$) and the EFLH used in this evaluation:

$$EFLH\ = \frac{TRM\ FLH_{Heat}}{Efficient\ Unit\ Oversizing\ Factor}$$

We applied this adjustment to furnaces and boilers separately because of the difference in $AFUE_{Eff}$, which is 97% for efficient furnaces and 95% for efficient boilers.

Reported and Evaluated Per Unit Savings

The difference between reported and evaluated savings is due to a combination of factors. First, we updated the EFLH value from 712 to 927 hours. Second, we updated the evaluated savings methodology to align with the Uniform Methods Project.[11] This change in methodology increased the evaluated savings.

Measure Verification

Vectren provided Cadmus with program tracking data for 495 program participants who installed a furnace rated at 97% AFUE or greater. Of these, 450 furnaces were replaced on failure and 45 were early retirement (Table 14). These tracking data contained quantities of installed units, efficiencies (AFUE), brand, model number, and deemed savings estimates. We also found eight additional furnaces in the tracking data that were not included in the scorecard. We determined an installation rate of 102% for the program.

[11] Jacobson, David. "Chapter 5: Residential Furnaces and Boilers Evaluation Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* April 2013. Available online: http://energy.gov/sites/prod/files/2013/11/f5/53827-5.pdf

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Table 14. Residential Prescriptive Furnaces Measure Verification

Measure	Reported Installations	Verified Installations	Installation Rate
Furnace Replacement>97% AFUE: Retrofit	487	450	102%
Furnace Replacement>97% AFUE: Early Retirement		45	

Engineering Desk Review 95% AFUE Boilers

Cadmus assessed gas energy savings for boilers installed in single-family and multifamily residential settings. We found several customers were also using their boilers for water heating. Therefore, we calculated savings for both space and water heating. Table 15 presents the boiler measure's reported savings for space heating and the evaluated savings for both space and water heating.

Table 15. Residential Boilers per-Unit Savings Comparison

Measure	Annual Gross Therm Savings	
	Reported	Evaluated
Boiler Replacement >95%: Space Heat	112.42	190.37
Boiler Replacement >95%: Water Heat	-	64.12

Cadmus used the Uniform Methods Project (UMP) equation 1,[12] shown here, to calculate space heat savings for each boiler installed, based on the provided participant data. Cadmus used the draft Ohio 2010 TRM water heating savings methodology (second equation).[13] Boiler space and water heat savings were calculated as:

$$\text{MMBtu Space Heat Savings} = \text{EFLH x BTUH} * \left(\frac{\text{AFUEeff}}{\text{AFUEbase}} - 1\right) / \text{Conversion}$$

$$\text{MMBtu Water Heat Savings} = \text{BTU HW}_{\text{Usage}} * \left(1 - \frac{\text{EF}_{\text{Base}}}{\text{EF}_{\text{Installed}}}\right) / \text{Conversion}$$

Table 16 shows the variables used in this evaluation.

[12] Jacobson, David. "Chapter 5: Residential Furnaces and Boilers Evaluation Protocol." *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* April 2013. Available online: http://energy.gov/sites/prod/files/2013/11/f5/53827-5.pdf

[13] State of Ohio. *Draft Ohio Technical Reference Manual*. 2010.

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Table 16. Boiler Calculation Variables

Description	Value	Unit	Source
AFUEeff - Efficiency of efficient boiler	Varies	%	Tracking database; verified with AHRI database
BTUH - Boiler capacity	Varies	BTUH	Tracking database; verified with AHRI database
$EF_{Installed}$ – Water heating efficiency of installed unit	Varies	%	Assumed equal to unit AFUEeff. Tracking database; verified with AHRI database.
AFUEbase - Baseline unit efficiency	82%	%	Federal standard
EFLH - Equivalent full load hours	946	Hours	Indiana 2015 TRM v2.2 EFLH values for Indianapolis with an HDD adjustment to Dayton, Ohio
Conversion	100,000	BTUH/ therm	Constant
$BTU\ HW_{Usage}$- Average domestic water heating load	180	therms/year	Ohio 2010 TRM
EF_{Base}- Efficieny of baseline water heater unit	61%	%	Federal standard*
Water heater baseline tank size	42	Gallons	RECS 2009 Analysis

* Federal standard for gas-fired storage water heaters as of April 16, 2015, states that for tanks with a rated storage volume at or below 55 gallons: EF = 0.675−(0.0015 × Rated Storage Volume in gallons).

A combination of factors resulted in the large difference in reported and evaluated per-unit savings of 112.42 and 190.37 CCF respectively for this boiler measure. First, the *ex ante* savings value calculation uses an assumed unit capacity of 100,000 BTUH; however, the average unit capacity for the installed boilers is 132,000 BTUH. Second, Cadmus updated the EFLH value from 712 to 946 (as discussed in the Engineering Desk Review 97% AFUE Furnaces section). Third, we updated the evaluated savings methodology to align with the Uniform Methods Project,[14] which effectively increased the evaluated savings. These factors together accounted for the large realization rate of 169%.

Measure Verification

Vectren provided Cadmus with tracking data of 22 program participants who installed a boiler rated at 95% AFUE or greater, as shown in Table 17. These tracking data contained quantities of installed units, efficiencies (AFUE), brand, model number, and deemed savings estimates. As shown in Table 17, we found three additional rebated boilers were used for water heat and did not meet the program's AFUE requirement of 95%. We also included impacts from these installations in the evaluation.

[14] Ibid

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Table 17. Residential Prescriptive Boilers Measure Verification

Measure	Reported Installations	Verified Installations	Installation Rate
Boiler Replacement >95%: Space Heat	22	22	100%
Boiler Replacement >95%: Water Heat	-	3	N/A

Programmable and WiFi-Enabled Thermostats Billing Analysis

Cadmus conducted a statistical billing analysis to determine the adjusted gross savings and gross realized savings ratios for programmable and WiFi-enabled thermostats installed from November 2014 through July 2015. This period allowed us to compare 12 months of pre- and up to 12 months of post-installation billing data. To estimate the gas savings resulting from the program, we used a pre- and post-installation Princeton Scorekeeping Method (PRISM).[15] We calculated gas savings estimates separately for programmable and WiFi-enabled thermostats.

Participant Group

For the impact analysis, Cadmus gathered data from a participant (treatment) group composed of participants from the Residential Prescriptive Rebate Program who received a rebate for a programmable or WiFi-enabled thermostat during the 2015 calendar year. Measure installations for these program participants occurred between July 7, 2014, and December 31, 2015.

We learned from Vectren that many rebate program participants had had their thermostats installed by HVAC contractors and that these installations may have coincided with other furnace tune-ups, replacements, or efficiency upgrades by the contractor. Additional data about these non-program HVAC upgrades were unavailable, and we would not have been otherwise able to separate the energy savings impact of the thermostat from any other upgrades during our billing analysis. Therefore, we screened out all contractors and HVAC businesses and included in our analysis only those participants who reported self-installing their thermostats or purchasing their thermostat from a hardware store, an online retailer, or directly from the manufacturer's online store.

Restricting the evaluated participant group to just self-installs significantly reduced the number of customers in the evaluation, from 865 to 92 for programmable thermostats and 1,821 to 640 for WiFi thermostats. So, to expand the size of the participant group for evaluation, we also included some of the participants who were surveyed for the process evaluation. Specifically, surveyed participants who responded that during 2015 they had not installed any new gas equipment, such as a new furnace or water heater, were eligible for inclusion in the billing analysis. This resulted in an additional 21 programmable thermostat participants and 11 WiFi thermostat participants in the billing analysis after initial screening for sufficient pre- and post-installation data.

[15] Princeton University. "PRISM: measuring savings the easy way." Available online: http://www.marean.mycpanel.princeton.edu/~marean/

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Nonparticipant Group

To isolate the impact of exogenous factors (e.g., rate change, changes in economic conditions, and non-program or naturally occurring improvements in energy efficiency) on energy use, Cadmus compared participants (the treatment group) with a randomly selected group of 10,000 residential nonparticipant customers (the comparison group). This approach is known as "quasi-experimental" design and, to be successful, the two groups must be similar to each other, on average. The pre- and post-change in energy use of the treatment group (supposedly because of the program, which in this case is the installation of thermostat measures through Residential Prescriptive Rebate Program) is compared to the change in energy use of the comparison group (reflecting what would have happened absent the program).

Data Preparation

To prepare the data for the billing analysis, Cadmus completed these activities:

- Matched measure-tracking information with gas billing data
- Used zip code mapping for all weather stations in the United States to determine the nearest station for each zip code
- Obtained daily average weather data from January 2013 through May 2016 for five Ohio National Oceanic and Atmospheric Administration (NOAA) weather stations, representing all zip codes associated with the program participants
- Used daily temperatures to determine base 45–65 HDDs for each station
- Matched billing data periods with the HDDs from the associated stations

We chose pre-installation periods separately for each customer so the periods would sufficiently pre-date installation. We defined these installation periods:

- The pre-installation period as one year before the thermostat installation
- The post-installation period as one year after the thermostat installation

We assigned the pre- and post-installation periods for the comparison group to match the average pre- and post-installation periods of the treatment group. Average installation for the treatment groups was March 2015, which gave the assigned comparison group pre- and post-installation periods of 12 months before and after this date.

Data Screening

Cadmus started with a census of participants for both treatment and comparison groups and identified final analysis samples after cleaning the data and screening for several criteria. We conducted the energy consumption analysis using participants who had not moved since participating and had at least ten months of pre- and ten months of post-installation period billing data. We also performed account-level reviews of all individual participants' pre- and post-installation monthly consumption to identify anomalies (e.g., periods of unoccupied units) that could bias the results.

We applied these screens to remove anomalies, incomplete records, and outlier accounts that could bias savings estimation:

- Inability to merge the participant program tracking data with the consumption data (e.g., missing records or accounts)
- Insufficient consumption data for accounts with fewer than 300 days (approximately 10 months) of use data in the pre- or post-installation period
- Accounts that changed natural gas use from the pre- or post-installation period by more than 70%[16]
- Accounts with low annual use in the pre- or post-installation period (e.g., less than 200 therms)
- Other extreme values, including vacancies in the billing data (outliers), heating or cooling system changes (e.g., adding or removing heating or cooling loads, base-load equipment changes, changes in occupancy, or non-residential customers)[17]
- Large gaps in interval data (i.e., zero consumption across months, distinct from missing values) and associated accounts

PRISM Modeling Approach

In the next step of the analysis process, Cadmus estimated PRISM models for pre- and post-installation billing data. A PRISM model estimates weather-normalized pre- and post-installation annual use for each account.

For each participant home, we estimated a heating PRISM model to weather-normalize raw billing data for the pre- and post-installation periods (using a variable heating reference temperature ranging from 45 to 65°F). The PRISM model used the following specification for gas participants:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \varepsilon_{it}$$

Where, for each customer 'i' and calendar month 't':

ADC_{it}	=	Average daily consumption in the pre-/post-installation program period
α_i	=	Participant intercept, representing the average daily therm base load
β_1	=	Model heating parameter value
$AVGHDD_{it}$	=	Variable base 45-65 average daily HDDs for the specific location

[16] Changes in use of this magnitude are probably because of vacancies, home remodeling or addition, seasonal occupation, or fuel switching. Changes in use over a certain threshold are not anticipated to be attributed to program effects and can confound the analysis of consumption for this purpose.

[17] Base-load changes could include adding or removing appliances (such range, dryer, furnace, or water heater) or changes in occupancy; in either case, this may confound the analysis for distinguishing program effects.

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ε_{it} = Error term

Using this model, we computed weather-normalized annual consumption (NAC) for each heating and cooling reference temperature, as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \varepsilon_i$$

Where, for each customer 'i':

NAC_i = Normalized annual MCF consumption

α_i = Model's average daily or base load for each participant

$\alpha_i * 365$ = Annual base load MCF usage (non-weather-sensitive)

β_1 = Heating parameter value: usage per HDD from the PRISM model

$LRHDD_i$ = Annual, long-run HDDs in a TMY3, from NOAA's 1991–2005 series and based on the home's location

$\beta_1 * LRHDD_i$ = Weather-normalized, annual, weather-sensitive heating usage

ε_i = Error term

From the models with appropriately defined parameters, we chose the one with the highest R-square for each participant during the pre- and post-installation periods as best representing consumption under typical weather conditions.

Once we obtained the pre- and post-installation usage for each customer, we screened the data using PRISM-based screening steps, excluding accounts from the analysis for these reasons:

- Post-installation weather-normalized (POSTNAC) use was 70% higher or lower than pre-installation weather-normalized (PRENAC) use, which could indicate property vacancies or that participants added or removed gas equipment unrelated to the program.
- PRENAC or POSTNAC estimates were missing (e.g., due to negative heating/cooling slopes or negative intercepts), indicating possible problems with the billing data.

From the PRISM models shown above, the average difference in normalized annual consumption (DNAC, which is PRENAC minus POSTNAC) yielded average program savings. To determine the percentage of savings, we divided the DNAC by the PRENAC.

Final Participant and Nonparticipant Samples

Table 18, Table 19, and Table 20 show the final participant and nonparticipant sample sizes after applying the screens described above.

Table 18. Programmable Thermostat Participant Account Attrition

Screen	Accounts Remaining	Accounts Dropped	Percent Dropped	Percentage Remaining
Original Gas Accounts	871	0	0%	100%

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Dropped in Merge with Billing Data	865	6	1%	99%
Self-installed (or Survey-Verified) Accounts	92	773	89%	11%
Insufficient Pre- and Post-Installation Days	60	32	35%	7%
Low or High Usage in Pre- or Post-Installation Periods	58	2	3%	7%
Changed Usage from the Pre- to Post-Installation (>70%)	58	0	0	7%
PRISM Screen: Low R-Squared, Low Heating Use	58	0	0%	7%
Outliers or Anomalies	47	11	19%	5%
Final Analysis Group	**47**	**824**	**95%**	**5%**

Table 19. WiFi Thermostat Participant Account Attrition

Screen	Accounts Remaining	Accounts Dropped	Percent Dropped	Percentage Remaining
Original Gas Accounts	1832	0	0%	100%
Dropped in Merge with Billing Data	1821	11	1%	99%
Self-installed (or Survey-Verified) Accounts	640	1,181	65%	35%
Insufficient Pre- and Post-Installation Days	221	419	65%	12%
Low or High Usage in Pre- or Post-Installation Periods	220	1	<1%	12%
Changed Usage from the Pre- to Post-Installation (>70%)	220	0	0%	12%
PRISM Screen: Low R-Squared, Low Heating Use	220	0	0%	12%
Outliers or Anomalies	193	27	12%	11%
Final Analysis Group	**193**	**1,639**	**89%**	**11%**

Table 20. Nonparticipant Account Attrition

Screen	Accounts Remaining	Accounts Dropped	Percent Dropped	Percentage Remaining
Original Gas Accounts	10,000	0	0%	100%
Dropped in Merge with Billing Data	10,000	0	0%	100%
Insufficient Pre- and Post-Installation Days	9,602	398	4%	96%
Low or High Usage in Pre- or Post-Installation Periods	9,330	272	3%	93%
Changed Usage from the Pre- to Post-Installation (>70%)	9,296	34	<1%	93%
PRISM Screen: Low R-Squared, Low Heating Use	9,296	0	0%	93%
Outliers or Anomalies	7,847	1,449	16%	78%
Final Analysis Group	**7,847**	**2,153**	**22%**	**78%**

Table 21 shows the final participant and nonparticipant sample sizes used in the billing analysis.

Table 21. Final Participant and Nonparticipant Sample Sizes

Programmable	WiFi-Enabled	Nonparticipant
47	193	7,847

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Evaluated Savings

Table 22 shows our evaluated gas savings for programmable and WiFi thermostat rebate participants in 2015. Our estimated savings for WiFi and programmable thermostats were statistically significant. However, the relative precision of 54% for our programmable thermostats savings estimate shows that these savings were imprecisely estimated due to the small analysis sample size (n=47.) Nonparticipant savings were not statistically different from zero, and therefore we did not subtract the savings (1 therm) that we estimated for nonparticipants from the participants' savings.

Table 22. Savings by Thermostat Type

Thermostat Type	Analysis Customers	Pre-Program Weather Normalized Usage (Therms/ Customer)	Weather-Normalized Estimated Savings (Therms/ Customer)	Standard Error	Lower 90% CI	Upper 90% CI	Relative Precision	Percent Savings
Programmable	47	882	33	11	15	51	54%	4%
WiFi	193	902	61	7	50	73	18%	7%
Nonparticipant	7,847	879	1	1	-1	2	216%	0%

To assess the reliability of our savings estimates, we benchmarked the results against other evaluations of similar WiFi and programmable thermostat programs, as shown in Table 23.

Table 23. Saving Results for Other Thermostat Evaluations

Utility	Thermostat Type	Fuel	Savings per Unit	Sample Size	Year	Analysis type
Citizens	Programmable	Natural Gas	47	N/A	2013	Deemed Savings Review
National Grid	WiFi	Natural Gas	51	35	2013	Billing Analysis
Gas Networks	Programmable	Natural Gas	75	415	2007	Billing Analysis
Société en commandite Gaz Métropolitain	Programmable	Natural Gas	65	56	2002	Billing Analysis
Liberty Utilities	WiFi	Natural Gas	66	23	2013	Billing Analysis
Puget Sound Energy	WiFi	Natural Gas	17	924	2015	Billing Analysis
Con Edison	Programmable	Natural Gas	20	25,083	2012	Mixed
NIPSCO	WiFi	Natural Gas	77	238	2015	Billing Analysis
NIPSCO	Programmable	Natural Gas	30	217	2015	Billing Analysis

The benchmarked studies showed that WiFi thermostats saved between 77 and 17 therms per thermostat, while programmable thermostats saved between 20 and 75 therms. These results show that Cadmus' estimates are within range, and of a similar magnitude, to estimates from evaluations of similar programs.

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Incentive Research: Thermostats

Cadmus used trade allies interviews and secondary research to assess the appropriateness of rebates for both programmable and WiFi-enabled thermostats. We first asked trade allies if they thought the thermostat rebate was appropriate. All trade allies we interviewed said they believed the rebate for both programmable and WiFi thermostats was set at the correct level to influence the market. However, this response had the potential for bias because trade allies may have been unlikely to suggest a smaller incentive that could affect their businesses.

Next, we reviewed the costs associated with installing a programmable or WiFi thermostat in a home. We studied 10 models available in the market for both types of thermostats, sorted by most popular when websites allowed, and calculated their average costs, as shown in Table 24 and Table 25.

Table 24. Equipment Cost of Programmable Thermostats

Brand	Model	Cost
Honeywell	RTH6350	$44.99
White-Rodgers	UP300	$44.08
Honeywell	RTH2510B1000/E1	$55.99
Lux	WIN100	$45.99
Orbit	83521	$49.99
Lux	TX500U	$35.00
Honeywell	RTHL221B1008	$19.88
Emerson	UP310	$60.00
Honeywell	RTH2410B	$34.98
Honeywell	RTH8500D	$121.34
Average Cost	**$51.22**	

Table 25. Equipment Cost of WiFi-Enabled Thermostats

Brand	Model	Cost
Nest	T3007ES	$249.00
Ecobee	EB-STATe3-02	$199.00
Honeywell	RTH8580WF	$99.00
Honeywell	RTH9580WF	$199.00
Honeywell	RCH9310WF5003	$249.99
Honeywell	RTH6580WF	$99.98
Emerson	UP500W	$129.00
Carrier	21026670	$249.00
Allure	EVERSENSE	$249.00
Schneider Electric	WISERAIR10WHTUS	$220.08
Average Cost	**$194.31**	

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We then compiled cost information for the contractor labor required to install a thermostat in the home using three sources—our trade ally interviews, RS Means (a proprietary vendor that compiles cost information for new construction and renovations), and a basic web search.[18] Trade allies said labor to install a thermostat can vary and that most installations took one to three hours depending on the amount of rewiring needed to incorporate the system; they also noted not all thermostats needed rewiring and cost varied depending on the house. They also said they may include thermostat installation as part of a larger HVAC upgrade and therefore may not split out the cost for a customer. If the thermostat had an additional diagnostic component, any subsequent labor would increase the cost.

Trade allies gave labor costs for thermostat installation ranging from $100 to $250, with an average installation cost of $150 and an average time of labor being three hours. Our web search identified installation labor costs between $193.89 and $250.12 for approximately 2.5 hours of labor, an average of $222.01 for labor.

RS Means estimated costs to install a thermostat between $64.48 and $137.69 and one hour of labor. RS Means also provided material costs for re-wiring that were not included in trade ally estimates.[19]

We averaged each of these sources to come up with a labor estimate of $143.54 to install a programmable or WiFi thermostat. Table 26 and Table 27 show this labor cost plus the average costs for hook-up and re-wiring and for the thermostat.

Table 26. Total Cost of Programmable Thermostat

Cost Category	Labor
Labor	$143.54
Hook-up and re-wiring	$28.99
Thermostat	$51.22
Total Cost	$223.75

Table 27. Total Cost of WiFi Thermostat

Cost Category	Labor
Labor	$143.54
Hook-up and re-wiring	$28.99
Thermostat	$194.31
Total Cost	$366.83

[18] Web data collected from homewyse using Evansville zip codes. Homewyse. "HVAC Estimates." Accessed June 2016: http://www.homewyse.com/services/cost_to_install_thermostat.html

[19] RS Means. "The Trusted Leader in Construction Cost Data for over 70 years." Accessed June 2016: https://www.rsmeans.com/?utm_source=bing&utm_medium=cpc&utm_campaign=RS%20Means%20Brand-Exact&utm_content=rs%20means&utm_term=rsmeans

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Table 28. Total Cost of WiFi – Learning Thermostat

Cost Category	Labor
Labor	$143.54
Hook-up and re-wiring	$28.99
Thermostat	$247.05
Total Cost	$419.58

Examining savings from learning thermostats, Cadmus found that on average wi-fi learning thermostats saved approximately 10 Ccf more than a basic wi-fi thermostat. Table 29 illustrates the varying savings by thermostat found in our analysis.

Table 29. Savings by Thermostat Type

Thermostat Type	Evaluated Ccf
Wi-fi (learning)	67.38
Wi-fi (basic)	57.59
Programmable	33.12

Additionally, we sought information about common levels of rebates for thermostats in other utilities and jurisdictions. Cadmus collected data from 10 utilities, mostly in the Midwest, that provided natural gas to customers, as presented in **Error! Not a valid bookmark self-reference.** and Table 31. The average rebate for WiFi thermostats was $72 and ranged from $50 to $100. For programmable thermostats, the average rebate was $21 and ranged from $10 to $25.

Table 30. Benchmarking WiFi Thermostat Incentives

Utility	Fuel	Cost of Natural Gas ($/therm)	State	Rebate/Incentive
Vectren Ohio	Natural Gas	$0.95	Ohio	$100
NIPSCO	Natural Gas	$0.90	Indiana	$50
Alliant Iowa	Natural Gas	$0.85	Iowa	$50
Consumers Energy	Both	$0.88	Michigan	$50-$100
Focus on Energy	Both	$1.05	Wisconsin	$75
MASS Saves	Both	$1.45	Massachusetts	$100
Gas Networks	Natural Gas	$1.63	New Hampshire	$100
Citizens Gas	Natural Gas	$0.90	Indiana	$100
National Grid	Natural Gas	$1.12	Rhode Island	$50

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Table 31. Benchmarking Programmable Thermostat Incentives

Utility	Fuel	Cost of Natural Gas ($/therm)*	State	Rebate/Incentive
Vectren Ohio	Natural Gas	$0.95	Ohio	$20
Columbia Gas of Ohio	Natural Gas	$0.95	Ohio	$25
Alliant Iowa	Natural Gas	$0.85	Iowa	$10
Dominion East Ohio	Natural Gas	$0.95	Ohio	$30
Consumers Energy	Both	$0.88	Michigan	$10
Laclede Natural Gas	Natural Gas	$1.16	Missouri	$25 or 50% of the equipment cost, whichever is lower
Atmos Energy	Natural Gas	$1.09	Kentucky	$25
NYSEG and RG&E	Natural Gas	$1.12	New York	$15
MASS Saves	Both	$1.45	Massachusetts	$25
Gas Networks	Natural Gas	$1.63	New Hampshire	$25

* Pricing information is derived from the U.S. Energy Information Administration using the latest year available for states. Available online: http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm

Net-to-Gross

Cadmus calculated freeridership and spillover for the 2015 Residential Prescriptive Rebate Program as a whole using findings from a survey conducted with 207 program participants. In 2015, respondents showed moderate freeridership (36% overall *ex post* population savings weighted average), considerably less than the 72% freeridership estimated for the program in 2014. Table 32 lists NTG results for the pure intention and intention/influence methods by measure type after including spillover estimates. The program's resulting NTG ratio is 67%.

Table 32. Residential Prescriptive Program NTG Ratio: Self-Report Method

Measure	*Ex Post* Population Savings (therms)	Pure Intention Method Score	Intention/ Influence Method Score	Final Freeridership	Final Spillover	Final NTG
HVAC (n=77)	79,244	53%	57%	54%	4%	50%
Programmable Thermostat (n=64)	29,572	42%	42%	42%	6%	64%
WiFi Thermostat (n=66)	118,918	24%	29%	27%	6%	79%
Overall	**227,734**	**36%**	**41%**	**38%**	**5%**	**67%**

Freeridership

We estimated freeridership using two different methods—the pure intentions method (i.e., standard self-report) as in previous evaluations, such as for Vectren's 2014 Ohio Residential Prescriptive Rebate Program, and a new intention/influence method for freeridership. The survey randomly asked

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respondents questions pertaining to only one of the methods, and we weighted their freeridership scores by their *ex post* gross energy savings to arrive at final measure-level freeridership estimates. The survey attempted to collect an equal amount of responses for each freeridership method.

Pure Intention Method Freeridership Findings

Table 33 presents the results of the pure intention freeridership analysis by measure. The estimated freeridership for the HVAC measure category is weighted by the analysis sample *ex post* gross evaluated energy savings. The overall HVAC measure category estimate of 50% is lower than the 2014 evaluation estimate of 72%. Cadmus used the separate programmable and WiFi thermostat pure intention method freeridership estimates when combining with the intention/influence method freeridership estimates, and a weighted pure intention method thermostat measure category freeridership estimate is not needed.

Table 33. Residential Prescriptive Program Pure Intention Freeridership Summary by Measure

Measure Category	Measure	Sample Size (Intention)	Freeridership	Weighted Measure Category Freeridership
HVAC	Furnace	35	50%	53%
	Boiler	4	64%	
Thermostats	Programmable	33	42%	
	WiFi	32	24%	

Figure 5 shows the distribution of freeridership estimates by measure category Cadmus assigned to participant responses to the pure intention freeridership method.

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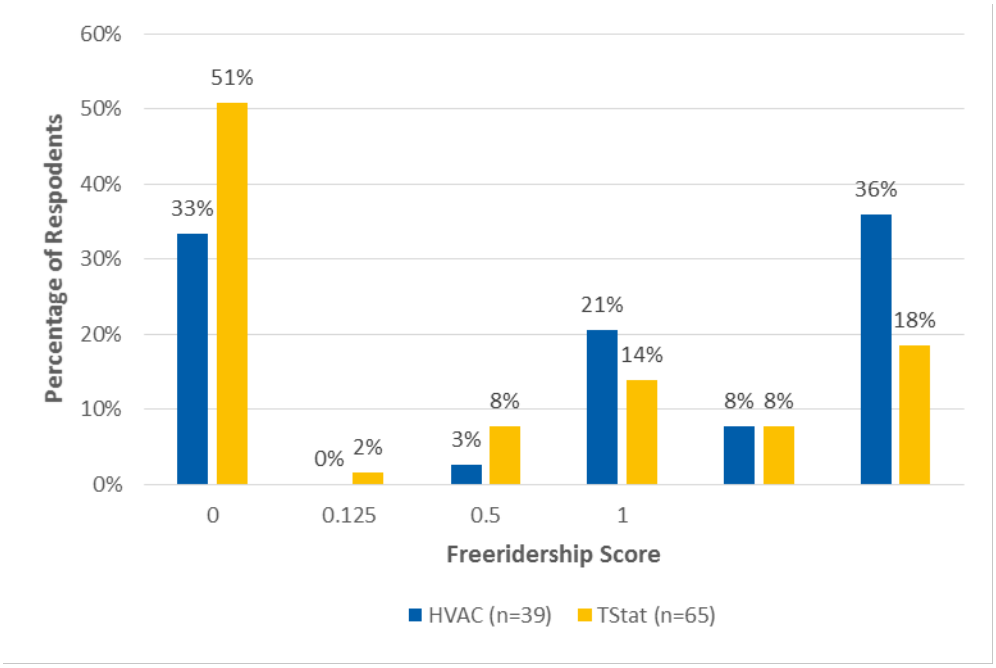
Figure 5. Residential Prescriptive Program Self-Report Freeridership Distribution by Measure Category (n=104)



The following describes the Residential Prescriptive Rebate Program HVAC participant responses and scoring for the freeridership questions, representing 37 (95%) of the 39 total HVAC surveys for the pure intention self-report freeridership method:

- Of the 39 respondents, 11 (31%) were estimated as 100% freeriders because they were already planning to purchase equipment before learning about the program and would have done so to the same level of efficiency at the same time in the program's absence.
- Two respondents (5%) reported they had already purchased or installed their new equipment before learning about the program and were also estimated as 100% freeriders.
- Three respondents (8%) were estimated as 75% freeriders because they were already planning to purchase equipment before learning about the program, although they would not have done it at the same time but would have within the same year in the program's absence.
- Eight respondents (21%) were estimated as 50% freeriders because, although they said they were not planning to purchase the product before learning about the program rebate, they would have purchased equipment to the same level of efficiency at the same time in the program's absence.
- Twelve respondents (31%) were estimated as 0% freeriders because they would not have purchased the equipment to the same level of efficiency without the program rebate. One respondent (3%) was also estimated as 0% freeriders because he or she would not have replaced the existing equipment within one year in the absence of the rebate.

The following describes Residential Prescriptive Rebate Program thermostat participant responses and scoring for the freeridership questions, representing 56 (86%) of the 65 total thermostat surveys for the pure intention self-report freeridership method:

- Of the 65 respondents, 10 (15%) were estimated as 100% freeriders because they were already planning to purchase the thermostat before learning about the program and would have done so to the same level of efficiency at the same time in the program's absence.
- Two respondents (3%) reported they had already purchased or installed thermostats before learning about the program and were also estimated as 100% freeriders.
- Three respondents (5%) were estimated as 75% freeriders because they were already planning to purchase equipment before learning about the program, but would not have done it at the same time but would have within the same year in the program's absence.
- Nine respondents (14%) were estimated as 50% freeriders because, although they said they were not planning to purchase the product before learning about the program rebate, they would have purchased a thermostat to the same level of efficiency at the same time in the program's absence.
- Seventeen respondents (26%) were estimated as 0% freeriders because they would not have purchased a thermostat to the same level of efficiency without the program rebate. Three respondents (5%) were also estimated as 0% freeriders because they would not have replaced their existing thermostat within one year in the absence of the rebate.
- Twelve respondents (18%) were estimated as 0% freeriders because they would not have replaced their thermostat at all in the absence of the program rebate.

Intention/Influence Freeridership Findings

Under the intention/influence method, Cadmus used one key question to determine how participant's purchasing decisions would have differed in the absence of the program.

Table 34 and Table 35 show the distribution of participant responses to the question: "If you had not received the incentives or other assistance from Vectren would you have done anything differently in regards to your purchase of your high-efficiency equipment?" We used the responses to determine each participant's final intention score, then weighted these individual scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average intention scores of 41% for HVAC participants, 29% for programmable thermostat participants, and 21% for WiFi thermostat participants, meaning that HVAC participants exhibited higher indications of freeridership than thermostat participants for the intention portion of the estimate.

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Table 34. Residential Prescriptive Program HVAC Freeridership Intention Score (n=38)

Intention Question / Response Options F1. If you had not received the incentives or other assistance from Vectren would you have done anything differently in regards to your purchase of your high-efficiency equipment?	**Intention Score**	**Count**	**Total Survey Sample *Ex Post* MMBTU Savings**	**Intention Score MMBTU Savings**
Canceled or postponed the purchase of furnace at least one year	0%	1	103	0
Repaired my old furnace within one year	0%	1	118	0
Purchased a less expensive furnace within one year	25%	6	789	197
Purchased a less energy efficient furnace within one year	0%	2	237	0
Purchased the same furnace without the rebate within one year	50%	26	3700	1850
Don't Know	25%	1	158	39
Refused	25%	1	118	30
Total		**38**	**5,225**	**2,116**
Intention Score - Weighted by Ex-Post Evaluated Savings (Intention Score Therm Savings ÷ Total Survey Sample *Ex Post* Therm Savings)	**41%**			

Table 35. Residential Prescriptive Program Thermostat Freeridership Intention Score (n=65)

		Programmable		**WiFi**	
Intention Question / Response Options F1. If you had not received the incentives or other assistance from Vectren would you have done anything differently in regards to your purchase of your high-efficiency equipment?	**Intention Score**	**Count**	**Total Survey Sample *Ex Post* Therm Savings**	**Count**	**Total Survey Sample *Ex Post* Therm Savings**
Canceled or postponed the purchase of [MEASURE] at least one year	0%	6	258	6	354
Repaired my old [MEASURE]	0%	2	86	0	0
Purchased a less expensive [MEASURE] within one year	25%	2	86	3	177
(Only asked if MEASURE=WiFi) Purchased a programmable thermostat within one year	0%	0	0	5	295
(Only asked if MEASURE=TStat) Purchased a manual thermostat within in one year	0%	0	0	2	118
Purchased the same [MEASURE] without the rebate within one year	50%	13	559	7	413
Don't Know	25%	5	215	7	413
Refused	25%	3	129	4	236
Average Intention Score - Weighted by *Ex Post* Savings		**29%**		**21%**	

Table 36 and Table 37 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 influential,' to 5, meaning the item was 'very influential' to your decisions." From responses to this question, we obtained data about how participants learned about the program from their contractor, rebates for the equipment, and information about energy efficiency from Vectren.

We assessed influence freeridership from participants' ratings to how important various program elements were in their decision to purchase energy-efficient products. Table 36 shows the distribution and scoring of HVAC participants' answers to the influence freeridership questions.

Table 36. Residential Prescriptive Program HVAC Freeridership Influence Responses (n=103)

Question F2 Response Options	Influence Score	Information about the program from a contractor	Rebates for the equipment	Information about energy efficiency that Vectren provided
1 - Not influential	50%	5	6	7
2	37.5%	2	2	2
3	25%	5	8	3
4	12.5%	9	8	7
5 - Very influential	0%	14	12	17
Don't Know	25%	3	1	1
Refused	25%	0	1	1
Average		**3.7**	**3.5**	**3.7**

Table 37 shows the distribution and scoring by measure of thermostat participants' answers to the influence freeridership questions.

Table 37. Residential Prescriptive Program Thermostat Freeridership Influence Responses (n=103)

Question F2 Response Options	Influence Score	Information about the program from a contractor		Rebates for the equipment		Information about energy efficiency that Vectren provided	
		Prgm	WiFi	Prgm	WiFi	Prgm	WiFi
1 - Not influential	50%	6	13	6	4	5	6
2	37.5%	1	0	2	2	1	5
3	25%	6	4	2	4	3	8
4	12.5%	5	8	11	7	6	9
5 - Very influential	0%	11	7	8	17	11	5
Don't Know	25%	2	0	1	0	2	0
Refused	25%	0	2	1	0	3	1
Average Influence Rating		**3.5**	**2.9**	**3.4**	**3.9**	**3.7**	**3.1**

Cadmus used the maximum rating given by each participant for any factor in Table 36 and Table 37 to determine the individual influence score, presented in Table 38 and Table 39. We weighted individual

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influence scores by their respective total survey sample verified energy savings to arrive at a savings-weighted average influence score of 16% for HVAC participants, 13% for programmable thermostat participants, and 8% for WiFi thermostat participants, meaning HVAC participants exhibited higher indications of freeridership than thermostat participants for the influence portion of the estimate.

Table 38 shows the distribution and scoring of HVAC participants' maximum rating to the influence freeridership questions.

Table 38. Residential Prescriptive Program HVAC Influence Freeridership Score (n=38)

Maximum Influence Rating	Influence Score	Count	Total Survey Sample *Ex Post* MMBTU Savings	Influence Score MMBTU Savings
1 - Not influential	50%	6	956	478
2	37.5%	2	316	118
3	25%	2	279	70
4	12.5%	9	1189	149
5 - Very influential	0%	19	2485	0
Average Maximum Influence Rating - Simple Average		**3.9**		
Average Influence Score - Weighted by *Ex Post* Savings		**16%**		

Table 39 shows the distribution and scoring of thermostat participants' maximum rating to the influence freeridership questions.

Table 39. Residential Prescriptive Program HVAC Influence Freeridership Score (n=38)

Maximum Influence Rating	Influence Score	Programmable		WiFi	
		Count	Total Survey Sample *Ex Post* Therm Savings	Count	Total Survey Sample *Ex Post* Therm Savings
1 - Not influential	50%	5	215	2	118
2	37.5%	0	0	0	0
3	25%	2	86	3	177
4	12.5%	8	344	9	531
5 - Very influential	0%	16	688	20	1180
Average Maximum Influence Rating - Simple Average		**4.0**		**4.3**	
Average Influence Score - Weighted by *Ex Post* Savings		**13%**		**8%**	

We then summed the intention and influence components to estimate the total intention/influence method freeridership for each measure, weighted by *ex post* gross program savings. The higher the

freeridership score, the more savings are deducted from the gross savings estimates. Table 40 summarizes the intention, influence, and freeridership scores by measure type.

Table 40. Residential Prescriptive Program Intention/Influence Freeridership Score

Measure Type	Intention Score	Influence Score	Freeridership Score
HVAC	41%	16%	57%
Programmable Thermostat	27%	13%	40%
WiFi Thermostat	21%	8%	29%

Spillover

Eight HVAC participants reported installing a total of 10 high-efficiency measures after participating in the program; they did not receive a rebate and said participation in the program was very influential on their decision to install additional measures. We attributed spillover savings to a high-efficiency dishwasher, clothes washers, insulation, and high-efficiency windows.

We used the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the program, because it more closely aligns with our preferred approach compared to the method in the 2010 Draft Ohio TRM. We divided the total survey sample spillover savings by the gross program savings from the survey sample to obtain the 4% spillover estimate for the thermostat measure category (Table 41).

Table 41. Residential Prescriptive Program HVAC Spillover Estimate

Survey Sample Spillover Therm Savings	Survey Sample Program Therm Savings	Spillover % Estimate
492	11,080	4%

Seven thermostat participants reported installing a total of eight high-efficiency measures after participating in the program; they did not receive an incentive and said participation in the program was very influential on their decision to install additional measures. We attributed spillover savings to a high-efficiency clothes washer, dishwasher, furnace, water heaters, insulation and high-efficiency windows.

We used the 2015 Indiana TRM to estimate savings for all spillover measures attributed to the program. We divided the total survey sample spillover savings by the gross program savings from the survey sample to obtain the 6% spillover estimate for the thermostat program measure category (Table 42).

Table 42. Residential Prescriptive Program Thermostat Spillover Estimate

Survey Sample Spillover Therm Savings	Survey Sample Program Therm Savings	Spillover % Estimate
389	6,646	6%

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Evaluated Net Savings Adjustments

Table 43 presents reported *ex ante* savings, verified *ex ante* savings, evaluated *ex post* savings, realization rates, and evaluated electric and demand net savings for each measure distributed through the Residential Prescriptive Rebate Program and for the program overall. Evaluated *ex post* savings reflect adjustments made for Cadmus' deemed savings review and the installation rate.

Table 43. 2015 Residential Prescriptive Program Year Savings

Measure	Reported *Ex Ante* Savings (therms)	Verified *Ex Ante* Savings (therms)	Evaluated *Ex Post* Savings (therms)	Realization Rate (therms)	NTG Ratio	Evaluated Net Savings (therms)
Furnace Replacement>97% AFUE: Retrofit	60,768	56,151	67,379	123%	50%	33,689
Furnace Replacement>97% AFUE: Early Retirement		5,615	7,485		50%	3,742
Boiler Replacement >95%: Space Heat	2,473	2,473	4,188	169%	50%	2,094
Boiler Replacement >95%: Water Heat	-	-	192	N/A	50%	96
Programmable thermostats	29,570	29,603	29,572	100%	64%	18,926
WiFi-Enabled thermostats	168,924	168,836	118,918	70%	79%	93,945
Total	**261,734**	**262,678**	**227,734**	**87%**	**67%**	**152,492**

Conclusions and Recommendations

Conclusion: Vectren began to allow online submission of rebate forms in 2015. The most frequent suggestion for program improvement from trade allies was to create an online portal where rebate applications could be submitted and tracked through the rebate approval process.
Recommendation: Review online rebate submittal process to ensure it is user-friendly and allows trade allies to track the status of their submitted rebate forms.

Furnaces and Boilers

Conclusion: The savings methodology used in previous evaluations did not use the installed equipment capacities in savings calculations. Cadmus believed it necessary to adjust methodology to more accurately represent savings.
Recommendation: We recommend aligning deemed savings calculation methodology with the Uniform Methods Project whenever practical.

Conclusion: The EFLHs in the Ohio 2010 TRM are based on conversations that are difficult to validate. Cadmus believed it necessary to use a different source for EFLH to more accurately represent savings.
Recommendation: We recommend that Vectren considering conducting a billing analysis or building simulations in future evaluations to confirm EFLH.

Conclusion: For a small number of rebates, the tracking database contained efficiencies and/or capacities that did not match the AHRI database. We compared models in the tracking database to the AHRI database where possible. For any mismatches, we used the AHRI database values. In a few cases, we found that equipment models that did not meet the efficiency criteria of the measure were given rebates.
Recommendation: We recommend checking qualified models against the AHRI database to verify equipment efficiency and capacity before validating rebates.

Conclusion: Many boilers were used for both space heating and domestic water heating. We were able to verify three of the 22 boiler installations as servicing domestic water heating through the participant survey, but it is likely that many more of these installations use the new boilers for domestic water heating. Efficient boilers used for domestic water heating have large potential savings that can be claimed.
Recommendation: We recommend collecting data about if a boiler will be used for domestic water heating on the rebate forms to more accurately represent savings for the efficient boiler measure.

WiFi and Programmable Thermostats:

Conclusion: WiFi thermostat customers saved an average of 61 therms, or 7% of pre-participation consumption. Programmable thermostat customers saved an average of 33 therms, or 4% of pre-participation consumption. Both savings estimates were statistically significant. However, programmable thermostat savings estimates were imprecise due to a small analysis sample size after removing contractor-installed thermostats.
Recommendation: Vectren's rebate application form should ask participants to provide information about any other furnace upgrades or tune-ups they performed in the same month as their thermostat installation. This will increase the usable sample size available in future evaluations, which can increase the precision of the savings estimates.

Conclusion: National benchmarking data for WiFi thermostat incentives show that most incentives are between $100 and $50 with an average of $72.
Conclusion: Data also suggests that the incremental cost of a WiFi thermostat compared to a programmable thermostat is approximately $103.20. Generally, incentives should not cover more than 50% of the incremental cost from the baseline measure. Table 44 depicts incremental cost for various types of thermostats.

Table 44 Incremental Cost by Thermostat Type

Measure	Incremental Cost
WiFi Learning Thermostat	$195.82
WiFi Thermostat	$103.20
Programmable Thermostat	$25.02

Recommendation: Learning thermostats are likely to have higher energy savings as models self-adjust to energy saving modules based on occupant behavior. These thermostat models have a higher incremental cost when compared to other wi-fi enabled thermostats. Cadmus recommends a three-tiered incentive similar to the levels in Table 45.

Table 45. Incentive levels by Thermostat Type

Measure	Incentive	Incremental Cost	Evaluated Ccf	Final NTG
WiFi Learning Thermostat	$75.00	$195.82	67.38	79%
WiFi Thermostat	$50.00	$103.20	57.59	79%
Programmable Thermostat	$10.00	$25.02	33.12	64%

Conclusion: Basic Wi-fi models do not include any of the "smart/learning" thermostat features offered by other thermostat models such as the NEST, Ecobee 3, and lyric thermostat. As a result these models save more energy than traditional wi-fi models. The lower retail price of these basic WiFi thermostat models may partially explain why participation in the WiFi thermostat rebate significantly exceeded the original planning goal.

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Recommendation: Review program design to consider a tiered incentive approach that distinguishes between "smart/learning" WiFi thermostats and basic WiFi thermostats that do not offer any of the "smart/learning" features.A smart/learning thermostat is any thermostat that has the capability to make automated adjustments to temperature based on occupant behavior. Commercial Prescriptive Rebate Program

Program Overview

Description

Cadmus evaluated the Vectren 2015 Commercial Prescriptive Rebate Program for natural gas furnaces rated ≥95% AFUE. The program offered a $300 rebate per furnace to commercial customers who may have otherwise purchased standard efficiency furnaces in the absence of the program. Outreach included direct-mail flyers to commercial customers, website advertising, and meetings with trade allies to educate and remind them of program offerings.

CLEAResult processed the program rebates, administered rebate payments according to participant applications, and calculated CCF savings. It also maintained the program tracking database, which Cadmus reviewed along with the *ex ante* savings algorithms to determine *ex post* gross savings.

Accomplishments

The Commercial Prescriptive Rebate Program reported participation and fuel savings that exceeded its 2015 goals while staying within budgeted expenditures. Table 46 presents the program performance as reported in the scorecard.

Table 46. Commercial Prescriptive *Ex Ante* Summary

Measure	Participation (Units)	Percentage of Goal Achieved (of Units)	CCF Savings	Percentage of CCF Savings Goal
≥95% AFUE furnaces	69	138%	10,531	156%

Process Evaluation Findings

Program Administration and Delivery

Vectren administers and implements the Commercial Prescriptive Rebate Program, now in its seventh year of operation. It manages day-to-day operations, including marketing, monitoring and verification, and coordinating with trade allies. A Vectren representative manages trade ally communications and customer rebate applications issues. If the list of approved appliances does not include a particular

product, Vectren will verify equipment specifications to ensure it meets the eligibility requirements. To provide quality assurance, Vectren verifies 2% of all rebates and checks that equipment was properly installed at the site.

Vectren contracts with CLEAResult to process rebate applications and provide reporting services. CLEAResult also administers verification of application and eligibility requirements on behalf of Vectren.

Trade allies play an important role in program delivery by helping customers complete applications and determine equipment selection and by promoting the program to customers.

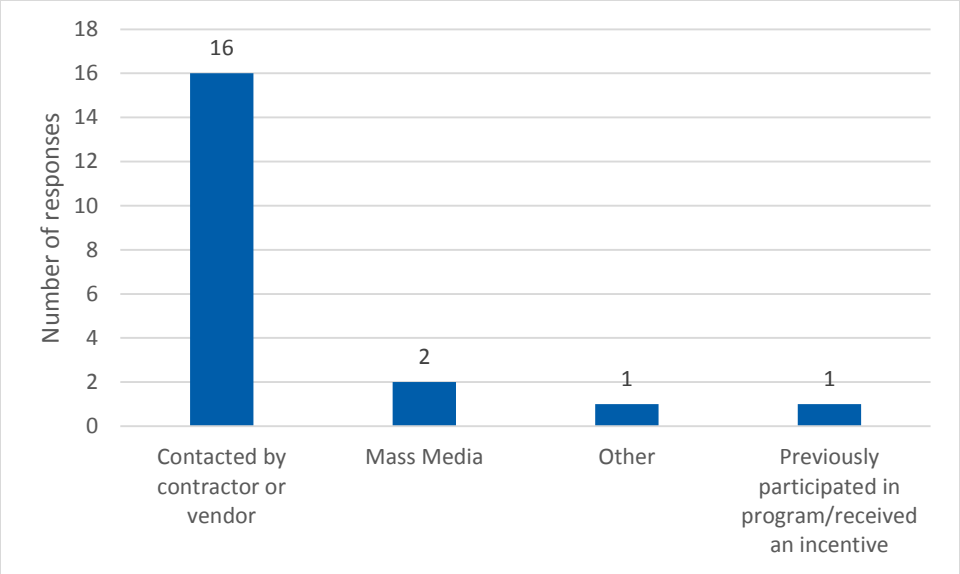
Vectren sets program goals according to the prior year's performance and may adjust them based on incentive changes or market research. Vectren noted that commercial furnaces can be difficult to plan for on an annual basis because the rate of furnace installations or replacements in the commercial sector can vary considerably.

Program Awareness

Vectren is responsible for most marketing and uses bill inserts, e-mail blasts, and one-on-one customer visits or conversations to promote the program. Additionally, it relies on its trade ally network to help promote the program to customers. Vectren encourages trade ally involvement by communicating with them two to three times a year via e-mail to explain program offers and changes and by providing brochures and applications to trade allies to hand out to potential participants. For trade allies who are more actively engaged in the program, the Vectren trade ally representative checks in more frequently to assess any of their concerns, questions, or comments.

Survey results indicated that participants overwhelmingly learned about the Commercial Prescriptive Rebate Program through trade ally interactions, as shown in Figure 6.

Figure 6. How did your organization learn about the rebates available from Vectren? (multiple responses allowed; n=21)



Decision-Making Process

Vectren said program participation fluctuated depending on the season and that fall was when most program participation occurs, primarily because customers are preparing for winter and trying to capture bill savings during the highest consumption month. Vectren staff believed customers chose to participate in the furnaces portion of the program because it was relatively easy and provided them with another financing source for their projects. Staff also said trade allies probably participated because the program provided an additional benefit for their customers and helped stimulate their overall business.

The majority of surveyed participants said the main benefit of participating in the program was the rebate but other benefits included energy savings and increased occupant comfort and others (Figure 7).

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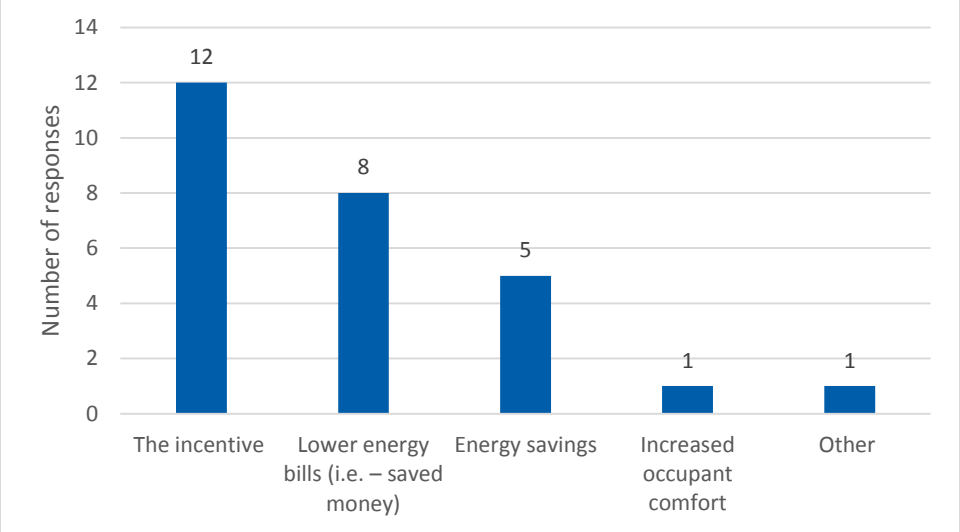
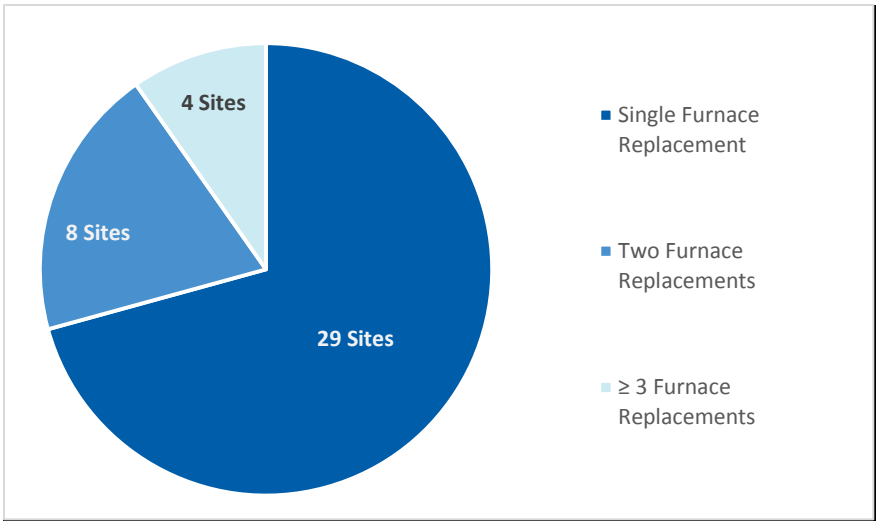
Figure 7. Benefits of Program Participation (multiple responses allowed; n=27)



Impact Evaluation Findings

In 2015, Vectren reported achieving 10,531 CCF of gas savings in the Commercial Prescriptive Rebate Program, which installed 69 furnaces across 41 participating business. The program database tracked *ex ante* savings for all 69 installed furnaces, all of which were residential-sized furnaces, ranging in capacity from 40 MBtu/h to 140 MBtu/h. Most locations (71%) installed a single furnace, while the rest installed two or more furnaces. Figure 8 shows the number of sites by number of furnaces installed.

Figure 8. Commercial Prescriptive Program Population by Install Quantity



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Engineering Review

To evaluate the commercial prescriptive program savings, Cadmus first attempted to recreate the *ex ante* savings reported in the scorecard. Because the total savings in the program tracking database matched the scorecard, our approach was to audit the savings for all 69 furnaces in the database using the claimed algorithm provided by CLEAResult:

$$\Delta CCF = CAP * 10 * EFLH * \left(\frac{\eta_{EE}}{\eta_{BASE}} - 1\right)$$

Where:

ΔCCF	=	Gas savings in CCF (100 cubic feet)
CAP	=	Input capacity of new equipment in MMBtu per hour (actual)
10	=	Conversion from MMBtu to CCF
EFLH	=	Equivalent full-load hours (810)
η_{BASE}	=	Baseline furnace efficiency (80%)
η_{EE}	=	Installed furnace efficiency (actual)

We found that the audited savings matched the *ex ante* savings for 64 furnaces. For the remaining five, the audited savings varied on average 3% from the *ex ante* savings. It remains unclear why the claimed algorithm could not successfully recreate savings for these five furnaces; nevertheless, any impact on the total audited savings was small, and we could still account for nearly 100% of the scorecard savings in this step.

We determined that the claimed algorithm was generally accurate except that its single assumption of 810 EFLH did not represent all building types in the population. The Indiana 2015 TRM v2.2 reports commercial furnace EFLHs by building type,[20] since heating loads depend on occupancy and use. This case-by-case assumption for EFLH would be more consistent with the furnace capacity and efficiency inputs in the claimed algorithm. The assumption of *ex ante* EFLH derives from the 2010 draft of the Ohio TRM, and its source is based on prototypical building simulation modelling. The Indiana TRM EFLH table is also based on modelling data, but it is a more recent and reasonable source.

Table 47 illustrates the differences between the inputs for the *ex ante* and *ex post* algorithms. The equation remained the same; only some of the inputs changed. For the *ex post* savings, Cadmus referred

[20] 2015 Indiana Technical Reference Manual v2.2. 2015. Page 252

to the Air Conditioning, Heating, and Refrigeration Institute (AHRI) online database for values based on the make and model information provided for each furnace in the tracking database.[21]

Table 47. Commercial Prescriptive Algorithm Inputs

Input	*Ex Ante* Value	*Ex Post* Value	*Ex Post Source*
CAP	Tracking Database Input MMBTUH	0.0971	AHRI Database Input MMBTUH
EFLH	810	923	Look-up by building type
η_{BASE}	0.8	0.8	Federal Standard
η_{EE}	Tracking Database Efficiency	0.9558	AHRI Database Efficiency

Cadmus created a region-specific EFLH table by building type using Indianapolis, Indiana data as a proxy for Dayton, Ohio. We chose Indianapolis because it is geographically close to Dayton and has similar latitude and heating degree days (HDDs). We referred to the commercial energy-efficient furnace section in the Indiana 2015 TRM v2.2 for the EFLH table by building type and location.[22] We then modified this table by applying an adjustment from an HDD table by U.S. city in the ASHRAE 2013 Fundamentals Handbook.[23]

Specifically, for each building type in the Indiana 2015 TRM, we adjusted the EFLH using a ratio of HDDs for Dayton and Indianapolis. This equation presents the adjustment ratio applied to the Indianapolis EFLHs in the TRM table:

$$Adjustment\ Ratio = \frac{HDD_{Dayton}}{HDD_{Indianapolis}} = \frac{5{,}301}{5{,}272}$$

Table 48 shows the resulting Dayton EFLHs. The building types are from the Indiana TRM with one exception. We added the "multifamily" descriptor because, in reviewing the tracking database, we determined that several furnace installations were in multifamily applications. However, the Indiana TRM does not provide a multifamily EFLH estimate in the commercial furnace section, so we assumed the same *ex post* EFLH as the residential prescriptive furnace program in this report.

[21] Air-Conditioning, Heating, and Refrigeration Institute. "Directory of Certified Product Performance." Accessed June 2016: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.

[22] *2015 Indiana Technical Reference Manual v2.2*. 2015. Pg 252.

[23] ASHRAE. *2013 ASHAE Handbook—Fundamentals.* Chapter 14 Appendix. 2013. Information available online: https://www.ashrae.org/resources--publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals

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Table 48. *Ex Post* EFLH by Building Type for Dayton

Building Type	EFLH Dayton
Assembly	879
Auto Repair	3,337
Big Box Retail	522
Fast Food Restaurant	1,260
Full Service Restaurant	1,170
Grocery	522
Light Industrial	1,119
Multifamily	927
Primary School	1,199
Religious Worship	928
Small Office	674
Small Retail	944
Warehouse	1,119
Other	1,139

Results from our engineering review showed that *ex post* savings surpassed *ex ante* savings by 14%. Table 49 shows the results in average savings per furnace.

Table 49. Commercial Prescriptive Rebate Program Average Per-Unit Savings Summary

Annual Gross Savings (CCF)		*Realization Rate*
Ex Ante	*Ex Post*	
153	174	114%

We compared the tracking database to the AHRI database and found only minor differences in equipment specifications. We determined that the main reason for the discrepancy between *ex ante* and *ex post* savings, therefore, was that we used a building-specific EFLH assumption in the evaluation rather than a single EFLH of 810.

Table 50 summarizes the results of the engineering review using the building type EFLHs applicable for the furnaces rebated through the program.

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Table 50. Commercial Prescriptive Rebate Program Evaluation Summary by Building Type

Building Type	Furnace Quantity	*Ex Ante* EFLH	*Ex Post* EFLH	*Ex Post* Adjustment Factor
Assembly	7	810	879	108%
Light Industrial	3		1,119	141%
Other	7		1,139	141%
Primary School	4		1,199	148%
Religious Worship	20		928	115%
Small Office	13		674	83%
Small Retail	12		944	116%
Multifamily	3		927	114%

Most of the installed furnaces (82%) were in a building type for which the EFLH assumption was higher than the *ex ante* claimed EFLH. Because our adjustment ratio was very close to 100%, the reason for the high EFLHs is in how the Indiana TRM determines EFLHs. Only the small office descriptor had lower than claimed EFLH, and it represented 19% of the population. We believe, therefore, that the claimed EFLH assumption has understated program savings in the 2015 population.

Measure Verification

Cadmus conducted telephone surveys with 20 of the 41 participating customers to determine the population's in-service rate. The 20 participants, encompassing 36 installations, confirmed that all reported furnaces are currently installed and functioning. Cadmus applied a 100% in-service rate to the entire population of 69 installations (Table 51).

Table 51. Commercial Prescriptive Measure Verification Results

Reported Installations	Verified Installations	In-Service Rate
69	69	100%

Cadmus multiplied the reported furnace quantity, the in-service rate, and the per-unit savings from the engineering review to determine the total program *ex post* savings of 12,031 CCF, as show in Table 52. As stated previously, *ex post* savings surpassed *ex ante* savings for the Commercial Prescriptive Rebate Program in 2015.

Table 52. Commercial Prescriptive Engineering Review Results

Participation		Average Per-Unit Savings (CCF)		Total Program Savings (CCF)		
Reported Installations	In-Service Rate	*Ex Ante*	*Ex Post*	*Ex Ante*	*Ex Post*	*Ex Post/ Ex Ante*
69	100%	153	174	10,531	12,031	114%

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Net-to-Gross

Cadmus calculated freeridership and spillover for the Commercial Prescriptive Rebate Program as a whole using findings from a survey conducted with 20 program participants. Survey respondents showed moderate indications of freeridership (42% overall savings weighted average). The resulting NTG ratio for the program is 58%, as there was no spillover activity attributable to the program.

We estimated freeridership using two different methods—the pure intention-based method, which has been used previously (such as in the 2014 Vectren Ohio Commercial Custom Program evaluation), and a new intention/influence freeridership method. (These are explained in the Pure Intentions Method and the Intention/Influence Method for Self-Reports sections of this report.) We randomly asked respondents questions pertaining to only one of the methods, attempting to collect an equal amount of responses for each one. We then weighted the respondents' freeridership scores by their *ex post* gross energy savings to arrive at a program-level freeridership estimate of 42%. Table 53 lists the NTG results for both freeridership methods. There was no spillover activity attributable to the program.

Table 53. Commercial Prescriptive Rebate Program NTG Ratio: Self-Report Method

Freeridership Method	n	Freeridership	Spillover	NTG
Pure Intention Method	10	29%	0%	71%
Intention/Influence Method	10	49%	0%	51%
Overall	**20**	**42%**	**0%**	**58%***

* Absolute precision at 90% confidence interval is ± 7%.

The 2015 pure intention method freeridership estimate of 29% is nearly identical to the 28% freeridership (n=25) estimated for the 2013 program for furnace and boilers measures. The increase in overall program freeridership from 2013 in 2015 derives from using the new intention/influence method, which estimated freeridership at 49% and resulted in an average overall program freeridership of 42%.

Pure Intention Method Freeridership Findings

Figure 9 shows the distribution of freeridership estimates Cadmus assigned to the 10 participant responses to the pure intention-based freeridership method. Three of the 10 respondents did not indicate freeridership; three indicated low freeridership (12.5%), one indicated moderate freeridership (50%), and one was a full freerider (100%).

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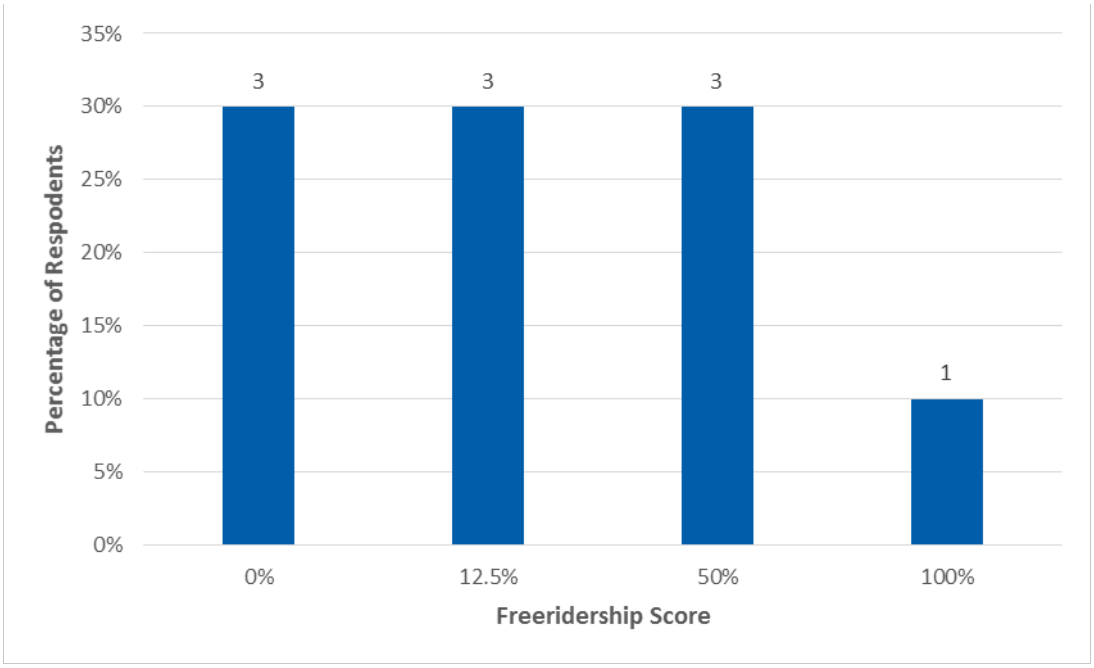
Figure 9. Commercial Prescriptive Program Self-Report Freeridership Distribution by Estimate (n=10)



The following descriptions of Commercial Prescriptive Rebate Program participant responses and scoring in relation to the freeridership questions represent eight of the 10 total survey respondents for the pure intention-based self-report freeridership methodology:

- One respondent (10%) reported already purchasing or installing the new equipment before learning about the program and was therefore estimated as a 100% freerider.
- One respondent (10%) was a 50% freerider because, although already planning to purchase equipment before learning about the program, this respondent would have done so to the same level of efficiency within the same year in the program's absence because the purchase was already included in the firm's most recent capital budget prior to participating.
- Two respondents (20%) were 50% freeriders because, although they said they were not planning to purchase the product before learning about the program rebate, when asked confirmatory questions, they said they would have purchased the same equipment, to the same level of efficiency, within the same year in the program's absence and had included the purchase in their capital budget prior to participating.
- Two respondents (20%) were 12.5% freeriders because, although they said they were not planning to purchase the product before learning about the program rebate, when asked confirmatory questions they said they would have purchased the same equipment, to the same level of efficiency, within the same year in the program's absence; they also said they did not have the purchase in their capital budget prior to participating.
- One respondent (10%) was a 0% freerider because he or she was not planning to purchase the product before learning about the program rebate, would not have purchased the same

quantity of equipment in absence of the program, and did not have the purchase in the capital budget prior to participating.

- One respondent (10%) was a 0% freerider because he or she would not have purchased equipment to the same level of efficiency in the absence of the program.

Intention/Influence Findings

Cadmus assessed intention by asking a brief set of questions to determine how the organization's project decision would have differed in the absence of the program. Table 54 includes the initial intention freeridership question and answers, along with our analysis of program participants' responses to this question and to a follow-up question based on their response. We used these follow-up questions to determine participants' final intention scores, which we multiplied by their respective total survey sample *ex post* therm savings to calculate intention-based freerider savings.

Table 54 shows the distribution of responses to the intention question: "If you had not received the rebate or other assistance from Vectren, such as an energy audit or technical information, what would have happened?" We used responses to the intention question to determine each participant's final intention score, then weighted individual intention scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average intention score of 47%.

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Table 54. Commercial Prescriptive Program Freeridership Intention Score (n=10)

Intention Question / Response Options A1. If you had not received the rebate or other assistance from Vectren, such as an energy audit or technical information, what would have happened?	**Intention Score**	**Count**	**Total Survey Sample *Ex Post* Therm Savings**	**Intention Score Therm Savings**
Canceled or postponed the project at least one year	0%	0	0	0
Would have reduced the size, scope, or efficiency of the project. A2. By how much would you have reduced the size, scope, or efficiency?				
Small amount	37.5%	0	0	0
Moderate amount	25%	1	149	37
Large amount	12.5%	0	0	0
(Refused)	25%	0	0	0
(Don't Know)	25%	0	0	0
Would have done the exact same project with no change A4. How likely is it that your business would have paid the full cost to complete the same project at the same time, without getting any rebate from Vectren?				
Very likely	50%	6	3,289	1,644
Somewhat likely	37.5%	2	262	98
Not too likely	25%	0	0	0
Not at all likely	0%	0	0	0
(Refused)	25%	0	0	0
(Don't Know)	25%	0	0	0
(Refused)	25%	0	0	0
(Don't Know)	25%	1	232	58
Total		10	3,932	1,838
Intention Score - Weighted by *Ex Post* Therm Savings (Intention Score Therm Savings ÷ Total Survey Sample *Ex Post* Therm Savings)	**47%**			

Table 55 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 influential,” to 5, meaning the item was “very influential” to your decisions.” Cadmus asked participants this question to obtain information about the program, the contractor, rebates for the equipment, and energy efficiency information Vectren provided.

Cadmus assessed influence freeridership from participants’ ratings to how important various program elements were in their decision to purchase the equipment. Table 55 shows the program elements that participants rated for importance, along with a count and average rating for each factor.

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Table 55. Commercial Prescriptive Program Freeridership Influence Responses (n=10)

Question A5 Response Options	Influence Score	Vectren Staff	Rebates for Equipment	Information about energy efficiency provided by Vectren	Information about energy efficiency from program staff or contractor
1 - Not influential	50%	2	0	1	0
2	37.5%	1	1	1	1
3	25%	3	2	2	3
4	12.5%	1	4	4	2
5 - Very influential	0%	2	3	2	4
Not Applicable	25%	1	0	0	0
Average		**3.0**	**3.9**	**3.5**	**3.9**

Cadmus used the maximum rating given by each respondent for any factor in Table 55 to determine the respondent's influence score, presented in Table 56. The counts refer to the number of responses for each factor/influence score response option. We weighted individual influence scores by their respective total survey sample *ex post* gross savings to arrive at a savings-weighted average influence score of 2% for Commercial Prescriptive Rebate Program participants.

Table 56. Commercial Prescriptive Program Influence Freeridership Score (n=10)

Maximum Influence Rating	Influence Score	Count	Total Survey Sample *Ex Post* Therm Savings	Influence Score MMBtu Savings
1 - Not influential	50%	0	0	0
2	37.5%	1	146	55
3	25%	0	0	0
4	12.5%	3	290	36
5 - Very influential	0%	6	3,496	0
Average Maximum Influence Rating - Simple Average		**4.4**		
Average Influence Score - Weighted by *Ex Post* Savings		**2%**		

Next, we summed the intention (47%) and intention/influence (2%) components to estimate the total intention/influence method freeridership of 49%, weighted by *ex post* gross program savings. The higher the freeridership score, the more savings are deducted from the gross savings estimates. Table 57 presents the program's intention, influence, and freeridership scores.

Table 57. Commercial Prescriptive Rebate Program Intention/Influence Freeridership Score

n	Intention Score	Influence Score	Freeridership Score
19	47%	2%	49%

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Spillover

No surveyed participants reported installing high-efficiency measures that were influenced by their program participation, for which they did not receive an incentive. The resulting spillover estimate for the program is 0% (Table 58).

Table 58. Commercial Prescriptive Program Spillover Estimate

Survey Sample Spillover Therm Savings	Survey Sample Program Therm Savings	Spillover Percentage Estimate
0	6,138*	0%

* 2015 evaluated gross energy savings.

Evaluated Net Savings Adjustments

Table 59 presents reported *ex ante* savings, verified *ex ante* savings, evaluated *ex post* savings, realization rates, and evaluated electric and demand net savings for the 2015 Commercial Prescriptive Rebate Program. Evaluated *ex post* savings reflect adjustments made for Cadmus' deemed savings review and the installation rate.

Table 59. 2015 Commercial Prescriptive Rebate Program Year Savings

Measure	Reported *Ex Ante* Savings (therms)	Verified *Ex Ante* Savings (therms)	Evaluated *Ex Post* Savings (therms)	Realization Rate (therms)	NTG Ratio	Evaluated Net Savings (therms)
Furnace Replacement >95% AFUE	10,531	10,531	12,031	114%	58%	6,978
Total	**10,531**	**10,531**	**12,031**	**114%**	**58%**	**6,978**

Conclusions and Recommendations

Conclusion: The program did not track building types in the tracking database for EFLH or reference a look-up table, which caused *ex ante* savings to be understated.

Recommendation: Even in a single weather region, EFLHs will vary for commercial applications depending on building type. In addition to changing the database to track building type, the field descriptors need to reference a look-up table for EFLHs. For the 2015 evaluation, Cadmus created a table of building types based on the Indiana TRM commercial EFLH table instead of using a single *ex ante* assumption of 810 hours. This assumption of *ex ante* EFLH derives from the 2009 draft of the Ohio TRM, and its source is based on prototypical building simulation modelling. The Indiana TRM EFLH table is also based on modelling data, but it is a more recent and reasonable source.

Conclusion: Several projects in the tracking database had *ex ante* savings that were not derived from the claimed algorithm.

Recommendation: Implement a quality control process that provides notes or explanations for project savings methodologies that may differ from the claimed algorithm. This process would ideally catch any discrepancies in methodology that should be corrected before the impact evaluation.

CERTIFICATE OF SERVICE

I hereby certify that a true copy of the foregoing Testimony submitted on behalf of the Environmental Law & Policy Center was served by electronic mail, upon all Parties of Record, on November 7, 2018.

/s/ Madeline Fleisher

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Madeline Fleisher

Summary: Testimony of Tamara Dzubay electronically filed by Madeline Fleisher on behalf of Environmental Law & Policy Center