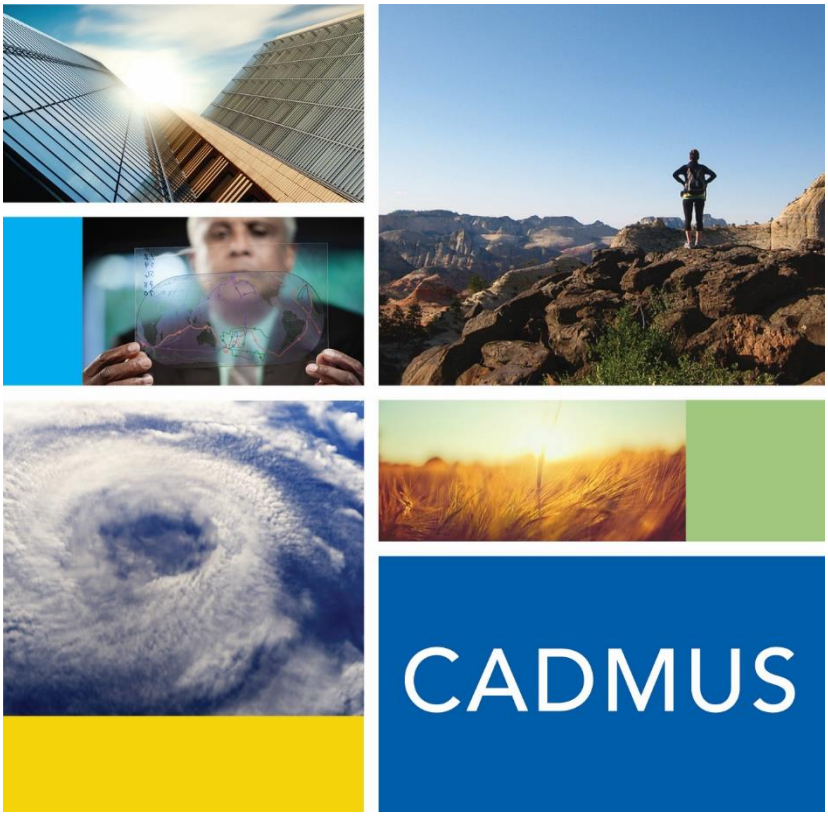

The Empire District Electric Company PAYS Feasibility Study

May 31, 2018

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Executive Summary

The Empire District Electric Company (Empire) commissioned a feasibility study to determine if Pay As You Save (PAYS) is a viable program design for the company to offer residential electric customers as part of its energy efficiency portfolio of programs. PAYS, registered by the U. S. Patent and Trademark Office, is a system developed by the Energy Efficiency Institute, Inc. (EEI).[1] Through the PAYS program, the utility pays all or part of the up-front cost for energy efficiency upgrades, and it recovers those funds through an on-bill tariff. The monthly tariff charged to the customer can be no more than 80% of the average monthly bill savings and last no longer than 80% of the measure's effective useful life. The design of the tariff ensures that the measure is an immediate cash-positive investment for the participant, and that its cost-effective over the life of the measure.

Objectives

To assess whether PAYS would be a feasible program model for Empire to offer customers, Cadmus investigated the following research topics:

- What measures are suitable for a PAYS tariff? (Based on electric savings only.)
- Could PAYS support enough of the up-front cost to be meaningful support for customers?
- What are the costs to launch and operate a PAYS program, under what circumstances could a PAYS program be cost-effective?
- Is there a gap in the market for financing in Empire's territory, and could a utility-administered financing program increase uptake of energy efficiency?

Key Findings

Measure Analysis

Cadmus reviewed costs and savings for 25 measures and four packages of measures to determine what percent of the measure or project cost could be covered by the PAYS tariff.

Just over half of the measures assessed only provide sufficient savings to allow PAYS financing to cover 30% or less of the cost of the measure over its expected useful life. Several measures provide savings sufficient for PAYS to finance from 50% to just over 100% of the full measure cost. A last group of measures provided sufficient savings for a reduced tariff to cover the full up-front cost over just 10 years, a term less than the maximum 80% of the EUL. This group of measures and packages included primarily ASHPs installed on an early replacement (ER) basis to replace electric heating equipment. ER measures provide far more savings than ROF measures because the baseline to calculate savings is the

[1] Service mark serial number 76320843

existing working equipment, which is typically less efficient than the current minimum federal standard that serves as the baseline for ROF equipment.

Federal census data indicates 43% of Empire customers have electric heat, indicating a potentially large market for the measures most likely to be well-suited to PAYS.

Customer Rate Sensitivity

Cadmus tested the sensitivity of the original measure-level financial analysis (discussed above) to four different rate structures: declining block (based on current Empire rates), inclining block (increased rate to discourage usage in the summer), time-of-use (TOU) rates (increased price for on-peak times throughout the year), and a decoupled rate structure (removing the utilities dis-incentive to achieve energy efficiency savings). For most measures, the reduced price in the winter months from the declining block, inclining block and TOU rates reduced the total bill savings from the measure, and therefore reduced the percentage of PAYS financing under the program rules. The decoupled rate structure increased rates by 1% per year, resulting in an increase in bill savings. However, the effect was modest, with no measure showing more than a 16% increase in the percentage of the measure cost that could be financed through PAYS.

Cost-effectiveness

Cadmus used the total resource cost test (TRC), the program administrator cost test (PAC), and the Ratepayer Impact Measure Test (RIM) to assess the potential cost-effectiveness of a PAYS program. Table 1 shows the program cost assumptions and inputs used in the analysis.

Table 1. Cost-effectiveness Inputs and Assumptions

Parameter	Value
Utility Assumptions	
Utility Cost of Capital / Interest Rate	5.73%
Opportunity Cost	2.88%
Line Loss	7.13%
Nonpayments /Nonpayment Loss Reserve fee	5.00%
NTG Ratio	1.0/0.62
Tariff Duration (years)	10
Annual Program Costs	
Utility Administration	$82,500
Marketing	$25,460
Evaluation	$30,000
Tariff Implementation Costs (<=71 participants) Fixed	$60,000
Tariff Implementation Costs (72 or more participants) Per Participant	$838

Under the TRC, the combined program achieves a benefits-to-savings ratio of 1:1 at 44 or 70 participants, depending on the assumed NTG ratio. When the program was evaluated with either the ER

ASHP or the ER standard whole home package as the only measure included in the program, the breakeven participation level under the TRC test, assuming full savings, dropped to 38 and 39 participants, respectively (Table 2). Where participation consists entirely of HPWHs installed on a ROF basis, the program is never cost-effective.

Table 2. TRC Breakeven Participation

Program	NTG=1	NTG=0.62
Combined program (45% ER ASHP, 45% ER standard whole-home package, and 10% ROF HPWH)	44	70
ASHP Replacement only	38	62
Standard whole-home package only	39	63

PAYS Set up and Administration

Based on the experience of PAYS programs offered by electric cooperatives in Virginia, North Carolina and Kentucky, the major hurdles to launching a PAYS program include achieving stakeholder approval, especially from regulators and government bodies, and sourcing capital.

Little information was available about potential legal or regulatory obstacles that Empire might face to offering a PAYS program. Empire staff was unsure if key aspects of the program, such as tying the tariff to the meter, were feasible under existing laws and regulations. The North Carolina program administrator reported that they did not perceive these issues as obstacles in their unregulated context. The Kentucky implementer interviewed was not involved in the initial program design and could not comment on this issue. The Kentucky program implementer did say that much of the delay in launching a PAYS program in his jurisdiction was due to the process to obtain approval from the state attorney general's office, and the Kentucky Public Service Commission. Both agencies were primarily concerned about the potential impact on nonparticipating ratepayers, and the implementer reported that the regulatory approval process was a primary cause of the long project development process for the first cooperative to propose a tariff.

The cooperatives both relied, wholly or in part, on federal grants to provide program capital. Empire, as a privately held company, is not eligible for these grant funds. Empire may be able to use capital intended for its DSM programs, but staff was not sure of the regulatory implications of this approach. Empire would need to consult the Missouri Energy Efficiency Investment Act (MEEIA), which governs how the IOUs fund and operate their energy efficiency programs, allows this use of funds, and the Missouri Public Service Commission.

Participation levels across four other programs that Cadmus reviewed (the programs in North Carolina and Kentucky, as well as programs in Arkansas and South Carolina) has participation rates ranging from 58 per year (Kentucky) to 198 per year (Arkansas). Cadmus identified several key characteristics of other PAYS programs that may have contributed to higher participation and savings. These included installing primarily heating and weatherization measures, targeting high-usage homes that rely on electricity for

space heating, expecting a certain level of nonpayment and using a nonpayment loss reserve to cover costs and protect ratepayers.

Available Financing Options and Program Alternatives

In Empire's territory, there are no energy- specific financing programs for electric measures, with the exception of PACE. However, PACE opportunities are limited to a small program in Taney County and a program that was approved in Joplin, Missouri in early 2018, but which had not yet launched at the time of this study. Empire customers have access to traditional unsecured and secured financing options from local and national lenders, as well as contractor or manufacturer financing options. Traditional unsecured loans are likely accessible to customers with poor credit and to renters, but are likely expensive. Rates vary widely but may start around 9% and increase for customers with lower credit scores. Secured financing is only available to homeowners, and then only to those homeowners with equity in their homes. Rates start much lower, at around 4%, but also increase based on the customer's credit score and other factors.

Cadmus compared four energy efficiency program design models to assess which might be most beneficial to Empire customers and to Empire's ability to achieve savings. These models included property assessed clean energy programs (PACE), a leasing model, non-PAYS on-bill financing, and PAYS. We found that PAYS financing is uniquely well-suited to serve the rental market, a segment of the residential population that traditional rebate programs typically do not serve well due to the split incentive barrier. PAYS ties the tariff to the meter, rather than the borrower. Tenants pay the financing charge and enjoy the saving benefit, but only so long as they live in the property, thus removing the barrier. PAYS is also well-suited to serve customers with poor credit, who may pay a premium to use traditional financing, or not have access to traditional financing at all.

On the other hand, PAYS is not well-suited to provide financing support for a broad array of measures, since the allowed tariff is dependent on the measure's expected savings. Finally, PAYS is not well-suited to serve customers with gas heat when only electricity savings are considered, since most measures will not achieve sufficient electric savings to allow for a meaningful amount of the measure cost to be financed. PAYS complexity makes it a more burdensome program model for a utility to administer, relative to other programs. But for certain key markets, it has the best potential for driving increased uptake of energy efficiency savings.

Potential for Financing to Increase Energy Efficiency Savings

A survey of 201 Empire customers found that financing is important for home energy upgrades, and that finding affordable, accessible financing is a barrier for some customers. Nearly half (48%) of the respondents who used financing to make an energy-related improvement reported they would have delayed or downgraded their recent purchase if financing had not been available. In addition, 57% said they would have considered a higher-efficiency model if more affordable financing had been available.

When asked about their concerns if faced with the need to make an $5,000 upgrade to their heating and cooling system, respondents were most likely to be concerned about not having sufficient cash to pay the up-front cost (69%) and an aversion to high interest rates (69%). Low income respondents were

significant more likely than other respondents to be concerned about knowing what financing options were available to them, and whether they could qualify for a loan. Renters were significantly more likely than homeowners to be concerned about qualifying for a loan. A PAYS program can address all of these concerns, for certain projects in all-electric homes.

Even a modest amount of PAYS financing ($300), together with a rebate, was enough to convince some respondents to select the high-efficiency option when they originally selected the standard option presented with the rebate alone. When presented with an early replacement scenario, which offered substantial energy savings in exchange for replacing working HVAC equipment, 67% of homeowners said that they would likely take advantage of the PAYS offer. Overall, the prospect of an on-bill tariff did not seem to be an obstacle for respondents.

Although financing is a barrier for some customers, a significant minority of Empire customers have negative attitudes toward financing and little appetite for long-term investments. Nearly a third of respondents who used cash for a recent purchase reported an aversion to using financing unless absolutely necessary. In addition, respondents' willingness to use financing fell sharply, to 35%, once interest rates rose above 3%. When asked why they didn't take advantage of the utility offer for a whole-home upgrade, survey respondents were most likely to indicate they did not think the project was cost-effective (22%).

Conclusion

Based on the study findings, Cadmus concludes that a PAYS program is feasible (TRC greater than 1) for Empire under certain scenarios described in this report.

Introduction

Pay as you Save (PAYS) uses an opt-in tariff mechanism to promote the installation of energy efficiency measures, while overcoming barriers associated with traditional energy-efficiency program designs. Cadmus investigated the feasibility for The Empire District Electric Company (Empire) to offer a PAYS program, and whether PAYS—or other program designs involving financing—would be likely to drive increased uptake of rebate-eligible efficiency measures.

Study Objectives and Scope

To be feasible, a PAYS program must be cost-effective, and allow customers to install measures that have up-front costs high enough to be reasonable candidates for financing. At the same time, the program must not present any legal or regulatory obstacles. To be effective, the program should address a gap in the private market for financing energy efficiency upgrades so that it increases the uptake of energy-efficient improvements beyond what the market would achieve without PAYS.

Cadmus used primary and secondary research and analysis to investigate whether PAYS would be a feasible and positive addition to Empire's energy efficiency portfolio. The specific research topics addressed by this study include:

- What portion of the measure cost could be financed through PAYS, within the defined tariff structure?
- What is the cost to set up the PAYS infrastructure and operate the program?
- What volume of participation is required for the program to be cost-effective?
- What impact do different rate structures have on measure- and program-level cost-effectiveness?
- Are there any regulatory or legal impediments to offering the PAYS model?
- Are there other existing financing solutions that effectively serve the PAYS market segment?
- What are customers' attitudes and awareness of energy- and non-energy-related financing options available in the Empire for home improvement projects? Does PAYS fill a gap in this market?
- What design features (rate, term, down payment requirement) are customers most likely to find attractive?

This study focused primarily on potential installations to achieve electricity savings in single family residential homes.[2]

About Empire

Empire is an investor-owned utility (IOU) that provides electric and gas service across southern Missouri and has approximately 130,000 residential electric customers across 16 counties. Empire currently offers energy efficiency programs for residential and multifamily customers. For all residential customers, Empire offers a program that provides rebates for central air conditioners and air source heat pumps (ASHPs), with about 75% of current participation from ASHPs. For multifamily customers, Empire offers direct install kit programs.

About PAYS

PAYS, which is a registered service mark, was developed by the Energy Efficiency Institute, Inc. (EEI). Through the PAYS program, the utility pays all or part of the up-front cost for energy efficiency upgrades, and it recovers costs through an on-bill tariff. According to EEI, the program design has three essential components[3]:

- A tariffed charge assigned to a meter location, not to an individual customer
- Billing and payment on the utility bill with disconnection for non-payment
- Independent certification that products are appropriate and savings estimates exceed payments for the near and long term

The PAYS design requires that the tariff amount, per year, be no more than 80% of the expected annual bill savings, and that the tariff be charged to the customer for no more than 80% of the EUL of the measure installed. The 20% cushion is designed to ensure that the customer realizes immediate cost savings from implementing the measure. To allow measures to be financed, the utility may require a copayment from the participant for any portion of the measure cost that is not recoverable within the structure of the PAYS tariff. This analysis only considered electricity savings in the calculation of costs and benefits. In some cooperative PAYS programs, however, savings from non-electric fuels are also accounted for in the determination of a PAYS investment amount.

Though no specific program structure is required under PAYS, the program is typically delivered as a direct-install style program, where the administrator (or a subcontracted implementer) recruits

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[2] The customer survey included responses from respondents in single-family and multifamily homes, and both owners and renters.

[3] Accessed 3/12/2018: http://www.eeivt.com/

customers likely to benefit from the program (such as lower-income customers in higher usage homes, or renters in higher usage apartments). The program administrator conducts an assessment on the home to identify savings opportunities and prepare a project proposal for the customer. This proposal will include the project cost, the amount that can be financed through PAYS, any necessary copay from the customer (if the full amount cannot be financed), estimated monthly savings, and the monthly tariff the utility will charge to recover the financed amount. If the homeowner agrees, the utility will either identify a contractor or help the customer select a contractor to install the upgrades, and perform a quality check on the completed project. The process to assess savings opportunities and review the project upon completion may involve a comprehensive energy audit, with a blower test and test-out (if shell measures are installed). The PAYS administrator typically absorbs the cost of the audit and test-out.

PAYS is currently offered by these cooperative/municipal utilities from around the country:

- Midwest Energy in Kansas
- Six cooperatives in Kentucky (through the How$mart KY program)
- Ouachita Electric Cooperative in Arkansas
- Roanoke Electric Cooperative in Virginia
- Sonoma County Water District

Methodology

Cadmus conducted several primary and secondary data collection tasks to assess the feasibility of PAYS from the perspectives of cost-effectiveness, program best practices, and market need.

Interviews

Cadmus interviewed Empire program staff and managers of PAYS programs in other utility jurisdictions. The interview with Empire staff addressed the utility's experience with and capacity for energy efficiency programs and collected their feedback on the potential benefits and limitations of the PAYS model. The external interviews collected data on the potential barriers and opportunities related to the PAYS model and lessons learned from implementation. Cadmus also requested itemized costs for PAYS administration from these PAYS managers.

As we were not aware of PAYS programs that have been implemented by IOUs (though many IOUs have implemented on-bill financing programs), we conducted external interviews with program implementers that oversee the PAYS programs of cooperative utilities. Specifically, we interviewed the PAYS administration staff at these organizations:

- Roanoke Electric Cooperative, a cooperative utility in North Carolina that administers a PAYS program branded as Upgrade to $ave.
- Mountain Association for Community Economic Development (MACED), a Kentucky community non-profit organization that administers the How$mart KY PAYS program in partnership with six eastern-Kentucky cooperative utilities.

Secondary Data Review

Cadmus reviewed several secondary resources to inform this study.

We used documentation and analysis of prior PAYS programs to understand program design elements and costs, and typical participation and installations. Our review included these resources:

- Ouachita Electric HELP PAYS program results[4]
- South Carolina Help My House Pilot Program Summary Report[5]

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[4] The Ouachita Electric HELP PAYS program is available at: http://www.oecc.com/pdfs/Ouachita%20Electric%20HELP%20PAYS%20Program%20-%20First%204%20Months%20of%20Activity.pdf

[5] South Carolina Help My House Pilot Program Summary Report is available at: http://www.eesi.org/files/HelpMyHouseFinalSummaryReport_June2013.pdf

- Example customer contracts and audits from prior PAYS programs
- PAYS program administrator pricing and proposal sheets

We also consulted other evaluations and unpublished research on other on-bill financing programs, including:

- 2015 Illinois On-bill Financing Program Evaluation (IL OBF)[6]
- Unpublished Cadmus research

We used details posted online about available Empire rebates and financing options, and other energy-specific financing programs available to Empire customers, to inform the financing gap analysis. Our review included these websites:

- Empire's current gas and electric energy efficiency programs, including its on-bill financing program for gas equipment upgrades[7]
- Property Assessed Clean Energy programs in Missouri from the Missouri Division of Energy[8] and Missouri Clean Energy District.[9]

Finally, we consulted federal statistical research to assess the building stock composition in Empire's service territory. We used data from both of the following sources:

- The U.S. Census Bureau's Five-Year American Community Survey. [10]
- The U.S. Energy Information Administration's Residential Energy Consumption Survey. [11]

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6 Cadmus. *Illinois On-bill Financing Program Evaluation*. Prepared for the Illinois Energy Association. June 1, 2015. Available online: https://www.icc.illinois.gov/docket/files.aspx?no=11-0689&docId=230270

7 Empire District. "Energy Solutions." Accessed March 13, 2018. Available at: https://www.empiredistrict.com/Energy/Solutions

8 Missouri Department of Economic Development. "Property Assessed Clean Energy." Accessed March 13, 2018. Available at: https://energy.mo.gov/assistance-programs/pace

9 Missouri Clean Energy District. Accessed March 13, 2018. Available at: https://www.mced.mo.gov/

10 US Census Bureau. "American Community Survey, 2015 5-Year Estimates." Available at: https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

11 US Energy Information Administration. "Residential Energy Consumption Survey." Available at: https://www.eia.gov/consumption/residential/

Measure-Level Financial Analysis

Starting with a list of common energy efficiency measures providing electrical savings in the Missouri Technical Resource Manual (TRM), we selected those measures that are likely to require financing (i.e., have a measure cost above a minimum threshold of about $250), and are not portable (i.e., will remain at the meter site regardless of transition of occupants). We added LEDs to this list to be considered as part of packaged upgrades. The list of measures we developed is illustrative, and not meant to be an exclusive list of what measures might be beneficial or eligible in a PAYS program. In most cases the specification of efficiency, capacity, square footage, or other details represents what information was available in TRM sources.

Table 3 shows the final list of measures we analyzed by end-use category. Since most PAYS programs typically involve a home energy audit that identifies multiple measures that are installed in one house, we also modeled two versions of a "whole home package". The standard package includes an ASHP and weatherization, as well as five LEDs. The comprehensive package includes the same measures, plus a HPWH and 4 windows. These "packages" are meant to be illustrative of the types of measures that might be installed in a whole home scenario, rather than exhaustive. (Cadmus did not include an energy audit as a measure, but included it as part of the implementation costs of the program).

Table 3. List of Measures

End-Use Category	Measure
Building Shell	Air Sealing
	Insulation (attic, wall)
	Windows
HVAC	Air Source Heat Pump (ASHP)
	Central Air Conditioner (CAC)
	Duct Sealing
Hot Water	Heat Pump Water Heater (HPWH)
Lighting and Appliances	Clothes Dryer
	Clothes Washer
	Refrigerator
Whole Home Packages	Standard: ASHP, air sealing, attic insulation, five LEDs
	Comprehensive: ASHP, air sealing, attic insulation, five LEDs, HPWH, duct sealing

Cadmus collected deemed values for estimated useful life (EUL), per-unit energy savings, demand reduction, incremental measure costs and full measure costs from the Missouri TRM[12] where available. We determined savings and demand reduction for both replace-on-failure (ROF) and early replacement (ER) scenarios where appropriate.[13] In cases where the Missouri TRM did not provide deemed values, or did not provide deemed inputs for savings algorithms, Cadmus used information from the Ameren Missouri TRM (Ameren TRM)[14] or the Illinois Statewide TRM for Energy Efficiency (IL TRM)[15]. For central air conditioner, clothes washer and dryer, air source heat pump, and wall insulation, we used the average of a random sample of retail prices posted online to determine a full measure cost estimate since no deemed estimates were available. Cadmus sampled retail prices from Home Depot, Ace Hardware, Ingram's Water and Air, AC Wholesalers, and Sears.

Cadmus calculated the monthly bill savings for each measure by multiplying the monthly energy savings by Empire's residential base variable rate for electricity, or $0.13006.[16] (Cadmus also assessed the sensitivity of this analysis to different rate structures. See Customer Rate Sensitivity Analysis for a discussion of the results.)

Cadmus determined the maximum measure cost that could be financed through PAYS for each measure as the present value of the maximum PAYS tariff (80% of the expected monthly bill savings) over a duration equal to 80% of the measure's EUL, discounted at the interest rate of 5.73%.[17]For those measures where the maximum PAYS tariff resulted in a financed amount greater than the full cost of the measure, including interest and fees, Cadmus assessed a reduced tariff based on a duration of 10 years (in all cases, shorter than 80% of the measure EUL). We selected the 10-year duration to reduce the

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12 Missouri Technical Reference Manual Volume 3: Residential Measures: https://energy.mo.gov/sites/energy/files/MOTRM2017Volume3.pdf

13 Cadmus used the TRM definition of "early replacement" for each measure. Typically, TRMs define early replacement savings assuming the measure replaced had one-third of its useful life remaining.

14 Ameren Missouri Technical Resource Manual Appendix F: http://dsmexplorer.esource.com/documents/Ameren%20Missouri%20-%202.10.2016%20-%202016%20TRM.pdf

15 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_3_Res_020817_Final.pdf

16 Empire District Residential Service Schedule RG, P.S.C. Missouri No. 5 Sec 1, 19th Revised Sheet No. 1. Available online: https://www.empiredistrict.com/Home/Document/3051

17 See the Administration Requirements section for an explanation of the interest rate.

total amount paid by the account holder and reduce the chance that the tariff will need to be transferred to another occupant, while still allowing for a very low monthly tariff charge.

Customer Rate Sensitivity Analysis

The PAYS program design is highly dependent on the customer bill savings, which set the threshold for the maximum tariff and therefore the maximum amount of financing available through the program. For the analysis of maximum PAYS financing by measure discussed in the previous section (see Measure-Level Financial Analysis) Cadmus used a flat per-kWh rate of $0.13006, which is Empire current base residential rate. However, the current Empire rate structure applies a reduced rate for usage above 600 kWh in the winter, designed to provide cost relief to homes that use electric heat. Because it is difficult to determine what percentage of measure savings would offset usage above the threshold, Cadmus did not incorporate this declining block structure into the primary analysis. In addition, Empire and the Missouri Public Service Commission are considering adopting alternative residential rate structures to encourage less energy consumption overall, or reduced usage during peak demand. These variations in rate structure have the potential to impact the amount of PAYS financing available for any measure, and the feasibility of the program.

To assess the sensitivity of the amount of PAYS financing available to the rate structure, Cadmus used similar rate structures offered by Empire or near-by utilities to model four alternative rate structures.

Block rates charge customers for consumption above a threshold at a different rate than usage below the threshold. Cadmus modeled Empire's current declining block rate, which has a single rate in the summer months, but a decreased rate for usage above the threshold of 600 kWh in the winter months. We also modeled a hypothetical inclining summer block rate structure, with a rate increase for usage above 600 kWh in the summer months that would encourage greater energy efficiency in the high-demand period. (The inclining block rate structure maintains the established declining block rates in the winter months, since the goal of utility bill relief in the winter still applies.) The inclining block rate proportions are modeled on the current inclining block rate in Consumers Energy territory in Michigan, and adjusted to reflect Empire Missouri's base rate.[18]

Whether a particular home would be able to reduce above-threshold usage by installing a given measure is dependent on a number of circumstances particular to that specific home and measure. This analysis determines the most extreme impact by applying the above-threshold rate to all savings. In fact, in most scenarios, the actual impact would be somewhat less.

[18] Michigan Public Service Commission, Consumers Energy Electric Rate Book, Residential Service Secondary Rate RS, March 2017. Available online at: http://www.michigan.gov/documents/mpsc/consumers13curcandd_579015_7.pdf

Time-of-use (TOU) rates are typically used to encourage demand reduction during peak times of the day, throughout the year. A TOU rate sets a higher price for energy used during peak times, encouraging customers to shift usage to off-peak periods. Cadmus modeled a TOU rate in response to Empire request to consider real-time pricing. A TOU rate approximates a real-time pricing approach, but does not peg the rate to wholesale prices. The fixed on-peak and off-peak rates facilitate billing and allow customers to plan ahead to optimally shift load to off-peak times (which typically include weekends and holidays). Cadmus adopted Ameren Missouri's existing optional TOU rates for this analysis.[19]

A **decoupled rate** is designed to avoid penalizing the utility for achieving energy efficiency. Decoupling rate adjustments allow a utility to increase variable rates charged to customers to offset any revenue losses due to efficiency gains, so that the revenue stream remains constant and sufficient to meet the utility's revenue needs. Any decoupling rate adjustment is likely to be uneven, as it depends on the revenue lost to efficiency gains in the prior years and any limitations set by regulators. For example, the decoupled rate adjustment for Liberty Utilities in Massachusetts allows for up to a 3% increase per period (peak or off-peak) relative to the prior period of the same type.[20] Cadmus used a simplified version of this structure, modelling the decoupled rate as a 1% annual rate increase to the base rate of $0.13006 per kWh over a 25-year period (the longest EUL for any of the measures analyzed).

[19] Ameren Missouri Residential Service Rate, Missouri P.S.C. Schedule 3rd Revised Sheet No. 54. Available online: https://www.ameren.com/-/media/rates/files/missouri/uecsheet54rate1mres.ashx

[20] Massachusetts Department of Public Utilities 17-93-A, Exhibit LU-2.

Table 4 shows the modeled rate structures.

Table 4. Alternative Rate Structures

Threshold	Rates ($/kWh)	
	Summer (June to October)	Winter (November to May)
Declining Block		
Tier 1: First 600 kWh	$0.1301	$0.1301
Tier 2: Additional kwh	$0.1301	$0.1057
Inclining Summer Block		
Tier 1: First 600 kWh	$0.1057	$0.1301
Tier 2: Additional kwh	$0.1500	$0.1057
Time of Use (TOU)		
On-peak hours	$0.3150	$0.0876
Off-peak hours	$0.0787	$0.0600
Decoupled Rate–		
Year 1	$0.1301	$0.1301
Annual Rate Increase	1%	1%

Cadmus used the load shapes provided by Empire to distribute the annual savings for each measure across each hour, day and month of the year. The load shape applied to each measure is provided in Appendix B. Monthly savings percentages by load shape are provided in Appendix C.

Because these load shapes are general to the territory, and therefore reflect a large percentage of customers that use gas heat, we created a hybrid load shape to accurately model monthly and hourly savings for measures that assume electric space heating: ASHPs, building shell measures, and the package measures. This load shape, labeled "All Electric Home", is the weighted average of the monthly savings for three measures modeled with three different load shapes. Table 5 shows the measures and the load shapes applied.

Table 5. Components of the All-Electric Home Load Shape

Measure	Load Shape
Refrigerator	Appl_InteriorEquipment
HPWH	Water Heater
ASHP, 15 SEER, early replacement – heating savings only	Heating_Gas
ASHP, 15 SEER, early replacement – cooling savings only	Electricity_HVAC, June-Sept percentages only, normalized to sum to 100%

To determine annual bill savings for the declining and inclining block structures, we aggregated savings by month, and applied the Tier 2 rate for that month. For annual savings under TOU rates, Cadmus mapped the annual savings to each hour of the year, defined in the load shape as on- or off-peak, and applied the appropriate rate to each hour's savings. For all three rate structures, Cadmus then calculated the weighted average dollar-per-kwh rate for the year, and applied that rate to the original measure-level analysis to determine the maximum tariff and the percentage of the measure cost that could be financed though PAYS.

To assess the impact of decoupled rates on PAYS feasibility, Cadmus calculated the average annual bill savings amount over the measure useful life, using the increasing decoupled rates. Cadmus did not discount the future savings to enable direct comparison of PAYS financing under the decoupled rates with PAYS financing in the primary analysis.

Program Level Cost-Effectiveness

For the program to achieve cost-effectiveness, the program measures must be able to generate sufficient savings to cover their own cost and additional savings that contribute to covering fixed or general costs, such as program administration. To assess the potential for cost-effectiveness at the program level, Cadmus selected two measures estimated to provide energy bill savings well in excess of the measure cost, based on the measure-level analysis: ASHPs and the standard whole home package, assuming an early-replacement scenario for both. We also included a third measure, a HPWH installed on a replace-on-failure basis. These measures are not the only measures that could cost-effectively be incorporated into a PAYS program, but are meant to be illustrative of the potential for cost-effectiveness across measures with different savings to cost ratios. The three measures are described in Table 6.

Table 6. Measures Used in Program Cost-Effectiveness Analysis

Measure	Baseline
Measure 1: ASHP	
SEER 15, 2 ton	Working electric furnace and CAC (Early Replacement)
Measure 2: Standard Whole Home Package	
ASHP (15 SEER, 2 ton)	Working electric furnace and CAC (Early Replacement)
Air Sealing	N/A
Ceiling Insulation to R-38	R-19
LEDs (n=5)	43-watt baseline 10.1-watt replacement
Measure 3: HPWH	
Heat Pump Water Heater	Federal standard electric water heater (Replace on Failure)

We applied the following standard cost-effectiveness tests:

- Program Administrator's Cost (PAC) test
- Total Resource Cost (TRC) test
- Ratepayer Impact Measure (RIM) test

Programs or measures are cost-effective when total benefits exceed total costs, or where the benefit to cost ratio (BC ratio) exceeds 1. The California Standard Practice Manual for assessing DSM program cost-effectiveness describes the basic benefit and cost methodologies we used for the tests. Cadmus modified these methodologies to incorporate costs specific to financing, such as opportunity cost of using capital for financing, nonpayment loss protection fees assigned to participants, and financing costs for the participants. Benefits and costs included in the tests are listed in Table 7.

Table 7. Benefits and Cost by Test Perspective

Parameter	PAC	TRC	RIM
Benefits			
Avoided Energy	✓	✓	✓
Avoided Capacity	✓	✓	✓
Line Loss	✓	✓	✓
Costs			
Program Administration	✓	✓	✓
Marketing	✓	✓	✓
Loan Administration Costs	✓	✓	✓
Loan Default Fee/Cost		✓	
Loan Opportunity/Carrying Cost	✓	✓	✓
Lost Revenue			✓
Measure Rebates	✓		✓
Incremental Measure Cost		✓	

PAC Test

The PAC test measures the dollar benefits of energy and demand savings against the utility's cost to determine if the value of the energy savings achieved is sufficient to cover the utility's costs of offering the program. Program benefits are equal to avoided energy and capacity, therefore a BC ratio greater than 1 indicates that it is less expensive for the utility to save energy by running the program than it would be to serve existing load.

Table 7 list the costs and benefits included in the different tests. The main benefits in the PAC are avoided energy, capacity, and transmission and distribution costs from reduced energy use due to measures install through the program.

The test looks at the lifetime costs and benefits. Therefore, savings over the useful life of the measure are included, discounted back to the present. Costs included in the PAC are the utilities' costs to operate the program. These include costs for utility administration, marketing, evaluation, implementation, and the utility's opportunity cost of capital. Utility nonpayment losses are assumed to be 5% of the total financing balance. The nonpayment losses and are not included in the test as the 5% fee charged to participants to cover nonpayment (a benefit or income to the utility) is directly offset by the assumed nonpayment rate of 5%.

TRC Test

The TRC test measures the dollar benefits of energy savings against all costs paid by either the participant or the utility to install the measures, and attempts to determine cost-effectiveness at a more holistic level (though it does not recognize non-energy benefits). In effect, the test answers the question: *Is the combined group (utility and participants) saving money by implementing this program and these projects?*

The TRC test considers costs to customers and the utility for measures financed through the program as well as benefits. Table 7 lists the components of the TRC test. The benefits included in the TRC tests, as in the PAC, are the avoided energy, capacity, and transmission and distribution costs. As participants reduce their energy use, the utility avoids fuel purchases and defers capacity and transmission and distribution construction, maintenance, and upgrades. Line losses are also reduced and counted as a benefit.

The costs included in the TRC are the utility costs to operate the program, as in the PAC. Unlike the PAC, the TRC also includes the participant costs. Participant costs include the incremental measure cost and the financing costs. The incremental measure cost is the amount the participant pays in excess of the standard equipment cost to purchase the more efficient equipment. The financing cost is the present value of the interest that the participant will pay over the life of the tariff.

RIM Test

The RIM test measures the impact on all ratepayers (participants and nonparticipants) who may experience rate increases designed to recover lost revenues. The RIM is similar to the PAC in that benefits include avoided energy costs, capacity costs, and line losses, however lost revenue from decreased energy use is included as an additional cost.

Many programs do not pass the RIM test because, while energy efficiency programs reduce costs, they also reduce sales. As a consequence, the average rate per unit of energy may increase. A passing RIM test indicates rates, as well as costs, will go down as a result of the program. Typically, this happens only for demand response programs or programs that are targeted to the highest marginal cost hours (when marginal costs are greater than retail rates).

Net-to-Gross Ratio

Applying the NTG ratio to the benefits and variable costs (nonpayment loss fee, participant financing costs, and measure cost) included in the cost-effectiveness tests determines whether the additional savings achieved by the program (beyond what people would have done on their own or with rebates) are sufficient to make the program cost-effective.

Cadmus assessed cost-effectiveness using both a net-to-gross (NTG) ratio of 1 (equivalent to gross savings) and a NTG ratio of 0.62. A NTG ratio of 1 is a reasonable estimate for NTG for a typical PAYS program that targets low income, high energy usage homes with working equipment. Without the trigger of broken or failing equipment, where the home has existed with high energy bills for several years, it is unlikely the participant would install efficiency measures on their own, even with the incentive of a rebate. This implies very low freeridership, and minimal contribution from the rebate program. At the same time, the energy audit will assess all cost-effective upgrades and advise participants that they have made significant improvements to the energy usage. As a result, the program is unlikely to generate much spillover.

To allow for a program design that is less proactive on the part of the administrator, and to account for overlap with the existing central air-conditioner rebate program, Cadmus also modeled cost-effectiveness assuming a 0.62 NTG ratio, which was the average attribution to financing from 2016 meta study of different approaches to attributing savings across complementary rebate and financing programs.[21]

Breakeven Analysis

The Cadmus team conducted a breakeven analysis to determine what level of participation, given the relative costs and benefits per measure, would be necessary for the program to be cost-effective and achieve a benefit/cost ratio of 1:1. This is useful for planning in the event that a program is not cost-effective based on expected participation levels. We conducted this analysis using the TRC and PAC costs and benefits and applied this analysis to the combined-measure program and each single-measure program scenario.

[21] Cadmus. *HERO Program Savings Allocation Methodology Study: Final Report*. Prepared for Pacific Gas & Electric, San Diego Gas and Electric, Southern California Edison, and Southern California Gas Company. October 3, 2016. Available online: http://www.calmac.org/publications/HERO_Allocation_Method_Study_Final_Report.pdf

Inputs

Benefits included avoided energy, capacity and transmission and distribution, and line losses. To calculate this amount, we used measure data collected for the measure-level financial analysis. We then applied the avoided costs, line losses, and retail rates provided by the utility.[22]

Table 8 shows the utility assumptions and associated program costs (see the Administration Requirements for PAYS section for a more detailed discussion of program costs). Fixed utility program costs include general program administration costs, marketing costs, evaluation costs (4% of the ASHP program). We assumed that program implementation and origination costs would be fixed at $60,000 for participation less than 72 customers. For 72 or more customers, we assumed implementation costs would be $838 per customer. We assumed tariff nonpayment and write-offs due to customer complaints or other factors would be 5%, and a nonpayment loss fee of 5% would offset the nonpayment. Empire currently offers a $250 rebate for ASHPs (SEER 15 to 15.9), which is included in the ASHP calculations, and in the standard package calculations (since the ASHP is one component of the package). The opportunity cost of capital/carrying cost represents the lost opportunity/expense of interest payments. Detailed cost-effectiveness assumptions are provided in Appendix A: Cost-Effectiveness Detailed Results.

[22] Hourly load profiles from the U.S. Department of Energy Open Data Catalog, base case for Kansas City, MO, were used in combination with the utility supplied avoided costs to calculate end use-specific avoided energy benefits. Source: https://openei.org/doe-opendata/dataset/commercial-and-residential-hourly-load-profiles-for-all-tmy3-locations-in-the-united-states

Table 8. Assumptions and Program Costs

Parameter	Value	Source
Utility Assumptions		
Utility Cost of Capital/Interest rate	5.73%	Interviews and secondary research
Opportunity Cost	2.88%	U. S. Department of the Treasury bond rate
Line Loss	7.13%	Empire
Nonpayments /Nonpayment Loss Reserve fee	5.00%	Interviews and secondary research
NTG Ratio	1.0 /0.62	Cadmus 2016[23]
Tariff Duration (years)	10	Measure estimated useful life (see Measure-Level Financial Analysis)
Annual Program Costs		
Utility Administration	$82,500	Assumed net cost for 1 full time employee equivalent (FTE)
Marketing	$25,460	Cadmus 2015 (IL OBF)
Evaluation	$30,000	Cadmus 2015 (IL OBF)
Tariff Implementation Costs (<=71 participants) Total	$60,000	Interviews and secondary research
Tariff Implementation Costs (72 or more participants) Per Participant	$838	Interviews and secondary research

Table 9 shows measure-specific inputs used in the cost-effectiveness analysis. Utility participant rebates are $250 for the ASHP, which is also included in the standard package. No rebate is available for the HPWH. Measure costs and savings for the ASHP and whole-home package measures assume an early replacement (ER) scenario, while heat pump water heater costs and savings assume the measure is replacing a failed appliance (ROF).

[23] Cadmus. *HERO Program Savings Allocation Methodology Study: Final Report*. Prepared for Pacific Gas & Electric, San Diego Gas and Electric, Southern California Edison, and Southern California Gas Company. October 3, 2016. Available online: http://www.calmac.org/publications/HERO_Allocation_Method_Study_Final_Report.pdf

Table 9. Measure Inputs

Measure	Scenario	EUL	RUL	kWh Savings	kW Savings	Measure Cost	Rebate
ASHP	ER	18	6	10,668	1.10	$3,400	$250
Standard Whole-Home Package	ER	19	6	11,745	1.26	$3,416	$250
HPWH	ROF	13	0	1,640	0.08	$1,000	$0

Customer Survey

Cadmus conducted an online survey of Empire's electric customers in Missouri to gauge market need for energy efficiency financing assistance and probable response to a PAYS or other on-bill financing programs. The customer survey addressed the following research topics:

- Need and access to financing for home improvements
- Customer barriers to uptake of higher efficiency central air conditioners and heat pumps
- Customer familiarity with different types of financing and the frequency of using these options
- Willingness to pay interest in financing energy purchases
- Acceptance of a tariffed financing program, in particular upon moving into a home under an existing tariff obligation
- Willingness to contribute a copayment for certain measures
- Customer demographics and building characteristics

Cadmus fielded the survey to a proprietary panel provided by Qualtrics. The survey sample consisted of 210 eligible respondents: 132 homeowners (63%) and 78 renters (37%). Cadmus screened the respondents to ensure they lived in one of the 16 Missouri counties served by Empire. In addition, we stratified the sample to represent the distribution of age in the territory, as shown in Table 10.

Table 10. Distribution of Survey Respondents by Age Group

Age Group	Distribution*
20 - 34	27%
35 - 49	24%
50 - 64	26%
65 and over	24%

*American Community Survey, 2015 5-Year Estimates

Financial Analysis

Measure Costs and Savings

To determine whether a PAYS program would be feasible for Empire, Cadmus collected estimates of the expected savings and costs related to common energy efficiency measures, to identify the best opportunities for cost-effective savings that also present a sufficient upfront cost barrier that financing might be necessary. Cadmus created a database of deemed costs and savings for each of the target measures, assuming different baseline scenarios. The Methodology section of this report provides details on Cadmus' data sources and our approach to collecting and analyzing this data. Table 11 shows the measures Cadmus analyzed for inclusion in a PAYS program. Measure savings are highly sensitive to the baseline conditions. For heating and cooling equipment, measures installed in place of working, older equipment (the ER scenario) achieve much higher savings than the same equipment installed on an ROF basis.

Table 11. Per-Unit Costs and Savings

Item #	Measure	Efficiency Level	Baseline Equipment	Scenario	Capacity/ Size	Per-Unit kWh Savings	Full Measure Cost	Source
1	**CAC**	SEER 14.5	Federal standard (13 SEER, 11 EER)	ROF	1 ton	183	$2,200	Missouri
2	**CAC**	SEER 14.5	SEER 10 (Est.); Federal standard (13 SEER, 11 EER)	ER	1 ton	360	$2,200	Missouri
3	**Clothes Dryer**	ENERGY STAR	Federal standard	ROF	8.45 lbs load	160	$445	Missouri
4	**Clothes Washer**	CEE Tier 1	Federal standard	ROF	3.45 cubic feet	99	$747	Missouri
5	**Clothes Washer**	CEE Tier 2	Federal standard	ROF	3.45 cubic feet	134	$1,019	Missouri
6	**Clothes Washer**	CEE Tier 3	Federal standard	ROF	3.45 cubic feet	152	$1,079	Missouri
7	**Refrigerator**	CEE Tier 1	Federal standard	ROF	22.5 cubic feet	58	$753	Missouri
8	**Refrigerator**	CEE Tier 2	Federal standard	ROF	22.5 cubic feet	87	$762	Missouri
9	**Refrigerator**	CEE Tier 3	Federal standard	ROF	22.5 cubic feet	117	$801	Missouri
10	**HPWH**	EF 2.0,	Federal standard electric water heater	ROF	50 gallons	1,640	$1,575	Illinois
11	**HPWH**	EF 2.0, 50 gallons	Efficiency = .904	ER	50 gallons	1,777	$1,575	Illinois

Item #	Measure	Efficiency Level	Baseline Equipment	Scenario	Capacity/ Size	Per-Unit kWh Savings	Full Measure Cost	Source
12	**Air Sealing**	Conservative deemed approach	Single-family ASHP for heating and cooling	N/A	1920	591	$500	Missouri
13	**Duct Sealing**	Level 2	HVAC	N/A	Not indicated	641	$325	Ameren
14	**Window Replacement**	Efficient Products	Not indicated in TRM	N/A	199 sq ft	106	$6,515	Ameren
15	**Ceiling Insulation**	Insulated to R-38	R-19, 15 SEER ASHP heat	N/A	1387 sq ft	369	$638	Missouri
16	**Wall Insulation**	R5	R11	N/A	990 sq ft	154	$1,488	Illinois
17	**LEDs**	Interior	43 Watt baseline	ROF	10.1 Watt	23	$5	Missouri
18	**ASHP**	15 SEER 2 ton	Electric Furnace and SEER 6.8 CAC	ER	2 ton	10,668	$5,088	Missouri
19	**ASHP**	15 SEER 2 ton	Gas or propane furnace	ER	2 ton	(5,771)	$5,088	Missouri
20	**ASHP**	15 SEER 2 ton	ASHP	ROF	2 ton	307	$5,088	Missouri
21	**ASHP**	15 SEER 2 ton	ASHP	ER	2 ton	1,774	$5,088	Missouri
22	**ASHP**	16 SEER 2 ton	Electric Furnace and SEER 6.8 CAC	ER	2 ton	10,736	$6,240	Missouri
23	**ASHP**	16 SEER 2 ton	Gas or propane furnace	ER	2 ton	(5,702)	$6,240	Missouri
24	**ASHP**	16 SEER 2 ton	ASHP	ROF	2 ton	376	$6,240	Missouri
25	**ASHP**	16 SEER 2 ton	ASHP	ER	2 ton	1,843	$6,240	Missouri
P1	**Standard Whole Home (ASHP, air sealing, attic insulation, five LEDs)**	See individual measures	See individual measures	ROF	See individual measures	1,384	$6,251	See individual measures
P2	**Standard Whole Home (ASHP, air sealing, attic insulation, five LEDs)**	See individual measures	See individual measures	ER	See individual measures	11,745	$6,251	See individual measures
P3	**Comprehensive Whole Home (Standard package plus HPWH and duct sealing)**	See individual measures	See individual measures	ROF	See individual measures	3,665	$8,151	See individual measures
P4	**Comprehensive Whole Home (Standard package plus HPWH and duct sealing)**	See individual measures	See individual measures	ER	See individual measures	14,163	$8,151	See individual measures

The first step in the measure analysis was to determine what percentage of an individual measure cost could be financed using the maximum tariff allowed under PAYS requirements. We calculated the amount that could be financed as the present value of the sum of the maximum tariff amount (80% of the average monthly savings) paid over 80% of the measure EUL, discounted at the interest rate of 5.7%. The measure cost in this case included a 5% nonpayment loss fee, and was net of available Empire rebates[24]. Empire offers rebates ranging from $250 to $450 for ASHPs and CACs.

We found that the maximum tariff did not allow for the full measure cost to be financed in most cases. Two measures, the 15 SEER and 16 SEER ASHP that replaced working gas or propane furnaces, result in negative electric savings by replacing gas use with electricity. No tariff is possible for those two measures. For seventeen of the twenty-five measures and four packages we analyzed, less than 50% of the measure cost could be financed through a PAYS program. These measures tended to be ROF scenarios, with the exception of the central air conditioner and two air source heat pumps. In addition, all home appliances (refrigerators and clothes washers) that we analyzed were included in this group. For these measures the average copayment (measure cost not covered by PAYS financing) required is $2,652. The estimated savings, costs and potential PAYS financing for these measures is shown in Table 12 (ordered from lowest percentage of cost financed to highest).

[24] See Administration Requirements for an explanation of the interest rate and the nonpayment loss reserve fee.

Table 12. Measures that Allow for Less than 50% PAYS Financing

Item #	Measure	Baseline Equip	Scenario	Empire Rebate	Financed Cost*	Max Monthly Tariff	PAYS Financing	PAYS Financing (% of financed cost)	Customer Copay
14	Window Replacement	Not indicated in TRM	N/A	$0	$6,841	$1	$115	2%	$6,726
20	ASHP, 15 SEER	ASHP	ROF	$250	$5,080	$3	$313	6%	$4,767
24	ASHP, 16 SEER	ASHP	ROF	$350	$6,185	$3	$383	6%	$5,802
7	Refrigerator	Federal standard	ROF	$0	$791	$1	$57	7%	$734
1	Central Air Conditioner	Federal standard (13 SEER, 11 EER)	ROF	$0	$2,310	$2	$186	8%	$2,124
8	Refrigerator	Federal standard	ROF	$0	$800	$1	$86	11%	$714
5	Clothes Washer	Federal standard	ROF	$0	$1,070	$1	$115	11%	$955
4	Clothes Washer	Federal standard	ROF	$0	$784	$1	$85	11%	$699
6	Clothes Washer	Federal standard	ROF	$0	$1,133	$1	$130	12%	$1,003
16	Wall Insulation	R5, CAC/Furnace	N/A	$0	$1,562	$1	$190	12%	$1,372
9	Refrigerator	Federal standard	ROF	$0	$841	$1	$114	14%	$727
2	Central Air Conditioner	SEER 10 (Est.)	ER	$0	$2,310	$3	$366	16%	$1,944
P1	Standard Whole Home	See individual measures	ROF	$250	$6,301	$12	$1,380	22%	$4,921
3	Clothes Dryer	Federal standard	ROF	$0	$468	$1	$138	29%	$330
25	ASHP, 16 SEER	ASHP	ER	$350	$6,185	$16	$1,878	30%	$4,307
21	ASHP, 15 SEER	ASHP	ER	$250	$5,080	$15	$1,808	36%	$3,272
P3	Comprehensive Whole Home	See individual measures	ROF	$250	$8,296	$32	$3,606	43%	$4,690

*Financed Cost is the full measure cost, less any available rebate, plus the 5% nonpayment loss fee, which is included in the financed amount.

Table 13 shows those measures where the maximum PAYS tariff covered most or all of the financed cost, including the loss reserve fee. In some cases, the maximum tariff recovered more than the full cost of the measure, and therefore could be reduced, or collected over a slightly shorter duration. This group of measures included building shell, and hot water heater measures and included both replace-on-failure and early-replacement scenarios. The HPWH are the most expensive items, and therefore the most likely to prevent an up-front cost barrier that might require financing. For the most expensive measures even the partial amount of financing provided by PAYS covers a significant portion of the up-front cost, and represent an amount of money that might commonly be financed.

Table 13. Measures that Allow Majority or Full Financing with Maximum PAYS Tariff

Item #	Measure	Baseline Equipment	Scenario	Empire Rebate	Financed Cost*	Max Monthly Tariff	PAYS Financing	PAYS Financing (% of financed cost)	Customer Copay
15	Ceiling Insulation	R-19, 15 SEER ASHP heat	N/A	$0	$670	$3	$457	68%	$213
10	Heat Pump Water Heater	Federal standard	ROF	$0	$1,654	$14	$1,335	81%	$319
11	Heat Pump Water Heater	Efficiency = .904	ER	$0	$1,654	$15	$1,446	87%	$207
12	Air Sealing	ASHP heat	N/A	$0	$525	$5	$533	100%	$0

*Financed Cost is the full measure cost, less any available rebate, plus the 5% nonpayment loss fee, which is included in the financed amount

For some early-replacement measures, the maximum PAYS tariff recovered far more than the total up-front cost. For those measures where the PAYS formula allowed for a financed amount greater than the full cost of the measure, including interest and fees, Cadmus assessed a tariff based on a tariff duration of 10 years (in all cases, shorter than 80% of the measure EUL). We selected the 10-year duration to reduce the total interest paid by the participant, while still allowing for a low monthly tariff charge. The five measures or packages where a 10-year tariff duration was possible are shown in Table 14, with additional information on the full measure cost, rebate, maximum monthly tariff (80% of monthly savings), percentage of total cost financed. No co-payment is needed for these measures.

Table 14. Measures with 10-Year Financing Potential

Item #	Measure	Baseline Equipment	Scenario	Empire Rebate	Financed Cost*	Adjusted Monthly Tariff	PAYS Financing	PAYS Financing (% of financed cost)	Customer Copay
P4	Comprehensive Whole Home	See individual measures	ER	$250	$8,296	$91	$8,296	100%	$0
22	ASHP, 16 SEER	Electric Furnace and SEER 6.8 CAC	ER	$350	$6,185	$68	$6,185	100%	$0
P2	Standard Whole Home	See individual measures	ER	$250	$6,301	$69	$6,301	100%	$0
13	Duct Sealing	Not indicated in TRM	N/A	$0	$341	$4	$341	100%	$0
18	ASHP, 15 SEER	Electric Furnace and SEER 6.8 CAC	ER	$250	$5,080	$56	$5,080	100%	$0

*Financed Cost is the full measure cost, less any available rebate, plus the 5% nonpayment loss fee, which is included in the financed amount.

Sensitivity to Interest Rates

Cadmus considered the 5.7% interest rate to be the most realistic scenario, and applied that to the program cost-effectiveness analysis (see discussion in Administration Requirements for PAYS). However, we also evaluated the sensitivity of the percentage of the measure cost that could be financed through PAYS to the interest rate charged, considering a 0% and 3% rate in addition to the 5.7% rate.

As shown in

Table 15, reducing the interest rate does allow increase the percentage of the full measure cost that can be financed by PAYS. However, the increase is less for those measures where PAYS only covers a small percentage of the measure cost at 5.7%, and greatest for those measures where PAYS already covers the full amount of the measure cost. Even at 0% interest, there would be no change to the grouping of measures presented in the previous section: measures where PAYS can finance less than 50%, measures where the maximum tariff covers 50% or more, and measures where the maximum tariff can be substantially reduced, and PAYS can still finance the full upfront cost.

Table 15. Sensitivity of PAYS Financed Amount as a Percentage of Cost to Interest Rate

Item #	Measure	Baseline Equip	Scenario	Financed Cost	PAYS Financing (% of total measure cost)		
					5.7% Interest	3% Interest	0% Interest
1	CAC	Federal standard	ROF	$2,310	8.1%	9.6%	11.9%
2	CAC	10 SEER	ER	$3,584	10.2%	12.2%	15.0%
3	Clothes Dryer**	Federal standard	ROF	$468	29.5%	33.9%	40.0%
4	Clothes Washer**	Federal standard	ROF	$784	10.8%	12.5%	14.7%
5	Clothes Washer**	Federal standard	ROF	$1,070	10.8%	12.4%	14.6%
6	Clothes Washer**	Federal standard	ROF	$1,133	11.5%	13.2%	15.6%
7	Refrigerator**	Federal standard	ROF	$791	7.2%	8.5%	10.4%
8	Refrigerator**	Federal standard	ROF	$800	10.7%	12.7%	15.4%
9	Refrigerator**	Federal standard	ROF	$841	13.6%	16.1%	19.6%
10	HPWH	Federal standard electric water heater	ROF	$1,654	80.7%	92.1%	**107.3%**
11	HPWH	EF = .904	ER	$1,654	87.5%	99.8%	**116.3%**
12	Air Sealing	Conservative deemed approach	ROF	$525	**101.6%**	**118.0%**	**140.6%**
13	Duct Sealing	N/A	N/A	$341	**355.1%**	**430.8%**	**543.0%**
14	Window Replacement	N/A	N/A	$541	**105.6%**	**128.1%**	**161.5%**
15	Ceiling Insulation (to R-38)	R-19, ASHP	N/A	$670	68.2%	86.2%	**114.7%**
16	Wall Insulation	N/A	ROF	$1,562	12.2%	15.4%	20.5%
18	ASHP, 15 SEER	Elec Furnace, CAC (SEER 6.8)	ER	$5,080	**214.0%**	**255.2%**	**314.6%**
19	ASHP, 15 SEER	Gas or propane furnace	ER	$5,080	-241.4%	-287.9%	-354.9%
20	ASHP, 15 SEER	ASHP	ROF	$5,080	6.2%	7.4%	9.1%
21	ASHP, 15 SEER	ASHP	ER	$5,080	84.2%	**100.5%**	**123.9%**
22	ASHP, 16 SEER	Elec Furnace, CAC	ER	$6,185	**176.9%**	**211.0%**	**260.1%**

Item #	Measure	Baseline Equip	Scenario	Financed Cost	PAYS Financing (% of total measure cost)		
					5.7% Interest	3% Interest	0% Interest
23	ASHP, 16 SEER	Gas or propane furnace	ER	$6,185	-197.1%	-235.1%	-289.9%
24	ASHP, 16 SEER	ASHP	ROF	$6,185	6.2%	7.4%	9.1%
25	ASHP, 16 SEER	ASHP	ER	$6,185	70.3%	83.9%	**103.4%**
P1	Standard Whole Home	See individual measures	ROF	$6,301	21.9%	26.0%	31.8%
P2	Standard Whole Home	See individual measures	ER	$6,301	**189.4%**	**225.8%**	**278.2%**
P3	Comprehensive Whole Home	See individual measures	ROF	$10,119	49.8%	58.9%	71.9%
P4	Comprehensive Whole Home	See individual measures	ER	$10,119	**155.3%**	**184.7%**	**226.8%**

Customer Rate Sensitivity Analysis

Cadmus assessed the sensitivity of the measure-level analysis to four alternative rate structures, as defined in the Methodology section. Table 16 shows how the percentage of the measure cost that can be financed through PAYS changes with each rate structure.

Table 16. Percentage of Measure Cost Financed by PAYS, by Rate Structure

Item #	Measure	Scenario	PAYS Financing (% of total measure cost)				
			Original Analysis	Declining Block	Inclining Block	TOU	Decoupled Rate
1	**CAC**	ROF	8.1%	8.1%	9.3%	9.1%	8.8%
2	**CAC**	ER	15.9%	15.9%	18.3%	17.9%	17.3%
3	**Clothes Dryer**	ROF	29.5%	25.8%	27.3%	23.0%	31.5%
4	**Clothes Washer**	ROF	10.8%	9.5%	10.0%	8.5%	11.6%
5	**Clothes Washer**	ROF	10.8%	9.4%	10.0%	8.4%	11.5%
6	**Clothes Washer**	ROF	11.5%	10.1%	10.6%	9.0%	12.3%
7	**Refrigerator**	ROF	7.2%	6.3%	6.7%	5.6%	7.8%
8	**Refrigerator**	ROF	10.7%	9.4%	9.9%	8.4%	11.6%
9	**Refrigerator**	ROF	13.6%	11.9%	12.6%	10.6%	14.7%
10	**HPWH**	ROF	80.7%	69.4%	72.5%	55.2%	85.7%
11	**HPWH**	ER	87.5%	75.2%	78.5%	59.8%	92.9%

12	**Air Sealing**	N/A	**101.6%**	84.9%	86.8%	62.0%	**109.0%**
13	**Duct Sealing**	N/A	**204.5%**	**171.0%**	**174.9%**	**124.9%**	**212.8%**
14	**Windows**	N/A	1.7%	1.4%	1.4%	1.0%	1.8%
15	**Ceiling Insulation**	N/A	68.2%	57.0%	58.3%	41.6%	56.8%
16	**Wall Insulation**	N/A	12.2%	10.2%	10.4%	7.4%	10.1%
17	**LEDs**	ROF	**132.8%**	**114.3%**	**119.4%**	86.4%	**134.8%**
18	**ASHP, 15 SEER**	ER	**214.0%**	**178.9%**	**183.0%**	**130.6%**	**233.2%**
19	**ASHP, 15 SEER**	ER	-115.7%	-92.3%	-90.7%	-70.7%	-126.1%
20	**ASHP, 15 SEER**	ROF	6.2%	5.3%	5.5%	3.8%	6.7%
21	**ASHP, 15 SEER**	ER	35.6%	30.6%	32.0%	21.7%	38.8%
22	**ASHP, 16 SEER**	ER	**176.9%**	**148.1%**	**151.6%**	**108.0%**	**192.8%**
23	**ASHP, 16 SEER**	ER	-93.9%	-74.7%	-73.2%	-57.3%	-102.4%
24	**ASHP, 16 SEER**	ROF	6.2%	5.5%	5.9%	3.8%	6.7%
25	**ASHP, 16 SEER**	ER	30.4%	26.3%	27.6%	18.5%	33.1%
P1	**Standard Whole Home**	ROF	21.9%	18.4%	18.9%	13.4%	23.2%
P2	**Standard Whole Home**	ER	**189.4%**	**159.1%**	**163.2%**	**115.6%**	**194.7%**
P3	**Comprehensive Whole Home**	ROF	43.5%	34.8%	35.7%	25.3%	42.0%
P4	**Comprehensive Whole Home**	ER	**171.7%**	**142.9%**	**146.6%**	**103.9%**	**180.2%**

The impact of the different rate structures depends on the bill savings to cost ratio of the measure over the duration of the tariff and the relationship of the load shape to the rate structure. The amount of PAYS financing is dependent on the measure's savings to cost ratio. As the bill savings to cost ratio increases, any change to the bill savings has a more pronounced effect on the percentage of the measure cost that can be financed through PAYS. For example, the percentage of the replace-on-failure CAC (Measure 1) cost that can be financed varies by just 1.2% from the least beneficial structure (declining block) to the most beneficial structure (inclining block), and achieves only a maximum of 9.3% financing. This is because the bill savings are so small relative to the measure cost that even a large incremental change in bill savings (by percent) accounts for only a small fraction of the measure cost. On the other hand, the percentage of financing for an early replacement 15 SEER ASHP (Measure 18) ranges from 131% under the TOU rates to 233% under the decoupled structure. For this measure, the bill savings are higher than the measure cost, and so an incremental change in bill savings results in an even larger change in the maximum PAYS financing.

The relationship of the rate structure to the measure load shape also has a significant impact on sensitivity. The declining block rate applies a lower price to savings during the winter season (October through May). This coincides with the majority of savings from electric heating measures. Since the only difference between the original analysis and the declining block rate was a rate decrease, the percentage of PAYS financing dropped somewhat for all measures under this rate structure. However, the effect was most pronounced for measures that make electric heating more efficient. For example, a clothes dryer (Measure 3) is not weather sensitive. Under the original analysis, a clothes dryer supported 29% PAYS financing. Under the declining block rates, this drops to 26%. Ceiling insulation, on the other hand, is assumed in our analysis to be reducing the heating load for an ASHP. Ceiling insulation savings allowed for 68% PAYS financing in the original analysis. Under the declining block rate, the percentage of savings drops to 57%.

The inclining block and TOU rates also applied a lower rate to savings in the winter months (and, for TOU, off-peak times), but applied a higher price to savings during summer months (June – September) or peak times. These rates also reduced the total bill savings for almost all measures, because the increase in bill savings during the summer was more than offset by the reduction in bill savings during the winter. TOU rates tended to reduce PAYS financing more than inclining block rates. For example, PAYS financing for a clothes washer (Measure 6) decreased from 12% in the original analysis to 10% under the inclining block rates and 8% under TOU rates. CACs were the only measure that showed an increase in PAYS financing under the inclining block and TOU rates, because the savings are concentrated in the high-price summer and on-peak times. But the impact was not enough to make PAYS viable for CACs. The maximum amount financed (18.3% for an early-replacement CAC under inclining block rates, Measure 2) is still well below 50%.

The decoupled rate structure increased the amount of PAYS financing for all measures, relative to the original analysis, simply by increasing the rates and holding all else equal. The impact of the increase in bill savings was modest however, resulting in an increase in PAYS financing of 3% to 13% for all measures.

Program Cost-Effectiveness

Cadmus performed cost-effectiveness for a PAYS program using three different tests: the PAC test, the TRC test, and the RIM test. We applied these tests to different program scenarios that incorporated one or more of three different measures: an ASHP, a whole-home package of upgrades, and a HPWH, assuming measures were installed in an all-electric home with a working electric furnace and central air-conditioner, and failed water heater. (Measure details are provided in the Methodology section).

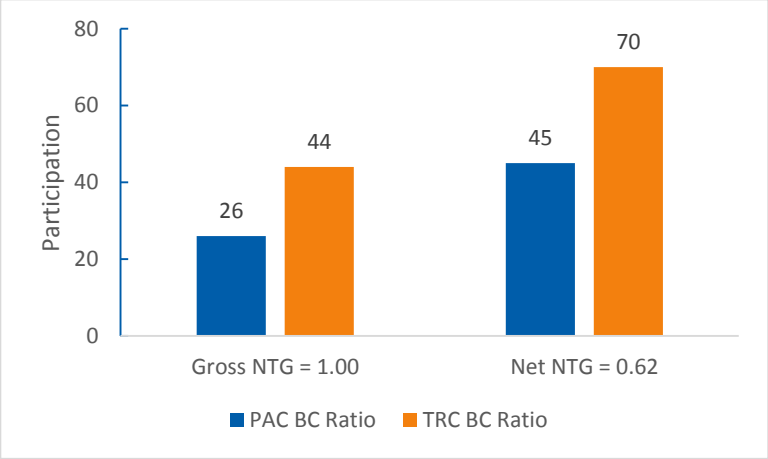
In the first program scenario, we assumed the program included all three measures. Then, we ran the tests again assuming single-measure programs, for each of the three measures (i.e., we tested a program that allowed only ASHPs, and then a program that allowed only the whole-home package, and then only the HPWH.)

For each program scenario and east test, we conducted a breakeven analysis to determine what level of participation was necessary for the program to have a cost-benefit ratio of 1, and then assessed cost-effectiveness across a range of participation levels to illustrate sensitivity. Finally, for all analyses, we considered measure savings with a NTG ratio of 1, and measure savings with an NTG ratio of 0.62.

Combined-Measure Program Results

For the combined program scenario, Cadmus assumed measure distribution of 45% ASHP installation, 45% Standard Whole Home Package, and 10% HPWHs. Cadmus assessed the breakeven participation level under the PCT and TRC tests using both an assumed NTG of 1.00 and an assumed NTG of 0.62. The PAC breakeven participation level for an NTG of 1.00 is 26, and for an NTG of 0.62 is 45. Under the TRC test, the breakeven participation level for an NTG of 1.00 is 44, and the breakeven participation level at an NTG of 0.62 is 70 (Figure 1). The breakeven analysis shows a PAYS program that financed primarily early-replacement measures in all-electric homes would be cost-effective even at relatively low levels of program participation. Breakeven results are not shown for the RIM test since the program is not cost-effective from the RIM perspective, regardless of the level of participation.

Figure 1. Combined Program Breakeven Participation Levels by Test



Cadmus also completed cost-effectiveness for program participation levels of 20, 80, and 200 to provide a range of results for the PAC, TRC and RIM tests. Figure 2 shows the PAC results, where the participation levels of 80 and 200 are cost-effective, but a participation level of 20 is not.

Figure 2. PAYS Program PAC Results at different Participation Levels

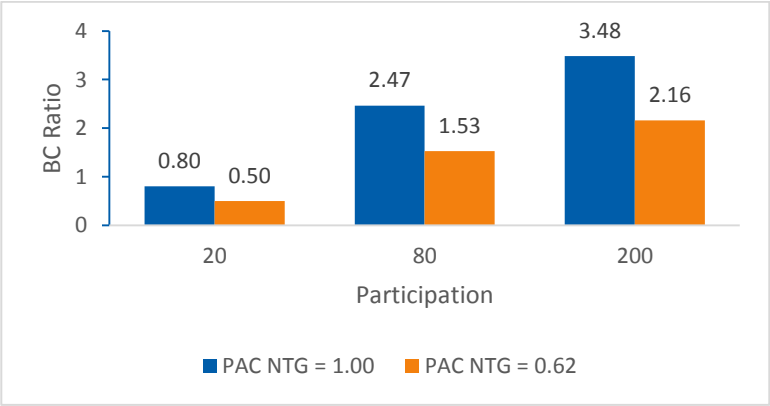


Figure 3 shows the TRC results as similar to the PAC, with the program being cost-effective at participation levels of 80 and 200 customers.

Figure 3. PAYS Program TRC Results at different Participation Levels

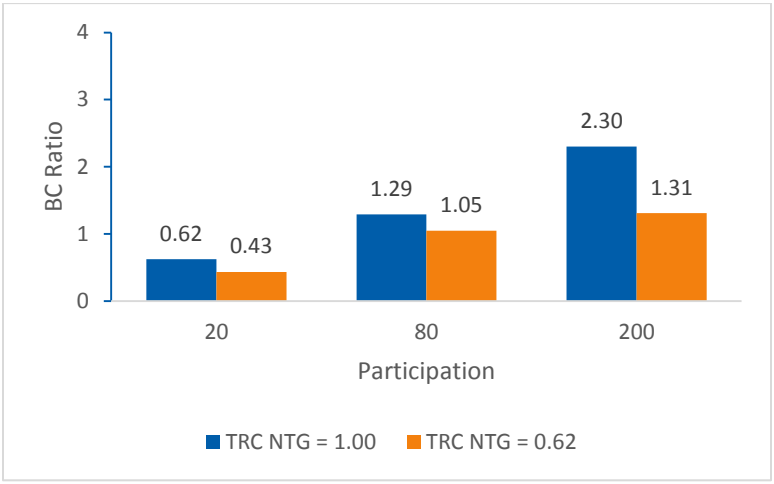
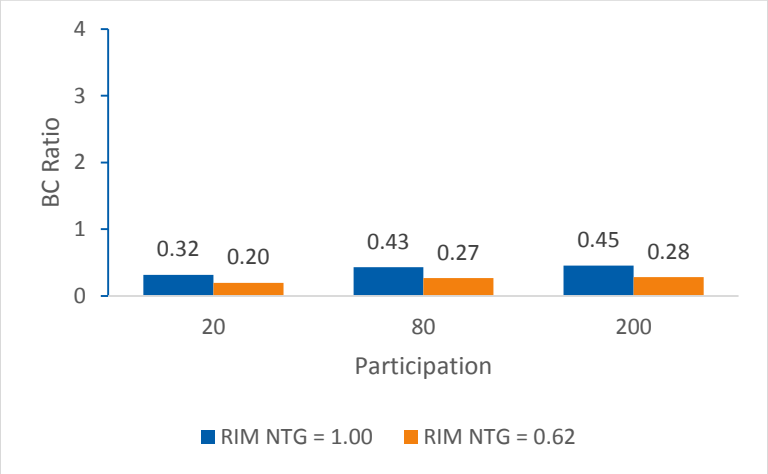


Figure 4 shows the RIM results. Under the RIM test, the program never achieves cost-effectiveness, regardless of the number of participants. Most energy efficiency programs do not pass the RIM test because while energy efficiency programs reduce costs, they also reduce sales. Typically, only demand response programs or programs that are targeted to the highest marginal cost hours (when marginal costs are greater than retail rates) pass the RIM test.

Figure 4. PAYS Program RIM Results



Single-Measure Program Cost-Effectiveness

Cadmus assessed the cost-effectiveness of a program that consisted of one measure type, for each of the three measures. Table 17 shows the breakeven quantities for the ASHP replacement and the whole-home measures. A single-measure program based on the HPWH measure is not cost-effective.

Table 17. Single-Measure Program Breakeven Quantities

Measure	PAC (NTG =1)	PAC (NTG=0.62)	TRC (NTG =1)	TRC (NTG=0.62)
ASHP	23	40	38	62
Standard Whole Home	23	41	39	63

Table 18 shows BC ratios for all three measures for both gross and net results. The PAC and TRC tests are cost-effective at 80 and 200 participants for all measures but HPWH. The HPWH measure is not cost-effective as a standalone program. Detailed cost-effectiveness results including benefits and costs by test are show in the appendix.

Table 18. Single-Measure Program Cost-Effectiveness Results

Quantity	NTG=1			NTG=0.62		
	PAC	TRC	RIM	PAC	TRC	RIM
All-electric ASHP replacement						
20	0.88	0.67	0.34	0.54	0.47	0.27
80	2.69	1.37	0.46	1.67	1.12	0.42
200	3.81	1.62	0.49	2.36	1.39	0.45
Whole-Home Standard Package						
20	0.88	0.67	0.32	0.54	0.47	0.26
80	2.61	1.35	0.42	1.62	1.11	0.38
200	3.62	1.58	0.44	2.25	1.37	0.41
HPWH						
20	0.08	0.08	0.07	0.05	0.05	0.05
80	0.30	0.22	0.17	0.19	0.16	0.13
200	0.48	0.30	0.22	0.30	0.23	0.17

Market Research Results

Cadmus used interviews, secondary research and a survey of Empire customers to assess the requirements for Empire to set up and administer a PAYS program. We also researched whether customer face a financing barrier, whether other existing financing options address that barrier, and whether other energy-specific financing program models might better serve Empire's customers.

Requirements to Set Up and Operate PAYS

Cadmus conducted interviews and secondary research to determine key costs for the set-up and administration of a PAYS program. Both the detail on associated costs, and the costs themselves, vary widely across sources, and no examples perfectly represent Empire's circumstances. Cadmus used the best available information, as well as our professional judgment to estimate potential administrative costs for a PAYS program administered by Empire.

Requirements to Design and Launch a PAYS Program

Set-up costs were difficult to quantify, and were not included in cost-effectiveness analyses in order to avoid unfairly over-burdening the program costs. However, this section presents a qualitative assessment of the time and resources needed to start-up a PAYS program.

Lead Time

Interviewees at Roanoke and MACED reported varying estimates of the lead time and cost of implementing a program. Roanoke staff estimated an implementation timeline of 6-9 months. As a cooperative utility, Roanoke was not required to obtain approval from the North Carolina Utilities Commission for its tariff. Major steps for Roanoke were developing a detailed program design, and sourcing capital. Roanoke did not dedicate much time to stakeholder engagement, or market research. In Kentucky, MACED staff reported that, of the six utilities that it partners with to implement the How$martKY program, the approval of the first tariff took roughly 18 months and faced significant legal scrutiny from regulators and the attorney general's office, but later tariffs were approved in speedier fashion.

Specific up-front costs were not reported by either program. However, such costs could include the following categories:

- Staff time, including both program design and legal/regulatory support
- Updates to utility billing software and systems
- Consulting and licensing fees for PAYS program design and intellectual property (estimated at between $40,000 and $50,000, based on other Cadmus research).

An on-bill financing program implemented by IOUs in Illinois required nearly two years to launch, and an additional two years for all five participating utilities to offer financing for common measures and to register participation. Major factors in the start-up process included coordinating across five utilities to select and contract with a single implementer/lender, complete significant upgrades to billing systems

to track financing payments and remit payments to the lender, and to coordinate program design across multiple utilities, including gas and electric utilities with overlapping territories.

Sourcing Capital

To secure funding for home retrofits, Roanoke took advantage of special lending programs available to cooperatives through the USDA Rural Utilities Service, while MACED used a combination of philanthropic program-related investments and federal funds. In contrast, the Illinois IOUs subcontracted with a lender specializing in the delivery of on-bill financing programs. The lender sourced capital from outside investors. Notably, the lender was able to secure funds at the same rate at which the utilities could borrow money for internal operations, due to the utilities' blanket agreement to guarantee payments to the lender, regardless of whether the borrower had completed their payment to the utility. The utilities adopted some risk from potential nonpayment, but the expected risk was considered to be negligible due to the relatively small size of the program.

Another option for Empire could be to incorporate the capital into their energy efficiency program budget, assuming the Missouri Energy Efficiency Investment Act (MEEIA), which governs how the IOUs fund and operate their energy efficiency programs, allows this use of funds. Empire does not currently have an approved MEEIA portfolio, so approval of the portfolio as a whole would have to be sought alongside approval of a financing program. Empire staff was not able to comment on the potential for MEEIA funds to be used in this manner.

For the cost-effectiveness evaluation, Cadmus assumed any costs to source funds were compensated by interest payments from borrowers.

Legal Considerations

Cadmus identified the following issues that may have legal or regulatory implications for Empire should they move forward with a PAYS program. Cadmus does not have legal expertise on staff and cannot comment on the actual risk associated with any of the issues listed below. This list should be considered a starting point for future research.

- Requirements or restrictions related to consumer financing
- Tying the tariff to the meter
- Providing the customer with an expected level of bill savings
- Potential liability if resident turnover results in lower savings
- Potential liability for measure operations or maintenance

Interviews with Empire staff and other PAYS administrators did not provide clarity on legal considerations that may affect a PAYS program. Empire staff noted that tying the tariff to the meter might create a difficult customer relations situation for the utility, but was not sure if existing laws or regulations could also be a barrier to this aspect of the program.

Roanoke noted that they did not need to obtain regulatory approval. They worked with EEI and Clean Energy Works (a nonprofit) to develop a detailed program design. Roanoke does tie the tariff to the meter, but noted they did no research on the legal implications of this, they "just did it." Roanoke currently does not perform post-installation monitoring or verification for PAYS projects, but is considering it for the future. Roanoke has had over 400 participants, but did not report concerns about meter transfers, actual savings achieved, or maintenance of installed equipment.

MACED did not provide details on the issues raised by stakeholders, especially the Kentucky Public Service Commission or the state's attorney general, but did note that discussions mostly centered on protecting ratepayers at large from risks associated with the lending aspect of the program. It was not clear if the MACED program tied the tariff to the meter, or what protocols they had in place to deal with issues that might arise when the meter transferred to a new account.

Administration Requirements for PAYS

Cadmus sourced annual administrative costs primarily from interviews, the IL OBF report, and unpublished Cadmus research including a third-party implementer proposed rate sheet. Where costs were available from multiple sources, Cadmus averaged reported costs.

The PAYS administrators Cadmus interviewed used two different structures. Roanoke, after initially managing the implementation of its Upgrade to $ave program internally, later hired a third-party program operator to oversee the audit and installation process, through Roanoke still performs test-out audits directly. In Kentucky, MACED implements the How$martKY program on behalf of six regional cooperatives. Historically, MACED has managed all field work and data management required by the program, but has since shifted portions of this work to utilities in some cases.

Staff at both companies provided per-participant cost estimates for program administration. Cadmus also reviewed a rate sheet provided to Cadmus by a third-party program implementer. Implementation costs were not specifically broken out by any of the three sources. However, Roanoke and MACED described the implementer role as including outreach, energy audits, and project management for participants. MACED's costs also included quality control, which may not be included in the other two costs. As shown in Table 19, these costs averaged $777 per participant.

Table 19. Estimated Per-Participant Implementation Costs for PAYS

Source	Cost Per Participant
Roanoke	$630
MACED	$1,000
Third-party implementer	$700
Average	**$777**

The IL OBF evaluation also provided utility costs. However, the Illinois program was coordinated across five utilities, and included outreach to hundreds of contractors across the state, whereas an Empire

program would be contained within one utility. A typical PAYS program involves just a few auditors and contractors, acting as subcontractors, to manage audits and installations. Cadmus considered the Illinois program model was sufficiently different from a typical PAYS program that we did not include the per-participant implementation costs in our calculation.

Nevertheless, the Illinois evaluation identified several fixed and variable costs that were not specifically noted to be included in the PAYS implementation cost, but that we expect would affect the utility. These included costs for the call center, marketing, and evaluation. Cadmus calculated the average cost across the five Illinois utilities for each category, and included these in the cost-effectiveness analysis as program-level costs. In addition, the PAYS third-party implementer assumes a minimum implementation fee of $5,000 per month if participation does not exceed 71 homes. Cadmus assumes this minimal implementation cost would apply to most program models, and so structured the cost-effectiveness analysis to apply the $60,000 per year minimum for participation levels below 72, and to use the per-participant variable cost for participation of 72 and above.

As a financing program, PAYS administration costs include a cost of capital. Cadmus assumes the utility would set the interest rate equal to the cost of capital, as the Illinois Energy Efficiency Loan Program and the Roanoke Upgrade to $ave program do, to avoid making money from the implementation of the program and to minimize costs to participations. However, the Roanoke Upgrade to $ave program relies on low-cost funds provided through a federal grant for which Empire would not be eligible. Therefore, Cadmus used the average of the Illinois OBF program's published 2018 interest rate, and the Empire cost of capital, to determine the interest rate used in the cost-effectiveness analysis (Table 20).

Table 20. Inputs to Determine a PAYS Interest Rate

Source	Rate
Illinois Energy Efficiency Loan Program interest rate (2018)	5.74%
Empire cost of capital (2016)	5.71%
Average	**5.73%**

Cadmus used the 10-year rate for a U. S. Treasury Bond as the opportunity cost of providing financing capital. The opportunity cost is calculated as the present value of the interest payments on the financed amount, discounted at the opportunity cost rate. This approach followed precedent from the IL OBF study and other research we have conducted.

Finally, Cadmus assumed that Empire would establish a nonpayment loss reserve. (See a more detailed discussion of the nonpayment loss reserve in the following sections.) The nonpayment loss reserve, funded through a 5% one-time fee on the cost of the financed measures, protects ratepayers from lost revenue associated with tariff nonpayment, tariff write-offs, and costs related to shutting off or reinstating service for delinquent customers. The nonpayment loss reserve would be managed in the same manner as the financing capital, and therefore not incur extra management costs.

Cadmus modeled the loss reserve fee on that implemented by the MACED How$mart KY program, and assumed it would be sufficient to cover all nonpayment and related costs. Therefore, Cadmus did not model these costs separately. There were no available estimates for write-offs or shut-off/turn-on costs. However, the IL OBF report estimated a nonpayment rate of 0.16% in its first three years, the Roanoke Upgrade to $ave program referenced an effective default rate of 0.75%, but noted they are still working with some of those customers, and the MACED How$mart KY program referenced a default rate of 1.9%. Cadmus assumed this fee was included in the financed amount.

Table 21 shows the fixed annual costs applied in the program cost-effectiveness analysis, and Table 22 shows variable costs, assessed on a per participant basis, used in the cost-effectiveness analysis.

Table 21. Fixed Costs for Administering PAYS

Cost Category	Cost	Basis	Source*
Utility Administration	$82,500	One FTE across multiple employees; costs assume mid-level salary plus benefits multiplier	Empire
Marketing	$25,460	Average of actual costs	Cadmus 2015 (IL OBF)
Evaluation	$30,000	4% of total program costs (Based on ASHP single-measure program total, assume 100 participants)	Cadmus 2015 (IL OBF)
Implementation (71 or fewer participants)	$60,000	$5,000 per month minimum fee	Third-party implementer project cost estimate
Cost of Capital	5.73%	Equal to interest rate	Average across various sources
Opportunity Cost	2.88%	U. S. Treasury Bond, 10-year rate	Cadmus 2015 (IL OBF)

*

Table 22. Variable Costs for Administering PAYS (Per Participant)

Cost Category	Cost Per Participant	Basis	Source
Program Implementation (72 or more participants)	$777	Per-participant fee	Third-party implementer project cost estimate
Call Center	$61	Average actual cost	Cadmus 2015 (IL OBF)
Customer nonpayment and write-offs	N/A	Covered by nonpayment loss reserve; nonpayments assumed to be 2% or less	Assumed
Shut-off fee	N/A	Assume necessary for less than 1% of customers, minimal cost	Assumed
Total	**$838**		

Implementation Lessons from Prior PAYS Programs

To date, most PAYS programs, such as those in Kentucky, Arkansas, South Carolina, and North Carolina, have been administered by rural electric cooperatives. As noted by Empire staff, Empire also has a large rural electric customer population. As a result, an Empire program may see similar attributes among participants as regional cooperative utility programs. Though interviews with PAYS program administrators and secondary research, Cadmus observed the following trends characterizing the design and implementation in other PAYS programs.

- **An expected measure mix of heat pumps and weatherization.** Interviews and a review of program documents confirmed that participation in these programs has largely consisted of a combination of heat pump installation and weatherization measures. Roanoke and MACED's programs are both structured to offer two primary measures packages: a HVAC upgrade (which is nearly always a high-efficiency heat pump) and a suite of envelope and miscellaneous measures such as roof and ceiling insulation, caulking, air and duct sealing, LEDs, water heater blankets, and programmable thermostats. The interview findings are confirmed by published measure data from programs in Arkansas (HELP PAYS) and South Carolina (Help My House), which show that more than 80% of participants received a heat pump, air sealing, duct sealing, and attic insulation in each program. These program offerings seen in jurisdictions elsewhere are in line with the cost-effectiveness results discussed above (see **Cost-effectiveness** section.)
- **Participation led by electric-heated homes.** Interviews with program managers at Roanoke and MACED reported that a large number of program participants in these PAYS program have electric heat. This is confirmed by the South Carolina Help My House pilot, in which 47% of participating households installed a heat pump that replaced an electric furnace, while 42% installed a heat pump that replaced an existing heat pump. It is expected that this would be the likely result of a program in Empire's service territory as well. In interviews with Empire staff, program managers reported that, due to the terrain of their service area, there are pockets of communities that cannot be served by natural gas distribution infrastructure and that have particularly high rates of electric heat.
- **Participation from high consumption homes.** Directly related to the high rate of electric-heat customers participating in programs, external interviewees have found that utility customers with high levels of consumption have disproportionately participated in their PAYS programs. Interviewees noted that their programs are not limited to homes with high consumption, but that they have promoted the program to customers who have complained about high bills as a mitigation measure and expect that this has resulted in some degree of participation.
- **Inclusion of a nonpayment loss reserve.** Both Roanoke and MACED programs incorporate a nonpayment loss reserve, which was recommended by interviewees. To date, Roanoke has experienced a low nonpayment rate of only 0.75% (three participants out of 400 to date), compared to a business-as-usual rate of 0.25% for their utility. MACED's rate has been slightly higher at 1.9% of dispersed funds, which MACED attributes to early program struggles with

customer contracting. Both programs have set aside a portion of program funds to serve as a nonpayment loss reserve, and staff feels they are within their limits.

- **Participation.** Participation has been reasonably strong, ranging from an average of 58 homes per year (MACED) to 198 (Ouachita HELP PAYS). Participation within each program we reviewed is: the Roanoke Upgrade to $ave program has completed over 400 projects from 2014 to 2017, the MACED program has completed 289 projects since 2011, the South Carolina Help my House pilot completed 125 projects from 2011 to 2012, and Arkansas Ouachita HELP PAYS program completed 198 projects from 2016 to 2017 (representing nearly 10% of their residential meters).

Empire Experience with Program Administration

Empire staff reported that administration of Empire's energy efficiency programs across their electricity service territories in Missouri, Oklahoma, Kansas, and Arkansas, and gas service territories in Missouri and Iowa, were consolidated in the summer of 2017, and are now administered by one employee.

Empire's gas and electricity programs are administered separately in terms of regulation and service area. Empire currently offers four programs to residential customers, including programs for single family and multi-family customers. For single-family customers, Empire offers rebates for cooling equipment to residential electric customers, and on-bill financing for residential gas customers. Staff reports the gas on-bill lending program is not well-subscribed.

Empire staff believed a PAYS program had potential benefits for customers, by reducing energy bills and increasing customer satisfaction for participants. They noted that Empire's service territory has many similarities to the cooperative that are implementing PAYS, in that it's smaller than many IOU territories, with a high concentration of rural customers, renters, and a large number of customers using electricity for heating. Staff also noted that their current rebate program for cooling equipment processes primarily rebates for ASHPs (about 75%) but that nearly all are replacements for failed equipment (ROF).

The primary concerns raised by Empire staff with regard to offering a PAYS program related to customer communications, potential legal and regulatory obstacles, and administrative complexity. Staff noted that within the company, energy efficiency is a priority, especially for lower-income customers. However, staff considered a PAYS program to be a difficult concept to communicate to customers. Although staff considered PAYS to potentially be a valuable tool for promoting energy efficiency to renters, the complexities involved in a transaction that included a renter, a landlord, and the utility would be difficult to communicate, and agreements might be difficult to enforce once a new tenant was involved. There was a also a hesitation within the company to involve the utility in any kind of real estate transaction, such a property owner trying to sell a property with a PAYS tariff attached.

Administratively, staff noted that Empire has tended to maintain implementation in-house moreso than other larger utilities. This allows Empire staff to develop a deeper understanding of program operations, and have more flexibility and control. Their preference was to keep all administration of a PAYS program in-house as well. However, they reported that PAYS administration would likely require hiring additional

staff, as existing staff were fully booked. They expected PAYS to require more staff time than the existing rebate programs, especially in order to manage customer communications.

Comparison of Financing Program Design Alternatives

To understand the potential need for and relative benefit of a PAYS program compared to alternative means of financing, Cadmus evaluated two key factors: (1) the current availability of financing programs in Empire's service area, and (2) the comparative benefits and drawbacks of a range of potential financing offerings.

Energy Financing Programs Available in Empire's Service Territory

While somewhat sparse, there are several existing dedicated options for energy efficiency finance available in Empire's electric service area in Missouri, including the following:

- **Property Assessed Clean Energy (PACE) Programs.** PACE programs are authorized in Missouri, but individual municipalities must choose to participate. Two PACE districts have jurisdictions that could overlap with Empire's service area, but only a small number of municipalities have signed on to these programs.[25]
- **Utility On-Bill Financing.** Empire currently has an on-bill financing program that is active for gas upgrades. Empire staff report that this program has low subscription rates. This program is not an energy efficiency program, and as such, it does not have energy savings requirements.
- **Bank and Credit Union Lending.** As with any other area, Empire customers have a range of options for both (unsecured) personal loans and home equity loans (which require collateral). Rates and conditions vary widely across lenders and depending on applicant credit scores.

The details of these options are summarized in Table 23. While there are both utility and PACE financing programs active in Empire's service territory, they are not broadly available. Only a small number of municipalities in the area served by Empire have authorized PACE districts, and Empire's own financing program serves only gas heating upgrades. Additionally, both of these programs are restricted to homeowners. A variety of private-sector options are available, but these either require home equity loan or charge high interest rates.

[25] This includes Joplin, the largest community served by Empire District in Missouri, which joined the Show Me PACE program in February 2018.

Table 23. Comparison of Home Energy Financing Options in Empire Service Area

Program Type	Property Assessed Clean Energy	On-bill Finance	Unsecured Personal Loan	Secured Home Loan
Program Name	Missouri Clean Energy District	Residential Customer Finance Program	Available from most local and national lenders. Springfield-based Educational Community Credit Union (ECCU) used as reference.	
Program Administrator	Missouri Clean Energy Funding LLC	Empire		
Eligible Area	Several municipalities in Taney County included	Empire gas service area	No limitations	No limitations
Eligible Customers	Homeowners	Residents in 1-4 unit housing	No limitations	Requires home ownership and available equity in the home
Credit Score Requirements	None	None	Credit score impacts rates significantly; may be unavailable at lower credit rates (lower 600s and below)	Credit score impacts rates somewhat; may be unavailable at lower credit rates (lower 600s and below)
Eligible Technology	Most energy efficiency measures	Gas heating equipment and associated measures	No limitations	No limitations
Relevant Terms	Max 10-year repayment period; max of $5,000; interest rates expected to be 6.5-6.75%	Max 10-year repayment period, soft max of $10,000, interest rate is 2% above annual prime rate	Terms vary by lender; ECCU offers rates of 9.75% to 19.25%	Terms vary by lender; ECCU offers rates of 4.40% to 5.00%

Comparison of Residential Financing Program Types

This section describes comparative strengths and weaknesses of different residential financing programs based on several metrics, including these:

- **Eligibility limitations.** Some residential energy financing options are limited to homeowners, and others are prohibitively expensive for residents with poor credit.
- **Implementation pathway.** Some financing options (like PACE and on-bill financing) require specific action by state legislators, municipal leaders, or utilities to become available. Other lending options are readily available from commercial lenders.
- **Accessibility.** As can be inferred by eligibility limitations, financing programs may be more or less suitable for different customers. This assessment considers how readily accessible a program is for two types of customers likely to have trouble accessing affordable financing: (1) a low-credit homeowner, and (2) a renter. Residents may not be able to access a particular option

due either to explicit lending rules (such as homeownership requirements), creditworthiness requirements (which make finance expensive for residents with poor credit), or a lack of deliberate program design elements (while some options may be open to renters, they may not provide a long-term profit motivation for renters to participate).

- **Outcomes when a customer moves.** When a home is sold or rented to a new tenant, the obligation to repay financing could either stay with the borrower or stay with the home, depending on the program.
- **Affordability.** While specific lending rates may vary from customer to customer and program to program, some financing pathways may be lower cost than others.
- **Ability to meet financing needs.** Financing programs may have special cost-effectiveness requirements or investment caps that limit the utility of a financing pathway.
- **Utility administrative complexity.** For programs implemented by a utility, these may face varying levels of complexity.

For most of the financing options discussed below, there is ample precedent of prior programs on which to draw conclusions about the above attributes (with lessons about PAYS implementation drawn primarily from the programs implemented in cooperative utility jurisdictions). Residential equipment leasing programs, however, are rare. The discussion of equipment leasing is informed primarily by the ductless heat pump leasing program currently implemented in Vermont by Green Mountain Power.[26]

Table 24compares these attributes for a range of potential financing approaches.

[26] Green Mountain Power. "Ductless Heat Pump." Accessed March 13, 2018. Available at: https://greenmountainpower.com/product/ductless-heat-pump/

Table 24. Comparison of Residential Financing Programs

Program Type	Property Assessed Clean Energy	Equipment Leasing	Non-PAYS On-bill Finance	PAYS
Eligibility Limitations	Limited to homeowners, credit rating of minimal importance. Also limited by municipal action.	Existing programs limited to homeowners, credit rating of minimal importance.	Generally limited to homeowners, measurement of credit-worthiness varies.	Often implemented without credit requirements, designed with value proposition for renters.
Implementation Pathway	Enabling statute passed in Missouri, individual municipalities must adopt.	Existing programs administered by utilities. Administration by third parties is possible.	Utility must administer or partner in program.	Utility must administer or partner in program.
Accessibility to Low-FICO Customers	**Good.** Use of property lien allows for alternative creditworthiness standard.	**Good.** Existing programs do not use credit scores as a leasing criteria.	**Potentially Good.** Utility may choose to rely on bill payment history rather than credit score.	**Good.** Credit score is not considered.
Accessibility to Renters	**Poor.** Renters are not eligible.	**Poor.** Renters are not eligible in existing programs.	**Poor.** Renters are generally not eligible.	**Best.** Renters are eligible and are not exposed to long-term costs.
Outcome When Customer Moves	Obligation stays with home, may be negotiated.	Unclear.	Varies depending on design, loan would likely be settled with home sale.	Obligation stays with home, and paid by new resident.
Affordability	**Okay.** Interest rates vary. Long loan terms reduce monthly payments but increase total interest charges and overall cost of project.	**Varies.** Existing programs have been designed to provide net savings but a direct comparison is difficult.	**Okay.** Programs typically offer moderate interest rates, but there is no restriction on the payment relative to the savings.	**Best**. Program design insures that payments are offset by monthly bill savings, making the investment cash flow positive for the participant.
Ability to Meet Full Financing Needs	**Best.** Reasonable borrowing and cost-effectiveness requirements often in place.	**Okay.** Equipment such as heat pumps could be viable for lease. Weatherization measures likely not viable for leasing models	**Good.** Reasonable borrowing and cost-effectiveness requirements often in place.	**Okay.** Subject to strict bill savings to cost requirements that protect the participant, but that may limit financeable amount.
Utility Administrative Complexity	**None**	**High,** including customer outreach and leasing agreements (assuming a utility-administered programs)	**Moderate,** including customer outreach and loan servicing.	**High,** including customer outreach, loan servicing, and additional requirements on project approval and administration

As made clear in the prior table, all solutions require tradeoffs. The goal of a utility-administered financing program is not to increase use of financing, rather to make financing more available as a tool to increase uptake of energy efficiency measures. Therefore, these programs are most effective when targeting a specific market segment with poor access to commercial financing or other programs. Homeowners with poor credit generally face high financing costs in the market, and renters are generally unable to access financing for their own energy improvements (because they are both unable to access home equity lending and because they lack the long-term guarantee of residency and associated energy savings needed for unsecured lending).

All of the programs noted offer a solution to the barrier to financing access posed by credit score. These program models can use alternative measures of creditworthiness (such as a reliable history of property tax and utility bill payments, or liens on real property or equipment) to enable able broader access to financing. Affordability varies across program models. Though not seeking a profit, programs generally need to recoup their costs through interest rates and fees. Because programs rarely have access to the most affordable capital, and because the financing volume is much smaller than what commercial lenders might see, these programs rarely offer the most affordable rates available in the market. However, for people who do not have access to the most affordable rates (especially those with poor credit), a dedicated energy efficiency financing program can be the only accessible, affordable option.

Renters are the market segment most often poorly served by financing programs. All models reviewed except PAYS are generally available to property owners only. PAYS is the only option that directly overcomes the split incentive problem in the rental market, by tying the tariffed repayment obligation to the meter rather than the borrower. Compared to other options, PAYS offers broader access to energy improvements, but comes at the cost of administrative complexity for utilities, and potential issues regarding turnover in housing and rental stock due to the tariff obligation. The PAYS model requires that the expected monthly customer tariffed charge be less than the value of expected monthly bill savings (typically yielding a net savings of 10 to 20%). This limits the measures that can be financed through the program without a co-payment, especially compared to non-utility programs that may have no energy-saving or cost-effectiveness requirements. As a result, PAYS participants are more likely to face higher up-front costs than borrowers in other financing programs (because of a required co-payment), but are also more likely to experience net energy savings.

The ability of the program to finance a broad array of measures, and to remove the entire up-front cost, for those measures, is an important factor for borrowers. PACE has the best ability to provide a large amount of financing, since the amount is based on the value of the property. Since PACE is not administered by utilities, and no regulatory energy savings requirements apply, it's also typically the least restrictive in terms of the measures that can be installed. Leasing programs in the residential sector are restricted to equipment that, in theory, could be repossessed in the event of default. Measures like insulation and air-sealing therefore would be ineligible. On-bill financing programs can be designed to allow a small amount of financing for non-energy saving improvements, but overall the program must drive enough energy savings to meet cost-effectiveness requirements. But the financing can be structured to cover the up-front cost for all eligible measures.

PAYS is the only program in our comparison that is not able to finance the full up-front cost for most measures that otherwise might be eligible. However, PAYS is able to finance the full up-front cost for the highest-saving, most cost-effective measures. An important factor to consider in this regard is that the PAYS program is structured to assure the borrower that the payments for the amount of money being financed will be offset by the bill savings from the equipment installed. While this type of assurance could be integrated into the other program models, it typically is not.

A final dimension to consider is the trade-off between the effectiveness of the program on measure uptake and the utility's administrative burden. For PACE, this is a null argument, since a utility has no ability to offer PACE on its own. PACE requires local government sponsorship, and is tied to local government jurisdictions rather than the utility jurisdiction. In Missouri, PACE has been enabled by state statute, but few municipalities offer PACE across the state. Leasing and on-bill financing are program models open to utilities.

Both external interviewees noted that PAYS expanded the impact of energy efficiency programs (in the case of Roanoke's program, providing a dramatic improvement over a prior utility on-bill financing program), but required a greater degree of administrative involvement and longer-term obligations for the utility than other programs.

Customer Needs and Motivation

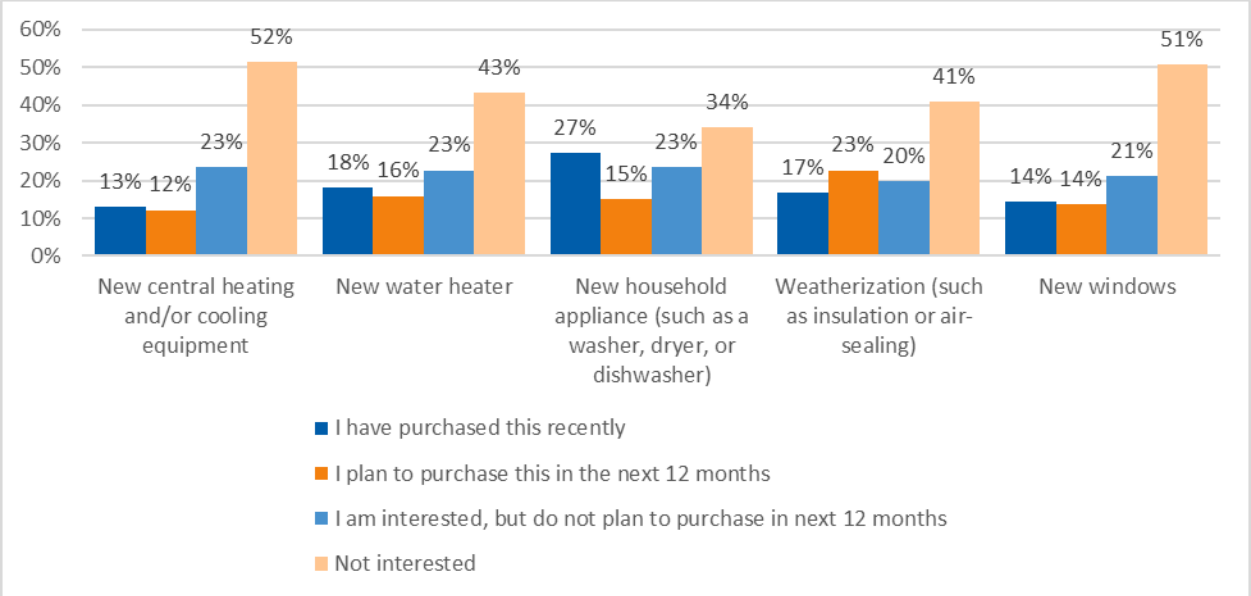
PAYS is intended to remove a financing barrier for residential customers, allowing greater uptake of energy efficiency measures. It is therefore important for Empire to understand the degree to which financing is in fact a barrier for their customers. Cadmus conducted an online survey with 210 residential customers in Empire's service territory to collect information on how they use financing, whether financing has the potential to increase energy efficiency savings, and customer attitudes towards financing in general and key characteristics of PAYS financing.

General Financing Needs and Awareness

The survey asked homeowners and renters about common energy upgrades they may have recently completed, or be interested in completing. Responses to these questions illustrate the role currently available financing plays in driving energy efficiency upgrades. Respondents who indicated no recent installations and no interest in any of the measures were terminated from the survey. This ensured that only respondents that were interested in efficiency improvements - and therefore were more likely to have recently considered their financial resources and options - answered the financial questions.

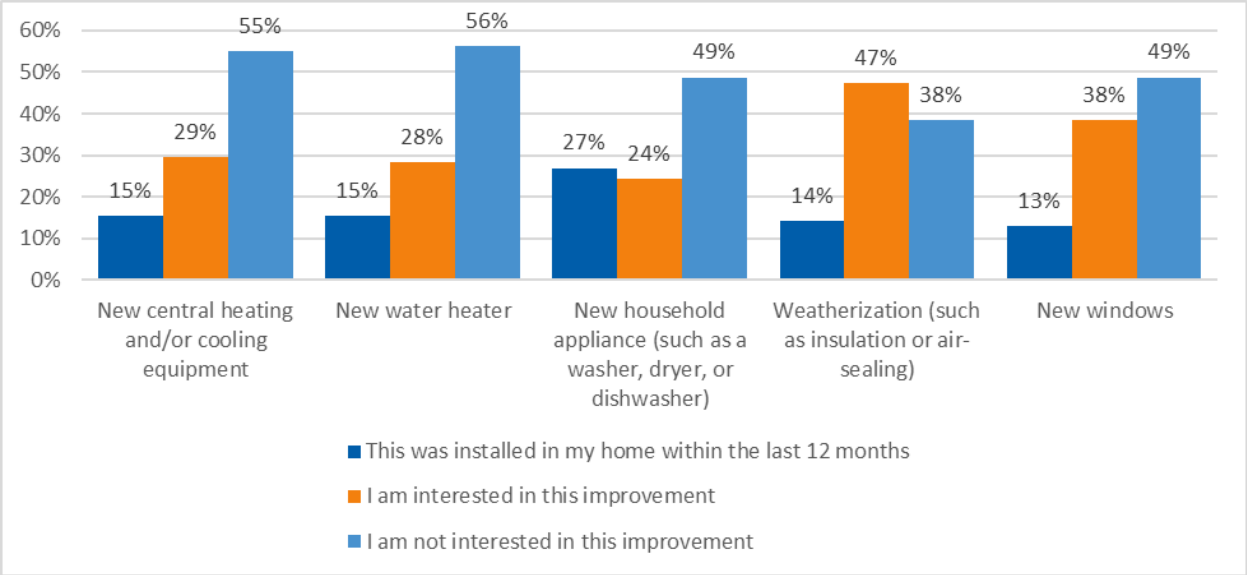
Figure 5 shows the rate of recent installation, or interest in installing, select common measures for homeowners. Household appliances were the top home improvement investment reported by homeowners, with 27% of respondents reporting that they had recently purchased a home appliance. A majority of homeowners expressed interest in or had recently invested in a new water heater, new household appliance, or weatherization. A slight majority of respondents expressed that they were not interested in new central heating and/or cooling equipment or new windows.

Figure 5. Homeowner Interest in Energy Efficiency Upgrades (n=132)



Cadmus asked renters about their interest in making energy efficiency upgrades to their home. As shown in Figure 6, weatherization (47%) and new windows (38%) garnered more interest from renters than the other efficiency upgrades presented. Of the 66 renters that indicated an improvement had recently been made, 27% paid for the improvement themselves.

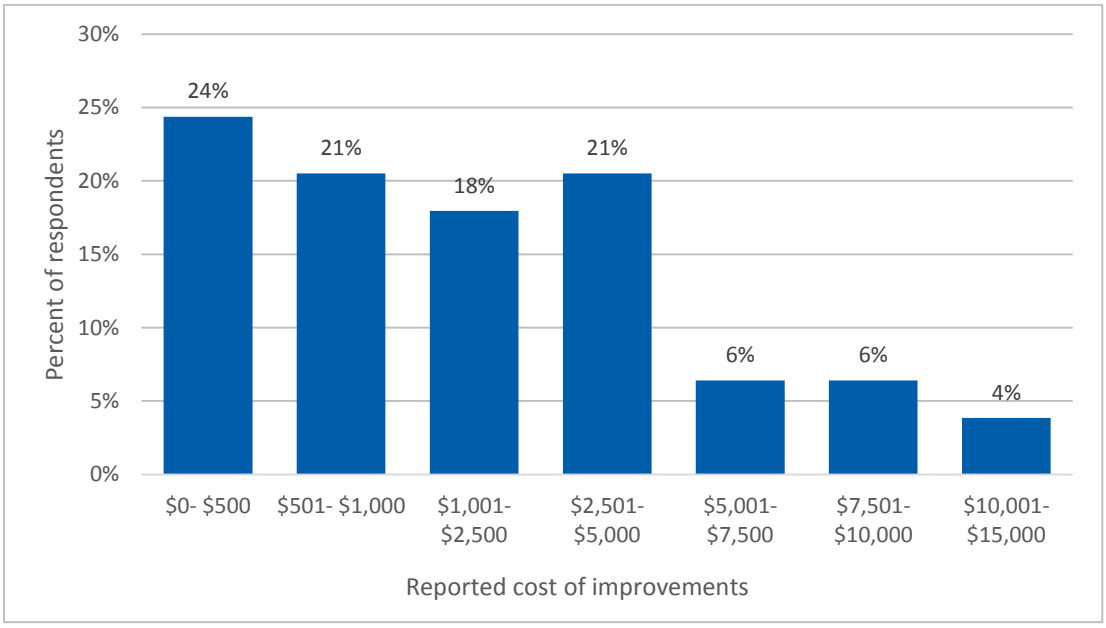
Figure 6. Renter interest in energy efficiency upgrades (n=78)



Sixty-six homeowners and 16 renters had recently purchased energy efficiency equipment or improvements. About half of the completed projects had a total cost over $1,000. Fifty-five percent of respondents reported spending more than $1,000 on their recent energy-related purchases, and 16%

reported spending more than $5,000 on recent upgrades. Figure 7 shows the frequency of projects by price range.

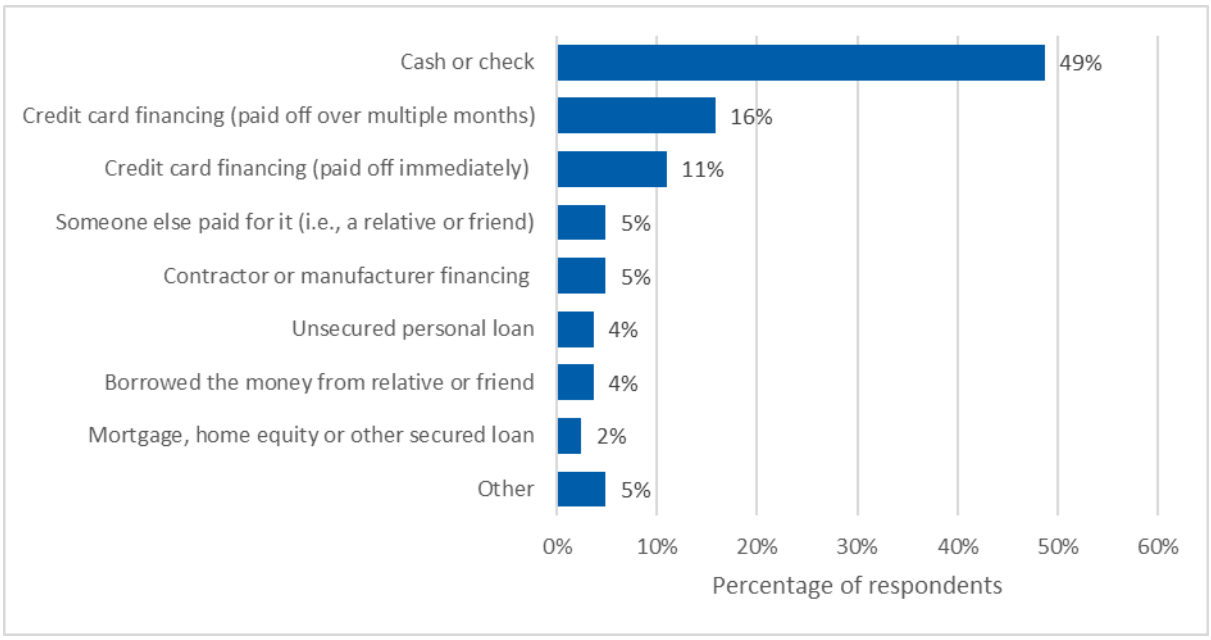
Figure 7. Reported Cost of Improvements Installed (n=78)



Need and Access to Financing for Home Improvements

Among respondents who had recently invested in an energy efficiency upgrade in their home, cash or check was the primary payment method used, followed by credit card financing, while a small share used a personal loan or other form of financing (Figure 8). Sixty-five percent made an immediate payment (paid cash, used credit card financing paid off immediately, or had someone else pay) to pay for their recent upgrades, and 30% used longer-term financing (including credit card financing paid off over time, contractor or manufacturer financing, unsecured loans, borrowing the money from a relative or friend, or a mortgage or home equity loan).

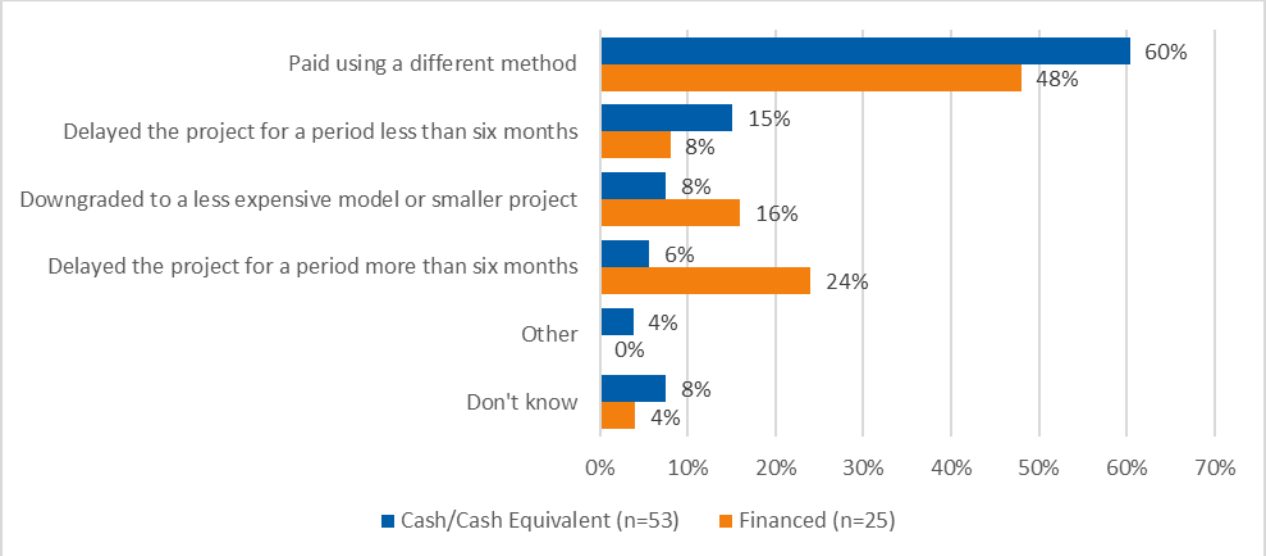
Figure 8. How respondents paid for recent energy efficiency upgrades (n=82)



Percentages may not match text exactly due to rounding.

When asked how they would have paid if the option they used had not been available to them, most respondents said they would have simply used a different payment method and made the purchase at the same time. However, 28% of those that paid with cash or a cash equivalent said they would have either delayed or downgraded the project, compared to 48% of those that used some type of long-term financing (Figure 9). This indicates a potential barrier to accessible financing for some customers.

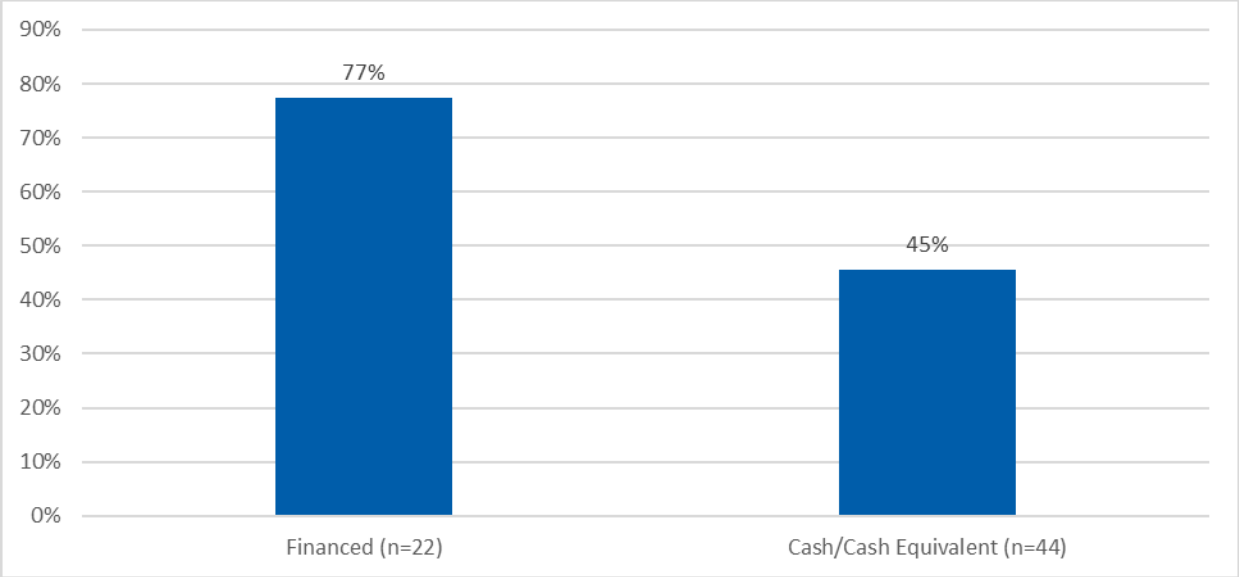
Figure 9. Respondents' payment choices if first option not available



Overall, 57% (n=78) of respondents that had completed a purchase reported that they would have considered a higher efficiency model than what they purchased had easier, more affordable financing

been available. Respondents that had used financing were more likely to state they would have upgraded to a high efficiency unit if easier, more affordable financing were available than those that used cash or a cash equivalent as shown in (Figure 10).

Figure 10. Would have purchased a higher efficiency model if easier, more affordable financing were available



As shown in Table 25, among those who used cash or a cash equivalent, the primary reasons reported for not using financing were that they had the cash available, and that they choose to avoid financing if possible. (Note that Cadmus considered using a credit card in order to get reward points, and then paying it off immediately, to be a cash-equivalent method of payment).

Table 25. Reasons for Not Using Financing to Pay for Energy Efficiency Upgrades (n=55)

Answer	%
I had the cash available	53%
I don't like to use financing unless I have to	29%
I wanted the credit card reward (i.e., bonus points or cash back)	7%
I don't think it was a big enough purchase to need to finance it	5%
Financing was too much hassle/cash was easiest option	4%
I wasn't sure I could qualify for financing	2%
Total	**100%**

Among those who did use financing, the primary reasons provided by respondents were that they did not have access to the entire amount in cash, and that they wanted to take advantage of a low interest rate available to them (Table 26).

Table 26. Reasons for Using Financing to Pay for Energy Efficiency Upgrades (n=27)

Answer	%
Did not have the entire amount available in cash	48%
Wanted to take advantage of an attractive interest rate offer	30%
Wanted to preserve cash savings	11%
Wanted to include as part of a new home purchase or mortgage refinancing	7%
Wanted the credit card reward (I.e., bonus points or cash back)	4%
Total	**100%**

Customer Familiarity with Different Types of Financing and Frequency of Use

As shown in Figure 11 and Figure 12, the survey asked respondents (renters and homeowners) about their familiarity and use of different traditional, private-sector options for financing larger home purchases. Homeowners were most likely (60%) to have used credit card financing at least once, followed by an unsecured personal loan. A similar number of homeowners had used unsecured financing (34%) or secured financing (31%), though homeowners were more likely to have used unsecured lending more than once. Contractor and manufacturer financing was the least well known type of financing, with nearly half of homeowners (48%) not sure of what it was or generally unfamiliar with how it works. Only 47% of renters had used credit card financing, while 46% had used unsecured financing. Like homeowners, renters were least likely to have used or be familiar with contractor or manufacturer financing, with 65% of renters saying they had no familiarity with this type of financing.

Figure 11. Homeowners' familiarity with different types of financing (n=124)

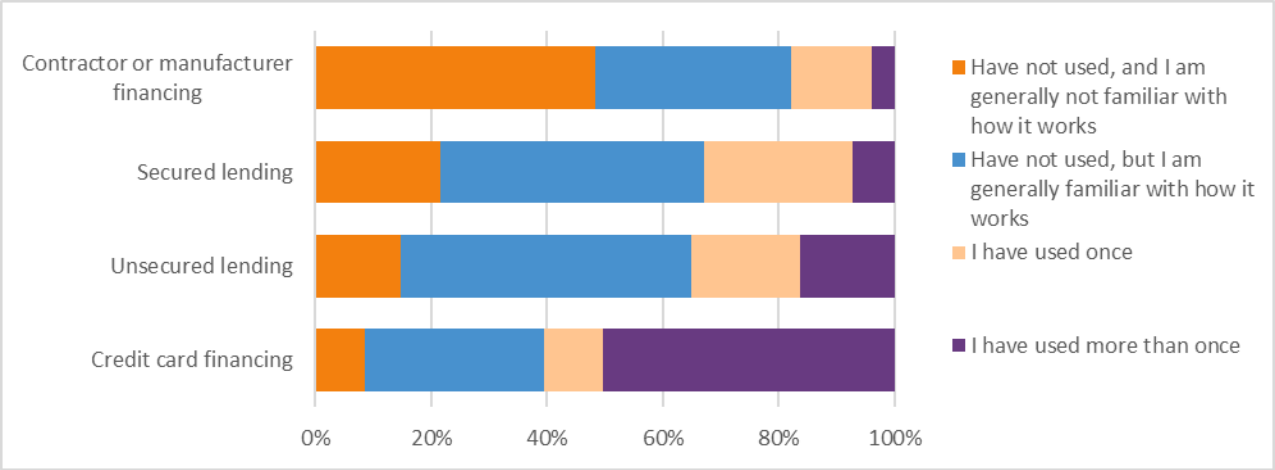
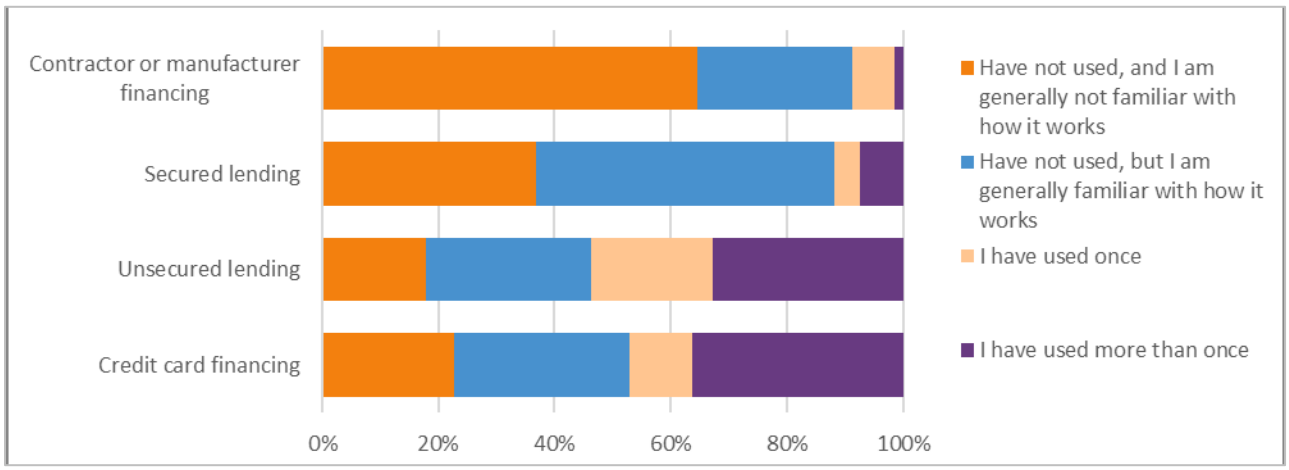


Figure 12. Renters' familiarity with different types of financing (n=66)



Customer Barriers to Uptake of Higher Efficiency CACs and Heat Pumps

The survey asked both homeowners and renters to imagine they needed to make a large-scale improvement for a total cost of about $5,000, and then asked them to rank their level of concern with several potential issues. As shown in Table 27, a majority of respondents cited two key investment barriers: not having sufficient cash to pay up front (69% rating as a 4 or a 5, with 5 being a very significant concern) and high interest rates (69% rating as a 4 or a 5). Customers also expressed concerns about not being able to qualify for a loan (46% rating as a 4 or a 5), not knowing their financing options (39% rating as a 4 or a 5), being unsure if they would be in their home long enough (35% rating as a 4 or a 5), and being unsure about being able to make regular monthly payments (33% rating as a 4 or a 5). (Percentages in the table may not match text due to rounding.)

Table 27. Reported Barriers to Large-Scale Purchase (n=98)

Potential Barrier	1 (Not A Concern)	2	3	4	5 (Very Significant Concern)
I don't have enough cash on hand right now to pay for this	15%	1%	15%	18%	50%
The interest rate I will have to pay may be too high	14%	5%	11%	25%	44%
I may not qualify for a loan	39%	7%	8%	13%	33%
I don't know if I'll live in my home long enough for a large purchase to be worthwhile	43%	13%	9%	9%	26%
I may not be able to manage regular monthly payments	38%	11%	18%	10%	22%
I rent or otherwise don't have full control over these decisions in my home	59%	6%	8%	5%	21%
I don't know of a contractor who can install this improvement	37%	11%	23%	9%	21%
I don't know what financing options are available	26%	9%	26%	19%	20%
Getting affordable financing will take too long and be a hassle	40%	11%	22%	10%	16%
I own my home, but don't have enough equity for a second mortgage or home equity loan	65%	7%	4%	10%	13%

Certain barriers stood out among low-income and renter respondents. Forty-six percent of low-income respondents rated not knowing what financing options are available a 4 or 5, compared to only 28% of higher-income respondents. Sixty-three percent of renters rated not qualifying for a loan a 4 or 5 compared to 37% of homeowners, while 54% of low-income respondents gave this concern a 4 or 5 compared to 33% of higher-income respondents. Renting or otherwise not having full control over these decisions in their homes was a *somewhat* or *very significant* concern for 43% of renters.

Assessment of Market Response to PAYS

The survey asked respondents a series of hypothetical questions to test their response to various aspects of PAYS. Because PAYS is a little-known program design, in some cases questions were necessarily complex. All scenarios reflected the savings, costs, and maximum potential of PAYS financing from the measure-level analysis.

Willingness to Accept Tariffs and Copayment

To understand homeowners' willingness to accept the terms of the PAYS model, including the tariff and copayment, the survey presented hypothetical scenarios regarding replacing respondents' heating and cooling system. In each scenario, Cadmus varied the available rebate and financing offers from the utility, and presented the total up-front cost, total rebate, total financing, monthly payment, and monthly savings for the utility offer, as well as the total cost for a baseline alternative. Cadmus used the costs and savings from the measure analysis to develop the scenarios.

Through Scenarios A and B, Cadmus tested the potential for a modest amount of PAYS financing, in addition to a rebate, to make an energy efficiency option more attractive. In both scenarios, the survey asked respondents to imagine that their heating and cooling system had failed and needed to be replaced. They were then asked to choose between a standard efficiency system that cost $3,500 and a new high-efficiency system that cost $5,000. The scenarios provided in the survey deliberately made the description of the system fuel-neutral to elicit responses from all respondents regardless of their heating fuel. The costs were based on the full measure cost for a new standard efficiency furnace and CAC or a new high-efficiency heat pump.

In Scenario A, the utility offers a $300 rebate for the new high-efficiency system, and the customer pays $4,700 out of pocket. In Scenario B, the utility offers a $300 rebate for the new system and finances a small amount ($300) through a PAYS tariff, and the customer pays $4,400 out of pocket. The monthly savings is $3, and the tariff amount is $2.66.

As shown in Table 28, the majority of respondents (61%) either selected the standard system or indicated they weren't sure. A substantial minority (38%) selected the high-efficiency option plus the utility rebate, while one respondent selected the high-efficiency option but rejected the rebate.

Table 28. Responses to Scenario A (n=132)

Option	%
Standard-efficiency system for $3,500	40%
High-efficiency system for $5,000, minus a $300 rebate	38%
High-efficiency system for $5,000, but I wouldn't use the rebate	1%
I'm not sure	21%
Grand Total	**100%**

Scenario B changed the scenario by adding a small amount of PAYS financing ($300), in addition to the rebate. (The amount of financing was dictated by the measure analysis, which indicated in a replace on failure scenario, PAYS could cover that amount of the cost of a new high-efficiency ASHP.) The survey only presented Scenario B to the 61% of respondents that were not convinced to purchase a high-efficiency system by Scenario A (i.e., those who selected the standard system or said they weren't sure). Table 29 shows that, among those who chose either the standard efficiency option or said they weren't sure in response to Scenario A, 11% chose the high efficiency option after PAYS was added in Scenario B.

Table 29. Response to Scenario B by "Unconvinced" Respondents (n=81)

Option	%
Standard-efficiency system for $3,500	59%
High-efficiency system for $5,000, minus a $300 rebate, plus $300 on-bill financing	11%
High-efficiency system for $5,000, but I wouldn't use the utility offer	5%
I'm not sure	25%
Total	**100%**

PAYS programs are not typically used to offer a small amount of financing. Cadmus also tested the response to PAYS scenarios that were more like the PAYS programs implemented in other jurisdictions and reflective of the measure analysis. The survey asked respondents to consider two scenarios where PAYS financing could cover either half or all of the proposed measures to be installed (Scenarios C and D).

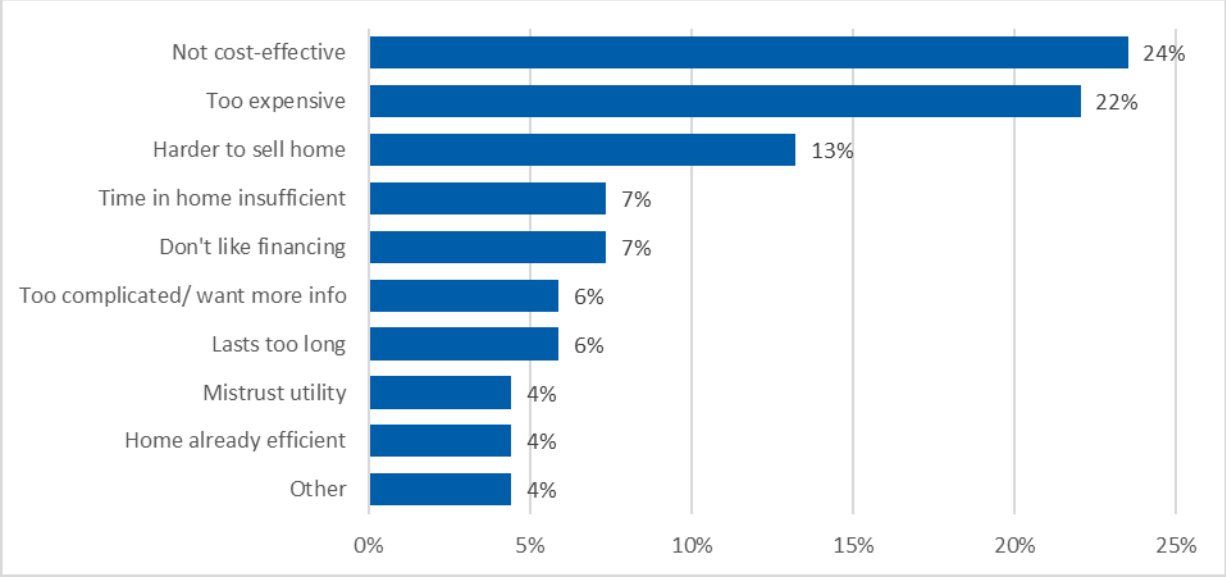
In Scenario C, respondents are asked to again imagine their heating and cooling system needs to be replaced. They still have the option of the standard system with no rebate and no savings, at a cost of $3,500. On the other hand, if the customer is willing to install a high-efficiency heating and cooling system, seal and insulate their attic, and make some other small improvements, the utility will finance half the amount on the utility bill. The total cost of the project is $9,000. The utility will finance $4,500, and the customer will pay $4,500 up front. The customer will save $45 dollars a month, in addition to enjoying increased home comfort from the improvement, and pay a $35 per month tariff for 15 years to cover the financed amount. Twenty-three percent of respondents indicated they would use the utility offer, as shown in Table 30.

Table 30. Response to Scenario C (n=132)

Option	%
Standard efficiency system for $3,500, with no other improvements	42%
All items recommended by the utility for $4,500 up front, and $4,500 financed on my utility bill	23%
High efficiency system for $5,000, with no other improvements and no assistance from the utility	9%
I'm not sure	26%
Total	**100%**

When asked why they did not choose the utility offer in Scenario C, respondents had a variety of responses, most of which had to do with the financial return on the project.

Figure 13. Reasons for Not Choosing Utility Offer in Scenario C (n=68)



In Scenario D, the survey presented an early replacement scenario, in which the utility would replace working heating and cooling equipment. The utility offers to replace their existing system with a high-efficiency system, a $5,000 value, and to finance the full cost of the upgrade on the utility bill. The utility estimates savings of $100 per month relative to the old working system and will charge a tariff of $50 per month for 10 years to recover the financing. The scenario also notes that if the respondent moves, the tariff will transfer to the next owner. Table 31 summarizes the terms of this scenario.

Table 31. Utility Financing Offer to Replace Working Heating and Cooling System

Category	Value
Utility financing	$5,000
Customer up-front cost	$0
Monthly energy savings	$100
Monthly charge	$50
Net monthly savings	$50

The alternative choice in this scenario is to do nothing, and so the survey asked the likelihood that the respondent would act on the utility offer. With this early replacement scenario, about two thirds of respondents (67%) said they would be *very* or *somewhat likely* to opt for this financing option, even if their current heating and cooling system was still working (Table 32).

Table 32. Likelihood to Accept Working HVAC Replacement Plus PAYS Financing (n=132)

Answer	%
Very likely	34%
Somewhat likely	34%
Not too likely	16%
Not at all likely	16%
Total	**100%**

To understand renters' perception of tariffed on-bill financing, the survey asked renter respondents how likely they would be to utilize a hypothetical offer from the utility. The offer included air-sealing and insulation improvements that the utility would finance up to $1,500, which would be repaid as a line item on the utility bill. The improvements would reduce their energy costs by $20 per month, with a $15 tariff for up to 12 years, for a net monthly saving of $5. Participants would be required to pay $500 up front to participate in the program. Even with a $500 copay, a majority (59.2%) of renter respondents said they would be *very* or *somewhat likely* to participate in the program (Table 33).

Table 33. Renters' Likelihood to Participate in Tariffed On-Bill Financing Program with Copay

Answer	%
Very likely	15%
Somewhat likely	44%
Not too likely	18%
Not at all likely	23%
Total	**100%**

Themes emerged among those who said they would not be likely to participate, including not being able to afford the up-front copay, a belief that the savings would not repay the up-front cost, a concern that renters would not be able to make those investments, and a feeling that those investments should be the landlord's responsibility.

Willingness to Move into a Residence with Efficiency Improvements and a Tariff

To understand respondents' willingness to buy a home with efficiency improvements and a tariff, the survey asked homeowners to express their likelihood of purchasing a home where efficiency improvements installed previously yielded $100 per month energy savings, an $80 per month tariff, and $20 of net monthly energy savings. Respondents were evenly split between being more or less likely to purchase the home, while 36% were not influenced either way (Table 34).

Table 34. Homeowners' Likelihood to Buy a Home with a Tariff

Answer	%
More Likely	32%
No Change	36%
Less Likely	32%
Total	**100%**

To understand renters' willingness to move into a home with efficiency improvements and a tariff, the survey asked renter respondents to express their likelihood of renting a home where efficiency improvements installed previously yielded different levels of monthly savings (Table 35).

Table 35. Renter Scenarios for Renting a Home with a Pre-existing Tariff

	Scenario E	Scenario F
Monthly energy savings	$10	$100
Monthly charge	$8	$80
Net savings	**$2**	**$20**

As shown in Table 36, overall, a higher share of renter respondents said that they would be more likely to move into a home with a pre-existing tariff and energy efficiency investments. For the lesser savings Scenario E, 40% of renters said they would be more likely to rent the apartment, while a majority (54%) said they would be more likely to opt for the apartment in Scenario F where they would see greater monthly savings. In both cases, a small minority (12% to 13%) said they would be less likely to rent the apartment, a much smaller share than homeowner respondents.

Table 36. Renters' Likelihood to Rent a Home with a Tariff (n=68)

Answer	Scenario E	Scenario F
More Likely	40%	54%
No Change	47%	34%
Less Likely	13%	12%
Total	**100%**	**100%**

Among those who responded that they would be less likely to rent or that their likelihood to rent would not change, the primary reasons included that the savings amount did not seem significant, they were not comfortable with financing, they felt the landlord should make the investment instead, and they were uncertain if the savings would materialize.

Willingness to Pay Interest

To gauge customers' willingness to pay interest, the survey presented different interest rates and asked respondents whether they would be more likely to pay up front or finance a large home improvement at that rate. As shown in Table 37, the majority of respondents (53%) said they would be more To gauge customers' willingness to pay interest, the survey presented different interest rates and asked

respondents whether they would be more likely to pay up front or finance a large home improvement at that rate.

Table 37. Respondents' willingness to pay interest (n=210)

Interest rate	More Likely to Pay Cash or Check	More Likely to Finance	I don't know
0%	23%	63%	14%
3%	31%	53%	16%
5%	39%	35%	26%
8%	50%	23%	26%
10%	56%	19%	26%

Customer Demographics

The following figures provide a general demographic breakdown of survey respondents, with a comparison to demographic data available from the American Community Survey (ACS) for the area served by Empire or data available from the U.S. Energy Information Administration's Residential Energy Consumption Survey (EIA RECS).[27,28]

Nearly two-thirds of the respondents surveyed were homeowners (Table 38). This aligns well with the ACS data for the area.

Table 38. Homeownership status

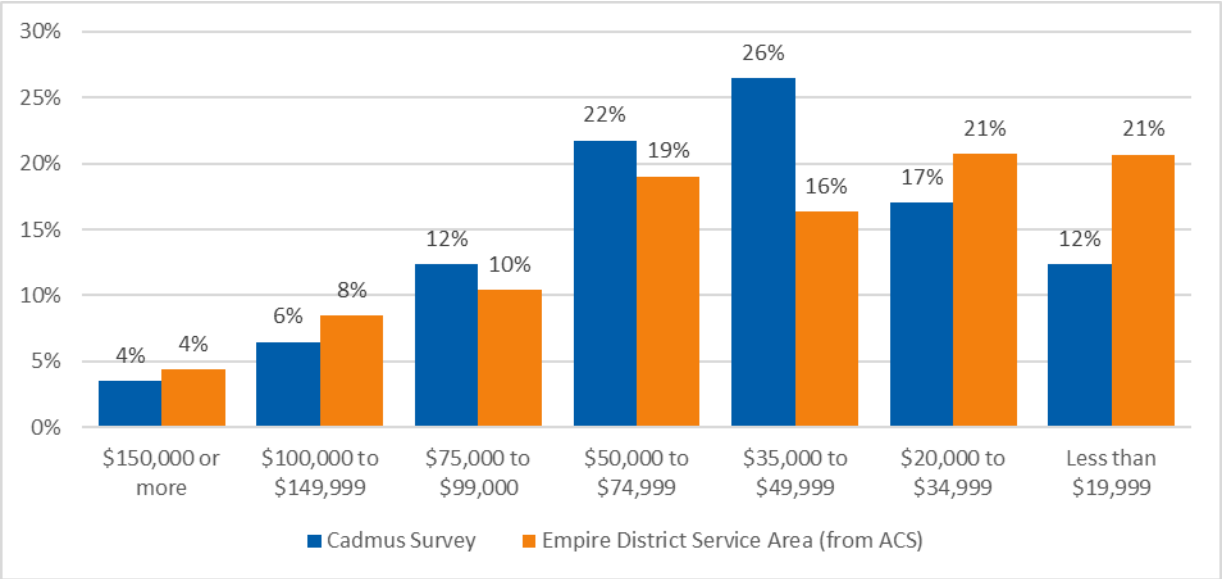
Category	Cadmus Survey	Empire Service Area (from ACS)
Homeowners	63%	65%
Renters	37%	35%
Total	**100%**	**100%**

As illustrated in Figure 14, 56% of respondents reported household incomes of less than $50,000. This compares to 58% of Empire's overall customer base as collected from census data, though the presence of very low-income residents (less than $20,000) was underrepresented in the survey.

[27] For this comparison, Cadmus collected aggregate demographic information for the sixteen counties included in Empire's service area, though Empire does not serve all of these counties in their entirety. Data was collected from the US Census Bureau's American Community Survey, 2015 5-year estimates.

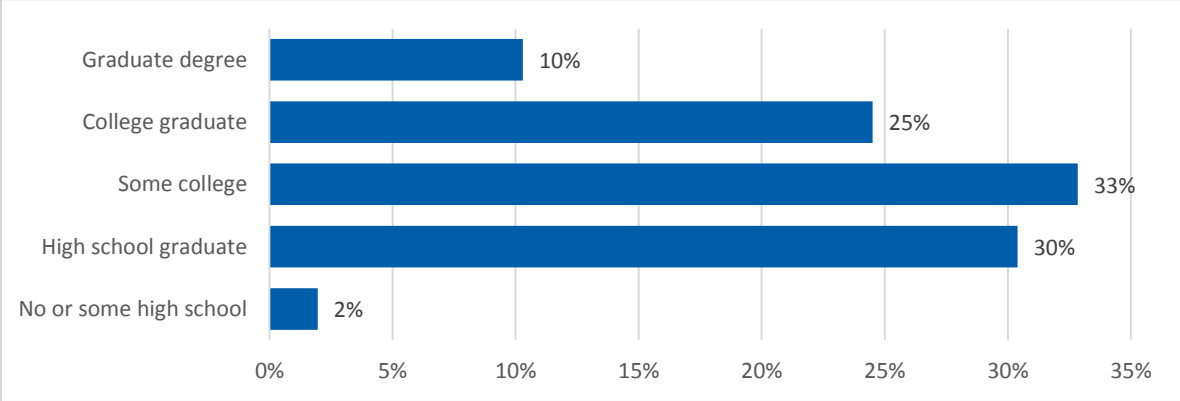
[28] US Energy Information Administration. "Residential Energy Consumption Survey." Available at: https://www.eia.gov/consumption/residential/

Figure 14. Household Income Distribution



The Cadmus survey sample had slightly higher levels of education than the best available comparable census data for Empire's service area, with 98% completing high school and 35% completing college (Figure 15). In comparison, according to the census data, 90% of Joplin, Missouri residents over 25 years of age hold a high school degree or higher, and 25% hold a bachelor's degree or higher.

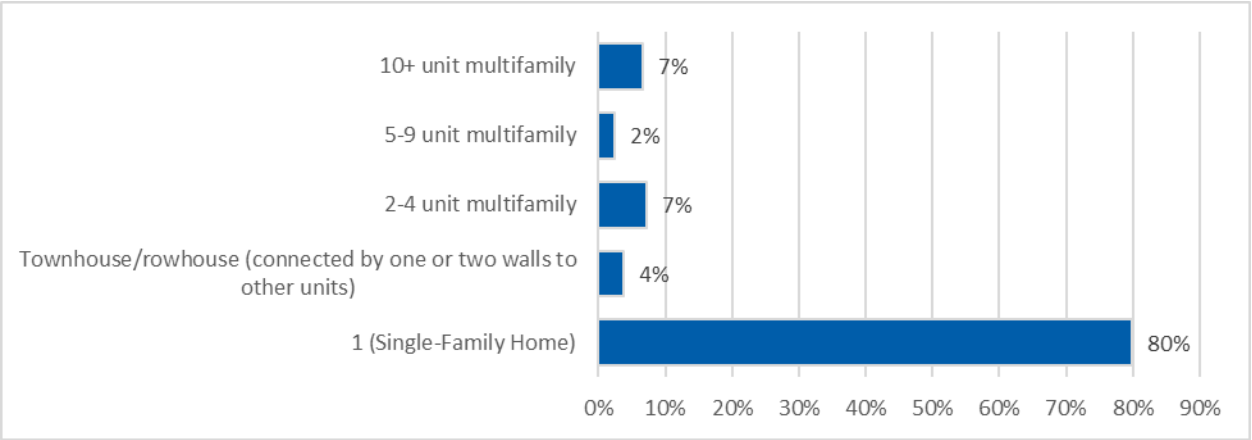
Figure 15. Education Levels of Cadmus Survey



Housing Type

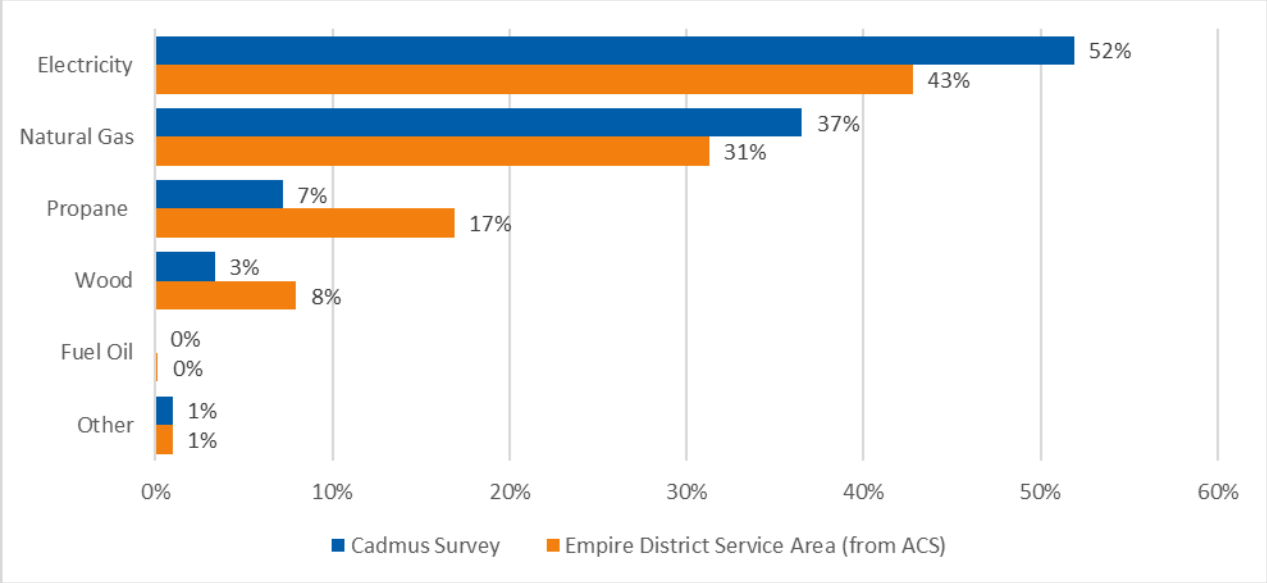
The survey asked respondents several questions about the housing unit they owned or rented. This included information about their heating and cooling systems and any efficiency investments they were aware of. The majority of respondents (80%) reported living in single-family homes (Figure 16).

Figure 16. Distribution of Housing Types in Cadmus Survey



For heating, just over half (52%) of respondents reported using electric heat, while 37% reported using natural gas heat (Figure 17). These percentages are broadly in line with those reported in the ACS data for Empire's service territory though the share of electric heat was greater in the survey population. According to the ACS data, 43% of the households in the sixteen-county area served by Empire (excluding Springfield) are primarily heated by electricity, with 31% served by natural gas, 17% by propane, and most of the remainder by wood.

Figure 17. Distribution of Home Heating Fuels in Cadmus Survey and Empire Service Area



As shown in Figure 18, nearly half of respondents reported using a furnace (either natural gas or electric) for heat, while just under 30% reported using a heat pump, and roughly 10% reported using electric resistance heating. While specific data on heating equipment types was not available for Empire's

service area, the EIA RECS survey estimates that roughly 40% of homes heated by electricity in the mixed-humid climate zone that includes southern Missouri use an air source heat pump, with a slight majority of homes using electricity heated by less efficient electric furnaces or baseboard electric resistance heat (Figure 19).

Figure 18. Distribution of Home Heating Technologies in Customer Sample

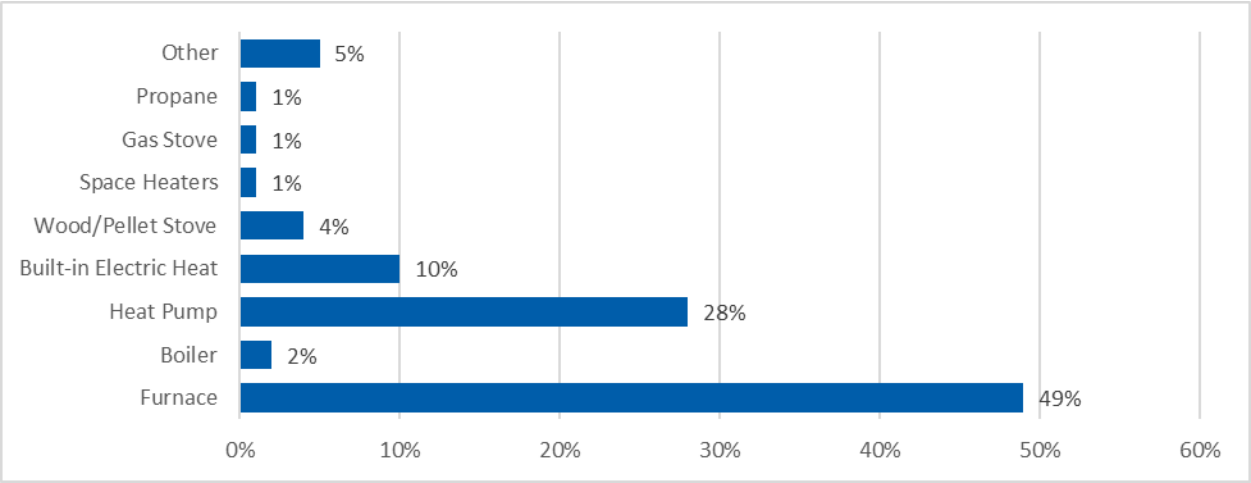
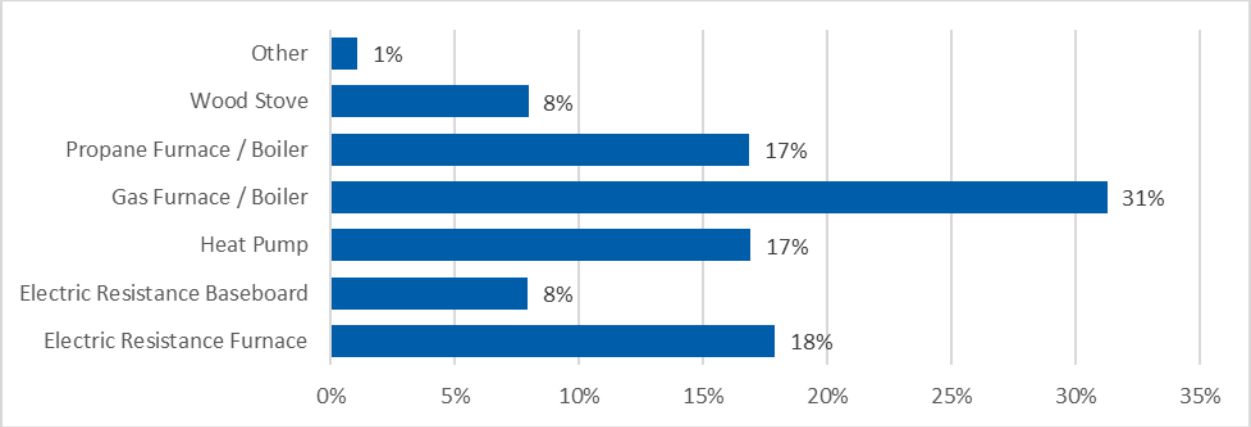
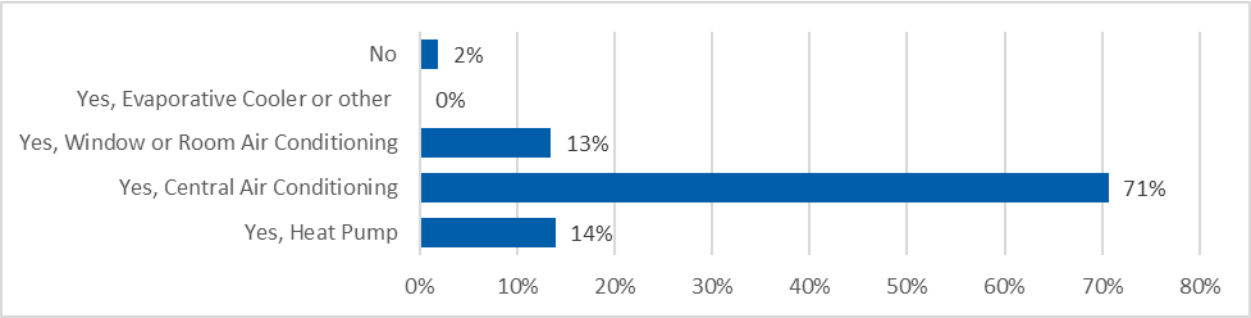


Figure 19. Distribution of Home Heating Technologies in EIA Mixed-Humid Climate Zone



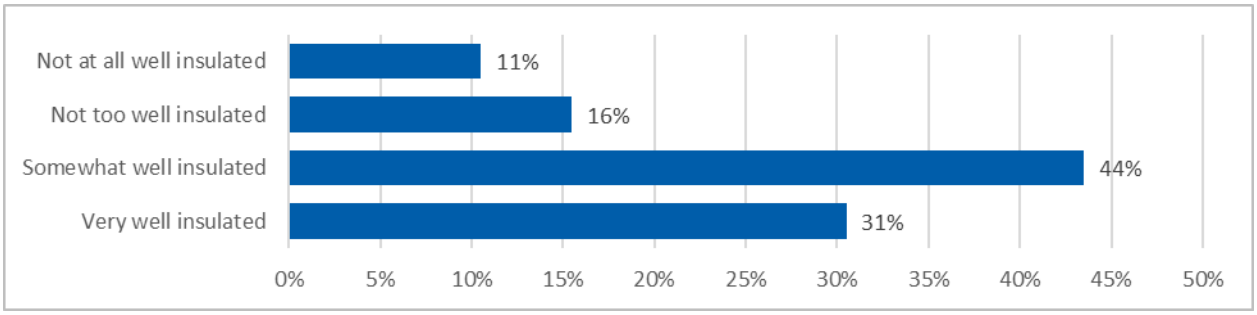
As shown in Figure 20, a majority (71%) reported using CAC, with the remainder roughly evenly split between respondents using room air conditioners and ASHPs for cooling. Only 2% of respondents reported having no air conditioning.

Figure 20. Distribution of Home Cooling Technologies in Cadmus Survey



A minority (27%) of respondents reported that their homes were *not too well insulated* or *not at all well insulated.* Twenty-eight percent of low-income respondents said their homes were *not well insulated* compared to 20% of higher-income respondents (Figure 21).

Figure 21. Distribution of Reported Home Insulation Levels in Cadmus Survey



Finally, most renters (90%) reported that they pay their electric bill directly, with only 10% reporting that this was included in their rent or paid in another way.

Conclusions and Recommendations

Based on the study findings, Cadmus concludes that a PAYS program is feasible for Empire. The specific conditions under which PAYS would be feasible are described in the following conclusions and recommendations.

Financial Analysis and Cost-effectiveness

The best measures for an Empire PAYS program are air source heat pumps, or a whole home package of measures that includes an air source heat pump, installed in all-electric homes in an early replacement scenario. ASHPs and the whole-home packages of measures provide sufficient savings that a PAYS tariff can be reduced from the maximum amount allowed by the PAYS design, and collected for a shorter time, and still cover the full cost of the measure without a customer co-payment. HPWHs are also potential candidates for a PAYS program, with savings that allow for 81% of the measures cost (for an ROF scenario) or 87% of the measure cost (for an ER scenario) to be financed. Other measures that provide enough savings for PAYS to cover 50% of the measure cost or more, are not expensive enough on their own to typically warrant financing. However, several of these measures, including attic insulation and air sealing, are highly cost-effective, and can be packaged with an ER ASHP to provide maximum bill savings.

Based on preliminary cost estimates, we found the PAYS program can be cost-effective at a modest level of participation. A program based on the three measures above (45% ASHP, 45% standard whole home package, and 10% HPWH), and a NTG ratio of 0.62, which may be overly conservative for an early replacement program, is cost effective (TRC of 1) at 70 participants.

Recommendation: If implementing a PAYS program in Empire's service territory, target the replacement of working heating and cooling equipment in all-electric homes with electric resistance heating. Do this by focusing on ASHPs, either on their own or as part of a whole-home package of upgrades, to achieve a cost-effectiveness ratio above 1. The early replacement of an ASHP in an all-electric home provides a significant cushion of savings that can compensate for the installation of a range of measures with only borderline savings-to-cost ratios, and for unforeseen program administration costs.

Customer rate sensitivity analysis shows that rates designed to encourage energy efficiency among customers tend to reduce the feasibility of PAYS, while the rate designed to remove the disincentive for utilities to pursue greater energy efficiency makes PAYS more feasible. The existing rate structure also may improve the feasibility of PAYS.

Recommendation: Empire should consider potential energy efficiency program such as PAYS, and potential rate changes designed to promote energy efficiency, holistically. Empire staff should consider the interactions of different programs and policies, to determine the optimal approach to reducing energy consumption while minimizing the impact on ratepayers.

Market Research Considerations

Based on the financing gap analysis, interviews, and secondary research, Cadmus drew several conclusions about the need for and design of a PAYS program in Empire's service territory.

More research should be done on identifying sources of capital for PAYS and the legal viability of a tariff tied to the meter. Based on the experience of other PAYS administrators, the primary obstacles to setting up a PAYS program are obtaining capital and ensuring there were no legal concerns related to the PAYS program design, especially the requirement that the tariff be tied to the meter. Cadmus was not able to confirm through this study whether there are legal or regulatory prohibitions on tying the tariff to the meter in Missouri.

Recommendation: Empire's legal counsel should thoroughly review the PAYS program design and discuss the potential legal and regulatory implications with the Missouri Public Service Commission prior to investing in detailed program design or other aspects of program set up.

A PAYS program appears to be the best program model to remove financing-related barriers to making energy efficiency upgrades in rental housing, due to the tied-to-the-meter feature. It is also a good option for customers with poor credit and customers who are very concerned about the cost of financing, because it only allows measures that provide bill savings that are greater than the tariff charge. No other common program design (PACE, a leasing model, or other on-bill financing) was likely to penetrate the rental market, and while other programs may strive to offer low interest rates, or reduce payments through long terms, PAYS is the only financing model that specifically limits eligible measures to those that provide immediate cash-positive savings (based on annual average savings).

However, the PAYS model is not ideal for the broader market or for all financing scenarios. In particular, PAYS can only finance the full up-front cost for the highest-savings measures, typically in a home that uses electricity for space or water heating and typically only under an early replacement scenario. This makes PAYS--a design requiring significant administrative oversight on the part of the utility--even with a third-party implementer of little use to customers who rely on gas for space heating.

Offering a financing program to residential customers may help Empire increase uptake of energy efficiency measures, particularly in some hard-to-reach markets. The gap analysis found that there were no other energy-efficiency financing options available to customers for electric energy efficiency upgrades, beyond what is available in the private market. PACE, the only potentially available program, is active in Missouri, but has yet to be adopted by all jurisdictions in Empire's service territory. While the Joplin, the largest single community served by Empire, recently joined the Show Me PACE financing district, only a minority of Empire's Missouri customers reside in municipalities with active PACE programs.

Survey results indicate that residential customers experience barriers to energy efficiency uptake due to the lack of affordable, accessible financing. Financing is currently an important driver of energy-related home improvements. Nearly half (48%) of the respondents who chose to use financing to make an

energy-related improvement reported they would have delayed or downgraded their recent purchase if financing had not been available. In addition, 57% said they would have considered a higher-efficiency model if more affordable financing had been available.

When faced with a large-scale improvement, all respondents were most likely to be concerned about financing-related issues: not having sufficient cash to pay the up-front cost (69%) and not finding affordable interest rates (69%). Low income respondents were significantly more likely than other respondents to be concerned about knowing what financing options were available to them, and whether they could qualify for a loan. Renters were significantly more likely than homeowners to be concerned about qualifying for a loan.

An aversion to financing among some customers, and high sensitivity to the cost-effectiveness of an investment among most customers, could be potential obstacles to a PAYS program in Empire's territory. Nearly a third of respondents who used cash for a recent purchase reported an aversion to financing, stating that they prefer not use financing unless they need to. In addition, while most respondents said they would be more likely to finance a project than pay cash at low interest rates (3% and lower), respondents' willingness to use financing fell sharply once interest rates rose above 3%. Finally, when asked why they didn't take advantage of the utility offer for a whole-home upgrade, survey respondents were most likely to indicate they did not think the project was cost-effective (22%).

Based on demographics of their residential customer base, Empire should be able to achieve the necessary breakeven participation for a targeted PAYS program to be cost-effective. Empire demographics are similar to cooperatives with existing PAYS programs. Across four PAYS programs we reviewed, participation ranged from an average of 58 projects per year to 198, with even the minimum participation level closest to the breakeven participation of 62.

Recommendation: Should Empire decide to offer a PAYS program, a typical PAYS program design is the best approach. Like existing cooperative utility programs, target high use, lower income all-electric homes through a direct outreach model that facilitates close communication with participants. To mitigate the administrative burden, hire a third-party implementer for at least the initial years of the program. However, if permitted under regulatory rules, issue the financing directly and track payments internally, using the same systems currently used for the gas on-bill program. While the breakeven participation needed for a program that achieves and NTG of 0.62 is within reach for Empire, the need to achieve early replacement savings, coupled with the reduced breakeven participation level, makes a direct-install approach more feasible.

Appendix A

Cost-Effectiveness Detailed Results

Table 39 through Table 42 show detailed cost effectiveness results including BC ratios, benefits, and costs by test for net and gross participation for each of the program participation scenarios.

Table 39. Cost-Effectiveness Results for Combined Program

Test	Quantity	GROSS			NET		
		BC Ratio	Benefits	Costs	Ratio	Benefits	Costs
TRC	20	0.62	$174,593	$281,183	0.42	$108,248	$257,115
TRC	80	1.29	$698,374	$540,465	0.97	$432,992	$444,193
TRC	200	2.30	$1,745,935	$759,008	1.20	$1,082,479	$904,350
PAC	20	0.80	$174,593	$217,508	0.50	$108,248	$217,508
PAC	80	2.47	$698,374	$283,205	1.53	$432,992	$283,205
PAC	200	3.48	$1,745,935	$501,072	2.16	$1,082,479	$501,072
RIM	20	0.32	$174,593	$551,311	0.20	$108,248	$551,311
RIM	80	0.43	$698,374	$1,618,416	0.27	$432,992	$1,618,416
RIM	200	0.45	$1,745,935	$3,839,099	0.28	$1,082,479	$3,839,099

Table 40. Cost-Effectiveness Results for Single-Measure Program (ASHP)

Test	Quantity	GROSS			NET		
		BC Ratio	Benefits	Costs	Ratio	Benefits	Costs
TRC	20	0.67	$190,423	$285,252	0.47	$118,062	$252,081
TRC	80	1.37	$761,692	$554,178	1.12	$472,249	$421,496
TRC	200	1.62	$1,904,229	$1,178,505	1.39	$1,180,622	$846,799
PAC	20	0.88	$190,423	$217,419	0.54	$118,062	$217,419
PAC	80	2.69	$761,692	$282,848	1.67	$472,249	$282,848
PAC	200	3.81	$1,904,229	$500,179	2.36	$1,180,622	$500,179
RIM	20	0.34	$190,423	$559,909	0.26	$120,142	$462,632
RIM	80	0.46	$761,692	$1,652,806	0.38	$480,567	$1,263,699
RIM	200	0.49	$1,904,229	$3,925,075	0.41	$1,201,417	$2,952,307

Table 41. Cost-Effectiveness Results for Single-Measure Program (Whole Home Package)

Test	Quantity	GROSS			NET		
		BC Ratio	Benefits	Costs	Ratio	Benefits	Costs
TRC	20	0.67	$193,777	$290,207	0.47	$120,142	$255,153
TRC	80	1.35	$775,108	$574,001	1.11	$480,567	$433,786
TRC	200	1.58	$1,937,769	$1,228,061	1.37	$1,201,417	$877,523
PAC	20	0.88	$193,777	$220,896	0.54	$120,142	$220,896
PAC	80	2.61	$775,108	$296,754	1.62	$480,567	$296,754
PAC	200	3.62	$1,937,769	$534,945	2.25	$1,201,417	$534,945
RIM	20	0.32	$193,777	$610,793	0.26	$120,142	$462,632
RIM	80	0.42	$775,108	$1,856,342	0.38	$480,567	$1,263,699
RIM	200	0.44	$1,937,769	$4,433,915	0.41	$1,201,417	$2,952,307

Table 42. Cost-Effectiveness Results for Single-Measure Program (HPWH)

Test	Quantity	GROSS			NET		
		BC Ratio	Benefits	Costs	Ratio	Benefits	Costs
TRC	20	0.08	$17,035	$224,242	0.05	$10,562	$214,255
TRC	80	0.22	$68,141	$310,141	0.16	$42,247	$270,193
TRC	200	0.30	$170,352	$568,413	0.23	$105,618	$468,542
PAC	20	0.08	$17,035	$202,667	0.05	$10,562	$202,667
PAC	80	0.30	$68,141	$223,841	0.19	$42,247	$223,841
PAC	200	0.48	$170,352	$352,663	0.30	$105,618	$352,663
RIM	20	0.07	$17,035	$244,954	0.05	$10,562	$228,885
RIM	80	0.17	$68,141	$392,989	0.13	$42,247	$328,713
RIM	200	0.22	$170,352	$775,533	0.17	$105,618	$614,842

Appendix B

Load Shapes by Measure

Table 43 presents the load shape assigned to each measure.

Table 43. Load Shapes by Measure

Item #	Measure	Loadshape
1	**Central Air Conditioner**	Electricity_HVAC
2	**Central Air Conditioner**	Electricity_HVAC
3	**Clothes Dryer**	Appl_InteriorEquipment
4	**Clothes Washer**	Appl_InteriorEquipment
5	**Clothes Washer**	Appl_InteriorEquipment
6	**Clothes Washer**	Appl_InteriorEquipment
7	**Refrigerator**	Appl_InteriorEquipment
8	**Refrigerator**	Appl_InteriorEquipment
9	**Refrigerator**	Appl_InteriorEquipment
10	**HPWH**	Water Heater
11	**HPWH**	Water Heater
12	**Air Sealing**	All Electric Home
13	**Duct Sealing**	All Electric Home
14	**Window Replacement**	All Electric Home
15	**Ceiling Insulation**	All Electric Home
16	**Wall Insulation**	All Electric Home
17	**LEDs**	InteriorLights
18	**Air Source Heat Pump**	All Electric Home
19	**Air Source Heat Pump**	All Electric Home
20	**Air Source Heat Pump**	All Electric Home
21	**Air Source Heat Pump**	All Electric Home
22	**Air Source Heat Pump**	All Electric Home
23	**Air Source Heat Pump**	All Electric Home

Item #	Measure	Loadshape
24	**Air Source Heat Pump**	All Electric Home
25	**Air Source Heat Pump**	All Electric Home
P1	**Standard Whole Home (ASHP, air sealing, attic insulation, five LEDs)**	All Electric Home
P2	**Standard Whole Home (ASHP, air sealing, attic insulation, five LEDs)**	All Electric Home
P3	**Comprehensive Whole Home (Standard package plus HPWH and duct sealing)**	All Electric Home
P4	**Comprehensive Whole Home (Standard package plus HPWH and duct sealing)**	All Electric Home

Appendix C

Load Shapes by Month

Table 44 presents the percentage of on-, off-, and total annual savings by month for each load shape used in the analysis.

Table 44. Load Shapes used in Measure-Level Financial Analysis

Load Shape	Source	Month	On-Peak	Off-Peak	Total
Electricity_Facility	Empire	1	4%	5%	9%
Electricity_Facility	Empire	2	3%	4%	8%
Electricity_Facility	Empire	3	3%	4%	8%
Electricity_Facility	Empire	4	3%	4%	7%
Electricity_Facility	Empire	5	3%	4%	7%
Electricity_Facility	Empire	6	3%	5%	8%
Electricity_Facility	Empire	7	3%	7%	10%
Electricity_Facility	Empire	8	4%	7%	11%
Electricity_Facility	Empire	9	3%	7%	9%
Electricity_Facility	Empire	10	3%	4%	7%
Electricity_Facility	Empire	11	3%	4%	8%
Electricity_Facility	Empire	12	3%	5%	8%
Electricity_HVAC	Empire	1	1%	3%	4%
Electricity_HVAC	Empire	2	1%	2%	3%
Electricity_HVAC	Empire	3	1%	1%	2%
Electricity_HVAC	Empire	4	0%	1%	1%
Electricity_HVAC	Empire	5	3%	1%	3%
Electricity_HVAC	Empire	6	6%	7%	13%
Electricity_HVAC	Empire	7	8%	15%	23%
Electricity_HVAC	Empire	8	12%	17%	29%
Electricity_HVAC	Empire	9	6%	10%	16%
Electricity_HVAC	Empire	10	1%	0%	1%
Electricity_HVAC	Empire	11	0%	1%	2%
Electricity_HVAC	Empire	12	1%	2%	3%
Water Heater	Empire	1	5%	6%	11%
Water Heater	Empire	2	5%	5%	10%
Water Heater	Empire	3	5%	6%	11%
Water Heater	Empire	4	4%	5%	9%
Water Heater	Empire	5	4%	4%	7%
Water Heater	Empire	6	2%	4%	7%
Water Heater	Empire	7	2%	5%	6%
Water Heater	Empire	8	1%	4%	5%

Load Shape	Source	Month	On-Peak	Off-Peak	Total
Water Heater	Empire	9	2%	5%	7%
Water Heater	Empire	10	3%	5%	8%
Water Heater	Empire	11	4%	5%	9%
Water Heater	Empire	12	4%	5%	9%
InteriorLights	Empire	1	5%	6%	12%
InteriorLights	Empire	2	4%	5%	9%
InteriorLights	Empire	3	3%	5%	9%
InteriorLights	Empire	4	3%	4%	7%
InteriorLights	Empire	5	2%	4%	6%
InteriorLights	Empire	6	1%	4%	5%
InteriorLights	Empire	7	1%	5%	6%
InteriorLights	Empire	8	1%	5%	7%
InteriorLights	Empire	9	1%	6%	8%
InteriorLights	Empire	10	3%	6%	9%
InteriorLights	Empire	11	5%	6%	11%
InteriorLights	Empire	12	5%	7%	12%
Appl_InteriorEquipment	Empire	1	5%	4%	9%
Appl_InteriorEquipment	Empire	2	4%	4%	8%
Appl_InteriorEquipment	Empire	3	5%	4%	9%
Appl_InteriorEquipment	Empire	4	4%	4%	9%
Appl_InteriorEquipment	Empire	5	5%	4%	8%
Appl_InteriorEquipment	Empire	6	4%	5%	8%
Appl_InteriorEquipment	Empire	7	3%	6%	9%
Appl_InteriorEquipment	Empire	8	3%	5%	8%
Appl_InteriorEquipment	Empire	9	2%	6%	8%
Appl_InteriorEquipment	Empire	10	4%	5%	9%
Appl_InteriorEquipment	Empire	11	4%	4%	8%
Appl_InteriorEquipment	Empire	12	4%	4%	8%
Cooling Only	Hybrid, based on Electricity_HVAC	1	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	2	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	3	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	4	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	5	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	6	6%	7%	16%
Cooling Only	Hybrid, based on	7	8%	15%	28%

Load Shape	Source	Month	On-Peak	Off-Peak	Total
	Electricity_HVAC				
Cooling Only	Hybrid, based on Electricity_HVAC	8	12%	17%	36%
Cooling Only	Hybrid, based on Electricity_HVAC	9	6%	10%	20%
Cooling Only	Hybrid, based on Electricity_HVAC	10	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	11	n/a	n/a	n/a
Cooling Only	Hybrid, based on Electricity_HVAC	12	n/a	n/a	n/a
Heating_Gas	Empire	1	9%	19%	28%
Heating_Gas	Empire	2	5%	12%	17%
Heating_Gas	Empire	3	4%	9%	13%
Heating_Gas	Empire	4	2%	5%	7%
Heating_Gas	Empire	5	0%	0%	0%
Heating_Gas	Empire	6	0%	0%	0%
Heating_Gas	Empire	7	0%	0%	0%
Heating_Gas	Empire	8	0%	0%	0%
Heating_Gas	Empire	9	0%	0%	0%
Heating_Gas	Empire	10	0%	2%	2%
Heating_Gas	Empire	11	3%	9%	12%
Heating_Gas	Empire	12	6%	14%	20%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	1	n/a	n/a	23%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	2	n/a	n/a	14%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	3	n/a	n/a	11%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	4	n/a	n/a	7%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	5	n/a	n/a	1%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	6	n/a	n/a	3%
All Electric Home	Hybrid, based on Electricity_HVAC and	7	n/a	n/a	4%

Load Shape	Source	Month	On-Peak	Off-Peak	Total
	Heating_Gas				
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	8	n/a	n/a	5%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	9	n/a	n/a	3%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	10	n/a	n/a	3%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	11	n/a	n/a	11%
All Electric Home	Hybrid, based on Electricity_HVAC and Heating_Gas	12	n/a	n/a	16%