

Utility Value of a Pay As You Save[®] Energy Efficiency Program

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ABSTRACT

Pay As You Save[®] (PAYS[®]) is a tariffed on-bill system that couples site-specific utility investment in energy upgrades on the customer-side of the meter with site-specific cost recovery through a charge on the bill that is less than the estimated savings. PAYS programs are inclusive because eligibility does not depend on criteria such as income, credit score, or home-ownership status. In 20 years of field experience across 18 utilities in eight states, energy upgrade programs using PAYS have reported take rates of 50%-90% with higher average capital investment per site compared to on-bill loans, while keeping utility uncollectibles below 0.1%. Utilities and regulators have sought measured energy and peak demand reduction metrics as inputs to financial analysis of the utility business case. This study analyzed weather normalized hourly meter data from Roanoke Electric Cooperative's (REC) Upgrade to Save energy efficiency upgrade program based on the PAYS system. Results show that homes upgraded over a 21 month period have generated an average annualized reduction in electricity consumption of 4,228 kWh and 1.3 kW of peak demand reduction in winter and 1.2 kW in summer. The resulting net present value to the utility is \$3,047 per home over the lifetime of the upgrades, and the total net present value of investments made during the period of this study is \$1 million. Thus, even after taking into account the cost of capital, program operation costs, and foregone revenue from foregone wasted energy, REC's PAYS investment portfolio is generating economic benefits for the utility.

Introduction

Traditionally, utilities have used loan or rebate programs to offer energy efficiency upgrades to their customers or member-owners. Program administrators and public advocates have increasingly recognized that loan programs restrict participation to those that have a qualifying credit score, own their home, and are able to make a sizable upfront investment. Among US households, 1/3 rent and 40% cannot cover a \$400 unexpected expense, and so a significant portion of customers and member-owners are effectively disqualified from using loans and rebates for whole home energy upgrades even when they would yield savings (Federal Reserve 2019). Utilities initially addressed these challenges by providing higher discounts, free products, and no cost weatherization assistance to qualifying low-income customers, but resources for such programs have never met the actual need. Thus, stakeholders and public advocates are increasingly turning to investment instruments that do not disqualify on the basis of credit score, renter status, or income. Pay As You Save (PAYS) is one such system that has demonstrated its ability to overcome the limitations of on/off-bill loans and Property Assessed Clean Energy (PACE) (Hummel and Lachman 2018).

The PAYS system has also allowed utilities to reimagine their existing tariff to meet new customer expectations and transitioning toward a utility business model of the future. At present, 18 utilities representing all types—investor owned utilities (IOUs), municipal utilities (munis), and cooperatives (coops) utilities— have implemented programs and several large IOUs are negotiating contracts to implement programs using the PAYS system. In 2018, the California Public Utilities Commission called for “inclusive financing for all cost-effective energy upgrades” while NYSERDA began exploring a PAYS system as a means of expanding the reach of state energy efficiency initiatives (Hummel and Lachman 2018). In December 2019, the Missouri Public Service Commission approved Evergy’s energy efficiency plan contingent on using the PAYS system (MO 2019). In May of 2020, the Georgia Public Service Commission approved Georgia Power’s Income Qualified Tariff-Based Energy Efficiency Pilot using the PAYS system and, in July, Ameren Missouri and staff of the Public Service Commission and other stakeholders announced a unanimous agreement to use the PAYS system for a two year program with the intention to scale in subsequent years (GA PSC 2020, MO PSC 2020). Also, in July 2020, the City of Minneapolis filed a tariff for inclusive financing using the PAYS system (MN PSC 2020; EEI 2020). Additionally, in 2020, the Virginia Legislature unanimously passed SB 754 granting rural electric cooperatives State Corporation Commission conditional pre-approval for on-bill tariff energy efficiency programs such as PAYS (VA 2020). In July 2020, Duke Energy reached a partial settlement with intervenors in its grid modernization rate case, agreeing to craft a tariffed on-bill program that could use the PAYS system, and that settlement has been submitted to the North Carolina Utilities Commission for consideration (NC 2020). Today, dozens of other IOUs, munis, and coops are in the process of conducting due diligence to run programs using the PAYS system and are seeking energy and demand reduction measurement and verification as inputs for building the business case.

For analysts of the utility business case, data on the magnitude of electricity and coincident peak demand reduction from deep energy efficiency upgrades using PAYS is a critical missing input. Grid utilization and peak demand drives many core utility costs such as meeting capacity requirements, buying third party power supply, and making transmission and distribution infrastructure investments. Ouachita Electric Cooperative and Roanoke Electric Cooperative have reported that their deep energy-efficiency programs using PAYS are generating positive cash flow with savings from peak demand and reduced wholesale electricity purchases exceeding program costs (Wynn 2019; Cayce 2019). To date, the only published report quantifying the utility value proposition of PAYS examined energy (kWh) reduction but not the critical coincident peak demand reduction (kW) (OptiMiser 2018). This study provides the first published validation of PAYS program impact for a utility that encompasses actual coincident peak demand reduction (kW), weather normalized measured electricity reduction (kWh), and utility return on investment. The program data is drawn from the *Upgrade to Save* (U2S) program sponsored by the Roanoke Electric Cooperative and operated by EEtility, both of whom generously made their data available for this study.

Background on Roanoke Electric Cooperative's *Upgrade to Save* Program

Roanoke Electric Cooperative (REC) is one of the 26 rural electric distribution cooperatives in North Carolina (NC) with 2,210 miles of line across a 1,500 square mile service territory in the northeast corner of the state that includes the counties of Hertford, Bertie, Gates, Northampton, Halifax, Chowan, and Perquimans. REC's 52 employees serve 14,700 meters, 95% of which are residential. Housing in the service area is exclusively single family with 50% stick-built; 40% manufactured, mobile, and trailer; and 10% prefabricated modular type homes. REC serves the 4th lowest income Congressional district in all the U.S., and 6 of its 7 counties are recognized by the Department of Agriculture as persistent poverty counties (Hummel and Lachman, 2018). According to the utility, over 50% of REC members have monthly electricity bills of over \$200/month and more than 35% have monthly bills above \$250. The combination of highly energy inefficient, aging, poorly constructed housing, and low average household income results in a high energy burden (i.e. percent income devoted to utility bills). Half of REC's member-owners devote more than 6% of the average median income for the counties toward energy bills, and the energy burden for households below that median figure is substantially higher (Hummel and Lachman, 2018).

In 2014, REC's Board set a goal of generating economic benefits for member-owners by capitalizing energy upgrades to 1,000 homes (7%) within 5 years. Previously, the utility had sought to leverage Federal Weatherization Assistance Program (WAP) grant funds, finding the level of funding in the service area was too low to meet the need, and it had introduced an on-bill loan program, finding low uptake of loans. The utility management team then identified and selected a tariffed on-bill investment. The Board unanimously approved use of the PAYS system for the design of its tariff. Roanoke Electric secured \$6 million in Treasury rate financing through the USDA Energy Efficiency & Conservation Loan Program within 90 days (REC 2014). In 2017, REC transferred program management to EEtility, a program operator that was producing better results managing a program using the same PAYS system for Ouachita Electric Cooperative Corporation in Arkansas, and EEtility transitioned over time to manage all aspects of the program by April 2019.

EEtility introduced a number of innovations including targeted outreach to homes with high energy use per square foot, scoping work to be PAYS compliant (i.e. estimated savings exceeding annual utility cost-recovery by at least 25% for a duration that is less than 80% of the lifetime of the upgrades), volume pricing with contractors, and remote QA/QC of contractor work using time-stamped and geocoded photographs. EEtility also introduced direct installation of low-cost upgrades for homes in need of major repairs due to structural integrity issues that precluded their immediate enrollment in *Upgrade to Save*. At no cost to the residents, these homes received LED lights, smart strips, aerators, water heater blankets, and AC coil cleaning.

During this period from 8/1/17 to 7/15/20, 541 homes received direct install upgrades and 327 investment grade homes received upgrades on PAYS terms. Members that accepted a PAYS upgrade offer usually received weatherization and HVAC improvement and many of those with internet also received demand response devices. The complete list of potential measures is as follows:

- Energy audits: identify cost-effective EE improvements, install LEDs, address health and safety issues including combustion air, venting bath fans, venting dryers, and furnace safety inspection and tune ups as needed
- Furnace replacement with high efficiency heat pumps to switch from propane or oil to electric heating
- Upgrades of existing heat pumps to more efficient models
- Envelope air sealing to reduce infiltration identified through blower door testing
- Duct system sealing where indicated by duct blaster testing
- Insulation of attic and knee walls when poorly insulated
- Demand response via smart thermostat and water heater load control switch

The REC Board of Directors decision to approve U2\$'s use of the PAYS system was informed by a financial analysis that included the value of avoided wholesale energy purchases and the value of energy efficiency compliance credits with the state's Renewable Portfolio Standard as well as reduced peak demand coincident with that of their wholesale power provider. The analysis found the benefits would exceed both program cost as well as foregone revenue on energy that would otherwise be wasted in the homes of member-owners (Wynn 2020). This study follows that initial analysis by examining data for homes both before and after upgrades were installed. The results that follow show the calculated electricity and peak load reduction of a sample of U2\$ homes using weather normalized hourly advanced meter infrastructure data, and from those results, this study then derives the net present value to the utility of the program investments made during that period.

Methodology

Period of Analysis: Upgrades completed between Aug. 1, 2017 and Apr. 15, 2019, which covers the first 21 months of EEtility's involvement as the program operator, are examined in this study. This period represents the transition from the prior program implementation protocols to EEtility best practices. EEtility best practices were fully implemented after April 2019.

Sample Selection: The primary source data for this analysis is 274 homes upgraded between Aug. 1, 2017 and April 15, 2020. Detailed data on upgrades, financing, and home characteristics were assembled from program records and databases and cross checked for accuracy. An additional 53 homes were upgraded between April 15 and July 15, 2020 and are included in calculations of the total program impact. The 250 homes upgraded prior to EEtility management are not included in the analysis. All 274 homes were modeled as described below and then filtered for model validity and weather correlation. 156 homes had at least 270 days of complete meter data in the 365-days pre-improvement and post-improvement periods. Filtering for degree-day models coefficient of determination (R^2) of 0.3 or greater excluded 9 homes leaving a final total of 147 homes.

Measurement & Verification: Hourly advanced metering infrastructure (AMI) data was used in accordance with the Department of Energy's Uniform Method Project Whole-Building Retrofit Protocol, which compares pre- and post-upgrade meter data normalized for weather (UMP

2017). Calculations of weather normalized energy and peak demand reductions were performed using Enpira software.

Calculated Electricity Reduction (kWh). Electricity reduction for upgraded homes was calculated using Individual Premise Analysis as outlined in the Department of Energy’s Uniform Methods Project (UMP 2017). Specifically, hourly usage for each upgraded home was totaled into 24-hour bins, where only complete bins were selected for regression. Average daily temperature from a nearby weather station was computed for each daily total. Optimized variable degree-day base regression models (Figure 1) were computed for the pre-improvement and post-improvement periods for each home with pre-improvement model heating balance point temperature mean 57°F +/- 6°F standard deviation and cooling 68°F +/- 3°F and post model heating 56°F +/- 5°F, cooling 68°F +/- 3°F. Then, 30-year typical meteorological year weather normals were applied to the pre-improvement and post-improvement models to determine pre-improvement and post-improvement normalized annual consumption.

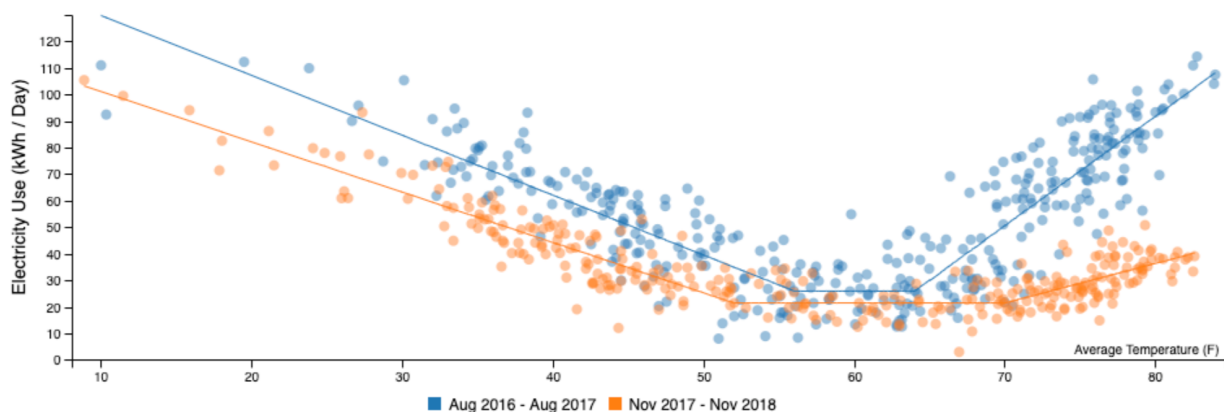


Figure 1. Variable Degree-Day Regression Models for a Program Home. Source: Enpira

Coincident Peak Demand Reduction (kW). REC’s wholesale power pricing includes demand charges assessed based on monthly demand at the peak hour in the month. The system winter peaks between 2015 and 2019 all occur between 6-8am and system summer peaks occur between 4-6pm. Analysis of coincident peak demand reduction was based on a comparison of pre-improvement and post-improvement temperature regression models using hourly interval meter data, a method considered appropriate for residential programs with HVAC and shell measures¹. Separate regression models of usage vs. average temperature are calculated for the morning and the afternoon peak periods for the pre-improvement and post-improvement periods for each home. The difference between the pre-improvement and post-improvement in the morning model with typical monthly winter peak period temperatures applied yields a winter peak demand reduction, and similarly typical monthly summer peak period temperatures applied to the afternoon model yield a summer peak demand reduction. The 2019 monthly peak demand reduction used nearby weather station temperatures during the peak hour on the peak day of each month as the input for the kW/degree regression models.

¹ See Uniform Methods Project, Chapter 10, 4.4 and 4.9 “Interval Meter Data Analysis”

Comparison Group Analysis: A comparison group of randomly selected REC residential homes that did not receive either direct installation improvements or full home energy upgrades through U2\$ were evaluated to quantify exogenous changes in electricity consumption between the first half (1/1/2017 to 6/30/2018) and second half (7/1/2018 to 1/1/2020) of the evaluation period. Homes in the sample that had 365 days of valid meter and weather data within the 18-month periods and had optimized variable degree-day regression models with coefficients of determination ≥ 0.3 were retained. Finally, the pre-improvement normalized annual consumption of the homes was ranked, and a cut-off selected such that the mean value of the remaining homes matched that of the U2\$ sample mean of 20,220 kWh/yr. This comparison group of 215 homes was used for cross-sectional analysis through calculation of the mean difference between the comparison group and the program homes.

Results

Upgrade to Save Produced Substantial Electricity Reduction: The sample of 147 U2\$ Program participant homes had a calculated mean annualized reduction in electricity consumption of 4,228 kWh (18%) and a median of 4,603 kWh (21%). A visualization of a sample home pre- and post-upgrade can be seen in Figure 2. The average project cost of the 147 home sample was \$7,344, the average for the 274 home source dataset was \$6,977. savings will likely trend toward the current median savings over time, as the sample set contains a number of low energy usage homes that were enrolled due to repeated high bill complaints rather than high energy intensity. The relatively high standard deviations for both reduction in absolute and percent electricity consumption largely reflect the inclusion of these homes in the sample set.

Table 1: *Upgrade To Save* Annualized Impacts on Electricity Usage, n = 147 homes

	Median	Mean	Standard Deviation
Electricity reduction, kWh	4,603	4,228	4,700
Electricity reduction, %	21%	18%	21%
Total energy cost reduction, %	29%	26%	17%
Project Cost	\$7,681	\$7,344	\$3,404
Pre-upgrade Estimated Reduction, kWh	6961	5,533	4,451
Difference in reduction, kWh (Pre-Upgrade Estimated - Calculated)	1,355	1,304	3,560

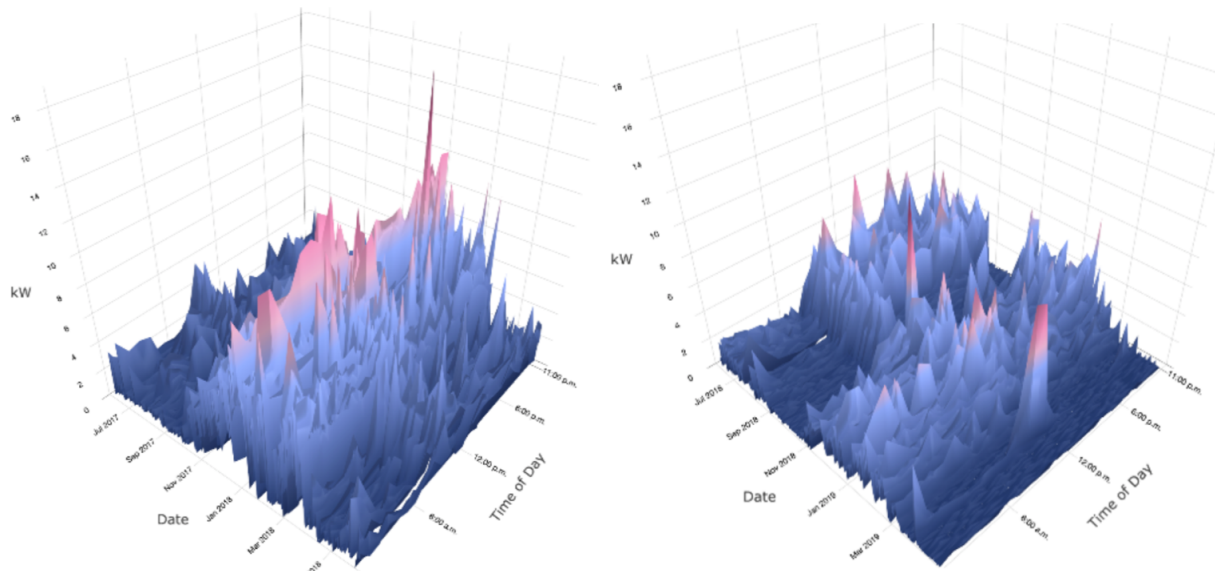


Figure 2. Visualization of pre and post electricity demand (kW) in each hour of the year of a home without demand response before upgrade (June 2017-May 2018) and after upgrade (June 2018 to May 2019). Source: Enpiria.

Beneficial Electrification Produced Energy Cost Reduction in All Cases and Net Electricity Reduction in Half of Cases: Of the 19% (28) homes in the sample with higher electricity consumption after the upgrade, half the participants chose beneficial electrification (BE) upgrades such as having the heating systems switched from fossil fuel, typically propane, to high efficiency electric heat pumps. Table 2 shows, as would be expected, that on average these homes *increased* their use of electricity by 749 kWh (7%) (negative electricity reduction) and had relatively higher project costs since it included removal of the old systems and installation of a new heat pump and weatherization. Although the average change in electricity reduction is negative, half of BE customers actually saw reductions in electricity use, despite switching the primary heating to electricity. This is likely the combination of weatherization upgrades that improved very poor building envelopes and replacement of inefficient AC systems with high efficiency heat pumps. For all BE customers, the primary value of the savings was in reduced fuel costs. The raw data needed to directly calculate fuel savings could not be easily extracted from the legacy systems. As such, to provide some indication of the likely gross fuel cost savings and total gross cost savings to these customers we drew on EEtility’s software vendor weather normalized estimates of fuel cost savings which were derived from inaccessible the fuel data inputs. To correct for expected overestimation² the estimated fuel savings were reduced by 23% resulting in an average of \$1,198 which, after subtracting the cost of higher electricity use, resulted in 35% estimated cost savings.

Table 2: Annualized Program Reduction, Beneficial Electrification Homes, n = 27 homes

² Pre-improvement electricity savings were found to be overestimated by 23%.

	Median	Mean	Standard Deviation
Electricity reduction, kWh	-610	-749	3,140
Electricity reduction, %	-7%	-7%	21%
Adjusted Estimate Fuel Savings	\$1,097	\$1,198	\$540
Adjusted Energy Cost Savings (Fuel+Elec.)	33%	34%	14%
Project Cost	\$9,057	\$9,459	\$2,316
Pre-upgrade Estimated Reduction, kWh	-1,314	-949	2,793
Difference in reduction, kWh (Pre-Upgrade Estimated - Calculated)	-26	-199	4,256

Electrically Heated Homes Alone Have Higher Electricity Reduction and Lower Project Cost: The typical electric utility would not have the option of including beneficial electrification through fuel switching since doing so is usually prohibited. To provide an indication of what the performance of an Upgrade to Save like program would be for such a utility we examined the performance of the sample with the BE homes removed. These homes use electricity as their primary heating source. Prior to the upgrade, these homes typically used electric strip heat or old inefficient heat pumps. Although the primary heat source post-upgrade is high efficiency electric heat pump, although a small number still use fuel of some type as a secondary heating source.

Table 3: Annualized Program Electric Reduction in Homes with Primary Electric Heating before Upgrade, n = 120 homes

	Median	Mean	Standard Deviation
Electricity reduction, kWh	5,544	5,348	4,244
Electricity reduction, %	26%	23%	17%
Project Cost	\$7,546	\$6,868	\$3,428
Pre-upgrade Estimated Reduction, kWh	7,563	6,991	3,307
Difference in reduction, kWh (Pre-Upgrade Estimated - Calculated)	1,500	1,643	3,291

Electrically heated (and cooled) homes (Table 3) saw a reduction in electricity use of 5,348 kWh/year or 23% (a 24% improvement over the full sample set) and a median reduction of 5,544 kW (26%).

The Type of Upgrade Strongly Influences Impact on Electricity Consumption and Load: Subdividing the sample based on type or combination of upgrades provides additional insight, although the sample sizes in some cases are too small to draw firm conclusions (Table 4). Overall, homes electrically heated prior to the upgraded, a combination of HVAC and home envelope improvement (weatherization), and homes that received HVAC only (because the building envelope performance did not require an upgrade) had the highest peak demand reduction >2 kW (24°F) for both, and 1.26kW and 1.86kW (91°F), respectively, and mean

reduction in electricity use 6,443kWh (27%) and 7,147 kWh (35%), respectively (Table 4). Pre-upgrade electrically heated homes receiving only weatherization saw reductions 70-75% lower than those with HVAC. BE homes always received a new HVAC and performed better on average when this was accompanied by weatherization.

Table 4. Peak Demand and Electricity Reduction by Upgrade Type

	Count	Electricity Reduction Mean (kWh)	Electricity Reduction Mean (%)	Peak Demand Reduction (kW) Winter (24°F)	Peak Demand Reduction (kW) Summer (91°F)
HVAC and WX	88	6,443	27	2.34	1.26
WX Only	26	1,230	6	0.70	0.38
HVAC Only	6	7,147	35	2.15	1.86
BE, HVAC + WX	24	-725	-7	-1.78	1.08
BE and HVAC	3	-945	-4	-1.09	0.53

Homes Without Upgrades Experienced a 1.8% Electricity Reduction Compared to 21% in Homes With Upgrades: The 215 comparison group homes saw an average reduction in electricity use of 367 kWh/year, or 1.8%. The program attributable reduction in electricity consumption is therefore 3861 kWh/year (4228kWh - 367kWh) or 19.1%. Further comparison to a broader sample of homes reveals that about half of the 1.8% reduction can be explained by the fact that both the comparison group and the program homes have a higher-than average pre-improvement energy usage compared to the general population, and so may have experienced regression to the mean value of the broader population. The balance of the comparison group energy savings may be explained by factors such as smaller average households due to migration to urban areas, reduced use in response to a rate increase that occurred during the program period, failure and replacement of older less efficient household equipment with newer more efficient appliances and lights, and improvements in energy conservation awareness due to REC's marketing efforts.

U2\$ Generated Substantial Winter and Summer Peak Demand Reduction: Based on a sample of 147 homes, REC's U2\$ program generates approximately 1.3 kW of peak demand reduction per home at the winter mornings with a temperature of 24°F, and 1.18 kW of peak demand reduction per home in summer afternoons with a temperature of 91°F (Table 5, Figures 3 and 4). Peak demand reduction for electrically heated and cooled homes was 1.97 kW (24°F) and 1.21 kW (91°F), and for BE homes was -1.7 kW (24°F) and 1.02 kW (91°F) (Table 5). The variability in the distribution of reduction (Figure 4) suggests that demand reduction can be dependably relied upon for a moderate sized sample of homes, but not for individual homes.

Table 5: Peak Demand reduction All Homes, n = 147 homes

	n	NCEMC Peak Hour	Average Temp	Median (kW)	Mean (kW)	Standard Deviation
All Homes	147	Winter (7-8am)	24°F ³	1.38	1.30	2.32
		Summer (5-6pm)	91°F ⁴	0.95	1.18	1.42
Electric Heat and Cooling	120	Winter (7-8am)	24°F	1.97	1.97	1.87
		Summer (5-6pm)	91°F	0.88	1.21	1.48
Beneficial Electrification	27	Winter (7-8am)	24°F	-1.29	-1.70	1.67
		Summer (5-6pm)	91°F	1.09	1.02	1.15

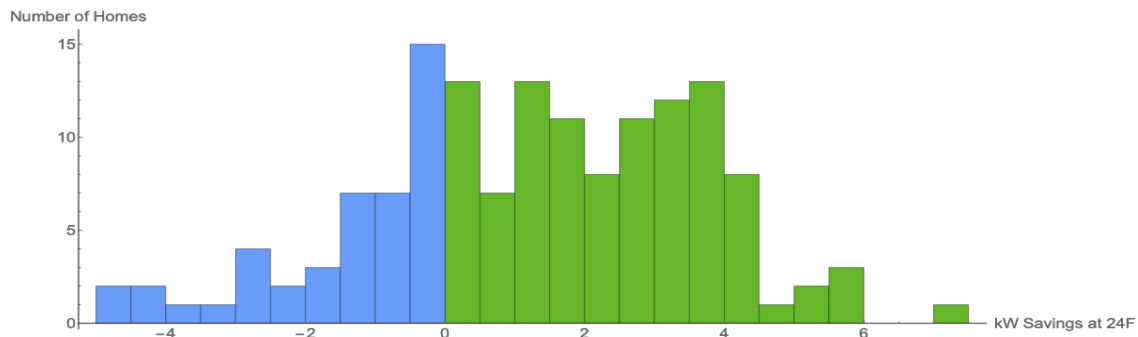


Figure 3: Upgrade To Save Program Demand reduction during Winter Mornings, kW

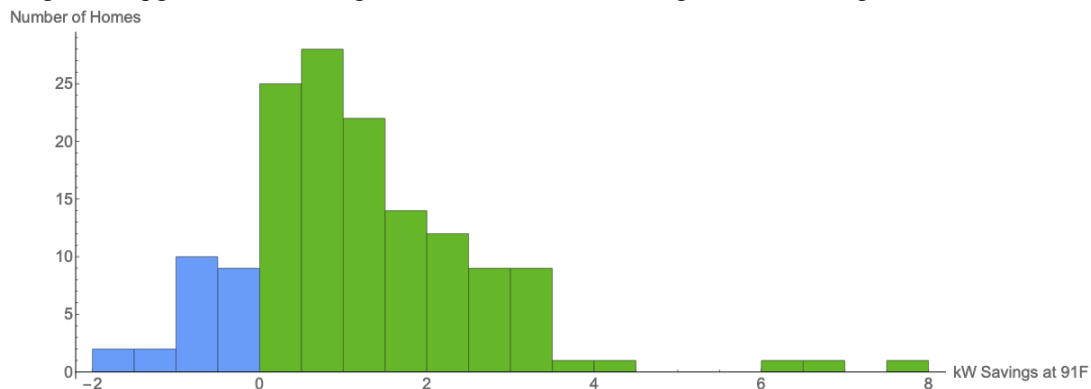


Figure 4: Upgrade To Save Program Demand reduction during Summer Evenings, kW

U2\$ Delivered Substantial Peak Demand Reduction at All Monthly System Peaks: For Roanoke Electric there is not one measure of peak demand reduction but 12 because its wholesale demand charge is based on Roanoke's load during the hour with the highest system load during each month. Enpira's regression models (winter mornings, summer afternoons) output peak load reduction per degree. Average demand reduction from the energy efficiency improvements at system peak is determined with reference to the average temperature within

³ Average of temperature during system peak for six winter peak months in 2019

⁴ Average temperature during system peak for six summer peak months 2019

REC's territory during the 12 peak hours (Figure 5). November-April are winter morning peaks, May to October are summer afternoon peaks.

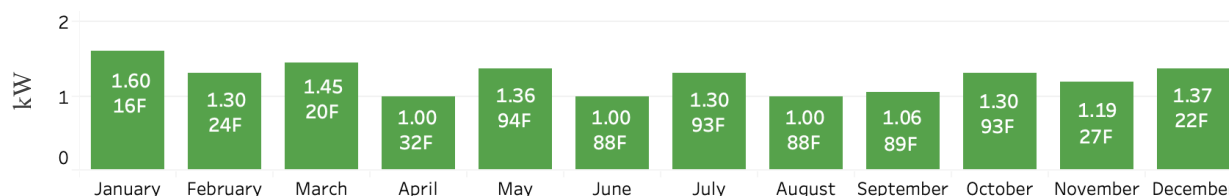


Figure 5. Peak Demand Reduction at 2019 System Peak Temperature by Month for Climate Normal Year (n=147).

U2\$ Produced a Positive Return on Investment for REC: Table 6 below summarizes U2\$'s utility return on investment over the life of the upgrades (15 years) given all value and cost streams that were identified and quantified. The average upgraded home has a net present value to REC of \$3,047 and the 327 homes upgraded by the program as of July 15, 2020 have an aggregate net present value of \$996,240. REC's PAYS investment portfolio is generating economic benefits for the utility with returns that exceed cost of capital, program operation cost, and lost revenue. These results are due to four main factors:

1. Two of largest program costs--the utility upgrade investment (\$6,532) and Program Operation (\$1,140) are recovered completely over time through the PAYS on-bill tariffed-charge
2. The deep energy efficiency upgrades generate significant avoided energy and demand costs (\$3,757)
3. The two other large costs, avoided retail revenue for wholesale power and margin over wholesale for retail operations (\$1,584) are limited by subsumption into the rate-base during REC's next rate case 3 years into 15 year measure lifetime, and
4. A home's participation in REC's demand response program is very valuable to REC even when recognizing just 40% (\$1,283) of the full potential.

While impressive, the actual value of the program to REC is undoubtedly higher. REC spends significant sums to maintain and increase customer satisfaction. Customer satisfaction with REC almost certainly has increased significantly among participants, but at present there is no data quantifying this increase or its value to REC. Quantification of the value of reduced delinquencies, charge-offs, and arrearages was also beyond the scope of this analysis. However, delinquent accounts, and charge-offs are costly for all utilities including REC. Since priority customers were those with high energy intensity and REC's membership generally low-income, it is very probable that lower energy costs and significantly lower energy costs in the future had a positive impact on delinquencies and arrearages among participants. Key model inputs and assumptions used to derive net present value are summarized in Table 7.

Table 6: Average Net Present Value Over 15 Years Per Participant and All [EEtility] Participants

Cost/Benefit	NPV(at 2%)	
	Per Upgrade	All Participants (n=327)
Avoided Wholesale Energy Costs	\$2,127	\$695,584
Avoided Wholesale Demand Costs	\$1,630	\$ 532,875
Energy Efficiency Credits	\$321	\$104,931
Demand Response	\$1,283	\$419,605
Utility Incentive for Minor Repairs	\$(122)	\$(39,894)
Utility Upgrade Investment	\$(6,224)	\$(2,035,381)
Program Operation Cost	\$(1,140)	\$(372,780)
Cost of HVAC Maintenance	\$(892)	\$(291,591)
Capital Cost Recovery	\$6,224	\$2,035,381
Program Cost Recovery	\$1,140	372,780
Avoided Retail Revenue - Wholesale cost	\$(416)	\$(136,179)
Avoided Retail Revenue - Margin over Wholesale	\$(1,168)	\$(381,971)
Revenue from Capital Markup	\$284	\$92,879
PROJECT TOTAL NPV	\$ 3,047	\$ 996,240

Table 7. Model Inputs

Utility Operation Inputs	Input Value	Source
Wholesale Energy Cost (\$/kWh)	\$0.034	Calculation
Wholesale Energy Charge Escalation	2%	EIA AEO
Wholesale Demand Charge (\$/kW)	\$12.38	Calculation
Wholesale Demand Charge Escalation	2%	EIA AEO
Total Residential Retail Rate (\$/kWh)	\$0.1281	Avg. retail rate
Annual Residential Retail Rate Escalator	1.74%	Historical increases
Margin on Wholesale Rate (\$/kWh)	\$0.0945	Calculation
Avoided Distribution Losses	3%	Assumed
Value of Energy Efficiency Credits (\$/MWh)	\$20	REC
Last Year Credits are Valued	2022	Last RPS compliance
Average Cost of HVAC Maintenance	\$100	REC
Program Operation Cost	\$960	EEtility Prog. Data
Demand Response Program Cost	\$400	REC
Participation in Demand Response	40%	Sample (n=274)
Annual Value of Demand Response Savings	\$247	REC
Program Operation & Rate Case Inputs	Input Value	Source
Program Start Year	2018	Median (2017-2019)
Year of Upgrade	2018	Median (2017-2019)
Next Rate Case	2020	REC
Upgrade Inputs	Input Value	Source
Number of Participants	327	8/2017- 7/2020
Upgrade Cost	\$6,532	Average (n=147)
Customer Copay	\$366	EEtility Prog. Data
Member Portion of Program Operation Fee	\$265	Calculation
Total Participant Cost	\$6,977	Calculation
Project Lifetime (years)	15	Upgrade measure life
Annual kWh of Target Population	20,221	Enpira: REC AMI (n=147)
Annual Electricity Reduction (kWh)	4,228	Average (n=147)
Financing Inputs	Input Value	Source
Utility Cost of Capital	2.14%	REC
Mark-up on Cost of Capital	0.86%	REC
Customer Cost of Capital	3.0%	REC
Cost Recovery Term	11	Average (n=147)
Customer Discount Rate	2%	Assumed

Conclusion and Recommendation

It has been established over 20 years that utility energy efficiency programs utilizing the Pay As You Save[®] system present a strong value proposition to their customers and members, but this study represents the first published value proposition for the utility and its governing body by weighing the foregone revenue to the utility against the reduced cost to serve their customers and the benefits of additional value streams.

This analysis verifies that Roanoke Electric Cooperative's *Upgrade to \$ave* program implemented by EEtility substantially cut the electricity use and peak electricity demand of participating households. Over the lifetime of the measures, the utility will recover both its initial investment and its program costs. REC's PAYS system investment in upgrades generated an average heating peak load reduction of 1.3 kW/home, a cooling peak load reduction of 1.2 kW/home, and an average per-home annualized reduction in electricity consumption of 4,228 kWh. For REC, this translated into a net present value of \$3,047 per home or \$996,240 for the program to date over the lifetime of the upgrades. Thus, REC's PAYS investment portfolio is generating substantial economic benefits for the utility even without fully quantifying all benefits streams.

This study is bounded in its scope, and future work can extend the analysis to additional dimensions of interest. For example, this paper draws no conclusions regarding the customer or member-owner perspective because such an analysis requires actual bill data for each household pre- and post- upgrade to which we did not have access at this time. A measurement of the difference in total energy costs pre- and post-upgrade as well as the net present value to the customer or member-owner will be the focus of future analysis.

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