BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Kansas City Power & Light Company's Notice of Intent to File an Application for Authority to Establish a Demand-Side Programs Investment Mechanism	))))	File No. EO-2019-0132
In the Matter of KCP&L Greater Missouri Operations Company's Notice of Intent to File an Application for Authority to Establish a Demand-Side Programs Investment Mechanism	))))	File No. EO-2019-0133

EVERGY MISSOURI METRO'S AND EVERGY MISSOURI WEST'S
NOTICE OF FILING PAYS® PILOT PROGRAM

COMES NOW, Evergy Metro, Inc. d/b/a Evergy Missouri Metro and ("Evergy Missouri Metro") and Evergy Missouri West, Inc. d/b/a Evergy Missouri West ("Evergy Missouri West")[1] (collectively "Evergy" or the "Company"), and, for their *Notice of Filing PAYS® Pilot Program* ("PAYS Notice"), state as follows:

1. On March 11, 2019, the Missouri Public Service Commission ("Commission") issued its *Amended Report and Order* ("Amended Report and Order") in the above-captioned dockets directing the Company to file a Pay As You Save® ("PAYS®") program, as follows:

> 2. If Evergy Missouri Metro and Evergy Missouri West offer a MEEIA Cycle 3 plan, the companies shall modify their respective MEEIA Cycle 3 portfolios to include a one-year Pay As You Save pilot program. The Companies, after consulting with the parties, shall file a one-year Pay As You Save pilot program at least 60 days before such pilot program go into effect. The Pay As You Save pilot program shall include the following:
>
> a. The budget for the pilot program shall be no less than 10 million dollars, and no more than 15 million dollars.
>
> b. Evergy Missouri Metro and Evergy Missouri West may administer the pilot program themselves or may employ a third party operator with experience to operate the pilot program.

[1] Effective October 7, 2019, Evergy Metro Inc. d/b/a Evergy Missouri Metro adopted the service territory and tariffs of KCP&L and Evergy Missouri West, Inc. d/b/a Evergy Missouri West adopted the service territory and tariffs of GMO. However, since the above MEEIA cases were filed using the KCP&L and GMO names, those names will be used in this pleading.

c. The pilot program shall identify a goal for the number of participants living in neighborhoods designated by the parties as predominately low or moderate-income customers or renters in multifamily housing with five or more units where the renter is responsible for paying their energy bills. The pilot program shall allow owners of multifamily units in participating buildings to use the program to install upgrades in common areas.

d. The pilot program shall have an appropriate earnings opportunity component for the Companies to be agreed upon by the parties.

e. The pilot program shall include customer protections by capping administrative costs (including total advertising costs as allocated to the total number of projects) for each individual customer project to a percentage of the total loan costs. Energy audit costs are a separate project Component and will not be included with administrative costs.

f. Participants in the Pay As You Save program shall be responsible for the capital provided for the energy efficiency measures minus any rebate.

g. Pay As You Save costs recovered through MEEIA from all ratepayers shall include: the rebate amount, administrative costs, the throughput disincentive, and an earnings opportunity (as agreed upon by the parties).

h. Any savings (kWh or kW) determined through the evaluation of the Pay As You Save program shall not be double counted with savings from other MEEIA programs at that same customer's premise.

i. Evergy Missouri Metro and Evergy Missouri West will notify the Commission of the pilot program's expected starting date, as selected by the Companies.

j. Evergy Missouri Metro and Evergy Missouri West shall submit progress reports both six months and one year after the Pay As You Save pilot program begins. The reports shall provide information based on benchmarks established by the parties to help identify the long-term feasibility and desirability of a Pay As You Save program, including participation rates.[2]

2. As such, Evergy Missouri Metro and Evergy Missouri West file concurrently with this Notice and **Attachment A**, the relevant tariffs and testimony required to implement a PAYS® pilot program, pursuant to the terms prescribed in the Commission's Amended Report and Order, as detailed above.

[2] See, *Amended Report and Order*, pp. 28-29, Ordering ¶ 2(a)-(j), dated March 11, 2020.

WHEREFORE, Evergy Missouri Metro and Evergy Missouri West submit this Notice to the Commission.

Respectfully submitted,

/s/ Roger W. Steiner

Roger W. Steiner, MBN 39586
Evergy, Inc.
1200 Main Street, 16th Floor
Kansas City, MO 64105
Telephone: (816) 556-2314
Facsimile: (816) 556-2110
E-Mail: Roger.Steiner@evergy.com

Attorneys for Evergy Missouri Metro and Evergy Missouri West

CERTIFICATE OF SERVICE

I do hereby certify that a true and correct copy of the foregoing document has been hand delivered, emailed or mailed, postage prepaid, to all counsel of record in this case on this 3rd day of June 20201

/s/ Roger W. Steiner

Counsel for Evergy Missouri Metro and Evergy Missouri West

Detailed Program Description

Pay as You Save®® (PAYS®®) Pilot

The following program template is a detailed description of the Pay as You Save® Pilot (PAYS®) program. Program tariffs are subject to change based on final program designs, as program revisions and modifications may be implemented during MEEIA 2021-2022.

Objective

The objective of this pilot is to promote the installation of energy efficient measures and create long term energy savings and bill reduction opportunities for Evergy Missouri residential customers. Evergy will fund the installation of energy efficient measures in Missouri residences and customer repayment of those services will be on a tariffed on-bill charge tied to the location. The program will be launched in September of 2021 as a 12-month Pilot. The objective is to understand the feasibility of a PAYS®® program and assess: A) The customer experience, market potential, and overall satisfaction with the program B) Evaluated savings C) Impacts to utility financials.

Target Market

The program target market is residential rate customers within the Evergy Missouri West and Evergy Missouri Metro service territory. Targeted marketing will be focused on high energy users per square foot.

Program Schedule

The pilot program will launch in September of 2021 and continue through August of 2022. Learnings from the Pilot will provide Evergy and its stakeholders with the information necessary to modify the Pilot as needed and potentially scale after the pilot phase.

General Program Description

The pilot finances home improvements that increase operational energy efficiency and home comfort. The pilot will offer an advanced home energy assessment, direct installation of energy saving measures, and custom bid outlining eligible improvement measures and their estimated savings. Measures are expected to include a mix of heating, cooling, and weatherization measures.

All measures will include a requirement that the installed cost of the measures does not exceed 80% of the estimated post upgrade bill savings - over 80% of the lifetime of the measures. Savings estimates begin with onsite building characteristics, HVAC system specifications, and direct air and duct leakage measures. Energy savings potential is calculated using a proprietary custom version of the OptiMiser

home energy use calculation engine. The implementation of the Program Administrator's proprietary OptiMiser software extensions uses the incremental measure savings outputs and fixed measure costs pre-negotiated with Program Partners to identify a qualifying offer that meets the PAYS® 80% rules above.

Following the completion of upgrades and close out of the project, Evergy will place a tariffed service charge on the participant's bill to recover the cost of the upgrades less any available MEEIA and other rebates.

Eligible Measures

The program will provide eligible customers with direct install measures. Participants with homes that do not have concerns which make the location unlikely to produce benefits for the lifetime of the upgrades will receive a full energy assessment, energy saving direct install measures, and offer for additional upgrades which may consist of qualifying energy and demand saving measures designed to achieve significant energy savings. The energy saving direct install measures will consist of energy star rated items such as LED bulbs, low flow shower heads, smart power strips, and sink aerators.

Measures installed through this program are eligible for incentives currently available through any of Evergy's other energy efficiency programs filed as a part of MEEIA Cycle 3.

Program level energy and demand savings goals and budgets can be found at the end of this Appendix and will be treated separately as the pilot is a standalone program.

Program Implementation

The utility has hired Program Administrator, EEtility to implement the pilot. The Program will seek to drive property owners and renters to achieve significant energy savings by offering installation of qualifying measures with no upfront cost to reduce financial barriers to investing in energy efficiency upgrades.

The program will identify locations with a high energy intensity per square foot. This approach will increase the likelihood that little to no copay will be required to present the customer with a PAYS® eligible offer.

The process will include the following:

- Visual home inspection with direct install of energy saving measures (**Tier 1**).
- Homes that do not have concerns which make the location unlikely to produce benefits for the lifetime of the energy efficiency upgrades will move forward with more in-depth data collection

using blowing door and cut blaster/pressure pans to record actual home features and conditions (**Tier 2**).

- Custom project – the program analyzes usage history, assessment data, and Program Partner installation costs to determine each participant's unique qualifying scope of work. The qualifying scope of work ensures that 80% of the estimated post upgrade savings over 80% of the lifetime of the measures makes up the monthly tariff charge; while 20% of the estimated post upgrade savings immediately flow to the participant, capped at 12 years (**Tier 3**).
    - Co-Pay option: If a project is not cost-effective, customers may agree to pay the portion of a project's cost that prevents it from qualifying for the Program as an upfront payment to the Program Partner.
    - The first three Tiers of the process described above are completed in the initial home visit.
- If Participant agrees to custom scope of work, the Program will facilitate installation through a network of trained Program Partners (**Tier 4**).
- Post-install QC inspections – 100% of installations will be remotely inspected for quality assurance using geo coded and time stamped photo documentation.
- Upon closeout, the customer will receive a "Pearl" home certificate and appraiser's letter. Pearl Home Certifications and accompanying appraisal letters are recognized by the Board of Realtors as homes with lower energy bills, more comfortable, and healthier than a comparable home without the energy efficient features listed in the certification report.
- Program Administrator to notarize and file Property Notice with the location's property records.
- Evergy to initiate on-bill charge 45 days following verification of installation.

The monthly tariff repayment is determined by total project cost plus interest, minus any co-payment or rebates applied. Repayment is capped at 12 years, or at 80% of the lifetime of the installed measures.

Market Transformation Elements

The pilot program will include education elements designed to educate customers on the benefits of energy efficiency as well as direct installation of select measures. For homes with concerns identified in Tier 1, a referral process will be put in place to provide customers with other programs or organizations that can help resolve those concerns. The pilot program will also provide tools and resources designed to encourage the adoption of energy efficiency.

Net to Gross Considerations

Program implementation is designed to minimize free-ridership and maximize net-to-gross ratios, while ensuring the program does the following appropriately: influences customer decisions, accurately tracks and verifies equipment and its installation, and drives market transformation.

Education/Marketing Strategy

The initial marketing strategy will utilize historic usage data and analytics to identify and customize targeted energy reports meant to encourage high energy intensity customers to enroll in the program. These energy reports will be distributed as an initial recruitment effort, followed by other tactics including but not limited to direct mail, email, and digital efforts.

Through experience and consulting other industry experts, we'll utilize best practices and tactics to target customers with promotional marketing and utilize our internal systems and processes to optimize the customers' experience and journey — all with the objectives to increase overall customer satisfaction and make for a simple and easy to understand process starting from time of enrollment through monthly payment.

EM&V

Detailed plans to analyze program performance through EM&V can be found in Appendix A.

Participation Goal – Number of Tier 4 PAYS® Pilot Installations

MO Residential Installations	934
LMI Enrollment goal	30% living in predominantly LMI neighborhoods

Pilot Budget

Utility Admin	$175,000.00
Program Implementor Start Up	$434,800.00
Program Incentives (include Tier 1 energy saving measures)	$1,004,840.00
Energy Efficient Investment (equipment/installation)	$7,005,000.00
Tier 2-4 Delivery	$1,177,885.00
Education & Marketing	$300,000.00
EM&V	$75,372.00
Total	**$10,172,897.00**

Pilot Targeted Savings

kWh Target/Savings	6,006,865
kW Target/Savings	1,877
Net-to-gross	100%

For the duration of the pilot, the net-to-gross factor will be assumed to be 1.

Pilot Cost Effectiveness

PAYS® Pilot	TRC	UCT	RIM	SCT	PCT
WEST	1.02	1.33	0.40	1.26	3.07
METRO	1.03	1.34	0.38	1.28	3.31

Evaluation, Measurement and Verification Plans
MEEIA Cycle III - PAYS

May 2021

Prepared by:

ADM Associates, Inc.
3239 Ramos Circle
Sacramento, CA 95827
916-363-8383

Table of Contents

1. Program Description

The Pay As You Save Program (PAYS) is designed to reduce the first-cost and split-incentive barrier for comprehensive whole-house retrofits. This program model assigns the repayment obligation to the utility meter rather than to the homeowner or renter, with the energy savings being used to pay down the cost of the retrofit.

Table 1-1 summarizes net savings for the PAYS program.

Table 1-1: Pilot Programs Targeted Net Savings

Program	Program Year	Evergy Missouri Metro		Evergy Missouri West		Program Overall	
		Expected Energy Savings (kWh)	Expected Peak Demand Reductions (kW)	Expected Energy Savings (kWh)	Expected Peak Demand Reductions (kW)	Expected Energy Savings (kWh)	Expected Peak Demand Reductions (kW)
PAYS	2021-22	3,003,432.5	938.5	3,003,432.5	938.5	6,006,865	1,877

Table 1-2 and Table 1-3 summarize the impact and process evaluation activities that will be completed for program years 2021 & 2022.

Table 1-2: Impact Evaluation Data Collection Activities Summary

Data Collection Activity	Impact Evaluation Research Objectives
Program Tracking Data Review and Audit	Verify that the tracking data provides sufficient information to calculate energy and demand impacts
	Verify proper application of deemed savings estimates
	Audit data to insure there are no duplicate or erroneous entries

Table 1-3: Summary of Process Evaluation Data Collection Activities

Data Collection Activity	Process Evaluation Research Objectives
Program Materials Review	Review reports and support materials for clarity and consistency with program objectives.
Program Staff Interviews	Assess program staff perspectives regarding program operations, strengths, weaknesses, barriers to success, and opportunities for improvement.
Customer Journey Mapping	Document customers' thoughts, feelings, and actions across the stages of program participation

Table 1-4 summarizes the proposed timing for these EM&V activities.

Table 1-4 Proposed Timing of EM&V Activities

Program	Process Evaluation Activities			Impact Evaluation Activities	
	Staff Interviews in Compliance with 20 CSR 4240-22.070 (8) (A)	**Database Records Review**	**Customer Journey Mapping**	**Participant Surveys**	**Contractor Surveys**
PAYS Program	2021,2022	2021,2022	2022	2021, 2022	2021, 2022 (TBD)

2. Impact Evaluation Activities

The general approach for impact evaluation of the PAYS pilot program would apply IPMVP Option C and analysis of customer billing data pre-and post-retrofit to evaluate savings impacts. We will also conduct the following analyses:

- **Compare savings acquisition costs to Evergy's other programs for similar measures:** In order to report PAYS program impacts, we will calculate savings by applying Evergy TRM protocols and compare the value of projects relative to their acquisition cost. Installation rates will be applied utilizing customer survey responses.
- **Comparison of savings to estimates for payback from program implementers:** When establishing the payback timeline, program implementers need to put an estimate of savings by month. This will vary by month due to seasonality of energy use. We will develop monthly savings profiles and compare this to the payback schedule established for PAYS participants and address the extent of over- or under-collection.

2.1 Estimating Net Savings

Net savings will apply a self-report approach. Questions will emphasize PAYS impact in defraying the first-cost barrier, and will examine the following counterfactuals:

- If the respondent would have completed a project in another ESI program
- If the respondent would have completed a project outside of ESI programs
- If the timeline of the project was advanced due to the financing option

2.1.1 Net-to-Gross Ratio

Program implementation is designed to minimize free-ridership and maximize net-to-gross ratios, while ensuring the program appropriately influences customer decisions, accurately tracks and verifies equipment and its installation, and drives market transformation.

ADM will use the self-reported data collected as part of the participant and trade ally surveys, to assess free ridership. A separate free ridership estimate will be developed for each category of measures identified in Sections 2.2.2.1 through Section 2.2.2.8.

2.1.2 Free Ridership

The free ridership self-report uses participant and trade ally surveys to develop an estimate of savings that would have occurred absent the program. In ADM's approach,

data are collected on contextual factors that influence customers' decisions in addition to customers' perceptions of program influence to estimate free ridership. Customers will be asked questions about the circumstances surrounding the decision to implement measures. The surveys will focus on factors that limit energy efficiency investments that the program may directly address. For example:

- How likely would the customer have installed these measures without participating in the PAYS program?
- Did participation in the PAYS program accelerate the customer's decision to install the program measures?

The responses to the questions about the decision-making context provide more information to help make decisions about program design and implementation than responses to rating scale questions.

For some projects, there may be program influences that are not directly observable by program participants. In such cases the participant's response creates an incomplete picture of the program's influence. For example, participation in the PAYS program could have been influenced by other factors including the ability to reduce monthly energy bills. In these cases, we propose enhanced self-report methodologies that incorporate self-reports from program implementers in addition to participant self-reports.

Survey respondents will be asked a series of questions to elicit feedback regarding influences on their decision to participate in the program. Each respondent will then be assigned a free ridership score based on a consistent free ridership scoring algorithm. The participant survey and trade ally survey will be provided to Evergy and Stakeholders for review.

2.2 Impact Evaluation Approach

This chapter describes the impact evaluation activities that ADM will perform for Evergy's PAYS Program. ADM will analyze each of the participants treated during the 2021 program year. We will summarize our results, necessary for compliance with the Evergy reporting.

ADM will compare savings attributed to the retrofit measures installed through the PAYS program from two different methodologies:

1. Calculating measure-specific savings totals per household according to the relevant unit energy savings methodology from the Evergy TRM. More details of this methodology are provided in Section 2.2.2.

2. Estimating monthly and annual billed consumption differences between treatment and control groups via regression modeling. More details of this methodology are provided in Section 2.2.1.

ADM will include the following as deliverables:

- Monthly phone call with Evergy PAYS evaluation project manager to discuss project status, results, and questions related to program evaluation;
- Draft impact evaluation reports for review;
- Final impact evaluation report;
- Analysis datasets, analysis program scripts, and data dictionaries with descriptions of variables.

2.2.1 Billing Analysis Methods

ADM will utilize a difference-in-differences (D-in-D) model approach for the impact evaluation of the PAYS program, involving a panel linear regression model to estimate energy savings for the treatment group in comparison to the matched control group. This proposed method requires monthly billing data for the program participants.

For this approach, the work effort will be divided into the following categories:

- Data preparation and cleaning, including true-up and calendarization;
- Create matched control group via propensity score matching for the treatment participants;
- Run regression model to calculate savings;
- Estimate and remove joint savings from other programs; and
- Estimate demand reductions.

We will finalize model specifications in collaboration with Evergy. The Uniform Methods Project (UMP) by the National Renewable Energy Laboratory[1] recommends a D-in-D method as it uses data from the treatment and control groups during the pre- and post-period and therefore allows the evaluator to control for outside factors that may also contribute to energy usage differences. We will explore the inclusion of independent and random variables such as Cooling/Heating Degree Days (C/HDD) for weather control and other household characteristics where applicable to improve model confidence.

Using propensity matching algorithms, evaluators will choose a group of Evergy customers, who have not participated in any other residential Evergy programs, as a control group to compare against participant billing data. ADM will test the validity of the

[1] https://www.nrel.gov/docs/fy18osti/70472.pdf

matched control group by performing *t*-tests for the average daily usage of each of the pre-period months between the remaining treatment group matched to customers in the control group. If the pre-period average daily usage differs such that the *t*-tests show a statistical difference at the 90% confidence level for any of the 12 pre-period months, the matches are considered invalid, and a new control group will be chosen.

ADM will present savings estimates in three formats for each program year:

- Daily and annual energy savings per home
- Annual percent savings per home
- Program-level savings

The percent savings per home is calculated by dividing the average annual energy savings estimated in the treatment group by the average annual energy consumption from the control group for each program year. The program-level savings are calculated by multiplying the average annual household impact estimate by the number of program participants and removing any double counted savings uplift.

2.2.1.1 *Data Requirements*

ADM proposes to estimate the PAYS program's energy impacts through a billing analysis, which will be compared to the unit energy savings calculated for each home. The data necessary to be provided by Evergy consists of the following:

- All treatment participant information
- Information for customers in a pool of potential control group participants
- The date the participant's audit was performed
- All retrofit measures and upgrades installed in the home during the PAYS audit.
- Treatment and control customer monthly billing data in pre-period through post-period;
- Treatment and control customer AMI interval data in pre-period through post-period, when available;
- Tracking data from Evergy downstream programs in each evaluated program year;
- Contact information of all treatment participants for use in survey deployment.

It is expected that data for all participants are used in the billing analysis regressions, but the actual sample sizes will depend on the quality of the billing data and the ability to find suitable control group matches for each with similar energy use.

2.2.1.2 *Data Preparation*

The evaluation team will use participant and non-participant billing data in the pre-period (before intervention of PAYS) and participant and non-participant billing data in the post-period (after intervention of PAYS) in a mixed effects panel regression model to predict electric savings, as detailed in the UMP behavioral chapter.

The following steps will be taken to prepare data:

1. Identify homes in the billing data that were assigned to the treatment or control group
2. Exclude homes without sufficient billing history
3. Exclude homes without sufficient post-period billing data
4. Exclude homes with consumption data indicating it is an outlier

ADM will examine data for outliers using multiple accepted identification techniques. These include simple Z-scores, Bonferroni Outlier Test, Grubbs Test for Outliers (G-test), or others as appropriate. In the past, we have often identified high outlier thresholds at around 200 kWh per day. This level of consumption is unrealistic for residential households and can reasonably be categorized as the result of a reading error rather than a valid reading from a high user. ADM aims to remove error reading rather than remove high and low users, as these subgroups contribute real behaviors to the average savings estimate.

ADM will report parameters necessary to portray model accuracy and significance such as coefficient p-values, and adjusted R-squared values at 90% confidence intervals. Program year savings estimates at the monthly- and annual-level will also be reported for the measure.

2.2.1.3 *True-Up*

Provided Evergy uses estimated meter reads, as part of the data preparation process, ADM will correct for estimated reads and adjusted actual reads by using a "true-up" process. For each metered read and all estimated reads immediately preceding it, ADM will total the billed usage and number of days spanning those bills. The total billed usage for that cumulative period will then be divided by the total number of days in each individual bill to generate a corrected usage value. Because the number of estimated reads per actual read is inconsistent, the number of estimated reads prior to the first actual read in the provided dataset will not be assumed. Therefore, the first metered read and all estimated reads preceding it will be excluded from the dataset. Similarly, estimated reads that do not have a corresponding actual read (generally towards the tail end of provided billing data) will also be excluded from analysis. The following equation provides the means for calculating the adjusted usage for billing data after the first metered read and all prior estimated reads have been excluded:

Equation 2-1 Billing Data Adjustment Calculation

$$Adjusted\ Usage = \sum_{i}^{n} Billed\ usage \times \frac{Billing\ days_m}{\sum_{i}^{n} Billing\ days}$$

Where:

i = First estimated bill in a sequence of estimated bills leading to a metered bill

n = A metered bill providing an adjustment factor for preceding estimated bills

m = The billing month of interest

$Billed\ usage$ = The total kWh billed in a month (monthly bills) or consumed in a month (AMI interval data)

$Billing\ days$ = The total number of days in a monthly bill's billing period or AMI interval month

2.2.1.4 *Calendarization*

Monthly billing periods in monthly billed data do not fall on consistent dates between participants. For example, one customer's June bill may run from May 16th to June 17th while another customer's may run from May 20th to July 5th. To make the monthly billing data consistent between participants and to represent each month accurately, ADM will calendarize the data into monthly calendar bills. Calendarization is the process of correcting monthly billing data to match calendar dates. For example, if 15 days in a billing

period belonged to June and 15 days belonged to July, 50% of the billed usage would be attributed to June and 50% attributed to July. The proportionated usage and number of days that fall under a given calendar month are then summed to generate a calendarized usage value and the number of billed days for that month. The following equation provides the method for calculating the monthly usage by calendar month:

Equation 2-2 Monthly Billing Data Calculation

$$Monthly\ usage_m = \sum_{i}^{n} \left(Adjusted\ usage_i \times \frac{Month\ days_i}{Billing\ days_i} \right)$$

Where:

i	= First bill containing the month of interest
n	= Last bill containing the month of interest
m	= The month of interest
$Monthly\ usage$	= The calendarized monthly usage for a given month
$Month\ days$	= The number of days belonging to the month of interest in a billing period
$Billing\ days$	= The number of days in a billing period

2.2.1.5 *Propensity Score Matching*

ADM will attempt to create a statistically similar control group using propensity score matching (PSM), a method that allows the evaluators to find the most similar household based on the customers' billed consumption trends in the pre-period and verified with statistical difference testing.

A propensity score is a metric that summarizes several dimensions of household characteristics into a single metric that can be used to group similar households. To create a post-hoc control group, ADM will compile billing data of a random sample of Evergy's residential customers who have not participated in other offerings during the program year to compare against households that participate in the PAYs program. This will allow ADM to compare the PAYS program participants to a group of similar households that have not participated in PAYS or other residential programs.

ADM will request additional billing data from customers that have not participated in PAYS or any other programs to attempt to build this control group. In addition, ADM will require information on the characteristics of these customers, such as minimum annual usage, rate schedule, or focused geographic region. With this information, ADM will attempt to create a statistically valid matched control group via seasonal pre-period usage. Matching variables may include, but are not limited to:

1. Seasonal or monthly pre-usage;
2. Household zip code.

ADM will ensure the chosen control group is statistically similar to the PAYS program participants by conducting a *t*-test for each month in the pre-period between each group. If the t-test does not show a statistical difference in usage between the selected control group and the PAYS treatment participants for the majority of pre-period months, and the groups are validly balanced, ADM will continue with the linear mixed effects D-in-D model presented in the following sub-section.

2.2.1.6 *Linear Regression*

This section defines the linear regression modeling specifications ADM will explore during the evaluation of the PAYS program.

The mixed-effects model specification contains customer-specific dummy variables to account for exogenous heterogeneity that cannot be explicitly controlled for and is not relevant to the estimation of program savings. The specification of customer-specific effects allows the model to capture much of the baseline differences across customers while obtaining reliable estimates of the impact of the program.

ADM will include independent variables such as Heating Degree Days (HDD) and Cooling Degree Days (CDD) for weather control and other household characteristics, where applicable, to improve model confidence. ADM will then fit a mixed effects panel regression model to estimate weather-dependent daily consumption differences between treatment and control households.

Equation 2-3: Difference-in-Differences (D-in-D) Panel Regression Model Specification

$$ADC_{it} = \alpha_0 + \beta_1(Post)_{it} + \beta_2(HDD)_{it} + \beta_3(CDD)_{it} + \beta_4(Post \times HDD)_{it} + \beta_5(Post \times CDD)_{it} + \beta_6(Post \times HDD \times Treatment)_{it} + \beta_7(Post \times CDD \times Treatment)_{it} + \varepsilon_{it}$$

Where:

ADC_{it} = Estimated average daily consumption (dependent variable) in home *i* during period *t*

$Post_{it}$ = Dummy variable indicating whether period *t* was in pre- or post-retrofit

$Treatment_i$ = Dummy variable indicating whether household *i* was in treatment group or control group

HDD_{it} = Average heating degree days during period *t* at home *i*

CDD_{it} = Average cooling degree days during period *t* at home *i*

ε_{it} = Customer-level random error

α_0 = The model intercept for home *i*

β_{1-8} = Coefficients determined via regression

The coefficients β_6 and β_7 represent the average change in daily weather-related consumption between the groups in the post-period. HDD and CDD are calculated from local weather data using a range of balance points (55- to 75-degree temperature base) and the HDD and CDD combination that yields the greatest model R-square will be used in the final analysis. This accounts for the "dead-band" in residential heating and cooling loads, as there is a range of temperatures in which a residential customer will be neither heating nor cooling.

As part of the regression analysis, ADM will explore the options for breaking out the population of PAYS participants into multiple regression subgroups, either by distinct measures or by groups defined by unit energy savings. The feasibility of this approach will be dependent on the overall number of program participants as well as the variability in the measures installed through the program each year. However, if statistically significant results can be achieved at the measure level, ADM will be able to conduct a more granular analysis of the savings achieved by measure.

2.2.1.7 *Remove Double-Counted Savings*

After regression models have been finalized, ADM will estimate and remove double-counted savings found from the customers in the treatment group from other Evergy energy efficiency programs.

The Evergy PAYS program reports may also increase the customer's propensity to participate in other programs. This additional participation is known as uplift. When a household participates in an efficiency program because of encouragement from another program, the resulting energy savings can appear twice: once in the regression-based estimate of PAYS program savings and again in the estimate of savings for the other energy efficiency program. Although uplift rarely displays a statistically significant difference between the treatment and control groups, the UMP recommends removing uplift from each group at the household level.

ADM will estimate savings from program uplift and subtract them from the efficiency program portfolio savings. To achieve this, ADM will gather information on the total net kWh saved in "other programs." We will calculate the uplift in savings on a per-household level for each treatment group in each cohort as follows:

Equation 2-4 Double Count Specification

$$Uplift = \left(\frac{OP\ kWh}{Household_{Treatment}} - \frac{OP\ kWh}{Household_{Control}}\right) \times \#\ Accounts_{Treatment}$$

Where:

$\frac{OP\ kWh}{Household_{Treatment}}$ = Other program kWh per household in the treatment group

$\frac{OP\ kWh}{Household_{Control}}$ = Other program kWh per household in the control group

$\#\ Accounts_{Treatment}$ = Total accounts in the treatment group

We will subtract the double counted savings, whether positive or negative, from the wave's gross savings estimates from the regression analysis to get total verified savings. Often, the difference in other program savings between the treatment group and the control group is not statistically significant at the 95% level. Nevertheless, it is standard practice to deduct double counted savings from the estimated savings for a behavioral program.

The approach for removal of double counted savings will differ based on whether the other program is a downstream or upstream program. The following sections detail our proposed methodology for each.

Downstream Programs

Downstream programs traditionally track installed measures at the customer level. This information usually contains available unique customer IDs, customer names, and customer addresses, which are easily correlated with PAYS program data. For downstream measures, ADM will request customer-level tracking data with gross and net savings from other programs Evergy offers to customers in the PAYS program.

To estimate program savings from downstream program uplift, ADM will:

1. Match the PAYS program treatment and control group customers to the utility energy efficiency program tracking data by customer ID or address;
2. Calculate the savings per treatment group subject from efficiency uplift as the difference between treatment and control groups in average efficiency program savings per subject
3. Multiply that difference by the number of subjects who are in the treatment group

ADM will summarize and remove program uplift for each of the other residential program offerings.

Upstream Programs

Estimating savings from program uplift for measures that the utility does not track at the customer level is more difficult. Because upstream programs are unable to track participation at the customer-level, ADM recommends a survey-based approach to verify the proportion of treatment group participants that interacted with the program during the year. Therefore, unlike downstream program uplift, upstream program uplift estimation requires survey data tracking a sample of participating customers' incentivized upstream measure purchases during the program year as well as similar data from a sample of non-program participants.

For this purpose, ADM will compare survey responses from PAYS participants to responses from the Home Energy Reports control group survey that focus on incentivized upstream measure purchases made at participating retailers during the program year. By comparing both groups, ADM will be able to estimate if there is a statistically significant difference in upstream measure purchases, and therefore energy savings uplift, between the treatment group and a generalized control population.

If a statistically significant difference in upstream measure purchases is found between the treatment and control groups, ADM will use to determine the average annual savings attributable to the upstream measures and subtract these savings from the PAYS program savings. If the purchase rates are not significant at the 95% confidence level, no savings uplift will need to be accounted for. Equation 2-5 below shows an example of how average annual uplift savings will be determined for upstream LED discounts.

Equation 2-5. Estimated Savings Uplift Attributable to Upstream LED Purchases

$$Uplift_{PAYS+LED} = (Bulbs_t - Bulbs_c) \times LED_{kWh} \times \#\ Accounts_t$$

Where:

$Bulbs_t$ = mean number of incentivized LEDs installed by surveyed PAYS program participants

$Bulbs_c$ = mean number of incentivized LEDs installed by surveyed Home Energy Reports program control group members

LED_{kWh} = annual savings per incentivized bulb[2]

$\#\ Accounts_t$ = Total PAYS program participants

[2] Calculated as program-level verified savings divided by verified quantity of all bulbs sold, per the Energy Saving Products M&V Report for the concurrent year.

The annual savings uplift calculated from Equation 2-5 can then be removed from the PAYS program savings following the same logic described for the removal of downstream measure uplift.

2.2.2 Unit Energy Savings

Data used for this evaluation will include:

- Program tracking data from the main tracking database;
- Deemed savings from the Evergy Technical Reference Manual
- Program applications and supporting documentation;
- Participant survey data collected through online survey
- Data from relevant secondary sources, such as the ENERGY STAR® database of certified products[3]

ADM will review data tracking systems associated with the program to ensure that the data provide sufficient information to calculate energy and demand impacts. The data review will include an assessment of whether savings reported in the tracking system comply with deemed savings values and guidelines set by the Evergy Technical Reference Manual (Evergy TRM).

Calculations for each of the expected measures that will generate savings for the PAYS program are detailed in the following subsections.

2.2.2.1 *ENERGY STAR® LED Light Bulbs*

ADM will check LED model numbers listed in the program tracking data against ENERGY STAR® databases[4] to verify that each LED model installed was ENERGY STAR® certified. Installation location information data should be available through the program tracking data. ADM will use this information to accurately establish hours of use and waste heat factors for program bulbs. In addition, measure in-service rates (ISR) will be determined from the participant survey.

ADM will analyze the savings from verified lighting measures using data for new/retrofitted fixtures on wattages before and after retrofit. Fixture wattages are generally taken from a table of standard wattages or cut sheets when feasible, with corrections made for non-operating fixtures. ADM will calculate energy savings and demand reductions using prescriptive algorithms from the Evergy TRM, Illinois Technical Reference Manual (IL TRM), and other relevant program sources, as necessary. If needed, ADM will adjust the

[3] Accessible via: https://www.energystar.gov/products/certified-products/detail/set; Last accessed: July 2019
[4] www.energystar.gov

baseline hours of use. Additionally, HVAC interactive effects will be accounted for using partially deemed algorithms from the Evergy TRM dependent upon heating and cooling systems serving areas where lighting systems are installed.

Savings algorithms for omni-directional LED bulbs were taken from the Evergy TRM. The equations used to calculate energy savings and demand reductions are shown in Equation 2-6 and Equation 2-7. The kWh savings and kW demand reductions from the installation of LED bulbs will be determined using Equation 2-6 through Equation 2-7 below:

Equation 2-6: kWh Energy Savings from LED Bulbs

$$\Delta kWh = \frac{W_{base} - W_{ee}}{1000} \times HOU \times WHF_e \times ISR$$

Equation 2-7: kW Peak Demand Reduction from LED Bulbs

$$\Delta kW = \frac{W_{base} - W_{ee}}{1000} \times CF \times WHF_d \times ISR$$

2.2.2.2 *Faucet Aerators*

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture. To qualify for this measure the installed equipment must be a low flow faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis. The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.2 GPM or greater, or a standard kitchen faucet aerator rated at 2.2 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures (and therefore the free ridership rate for this measure will be 0), use of the faucet at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

ADM will utilize savings algorithms found in the Evergy TRM for all faucet aerators (kitchen and bathroom) installed in the program. Final savings will be based on the number of faucet aerators per household, the number of faucet aerators retrofitted, and the type of water heating unit in the home. The kWh savings and kW demand reductions from the installation of faucet aerators will be determined using Equation 2-8 and Equation 2-9 below:

Equation 2-8: kWh Energy Savings for Faucet Aerators

$$\Delta\text{kWh} = \%\text{ElectricDHW} \times ((\text{GPM\_base} \times \text{L\_base} - \text{GPM\_low} \times \text{L\_low}) \times \text{Household} \times 365.25 \times \text{DF} / \text{FPH}) \times \text{EPG\_electric} \times \text{ISR}$$

Where:

%ElectricDHW	= proportion of water heating supplied by electric resistance heating
GPM_base	= Average flow rate, in gallons per minute, of the baseline faucet "as-used." This includes the effect of existing low flow fixtures and therefore the free ridership rate for this measure should be 0.
	= Measured full throttle flow * 0.83 throttling factor[5]
GPM_low	= Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"
	= Rated full throttle flow * 0.95 throttling factor[6]
L_base	= Average baseline daily length faucet use per capita for faucet of interest in minutes
L_low	= Average retrofit daily length faucet use per capita for faucet of interest in minutes
Household	= Average number of people per household
DF	= Drain Factor
FPH	= Faucets Per Household
EPG_electric	= Energy per gallon of water used by faucet supplied by electric water heater
	= 0.0795 kWh/gal (Bath), 0.0969 kWh/gal (Kitchen), 0.0919 kWh/gal (Unknown)
WaterTemp	= Assumed temperature of mixed water
	= 86ºF for Bath, 93ºF for Kitchen, 91ºF for Unknown[7]

[5] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single-Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

[6] 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single-Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265.

[7] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown an average of

SupplyTemp = Assumed temperature of water entering house

= 54.1ºF[8]

RE_electric = Recovery efficiency of electric water heater

= 98%[9]

ISR = In service rate of faucet aerators dependent on install method

= 0.95 (direct install – single family)[10]

Equation 2-9: kW Peak Demand Savings for Faucet Aerators

$$\Delta\text{kW} = \Delta\text{kWh} / \text{Hours} \times \text{CF}$$

Where:

ΔkWh = kWh savings from faucet aerators

Hours = Annual electric DHW recovery hours for faucet use per faucet

= ((GPM_base L_base) * Household/FPH * 365.25 * DF) * 0.545 / GPH

GPH = Gallons per hour recovery of electric water heater calculated for 70.9ºF temp rise (125-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank

= 25.5

CF = Coincidence Factor for electric load reduction

= 0.022[11]

2.2.2.3 *Low Flow Showerheads*

This measure relates to the installation of a low flow showerhead in a single or multi-family household. To qualify for this measure, the installed equipment must be a low flow

91% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*93) + (0.3*86) = 0.91.

[8] 2 US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

[9] Electric water heaters have recovery efficiency of 98%. http://www.ahridirectory.org/ahridirectory/pages/home.aspx

[10] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009 - 5/31/2010) Evaluation Report: All Electric Single-Family Home Energy Performance Tune-Up Program Table 3-8.

[11] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-FamilyHomes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period,

showerhead rated at least 0.5 gallons per minute (GPM) less than the existing showerhead. Savings are calculated on a per showerhead fixture basis. The baseline condition is assumed to be a standard showerhead rated at 2.0 GPM or greater. Average measured flow rates are used in the algorithm and are lower, reflecting the penetration of previously installed low flow fixtures (and therefore the free ridership rate for this measure will be 0), use of the shower at less than full flow, debris buildup, and lower water system pressure than fixtures are rated at.

ADM will utilize savings algorithms found in the Evergy TRM all low flow showerheads in the program. Final savings will be based on the number of showerheads per household, the number of showerheads retrofitted, and the type of water heating unit in the home. The kWh savings and kW demand reductions from the installation of faucet aerators will be determined using Equation 2-10 and Equation 2-11 below:

Equation 2-10: kWh Energy Savings for Low Flow Showerheads

$$\Delta\text{kWh} = \%\text{ElectricDHW} \times ((\text{GPM\_base} \times \text{L\_base} - \text{GPM\_low} \times \text{L\_low}) \times \text{Household} \times \text{SPCD} \times 365.25 / \text{SPH}) \times \text{EPG\_electric} * \text{ISR}$$

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

GPM_base = Flow rate of the baseline showerhead

= 2.67[12]

GPM_low = As-used flow rate of the low-flow showerhead

L_base = Shower length in minutes with baseline showerhead

= 7.8 min[13]

L_low = Shower length in minutes with low-flow showerhead

= 7.8 min[14]

so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022.

[12] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

[13] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. This study of 135 single and multi-family homes in Michigan metered energy parameters for efficient showerhead and faucet aerators.

[14] Ibid.

Household = Average number of people per household

SPCD = Showers Per Capita Per Day

= 0.6[15]

SPH = Showerheads per household so that per-showerhead savings fractions can be determined

EPG_electric = Energy per gallon of hot water supplied by electric

= 0.117 kWh/gal

ShowerTemp = Assumed temperature of water

= 101ºF[16]

SupplyTemp = Assumed temperature of water entering house

= 54.1ºF[17]

RE_electric = Recovery efficiency of electric water heater

= 98%[18]

ISR = In service rate of showerhead

Equation 2-11: kW Peak Demand Savings for Low Flow Showerheads

$$\Delta\text{kW} = \Delta\text{kWh}/\text{Hours} \times \text{CF}$$

Where:

ΔkWh = kWh savings from low flow showerheads

Hours = Annual electric DHW recovery hours for showerhead use

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5 kW electric resistance storage tank

= 27.51

[15] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[16] Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
[17] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html
[18] Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx

CF = Coincidence Factor for electric load reduction

= 0.0278[19]

2.2.2.4 *Pipe Insulation*

This measure describes adding insulation to un-insulated domestic hot water pipes. The measure assumes the pipe wrap is installed to the first length of both the hot and cold pipe up to the first elbow. This is the most cost-effective section to insulate since the water pipes act as an extension of the hot water tank up to the first elbow which acts as a heat trap. Insulating this length therefore helps reduce standby losses. Default savings are provided per 3ft length and are appropriate up to 6ft of the hot water pipe and 3ft of the cold. The baseline is an un-insulated hot water pipe.

ADM will utilize savings algorithms found in the Evergy TRM for all pipe insulation in the program. Final savings will be based on the length of pipe that the pipe wrap insulation covers. The kWh savings and kW demand reductions from the installation of pipe insulation will be determined using Equation 2-12 and Equation 2-13 below:

Equation 2-12: kWh Energy Savings for Pipe Insulation

$$\Delta\text{kWh} = ((1/R_{\text{exist}} - 1/R_{new}) \times (\text{L} \times \text{C}) \times \Delta\text{T} \times 8{,}766)/\,\eta_{DHW}\,/\,3413$$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]

= 1.0[20]

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu]

= 1.0 + R value of insulation

L = Length of pipe from water heating source covered by pipe wrap (ft)

C = Circumference of pipe (ft) (Diameter (in) * π/12)

= 0.5” pipe = 0.131ft, 0.75” pipe = 0.196ft

[19] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-FamilyHomes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278.

[20] Navigant Consulting Inc., April 2009; “Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets”, p77.

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

= 60°F[21]

η_{DHW} = Recovery efficiency of electric hot water heater

= 0.98[22]

Equation 2-13: kW Peak Demand Savings for Pipe Insulation

$$\Delta\text{kW} = \Delta\text{kWh} / 8766$$

Where:

ΔkWh = kWh savings from pipe wrap installation

2.2.2.5 *Advanced Power Strips*

This measure relates to Advanced Power Strips (Tier 1) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e., entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it. This measure characterization provides savings for a 7-plug strip. The assumed baseline is a standard power strip that does not control connected loads.

ADM will utilize savings algorithms found in the Evergy TRM for all advanced power strips in the program. The kWh savings and kW demand reductions from the installation of advanced power strips will be determined using Equation 2-14 and Equation 2-15 below:

Equation 2-14: kWh Energy Savings for Advanced Power Strips

$$\Delta\text{kWh}_{7-\text{Plug}} = 103\ \text{kWh}^{23}$$

Equation 2-15: kW Peak Demand Savings for Advanced Power Strips

$$\Delta\text{kW} = \Delta\text{kWh} / \text{Hours} \times \text{CF}$$

Where:

[21] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
[22] Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx
[23] Ibid.

Hours = Annual number of hours during which the controlled standby loads are turned off by the Advanced power Strip

= 7,129[24]

CF = Summer Peak Coincidence Factor for measure

= 0.8[25]

$\Delta kW_{7\text{-}Plug}$ = 0.0115 kW

2.2.2.6 *Home Envelope and Weatherization Measures*

For insulation and air sealing improvements, ADM will review data tracking systems associated with the program to ensure that the data provides sufficient information to calculate energy savings and demand impacts in addition to information that enables the identification of unique customers for surveying. This will include an assessment of whether savings reported in the tracking system comply with savings values and guidelines from the Evergy TRM.

Air Sealing

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door test. The initial and final tested leakage rates are performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

ADM will utilize savings algorithms found in the Evergy TRM for all air sealing in the program. The kWh savings and kW demand reductions from the air sealing will be determined using Equation 2-16 through Equation 2-20 below:

Equation 2-16: kWh Energy Savings for Air Sealing

$$\Delta\text{kWh} = \Delta\text{kWh\_cooling} + \Delta\text{kWh\_heating}$$

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to air sealing

[24] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips.

[25] Efficiency Vermont coincidence factor for advanced power strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing OR

= If gas furnace heat, kWh savings for reduction in fan run time

Equation 2-17: kWh Savings for Reduction in Annual Cooling Requirement Due to Air Sealing

$$\Delta\text{kWh}_{\text{cooling}} = [(((\text{CFM50\_existing} - \text{CFM50\_new})/\text{N\_cool}) \times 60 \times 24 \times \text{CDD} \times \text{DUA} \times 0.018) / (1000 \times \eta_{\text{Cool}})] \times \text{LM}$$

Where:

CFM50_existing = Infiltration at 50 Pascals as measured by blower door before air sealing

CFM50_new = Infiltration at 50 Pascals as measured by blower door after air sealing

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

CDD = Cooling Degree Days

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their air conditioner when conditions may call for it)

η_{Cool} = Efficiency (SEER) of air conditioning equipment (kBtu/kWh)

LM = Latent multiplier to account for latent cooling demand[26]

Equation 2-18: kWh Savings for Reduction in Annual Electric Heating Due to Air Sealing

$$\Delta\text{kWh}_{\text{heating}} = (((\text{CFM50\_existing} - \text{CFM50\_new})/\text{N\_heat}) \times 60 \times 24 \times \text{HDD} \times 0.018) / (\eta_{\text{Heat}} \times 3{,}412)$$

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

HDD = Heating Degree Days

η_{Heat} = Efficiency of heating system

[26] Derived by calculating the sensible and total loads in each hour. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

Equation 2-19: kWh Savings for Reduction in Fan Run Time (Gas Furnace Heat) Due to Air Sealing

$$\Delta\text{kWh}_{\text{heating}} = \Delta\text{Therms} \times \text{Fe} \times 29.3$$

Where:

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption

= 3.14%[27]

Equation 2-20: kW Peak Demand Savings for Air Sealing

$$\Delta\text{kW} = (\Delta\text{kWh\_cooling} / \text{FLH\_cooling}) \times \text{CF}$$

Where:

FLH_cooling = Full load hours of air conditioning

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[28]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%[29]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[30]

[27] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300-record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% Fe. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[28] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[29] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[30] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

2.2.2.7 *Ceiling/Attic Insulation*

Insulation is added to ceiling/attic. This measure requires a member of the implementation staff evaluating the pre- and post-R-values and measure surface areas. The existing condition will be evaluated by implementation staff and is likely to be little or no attic insulation.

ADM will utilize savings algorithms found in the Evergy TRM for all wall and ceiling/attic insulation in the program. The kWh savings and kW demand reductions from the installation of ceiling/attic insulation will be determined using Equation 2-21 through *Equation 2-25*below:

Equation 2-21: kWh Energy Savings for Ceiling/Attic Insulation

$$\Delta\text{kWh} = \Delta\text{kWh\_cooling} + \Delta\text{kWh\_heating}$$

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= If gas furnace heat, kWh savings for reduction in fan run time

Equation 2-22: kWh Savings for Reduction in Annual Cooling Requirement Due to Ceiling/Attic Insulation

$$\Delta\text{kWh}_{\text{cooling}} = ((((1/\text{R\_old} - 1/\text{R\_wall}) \times \text{A\_wall} \times (1 - \text{Framing\_factor\_wall}) + (1/\text{R\_old} - 1/\text{R\_attic}) \times \text{A\_attic} \times (1 - \text{Framing\_factor\_attic})) \times 24 \times \text{CDD} \times \text{DUA}) / (1000 \times \eta\text{Cool})) \times \text{ADJ}_{\text{WallAtticCool}}$$

Where:

R_wall = R-value of new wall assembly (including all layers between inside air and outside air)

R_attic = R-value of new attic assembly (including all layers between inside air and outside air)

R_old = R-value value of existing assemble and any existing insulation (Minimum of R-5 for uninsulated assemblies[31])

A_wall = Net area of insulated wall (ft^2)

[31] An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX).

A_attic = Total area of insulated ceiling/attic (ft^2)

Framing_factor_wall = Adjustment to account for area of framing

= 25%[32]

Framing_factor_attic = Adjustment to account for area of framing

= 7%[33]

CDD = Cooling Degree Days

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their air conditioner when conditions may call for it)

= 0.75[34]

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

$ADJ_{WallAtticCool}$ = Adjustment for cooling savings from basement wall insulation to account for prescriptive engineering algorithms overclaiming savings[35]

= 80%

Equation 2-23: kWh Savings for Reduction in Annual Electric Heating (Resistance or Heat Pump) Due to Ceiling/Attic Insulation

$$\Delta kWh_{heating} = ((((1/R\_old - 1/R\_wall) \times A\_wall \times (1 - Framing\_factor\_wall)) + (1/R\_old - 1/R\_attic) \times A\_attic \times (1 - Framing\_factor\_attic)) \times 24 \times HDD] / (\eta Heat \times 3412)) \times ADJ_{WallAtticHeat}$$

Where:

HDD = Heating Degree Days

ηHeat = Efficiency of heating system

[32] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

[33] Ibid.

[34] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

[35] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 80%.

$ADJ_{WallAtticHeat}$ = Adjustment for wall and attic insulation to account for prescriptive engineering algorithms overclaiming savings[36]

= 60%

Equation 2-24: kWh Savings for Reduction in Fan Run Time (Gas Furnace Heat) Due to Ceiling/Attic Insulation

$$\Delta\text{kWh}_{\text{heating}} = \Delta\text{Therms} \times \text{Fe} \times 29.3$$

Where:

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption

= 3.14%[37]

Equation 2-25: kW Peak Demand Savings for Ceiling/Attic Insulation

$$\Delta\text{kW} = (\Delta\text{kWh\_cooling} / \text{FLH\_cooling}) \times \text{CF}$$

Where:

FLH_cooling = Full load hours of air conditioning

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 68%[38]

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during system peak hour)

= 72%[39]

[36] As demonstrated in two years of metering evaluation by Opinion Dynamics, see Memo "Results for AIC PY6 HPwES Billing Analysis", dated February 20, 2015. TAC negotiated adjustment factor is 60%

[37] F_e is not one of the AHRI certified ratings provided for residential furnaces but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300-record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% Fe. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[38] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[39] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[40]

2.2.2.8 *Energy-Efficient HVAC Equipment*

ADM's desk review of all rebated HVAC equipment upgrades will confirm that all models meet efficiency standards prescribed by the program criteria.[41] In addition, the desk review will verify that program data includes adequate information to calculate energy savings and demand impacts, as well as information that enables the identification of unique customers for surveying. Savings will be determined per HVAC measure, following the Evergy TRM.

ADM will rely on the Evergy TRM for all energy-efficient HVAC measures with savings algorithms defined in IL TRM, Vol3, v7. Calculations will be based on if the HVAC unit was defined as time of sale or early replacement. Time of sale units relate to the replacement of an existing unit at the end of its useful life, or the installation of a new heating and cooling system in a new home. Early replacements units relate to the early removal of functioning heating and cooling systems from service, prior to its natural end of life, and replacement with a new HVAC unit. Participant surveys will be used to gather data from rebate recipients to confirm installation of rebated measures.

Central Air Conditioner

This measure characterizes time of sale and early replacement central air conditioners following the Evergy TRM. ADM will utilize savings algorithms found in the Evergy TRM for all central air conditioners in the program. The kWh savings and kW demand reductions from the installation of central air conditioners will be determined using Equation 2-26 through

Equation *2-29* below:

Equation 2-26: kWh Energy Savings for Central Air Conditioners (Time of Sale)

$$\Delta\text{kWH} = (\text{FLHcool} \times \text{Capacity} \times (1/(\text{SEER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff}))))/1000$$

[40] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[41] https://www.evergy.com/-/media/documents/ways-to-save/rebates/rebate-incentive-chart.pdf?la=en

Equation 2-27: kWh Energy Savings for Central Air Conditioners (Early Replacement)

$$\Delta\text{kWH for remaining life of existing unit (first 6 years)} = (\text{FLHcool} \times \text{Capacity} \times (1/(\text{SEER}_{exist} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff}))))/1000$$

$$\Delta\text{kWH for remaining measure life (next 12 years)} = (\text{FLHcool} \times \text{Capacity} \times (1/(\text{SEER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff}))))/1000$$

Where:

FLHcool = Full load cooling hours

Capacity = Size of new equipment in Btu/hr (note 1 ton = 12,000Btu/hr)

$SEER_{base}$ = Seasonal energy-efficiency ratio of baseline unit (kBtu/kWh)

= 13[42]

$SEER_{exist}$ = Seasonal energy-efficiency ratio of existing unit (kBtu/kWh)

$SEER_{ee}$ = Rated seasonal energy-efficiency ratio of ENERGY STAR® unit (kBtu/kWh)

$SEER_{adj}$ = Adjustment percentage to account for in-situ performance of the unit

$= [0.805 \times \left(\frac{EER_{ee}}{SEER_{ee}}\right) + 0.367]$

$DeratingCool_{Eff}$ = Efficient central air conditioner cooling derating

= 0% if Quality Installation is performed

= 10% if Quality Installation is not performed or unknown[43]

$DeratingCool_{Base}$ = Baseline central air conditioner cooling derating

= 10%

Equation 2-28: kW Peak Demand Savings for Central Air Conditioners (Time of Sale)

[42] Based on Minimum Federal Standard.

[43] Based on Cadmus assumption provided in preparation of the 2014 Interstate Power and Light TRM based upon proper refrigerant charge, evaporator airflow, and unit sizing, Appears conservative in comparison to ENERGY STAR statements (see 'Sponsoring an ENERGY STAR Verified HVAC Installation (ESVI) Program'). Note pending ComEd evaluation will provide an update to these assumptions.

$$\Delta\text{kW} = (\text{Capacity} \times (1/(\text{EER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))/1000 \times \text{CF}$$

Equation 2-29: kW Peak Demand Savings for Central Air Conditioners (Early Replacement)

$$\Delta\text{kW for remaining life of existing unit (first 6 years)} = (\text{Capacity} \times (1/(\text{EER}_{exist} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))/1000 \times \text{CF}$$

$$\Delta\text{kW for remaining measure life (next 12 years)} = (\text{Capacity} \times (1/(\text{EER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))/1000 \times \text{CF}$$

Where:

EER_{base} = EER Efficiency of baseline unit

= 10.5[44]

EER_{exist} = EER Efficiency of existing unit

EER_{ee} = EER Efficiency of ENERGY STAR unit

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/Cs (during system peak hour)

= 68%[45]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/Cs (average during peak period)

= 46.6%[46]

Other variables as defined above.

Air Source Heat Pump

This measure characterizes time of sale and early replacement air source heat pumps following the Evergy TRM. ADM will utilize savings algorithms found in the Evergy TRM for all air source heat pumps in the program. The kWh savings and kW demand reductions

[44] The federal Standard does not currently include an EER component. The value provided is based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.

[45] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[46] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

from the installation of air source heat pumps will be determined using Equation 2-30 through Equation 2-33 below:

Equation 2-30: kWh Energy Savings for Air Source Heat Pumps (Time of Sale)

$$\Delta\text{kWh} = ((\text{FLH\_cooling} \times \text{Capacity\_cooling} \times (1/(\text{SEER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff})))) / 1000) + ((\text{FLH\_heat} \times \text{Capacity\_heating} \times (1/(\text{HSPF}_{base} \times (1 - \text{DeratingHeat}_{Base})) - 1/(\text{HSPF}_{ee} \times \text{HSPF}_{adj} \times (1 - \text{DeratingHeat}_{Eff})))) / 1000)$$

Equation 2-31: kWh Energy Savings for Air Source Heat Pumps (Early Replacement)

$$\Delta\text{kWH for remaining life of existing unit (first 6 years)} = ((\text{FLH\_cooling} \times \text{Capacity\_cooling} \times (1/(\text{SEER}_{exist} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff})))) / 1000) + ((\text{FLH\_heat} \times \text{Capacity\_heating} \times (1/(\text{HSPF}_{exist} \times (1 - \text{DeratingHeat}_{Base})) - 1/(\text{HSPF}_{ee} \times \text{HSPF}_{adj} \times (1 - \text{DeratingHeat}_{Eff})))) / 1000)$$

$$\Delta\text{kWH for remaining measure life (next 12 years)} = ((\text{FLH\_cooling} \times \text{Capacity\_cooling} \times (1/(\text{SEER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{SEER}_{ee} \times \text{SEER}_{adj} \times (1 - \text{DeratingCool}_{Eff})))) / 1000) + ((\text{FLH\_heat} \times \text{Capacity\_heating} \times (1/(\text{HSPF}_{base} \times (1 - \text{DeratingHeat}_{Base})) - 1/(\text{HSPF}_{ee} \times \text{HSPF}_{adj} \times (1 - \text{DeratingHeat}_{Eff})))) / 1000)$$

Where:

FLH_cooling	= Full load hours of air conditioning
Capacity_cooling	= Cooling Capacity of Air Source Heat Pump (Btu/hr)
$SEER_{exist}$	= Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh)
$SEER_{base}$	= Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)
	= 14[47]
$SEER_{ee}$	= Rated Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)
$SEER_{adj}$	= Adjustment percentage to account for in-situ performance of the unit[48]

[47] Based on Minimum Federal Standard effective 1/1/2015.
[48] In situ performance based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.

$= [0.805 \times \left(\frac{EER_{ee}}{SEER_{ee}}\right) + 0.367]$

$DeratingCool_{Eff}$ = Efficient air source heat pump cooling derating

= 0% if Quality Installation is performed

= 10% if Quality Installation is not performed or unknown[49]

$DeratingCool_{Base}$ = Baseline Cooling derating

= 10%

FLH_heat = Full load hours of heating

Equation 2-32: kW Peak Demand Savings for Air Source Heat Pumps (Time of Sale)

$$\Delta\text{kW} = (\text{Capacity\_cooling} \times (1/(\text{EER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))) / 1000 \times \text{CF}$$

Equation 2-33: kW Peak Demand Savings for Air Source Heat Pumps (Early Replacement)

$$\Delta\text{kW for remaining life of existing unit (first 6 years)} = (\text{Capacity\_cooling} \times (1/(\text{EER}_{\text{exist}} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))) / 1000 \times \text{CF}$$

$$\Delta\text{kW for remaining measure life (next 12 years)} = (\text{Capacity\_cooling} \times (1/(\text{EER}_{base} \times (1 - \text{DeratingCool}_{Base})) - 1/(\text{EER}_{ee} \times (1 - \text{DeratingCool}_{Eff})))) / 1000 \times \text{CF}$$

Where:

EER_{exist} = Energy Efficiency Ratio of existing cooling system (kBtu/hr / kW)

EER_{base} = Energy Efficiency Ratio of baseline air source heat pump (kBtu/hr / kW)

= 11[50]

EER_{ee} = Energy Efficiency Ratio of efficient air source heat pump (kBtu/hr / kW)

[49] Based on Cadmus assumption provided in preparation of the 2014 Interstate Power and Light TRM based upon proper refrigerant charge, evaporator airflow, and unit sizing, Appears conservative in comparison to ENERGY STAR statements (see 'Sponsoring an ENERGY STAR Verified HVAC Installation (ESVI) Program'). Note pending ComEd evaluation will provide an update to these assumptions.

[50] The Federal Standard does not include an EER requirement. The value provided is based on Opinion Dynamics and Cadmus metering study of Ameren HVAC program participants; See 'AIC HVAC Metering Study Memo FINAL 2_28_2018'.

CF_{SSP} = Summer System Peak Coincidence Factor for heat pumps (during system peak hour)

= 72%[51]

CFP_{JM} = PJM Summer Peak Coincidence Factor for heat pumps (average during peak period)

= 46.6%[52]

Other variables as defined above.

Ground Source Heat Pump

This measure characterizes time of sale and early replacement ground source heat pumps (non-fuel switch) following the Evergy TRM. ADM will utilize savings algorithms found in the Evergy TRM for all ground source heat pumps in the program. The kWh savings and kW demand reductions from the installation of ground source heat pumps will be determined using Equation 2-34 through Equation 2-37 below:

Equation 2-34: kWh Energy Savings for Ground Source Heat Pumps (Time of Sale)

$$\Delta\text{kWh} = [\text{FLH}_{\text{cool}} \times \text{Capacity\_cooling} \times (1/\text{SEER}_{base} - 1/\text{EER}_{PL})/1000] + [\text{FLHheat} \times \text{Capacity\_heating} \times (1/\text{HSPF}_{ASHP} - 1/(\text{COP}_{PL} \times 3.412))/1000] + [\text{ElecDHW} \times \%\text{DHWDisplaced} \times ((1/\text{EF}_{ELEC} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (\text{T}_{OUT} - \text{T}_{IN}) \times 1.0) / 3412)]$$

Equation 2-35: kWh Energy Savings for Ground Source Heat Pumps (Early Replacement)

$$\Delta\text{kWH for remaining life of existing unit (first 8 years)} = [\text{FLHcool} \times \text{Capacity\_cooling} \times (1/\text{SEER}_{exist} - 1/\text{EER}_{PL})/1000] + [\text{ElecHeat} \times \text{FLHheat} \times \text{Capacity\_heating} \times (1/\text{HSPF}_{exist} - 1/(\text{COP}_{PL} \times 3.412))/1000] + [\text{ElecDHW} \times \%\text{DHWDisplaced} \times ((1/\text{EF}_{ELEC} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (\text{T}_{OUT} - \text{T}_{IN}) \times 1.0) / 3412)]$$

$$\Delta\text{kWH for remaining measure life (next 17 years)} = [\text{FLHcool} \times \text{Capacity\_cooling} \times (1/\text{SEER}_{base} - 1/\text{EER}_{PL})/1000] + [\text{ElecHeat} \times \text{FLHheat} \times \text{Capacity\_heating} \times (1/\text{HSPF}_{base} - (1/(\text{COP}_{PL} \times 3.412))/1000] + [\text{ElecDHW} * \%\text{DHWDisplaced} \times ((1/\text{EF}_{ELEC} \times \text{GPD} \times \text{Household} \times 365.25 \times \gamma\text{Water} \times (\text{T}_{OUT} - \text{T}_{IN}) \times 1.0) / 3412)]$$

Where:

[51] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'

[52] 1 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

FLH_{cool}	= Full load cooling hours
Capacity_cooling	= Cooling Capacity of ground source heat pump (Btu/hr)
$SEER_{base}$	= SEER Efficiency of new replacement baseline unit
$SEER_{exist}$	= SEER Efficiency of existing cooling unit
EER_{PL}	= Part Load EER Efficiency of efficient ground source heat pump unit[53]
ElecHeat	= 1 if existing building is electrically heated
	= 0 if existing building is not electrically heated
FLHheat	= Full load heating hours
Capacity_heating	= Heating Capacity of ground source heat pump (Btu/hr)
$HSPF_{base}$	= Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)
$HSPF_{exist}$	= Heating System Performance Factor of existing heating system (kBtu/kWh)
COPPL	= Part Load Coefficient of Performance of efficient unit[54]
ElecDHW	= 1 if existing DHW is electrically heated
	= 0 if existing DHW is not electrically heated
%DHWDisplaced	= Percentage of total DHW load that the ground source heat pump will provide
EF_{ELEC}	= Energy Factor (efficiency) of electric water heater
GPD	= Gallons Per Day of hot water use per person
Household	= Average number of people per household
γWater	= Specific weight of water
T_{OUT}	= Tank temperature
	= 125°F

[53] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a ground source heat pump.
[54] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a ground source heat pump.

T_{IN} = Incoming water temperature from well or municipal system

= 54°F[55]

Equation 2-36: kW Peak Demand Savings for Ground Source Heat Pumps (Time of Sale)

$$\Delta\text{kW} = (\text{Capacity\_cooling} \times (1/\text{EER}_{base} - 1/\text{EER}_{FL}))/1000 \times \text{CF}$$

Equation 2-37: kW Peak Demand Savings for Ground Source Heat Pumps (Early Replacement)

$$\Delta\text{kW for remaining life of existing unit (first 8 years)} = (\text{Capacity\_cooling} \times (1/\text{EER}_{exist} - 1/\text{EER}_{FL}))/1000 \times \text{CF}$$

$$\Delta\text{kW for remaining measure life (next 17 years)} = (\text{Capacity\_cooling} \times (1/\text{EER}_{base} - 1/\text{EER}_{FL}))/1000 \times \text{CF}$$

Where:

EER_{base} = Energy Efficiency Ratio of new replacement baseline unit

EER_{exist} = Energy Efficiency Ratio of existing cooling unit (kBtu/hr / kW)

EER_{FL} = Full Load Energy Efficiency Ratio of ENERGY STAR ground source heat pump unit[56]

CF_{SSP} = Summer System Peak Coincidence Factor for heat pumps (during system peak hour)

= 72%[57]

CF_{PJM} = PJM Summer Peak Coincidence Factor for heat pumps (average during peak period)

= 46.6%[58]

Other variables as defined above.

[55] US DOE Building America Program. Building America Analysis Spreadsheet.
[56] As per conversations with David Buss territory manager for Connor Co, the EER rating of an air source heat pump equate most appropriately with the full load EER of a ground source heat pump unit.
[57] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.
[58] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

Ductless Mini-Split Heat Pump

This measure characterizes time of sale and early replacement ductless mini-split heat pumps (non-fuel switch) following the Evergy TRM. ADM will utilize savings algorithms found in the Evergy TRM for all ductless mini-split heat pumps in the program. The kWh savings and kW demand reductions from the installation of ground source heat pumps will be determined using Equation 2-38 through Equation 2-41 below:

Equation 2-38: kWh Energy Savings for Ductless Mini-Spilt Heat Pumps (Time of Sale)

$$\Delta\text{kWh} = [(\text{Elecheat} \times \text{Capacity}_{heat} \times \text{EFLH}_{heat} \times (1/\text{HSPF}_{Base} - 1/\text{HSPF}_{ee})) / 1000] + [(\text{Capacity}_{cool} \times \text{EFLH}_{cool} \times (1/\text{SEER}_{Base} - 1/\text{SEER}_{ee})) / 1000]$$

Equation 2-39: kWh Energy Savings for Ductless Mini-Spilt Heat Pumps (Early Replacement)

$$\Delta\text{kWH for remaining life of existing unit (first 6 years)} = [(\text{ElecHeat} \times \text{Capacity}_{heat} \times \text{EFLH}_{heat} \times (1/\text{HSPF}_{exist} - 1/\text{HSPF}_{ee})) / 1000] + [(\text{Capacity}_{cool} \times \text{EFLH}_{cool} \times (1/\text{SEER}_{exist} - 1/\text{SEER}_{ee})) / 1000]$$

$$\Delta\text{kWH for remaining measure life (next 12 years)} = [(\text{ElecHeat} \times \text{Capacity}_{heat} \times \text{EFLH}_{heat} \times (1/\text{HSPF}_{base} - 1/\text{HSPF}_{ee})) / 1000] + [(\text{Capacity}_{cool} \times \text{EFLH}_{cool} \times (1/\text{SEER}_{base} - 1/\text{SEER}_{ee})) / 1000]$$

Where:

ElecHeat	= 1 if existing building is electrically heated
	= 0 if existing building is not electrically heated
Capacity_{heat}	= Heating capacity of the ductless heat pump unit in Btu/hr
EFLH_{heat}	= Equivalent Full Load Hours for heating
HSPF_{base}	= Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)
HSPF_{exist}	= HSPF rating of existing equipment (kbtu/kwh)
HSPF_{ee}	= HSPF rating of new equipment (kbtu/kwh)
Capacity_{cool}	= the cooling capacity of the ductless heat pump unit in Btu/hr
SEER_{base}	= SEER rating of new replacement baseline unit
SEER_{ee}	= SEER rating of new equipment (kbtu/kwh)
SEER_{exist}	= SEER rating of existing equipment (kbtu/kwh)
EFLH_{cool}	= Equivalent Full Load Hours for cooling

Equation 2-40: kW Peak Demand Savings for Ductless Mini-Split Heat Pumps (Time of Sale)

$$\Delta\text{kW} = (\text{Capacitycool} \times (1/\text{EERbase} - 1/\text{EERee})) / 1000) \times \text{CF}$$

Equation 2-41: kW Peak Demand Savings for Ductless Mini-Split Heat Pumps (Early Replacement)

$$\Delta\text{kW for remaining life of existing unit (first 6 years)} = (\text{Capacitycool} \times (1/\text{EER}_{exist} - 1/\text{EER}_{ee})) / 1000) \times \text{CF}$$

$$\Delta\text{kW for remaining measure life (next 12 years)} = (\text{Capacitycool} * (1/\text{EER}_{base} - 1/\text{EER}_{ee})) / 1000) \times \text{CF}$$

Where:

EER_{base} = Energy Efficiency Ratio of new replacement unit

EER_{exist} = Energy Efficiency Ratio of existing cooling system (kBtu/hr/kW)

EER_{ee} = Energy Efficiency Ratio of new ductless mini-split heat pumps (kBtu/hr/kW)

CF_{SSP} = Summer System Peak Coincidence Factor for heat pumps (during utility peak hour)

CF_{PJM} = PJM Summer Peak Coincidence Factor for heat pumps (average during PJM peak period)

2.2.3 Demand Reduction

The kW peak reduction will be determined by dividing the kWh annual savings by the number of hours in the year (8,760).

3. Process Evaluation Activities

This chapter describes the process evaluation activities that ADM will perform for Evergy's programs.

The process evaluation will include the following activities:

- Annual reviews of the program database and materials and in-depth interviews with Evergy and implementer staff
- Non-participant feedback from the annual general population survey
- Feedback from surveys and/or interviews with program contractors (trade allies)
- Customer journey mapping of the PAYS program

3.1 Process Evaluation Approach

We will conduct the following activities: 1) in-depth interviews with Evergy and implementer staff at the beginning and end of the pilot year and a review of the program database and materials at the end of the pilot year; 2) a telephone or online survey of program participants at the end of the pilot year; and 3) feedback on program awareness and interest from the general population survey.

Program-specific areas of focus for this process evaluation will include factors that influenced participants to enroll in PAYS financing. Did participants enroll because they expected to remain in their homes for the duration of the financing? Were they at all concerned that doing so might make it difficult to sell their house later and, if so, what convinced them to take that risk? The evaluation also will assess whether participants experienced a net reduction in their energy bill. How influential was the PAYS program in their decision to install energy efficiency measures? Did the participants install additional measures because of the PAYS program influence? How did the PAYS program affect the bill payment history of program participants?

We will also develop a customer journey mapping during PY2022 to illustrate ways in which participants and contractors have engaged in this program during the pilot period.

3.2 Process Evaluation Objectives

The process evaluation objectives will conform to industry best practices by ensuring that ADM gathers data from a variety of sources including program staff, market actors, trade allies, program participants, and non-participants. As part of addressing the five high-level CSR-mandated questions, the process evaluation, Specifically, each process evaluation will address several key research questions:

- Is the program design appropriate for its objectives?

- What is the general level of program awareness?
- How effective is program communication, within and between Evergy and implementers and between the program and its implementer?
- How effective is program marketing and outreach? What is most and least effective?
- How effectively is the program delivered by EEtility?
- Does the mix of measures installed through the program reflect expectations?
- Are program rules, procedures, and processes reasonable?
- What are customers' motives for saving energy?
- Why did the customers decide to participate in the PAYS program, specifically.
- How has the PAYS program met customer expectations, either positively or negatively.
- How do customers make decisions about energy-using equipment and products?
- What are the barriers to program participation? Specifically, were the program requirements a barrier to participation?
- How can the program improve communication, marketing and outreach, delivery, and processes or otherwise remove barriers to participation?

ADM will also investigate how the COVID-19 crisis affected program implementation and delivery, if Evergy staff deem that appropriate.

3.3 Program Tracking Review

The first critical task will be to review the program databases that will complement the impact evaluation review of the program databases. Specifically, this review will determine whether the program database is capturing all critical information. The database review will also include summaries of the essential program metrics as appropriate such as:

- Number of measures installed by program and program delivery channel
- Number of unique participants by program and by utility relative to program participation estimates

Application process metrics by program, including application processing times, reasons for denial, and distribution of participants by geographic location

3.4 Program Marketing Materials and Website Review

ADM will review the current program marketing materials. This will include examining relevant program documents such as program marketing materials, application/rebate forms, and website materials.

The findings from this review will be summarized in an overall assessment of the effectiveness of current marketing and outreach activities. Specifically, ADM will provide a summary of the overall effectiveness of these materials, including any available data on web site visits, click-throughs, and associated metrics. The review also will compare the current market tactics to industry best practices for marketing residential energy-efficiency PAYS programs.

3.5 Program Staff and Implementer Review

ADM will conduct interviews with both the program staff and implementer staff. ADM will conduct interviews with the utility program staff responsible for deploying the programs. The in-depth interviews will be conducted via telephone. These interviews will discuss the respondent's roles and responsibilities for the program, the effectiveness of current program design, assess overall program operations, outreach and marketing approaches, customer and contractor satisfaction, barriers to participation and areas for program improvement.

ADM will also conduct interviews with appropriate staff from the EEtility. The in-depth interviews will be conducted via telephone. The discussions will cover the same process evaluation topics to ensure consistency across all interview guides.

3.6 Participant Surveys

ADM will field participant surveys in Year 2 or Year 3, depending upon participation levels. These participant surveys will address the following key areas:

- Customer satisfaction with all PAYS components
- Reasons driving program participation
- Measure installation rates
- Determination of Net-to-Gross by assessing free-ridership and spillover from PAYS participants.
- Identifying other program benefits including non-energy benefits such as improved occupant health, safety, and comfort due to program participation.
- Changes in bill payment behavior due to PAYS participation

3.6.1 Customer Journey Mapping

ADM Evaluators will conduct customer journey mapping for the PAYS program once per evaluation cycle. The customer journey mapping will document customers' thoughts, feelings, and actions across the stages of program participation. The maps will illustrate the PAYS program processes, customer engagement points, and key performance indicators as well as the overall customer experience, including key decision-points. One of the key benefits of this technique will be to identify key "pain points" that must be addressed or eliminated to improve overall program operations. ADM will incorporate the MO Code of State Regulations 20 CSR 4240-22.070 (8) research questions into the journey map and document each program's progress in meeting these objectives annually.

The findings will be synthesized from the in-depth interviews with program staff, trade allies, implementation contractors as customer input from the customer surveys to create the journey maps. The journey map will identify program "disconnects," point to actionable recommendations for program improvement and identify additional market opportunities.

4. Cost – Benefit Analysis

4.1 Calculation

Cost-effectiveness values will be calculated utilizing a transparent excel based workbook and will include ADM-verified EM&V findings, including energy and demand impacts, incremental costs, NTG ratios, participation numbers, and measure lifetimes. All program and avoided cost data, and discount rates, will be provided by Evergy. The results will be included in the EM&V report.

4.2 Cost Tests Utilized

ADM will perform the Participant Cost Test, Ratepayer Impact Measure, Utility Cost Test, and Total Resource Cost, Societal Cost Test for annually for MEEIA Cycle 3. This will give an all-encompassing perspective on the program's annual cost effectiveness, as well as the cost effectiveness of the program over the portfolio cycle.

A common misperception is that there is a single best perspective for evaluation of cost-effectiveness. Each test is useful and accurate, but the results of each test are intended to answer a different set of questions. The questions to be addressed by each cost test[59] are shown in Table 4-1, below and on the next page.

Table 4-1: Questions Addressed by the Various Cost Tests

Cost Test	Questions Addressed
Participant Cost Test (PCT)	■ Is it worth it to the customer to install energy efficiency? ■ Is the customer likely to want to participate in a utility program that promotes energy efficiency?
Ratepayer Impact Measure (RIM)	■ What is the impact of the energy efficiency project on the utility's operating margin? ■ Would the project require an increase in rates to reach the same operating margin?
Program Administrator Cost Test (PACT –also referred to as the Utility Cost Test or UCT)	■ Do total utility costs increase or decrease? ■ What is the change in total customer bills required to keep the utility whole?

[59] National Action Plan for Energy Efficiency (2008) Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers. *Energy and Environmental Economics, Inc., and Regulatory Assistance Project*. *Last accessed July 2019 via:* https://www.epa.gov/sites/production/files/2015-08/documents/cost-effectiveness.pdf

Cost Test	Questions Addressed
Total Resource Cost Test (TRC)	■ What is the regional benefit of the energy efficiency project including the net costs and benefits to the utility and its customers? ■ Are all the benefits greater than all the costs (regardless of who pays the costs and who receives the benefits)? ■ Is more or less money required by the region to pay for energy needs?
Societal Cost Test (SCT)	■ What is the overall benefit to the community of the energy efficiency project including indirect benefits? ■ Are all the benefits, including indirect benefits, greater than all the costs (regardless of who pays the cost and who receives the benefits)?

Overall, the results of all five cost-effectiveness tests provide a more comprehensive picture than the use of any one test alone. The TRC and SCT cost tests help to answer whether energy efficiency is cost-effective overall. The PCT, UCT, and RIM help to answer where the selection of measures and design of the program is balanced from participant, utility, and non-participant perspectives, respectively. The scope of the benefit and cost components included in each test ADM performed are summarized in Table 4-2, below and on the next page.

Table 4-2: Summary of Benefits and Costs Included in Cost-Effectiveness Test

Test	Benefits	Costs
PCT (Benefits and costs from the perspective of the customer installing the measure)	■ Incentive payments ■ Bill Savings ■ Applicable tax credits or incentives	■ Incremental equipment costs ■ Incremental installation costs
UCT (Perspective of utility, government agency, or third party implementing the program)	■ Energy-related costs avoided by the utility ■ Capacity-related costs avoided by the utility, including generation, transmission, and distribution	■ Program overhead costs ■ Utility/program administrator incentive & installation costs

Test	Benefits	Costs
TRC (Benefits and costs from the perspective of all utility customers in the utility service territory)	■ Energy-related costs avoided by the utility ■ Capacity-related costs avoided by the utility, including generation, transmission, and distribution ■ Additional resource savings ■ Monetized environmental and non-energy benefits ■ Applicable tax credits	■ Program overhead costs ■ Program installation costs ■ Incremental measure costs
SCT (Benefits and cost to all in the utility service territory, state, or nation as a whole.)	■ Energy-related costs avoided by the utility ■ Capacity-related costs avoided by the utility, including generation, transmission, and distribution ■ Non-monetized environmental and non-energy benefits	■ Program overhead costs ■ Program installation costs ■ Incremental measure costs
RIM (Impact of efficiency measure on non-participating ratepayers overall)	■ Energy-related costs avoided by the utility ■ Capacity-related costs avoided by the utility, including generation, transmission, and distribution	■ Program overhead costs ■ Utility/program administrator incentive & installation costs ■ Lost revenue due to reduced energy bills

4.3 Non-Energy Impacts (NEBs)

As part of the pilot program evaluation ADM will identify utility non-energy impacts for review and discussion between Evergy and the DSM advisory group. During the first part of the program year ADM will explore the feasibility of collecting data to calculate the following:

- Therms Savings
- Water savings
- Reduction in payment averages
- Reduction in payment assistance funding

5. Reporting and Scheduling

5.1 Evaluation Schedule

The detailed proposed pilot evaluation schedule for 2021-2022 is shown in Table 5-1, below.

Table 5-1: 2021 Evaluation Schedule

Time Period	Party	Activities
May 2021	ADM	Complete EM&V Plan
May 2021	Evergy	PAYS Filing
September 2021	Evergy	PAYS Filing/Pilot Inception
February 2022	ADM	Complete initial EM&V Process Evaluation Memo[60]
March 2022	ADM/EEtility/Evergy	Complete 6-month Progress Report[61]
July 2022	ADM	Informal internal progress report comparing the actual savings of participants vs estimated savings projected by EEtility
September 2022	ADM/EEtility/Evergy	Complete 12-month Progress Report[61]
October 2022	ADM	Complete Final EM&V Report

ADM will work with stakeholders, including the EM&V Auditor, on a regular basis throughout the evaluation process, involving stakeholders through the following key review touch points:

- Annual evaluation report review
- Survey instrument review (as they become available)
- Progress updates (quarterly)
- Ad hoc meetings (as required – particularly for key approach issues)

[60] Evaluation of the Pilot help answer:
- Satisfaction of participating customers with the program
- Average amount financed per home
- Participation rates and barriers to participation
- Customer progression through the program tiers
- Participations rates in low to moderate income or multi-family properties
- Total incentive spent for the Pilot
- Statistics around the types of measures installed
- Impact to utility financials

[61] Reports shall provide information based on benchmarks established by the parties to help identify the long-term feasibility and desirability of a Pay As You Save program, including participation rates.

5.2 EM&V Reporting

The annual EM&V report will provide the final estimate of the effects of the programs achieving energy and demand savings and will summarize all the work conducted in evaluating the program. The report will present an overview of the EM&V efforts and identify key issues confronted in the evaluation along with a summary of how they were handled. ADM will provide a combined annual evaluation report for both territories. A Draft of the report will be provided for Evergy and the Missouri Stakeholder group comment.

The final evaluation report will include the following information:

- Verified energy and peak demand savings achieved by the program;
- A comparison of targeted savings, reported savings, and verified savings;
- Number of participants and count of total measures in the program;
- A comparison of targeted program budget and actual program spending, with an explanation for any non-spending;
- A description of any proposed changes in program plans;
- Actionable recommendations to strengthen program processes and answers to questions 1 through 5 as stated in in the process evaluation requirements of the Missouri Code of State Regulations (“MO Regulations”) 20 CSR 4240-22.070 (8) (A).
- Results for the five standard cost tests for each program.