Opinion Dynamics

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Ameren Missouri Program Year 2021

Volume 2: Residential Portfolio Appendices

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Opinion Dynamics

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Appendix A. Detailed Impact Analysis Methodology

Residential Lighting

Gross Impact Methodology

Electricity and Demand Savings

To calculate ex post gross energy (MW) and demand (MWh) savings for the PY2021 Residential Lighting Program, the evaluation team applied the September 2021 Ameren Missouri TRM Appendix I (v4.0) and Appendix F (v4.0) deemed savings tables to the program tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in the following equations.

Equation 1. Residential Energy Savings Equation

$$\Delta kWh_{RES} = [(Watt_{Base} - Watt_{EE}) \times \%RES \times ISR \times (1 - LKG) * (HOU_{RES} \times WHFe_{RES}] \div 1{,}000$$

Equation 2. Non-Residential Energy Savings Equation

$$\Delta kWh_{NRES} = [(Watt_{Base} - Watt_{EE}) \times (1 - \%\text{RES}) \times \text{ISR}\ (1 - LKG) * (HOU_{NRES} \times WHFe_{NRES}] \div 1{,}000$$

Equation 3. Total Energy Savings Equation

$$\Delta kWh = \Delta kWh_{RES} + \Delta kWh_{NRES}$$

Equation 4. Residential Demand Savings Equation

$$\Delta kW = \Delta kWh\ x\ CF$$

Table 1 lists each of the savings calculation parameters, providing a description, the source of the PY2021 evaluation numbers, and the final parameter values used for computing ex post gross savings.

Table 1. Ex Post Savings Assumption Sources

Parameter	Description	Source of Assumption	Online Store		Upstream Lighting	
			Residential	Commercial	Residential	Commercial
$Watt_{Base}$	Minimum EISA-compliant efficiency baselines taken from applicable Appendix I lumen ranges	TRM Appendix I	Minimum efficiency baselines taken from applicable Appendix I lumen ranges			
$Watt_{EE}$	Actual product wattage	Looked-up for each bulb	Actual product wattage			
%RES	% of bulbs installed in residential	TRM Appendix F	100%	0%	96%	4%

Parameter	Description	Source of Assumption	Online Store		Upstream Lighting	
			Residential	Commercial	Residential	Commercial
	applications, by channel					
LKG	% of bulbs installed outside Ameren Missouri service territory, by channel (i.e., leakage rate)	TRM Appendix F	0%		4%	
HOU	Hours of use for residential and commercial installations	TRM Appendix F	995	3,612	995	3,612
ISR	In-service rates at the channel by bulb type levels	TRM Appendix F	79.67% (Standard) 80.08% (Reflector) 83.92% (Specialty)		86.72% (Standard) 92.22% (Reflector) 92.23% (Specialty)	
WHFe	Waste heat factor for residential and commercial installations	TRM Appendix F	0.99	1.1	0.99	1.1
CF	TRM Appendix I	TRM Appendix F	0.0001492529	0.0001899635	0.0001492529	0.0001899635

Note that several parameter values shown in TRM Appendix F were calculated as part of the PY2019 Lighting Program evaluation. These parameters include the %RES, ISRs, and LKG. Details on the derivation of these parameters are contained in the PY2019 evaluation report Appendix A.

Net Impact Methodology and Results

A NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR represents the share of *program-induced* savings.

For the Lighting Program, the NTGR consists of participant free ridership (FR), participant spillover (PSO), and non-participant SO (NPSO), and is calculated as (1 – FR + PSO + $NPSO$). FR is the proportion of the program-achieved ex post gross savings that would have been realized absent the program. PSO occurs when participants take additional energy-saving actions that are influenced by program interventions but that did not receive program support. NPSO is the reduction in energy consumption and/or demand by nonparticipants because of the influence of the program.

For PY2021, the evaluation team relied on NTGR results estimated as part of the PY2019 evaluation (details on the derivation of the NTGRs can be found in the PY2019 evaluation report Appendix A). However, we re-weighted last year's values to reflect the proportion of ex post gross savings across channel (and bulb type) present in the PY2021 program tracking data. Table 2 shows the final NTGRs used for the PY2021 evaluation.

Table 2. PY2020 Lighting Program NTGRs

Channel	Free-Ridership (FR)	Participant Spillover (PSO)	Non-Participant Spillover (NPSO)	NTGR (1-FR+PSO+NPSO)	% Ex Post Gross
Upstream	43.9%	0.0%	7.4%	63.5%	98.6%
Online	12.9%	1.7%	0.0%	88.8%	1.4%
Overall Program	**43.5%**	**0.0%**	**7.3%**	**63.8%**	**100.0%**

Home Energy Reports (HERs)

The following subsections discuss the detailed methodology for estimating savings from Ameren Missouri's HER Program.

Equivalency Analysis

The evaluation team performed an equivalency analysis to ensure that the treatment and control groups for each of the four waves participating in the HER Program in PY2021 were equivalent in terms of energy consumption (see Table 3). We compared average daily consumption (ADC) of electricity between treatment and control groups during their pre-participation periods to assess whether these groups were equivalent before cleaning billing data to ensure quality and completeness. Because of these waves were introduced at different times, pre-participation data periods vary. We rely on an intent-to-treat (ITT) approach and consequently, used the population of treatment and control customers in this equivalency analysis who had at least one month of PY2021 billing data. We found that the two groups were equivalent for each of the waves. We used consumption data for the year prior to program participation to calculate ADC for each wave.

Table 3. Pre-Participation Average Daily Consumption of HER Program Treatment and Control Groups by Wave

Wave	Treatment (Pre-Participation) Consumption	Control (Pre-Participation) Consumption
Wave 1	47.05	46.91
Wave 2	64.69	64.78
Wave 3	41.24	41.17
Wave 4	33.20	33.28

Figure 4 through Figure 4 present the pre-participation period electric consumption for both treatment and control groups for each of the waves. These figures exhibit equivalency in ADC between these groups.

Figure 1. Wave 1 Pre-Period Average Daily Consumption

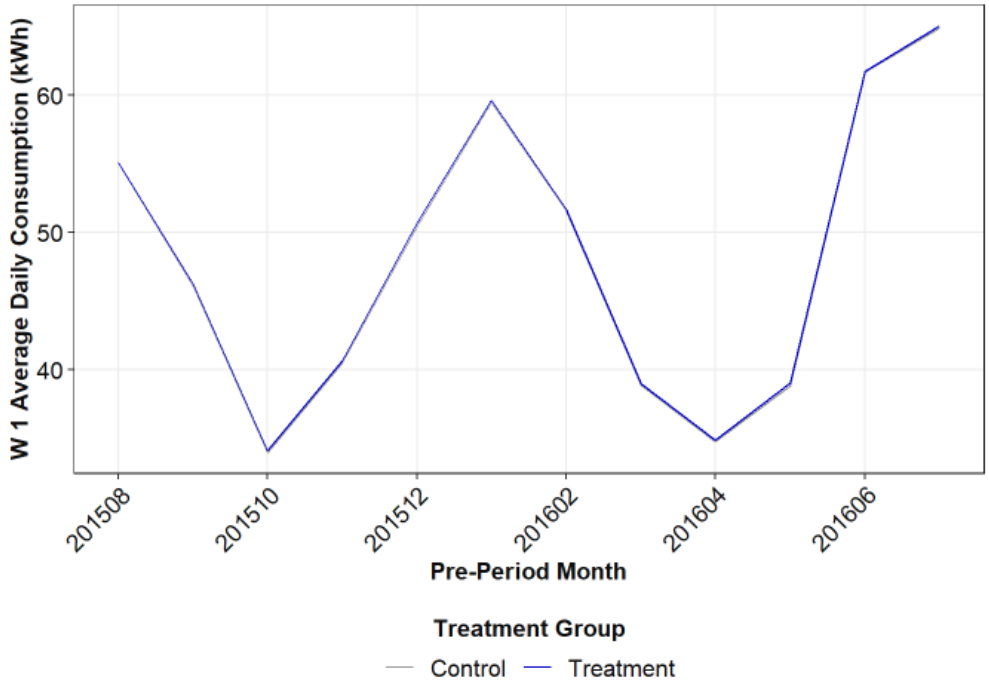


Figure 2. Wave 2 Pre-Period Average Daily Consumption

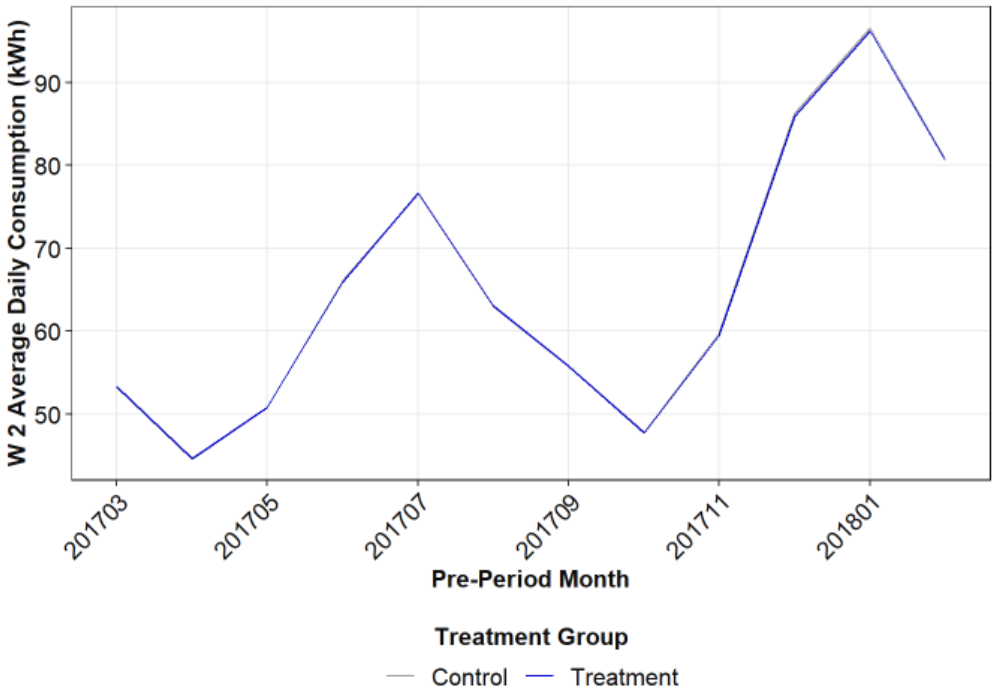


Figure 3. Wave 3 Pre-Period Average Daily Consumption

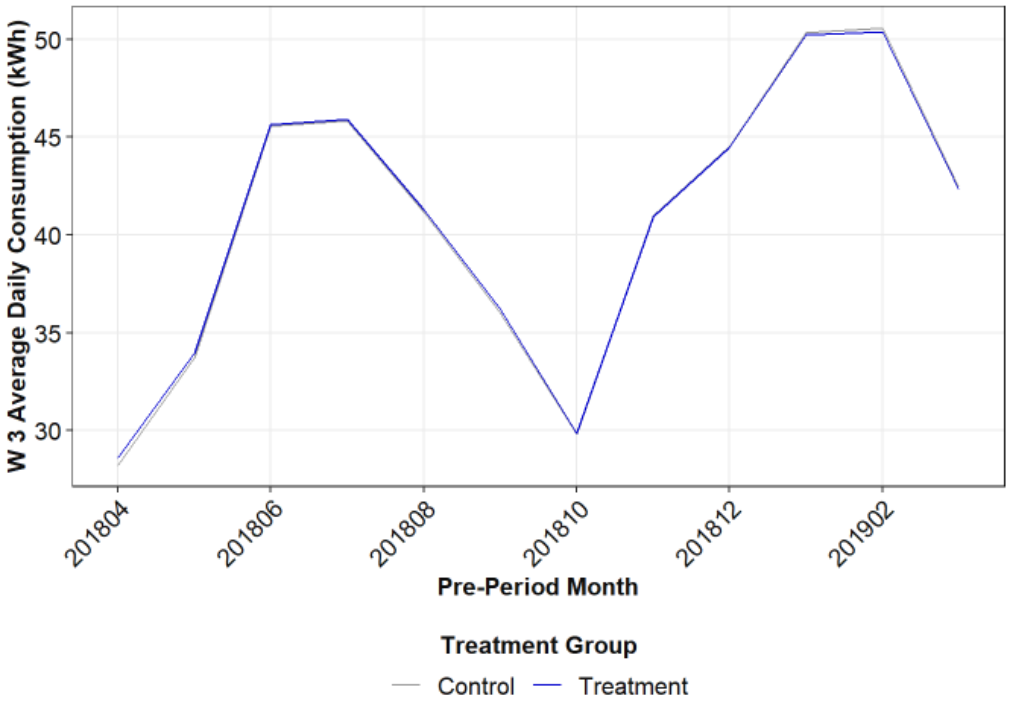
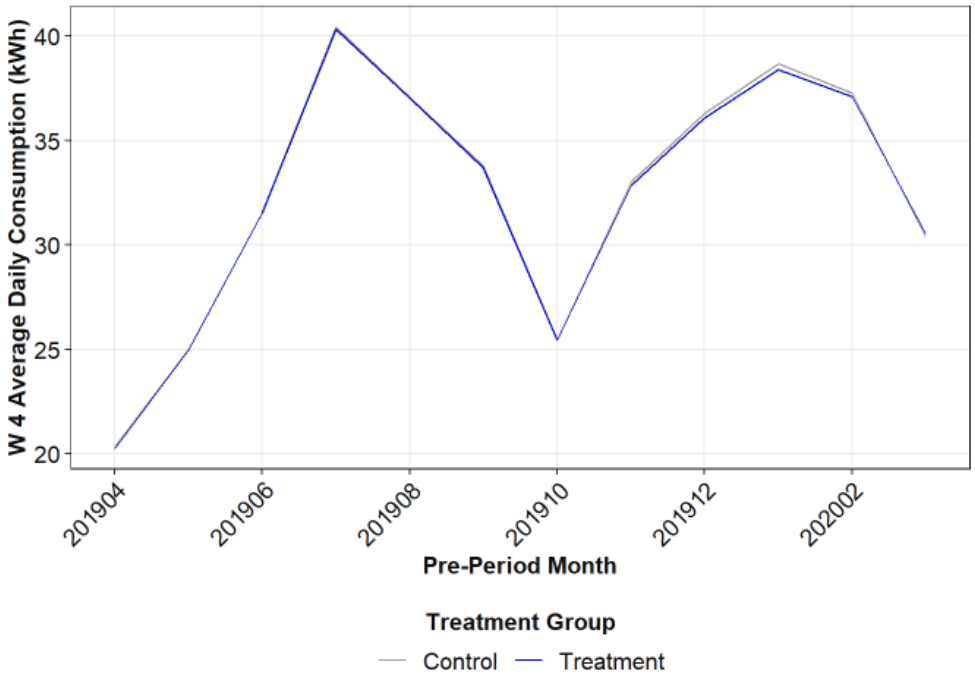


Figure 4. Wave 4 Pre-Period Average Daily Consumption



Data Sources

Participant data and treatment/control assignments were sourced from previous program year evaluation participant tracking files for Waves 1–4. Note that the evaluation team did not receive information on participants who opted out of receiving HERs, nor did we have information on which participants were net metered. As such, the modeled results presented in the remainder of this section do not account for either. Billing data was sourced from both historic HER Program evaluations (2015–2018) and from billing data provided by Ameren Missouri on an ongoing basis throughout the year (2018–2021).

Data Cleaning Results

This section shows the results of the evaluation team's data cleaning effort for the consumption analysis (Table 4). The final customer count includes all customers the implementation team assigned to a treatment or control group who had sufficient consumption data for the PY2021 analysis. The primary reason for dropping customers was insufficient data in the pre-period (i.e., lacking at least nine months of data before the treatment period).

Table 4. Data Cleaning Results for Treatment and Control Groups by Wave

Wave	Metric	Unique Customers	
		Treatment	Control
Wave 1	Initial	68,401	22,845
	Final	67,278	22,754
	% Remaining	*98%*	*100%*
Wave 2	Initial	30,045	8,321
	Final	29,790	8,286
	% Remaining	*99%*	*100%*
Wave 3	Initial	132,586	53,192
	Final	115,579	46,446
	% Remaining	*87%*	*87%*
Wave 4	Initial	39,426	21,911
	Final	32,060	17,916
	% Remaining	*81%*	*82%*

Modeling Program Impacts

Energy Savings

We conducted a statistical analysis to determine program impacts using monthly electric billing data for all Ameren Missouri customers who received a HER and/or eHER (the treatment group) and a randomly selected group of customers who did not receive a HER (the control group). The evaluation team used an ITT approach in PY2021, and we estimated savings using a lagged dependent variable (LDV) model.

Lagged Dependent Variable Model

The evaluation team used an LDV model to estimate the electric savings experienced by the HER Program's treatment group for PY2021. The LDV model uses information from the pre-participation period to calculate pre-period usage variables, which help control for each customers' individual usage patterns. We used three

levels of pre-participation period consumption for each customer: overall pre-participation period ADC, summer pre-participation period ADC, and winter pre-participation period ADC. Since this is an RCT, the LDV model uses the control group to control the model for exogenous factors that might affect ADC. We employed the following estimating equation:

Equation 5. Lagged Dependent Variable Model Estimating Equation

$$ADC_{it} = \alpha + \beta_1 Treatment_i + \beta_2 PreUsage_i + \beta_3 PreWinter_i + \beta_4 PreSummer_i + \beta_5 MonthYear_t + \beta_6 PreUsage_i \cdot MonthYear_t + \beta_7 PreWinter_i \cdot MonthYear_t + \beta_8 PreSummer_i \cdot MonthYear_t + \varepsilon_{it}$$

where:

ADC_{it} = Average daily consumption (kWh or therms) for household *i* at time *t*

α = Model intercept

β_1 = Coefficient for the change in consumption for the treatment group

β_2 = Coefficient for the average daily usage across household *i*'s available pretreatment meter reads

β_3 = Coefficient for the average daily usage over the months of December through March across household *i*'s available pretreatment meter reads

β_4 = Coefficient for the average daily usage over the months of June through September across household *i*'s available pretreatment meter reads

β_5 = Vector of coefficients for month-year dummies

β_6 = Vector of coefficients for month-year dummies by average daily pretreatment usage

β_7 = Vector of coefficients for month-year dummies by average daily winter pretreatment usage

β_8 = Vector of coefficients for month-year dummies by average daily summer pretreatment usage

$Treatment_i$ = Variable to represent treatment and control groups (0 = control group, 1 = treatment group)

$PreUsage_i$ = Average daily usage for household *i* over the entire pre-participation period

$PreWinter_i$ = Average daily usage for household *i* over the pre-participation months of December through March

$PreSummer_i$ = Average daily usage for household *i* over the pre-participation months of June through September

$MonthYear_t$ = Vector of month-year dummies

ε_{it} = Error

We used the LDV model to estimate the electric savings from the PY2021 HER Program. The unadjusted per household savings are shown in Table 5.

Table 5. Unadjusted Per-Household Daily Net Electric Savings

Wave	Unadjusted Net Savings (% per household)	Unadjusted Net Savings (kWh per household)
Wave 1	0.96%	156
Wave 2	1.40%	294
Wave 3	0.96%	122
Wave 4	0.55%	64

Billing Analysis Model Coefficients

Table 6 provides the billing analysis model coefficients for the LDV model.

Table 6. LDV Model Billing Analysis Model Coefficients

Wave	Term	Estimate	Standard Error
1	(Intercept)	7.24	0.20
1	treat	-0.43	0.04
1	pre_adc	-0.42	0.02
1	pre_adc_summ	0.07	0.01
1	pre_adc_win	1.22	0.01
1	my022021	0.75	0.29
1	my032021	0.41	0.28
1	my042021	-1.99	0.28
1	my052021	-4.52	0.28
1	my062021	0.47	0.28
1	my072021	1.97	0.28
1	my082021	3.49	0.28
1	my092021	0.14	0.28
1	my102021	-1.64	0.28
1	my112021	-0.21	0.28
1	my122021	1.06	0.45
1	pre_adc:my022021	-0.41	0.03
1	pre_adc:my032021	1.20	0.02
1	pre_adc:my042021	1.63	0.03
1	pre_adc:my052021	1.57	0.03
1	pre_adc:my062021	0.83	0.03
1	pre_adc:my072021	0.68	0.03
1	pre_adc:my082021	0.68	0.03
1	pre_adc:my092021	1.14	0.03
1	pre_adc:my102021	1.49	0.03
1	pre_adc:my112021	1.02	0.03
1	pre_adc:my122021	0.63	0.04
1	pre_adc_summ:my022021	0.10	0.01
1	pre_adc_summ:my032021	-0.36	0.01

Wave	Term	Estimate	Standard Error
1	pre_adc_summ:my042021	-0.42	0.01
1	pre_adc_summ:my052021	-0.17	0.01
1	pre_adc_summ:my062021	0.43	0.01
1	pre_adc_summ:my072021	0.54	0.01
1	pre_adc_summ:my082021	0.54	0.01
1	pre_adc_summ:my092021	0.21	0.01
1	pre_adc_summ:my102021	-0.23	0.01
1	pre_adc_summ:my112021	-0.28	0.01
1	pre_adc_summ:my122021	-0.14	0.02
1	pre_adc_win:my022021	0.33	0.01
1	pre_adc_win:my032021	-1.02	0.01
1	pre_adc_win:my042021	-1.38	0.01
1	pre_adc_win:my052021	-1.52	0.01
1	pre_adc_win:my062021	-1.35	0.01
1	pre_adc_win:my072021	-1.30	0.01
1	pre_adc_win:my082021	-1.31	0.01
1	pre_adc_win:my092021	-1.47	0.01
1	pre_adc_win:my102021	-1.45	0.01
1	pre_adc_win:my112021	-0.93	0.01
1	pre_adc_win:my122021	-0.68	0.02
2	(Intercept)	5.09	0.32
2	treat	-0.81	0.07
2	pre_adc	0.33	0.03
2	pre_adc_summ	-0.18	0.01
2	pre_adc_win	0.81	0.01
2	my022021	-1.53	0.45
2	my032021	1.80	0.43
2	my042021	-1.25	0.44
2	my052021	-4.60	0.44
2	my062021	0.45	0.44
2	my072021	1.95	0.44
2	my082021	3.35	0.44
2	my092021	-0.49	0.45
2	my102021	-0.87	0.45
2	my112021	0.57	0.45
2	my122021	1.11	0.74
2	pre_adc:my022021	-0.31	0.04
2	pre_adc:my032021	0.86	0.04
2	pre_adc:my042021	1.21	0.04
2	pre_adc:my052021	0.95	0.04

Wave	Term	Estimate	Standard Error
2	pre_adc:my062021	0.06	0.04
2	pre_adc:my072021	-0.15	0.04
2	pre_adc:my082021	-0.17	0.04
2	pre_adc:my092021	0.43	0.04
2	pre_adc:my102021	0.70	0.04
2	pre_adc:my112021	0.72	0.04
2	pre_adc:my122021	0.81	0.06
2	pre_adc_summ:my022021	0.09	0.02
2	pre_adc_summ:my032021	-0.27	0.02
2	pre_adc_summ:my042021	-0.30	0.02
2	pre_adc_summ:my052021	0.07	0.02
2	pre_adc_summ:my062021	0.76	0.02
2	pre_adc_summ:my072021	0.90	0.02
2	pre_adc_summ:my082021	0.91	0.02
2	pre_adc_summ:my092021	0.50	0.02
2	pre_adc_summ:my102021	0.06	0.02
2	pre_adc_summ:my112021	-0.20	0.02
2	pre_adc_summ:my122021	-0.27	0.03
2	pre_adc_win:my022021	0.28	0.01
2	pre_adc_win:my032021	-0.82	0.01
2	pre_adc_win:my042021	-1.12	0.01
2	pre_adc_win:my052021	-1.17	0.01
2	pre_adc_win:my062021	-0.93	0.01
2	pre_adc_win:my072021	-0.86	0.01
2	pre_adc_win:my082021	-0.85	0.01
2	pre_adc_win:my092021	-1.07	0.01
2	pre_adc_win:my102021	-1.05	0.01
2	pre_adc_win:my112021	-0.75	0.01
2	pre_adc_win:my122021	-0.67	0.02
3	(Intercept)	2.25	0.08
3	treat	-0.34	0.02
3	pre_adc	0.48	0.01
3	pre_adc_summ	-0.20	0.01
3	pre_adc_win	0.73	0.01
3	my022021	-0.08	0.11
3	my032021	0.58	0.10
3	my042021	-0.60	0.10
3	my052021	-1.64	0.11
3	my062021	0.95	0.11
3	my072021	1.70	0.11

Wave	Term	Estimate	Standard Error
3	my082021	2.57	0.10
3	my092021	0.30	0.11
3	my102021	-0.66	0.11
3	my112021	0.38	0.11
3	my122021	0.35	0.17
3	pre_adc:my022021	-0.14	0.02
3	pre_adc:my032021	0.97	0.02
3	pre_adc:my042021	1.10	0.02
3	pre_adc:my052021	1.02	0.02
3	pre_adc:my062021	0.24	0.02
3	pre_adc:my072021	0.14	0.02
3	pre_adc:my082021	0.06	0.02
3	pre_adc:my092021	0.61	0.02
3	pre_adc:my102021	1.13	0.02
3	pre_adc:my112021	0.87	0.02
3	pre_adc:my122021	0.63	0.03
3	pre_adc_summ:my022021	0.03	0.01
3	pre_adc_summ:my032021	-0.31	0.01
3	pre_adc_summ:my042021	-0.27	0.01
3	pre_adc_summ:my052021	-0.03	0.01
3	pre_adc_summ:my062021	0.62	0.01
3	pre_adc_summ:my072021	0.72	0.01
3	pre_adc_summ:my082021	0.77	0.01
3	pre_adc_summ:my092021	0.37	0.01
3	pre_adc_summ:my102021	-0.15	0.01
3	pre_adc_summ:my112021	-0.26	0.01
3	pre_adc_summ:my122021	-0.17	0.02
3	pre_adc_win:my022021	0.19	0.01
3	pre_adc_win:my032021	-0.90	0.01
3	pre_adc_win:my042021	-1.13	0.01
3	pre_adc_win:my052021	-1.23	0.01
3	pre_adc_win:my062021	-0.99	0.01
3	pre_adc_win:my072021	-0.96	0.01
3	pre_adc_win:my082021	-0.93	0.01
3	pre_adc_win:my092021	-1.16	0.01
3	pre_adc_win:my102021	-1.25	0.01
3	pre_adc_win:my112021	-0.83	0.01
3	pre_adc_win:my122021	-0.64	0.01
4	(Intercept)	1.11	0.10
4	treat	-0.17	0.04

Wave	Term	Estimate	Standard Error
4	pre_adc	0.34	0.02
4	pre_adc_summ	-0.16	0.01
4	pre_adc_win	0.92	0.01
4	my022021	-0.12	0.14
4	my032021	0.90	0.13
4	my042021	-0.48	0.14
4	my052021	-1.47	0.14
4	my062021	2.22	0.14
4	my072021	3.25	0.14
4	my082021	4.32	0.14
4	my092021	1.32	0.14
4	my102021	0.05	0.14
4	my112021	0.90	0.14
4	my122021	0.16	0.23
4	pre_adc:my022021	-0.51	0.03
4	pre_adc:my032021	0.86	0.03
4	pre_adc:my042021	1.19	0.03
4	pre_adc:my052021	1.02	0.03
4	pre_adc:my062021	0.42	0.03
4	pre_adc:my072021	0.30	0.03
4	pre_adc:my082021	0.36	0.03
4	pre_adc:my092021	0.91	0.03
4	pre_adc:my102021	1.34	0.03
4	pre_adc:my112021	0.89	0.03
4	pre_adc:my122021	0.80	0.06
4	pre_adc_summ:my022021	0.19	0.02
4	pre_adc_summ:my032021	-0.22	0.01
4	pre_adc_summ:my042021	-0.24	0.01
4	pre_adc_summ:my052021	0.09	0.01
4	pre_adc_summ:my062021	0.66	0.01
4	pre_adc_summ:my072021	0.76	0.01
4	pre_adc_summ:my082021	0.75	0.01
4	pre_adc_summ:my092021	0.35	0.02
4	pre_adc_summ:my102021	-0.17	0.02
4	pre_adc_summ:my112021	-0.24	0.02
4	pre_adc_summ:my122021	-0.19	0.03
4	pre_adc_win:my022021	0.37	0.01
4	pre_adc_win:my032021	-0.95	0.01
4	pre_adc_win:my042021	-1.28	0.01
4	pre_adc_win:my052021	-1.38	0.01

Wave	Term	Estimate	Standard Error
4	pre_adc_win:my062021	-1.21	0.01
4	pre_adc_win:my072021	-1.17	0.01
4	pre_adc_win:my082021	-1.20	0.01
4	pre_adc_win:my092021	-1.43	0.01
4	pre_adc_win:my102021	-1.46	0.01
4	pre_adc_win:my112021	-0.93	0.01
4	pre_adc_win:my122021	-0.80	0.03

Note: All treatment coefficients are statistically significant at the 90% confidence level.

Demand Reductions

We calculated demand impacts based on the Missouri TRM, which applies a peak adjustment factor to modeled energy savings results. The factor value used to arrive at PY2021 HER demand savings was 0.0004660805 kW.

Participation Uplift and Joint Savings Analysis

We also determined whether the Ameren Missouri HER Program treatment generated participation uplift in other PY2021 programs (i.e., an increase in participation in other energy efficiency programs in PY2021 as a result of the Ameren Missouri HER Program). To complete this analysis, we calculated whether more treatment than control group members participated in other residential energy efficiency initiatives after receiving HERs compared to participation before receiving HERs. We cross-referenced the HER Program database—both treatment and control groups—with the databases of other residential energy efficiency programs offered by Ameren Missouri in PY2021. We include the following residential programs in our analysis for 2021:

- Appliance Recycling
- Efficient Products
- Peak Time Savings
- Single Family Income Eligible (SFIE)
- Multifamily Income Eligible (MFIE)
- Multifamily Market Rate (MFMR)
- Heating, Ventilation, and Air Conditioning (HVAC)
- Online Retail Lighting
- DIY Kits

Through this analysis, we calculated the number of customers who participated in both the HER Program and other energy efficiency programs in PY2021 for each wave. To ensure the participation uplift was attributable solely to the HER Program, we calculated participation uplift using a post-only difference (POD) estimator. We identified the total number of treatment and control group customers who participated in an Ameren Missouri energy efficiency program in PY2021. Any statistically significant positive difference between the treatment and control population was the net participation due to the HER Program. We ignored any negative POD.

To arrive at the participation uplift rate, the evaluation team calculated the POD estimator for each wave for each program using Equation 6:

Equation 6. POD Estimator

POD = Current PY Treatment Group Participation Rate in EE Program –

Current PY Treatment Group Participation Rate in EE Program

We multiplied the positive and significant POD statistic by the total number of treatment customers in the relevant wave to obtain the participation uplift value. The uplift value is the total number of participants who, according to this analysis, participated in other energy efficiency programs due to HER treatment. There is an uplift value for each energy efficiency program and wave where at least some participation in the program occurred. Equation 7 was used to calculate participation uplift.

Equation 7. Participation Uplift Rate

Participation Uplift = (POD for Wave) x (Total Number of HER Treatment Participants in Wave)

Finally, we calculated the savings adjustment value. We multiplied the participation uplift by the per participant energy efficiency program savings value of the treatment group participants in the associated program and wave to obtain the savings adjustment. The savings adjustment is the value used to adjust the current HER Program energy savings downward to control for the double-counting of savings. There is a savings adjustment value for each energy efficiency program (Equation 8) and wave where at least some participation in the program occurred.

Equation 8. Savings Adjustment

Savings Adjustment = (Participation Uplift for Wave) x (Per Participant EE Program Savings of Treatment Group of Wave)

We observed a statistically significant uplift effect for at least one wave for three programs – Appliance Recycling, HVAC, and Online Retail Lighting. Table 7 shows the uplift, per-participant savings, and savings adjustments for programs and waves that had significant and positive uplift for treatment customers in PY2021.

Table 7. Program Savings Adjustments

Program	Wave	Per Participant Savings (kWh)	Uplift	Statistical Significance (90%)	Savings Adjustment (kWh)
Appliance Recycling	1	532	87.33	Yes	46,490
Appliance Recycling	3	532	50.50	Yes	26,885
Appliance Recycling	4	532	42.80	Yes	22,785
HVAC	3	1,975	102.61	Yes	205,838
Lighting	2	543	28.52	Yes	15,490

HVAC Program

Gross Impact Methodology

Air Source Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential HVAC Program ASHP measures, the evaluation team applied Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 9. Air Source Heat Pump Energy and Demand Savings Equations (Replace on Fail)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Equation 10. Air Source Heat Pump Energy and Demand Savings Equations (Early Replacement—First Six Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Exist}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Equation 11. Air Source Heat Pump Energy and Demand Savings Equations (Early Replacement—Next 12 Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

where:

EFLHCool = Equivalent full load hours of air conditioning = 869

EFLHHeat = Equivalent full load hours of heating = 1,496

CapacityCool = Cooling capacity of ASHP (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

CapacityHeat = Heating capacity of ASHP (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

SEERBase = Seasonal Energy Efficiency Ratio of baseline cooling system (kBtu/kWh) = 14 if replacing ASHP, 13 if replacing CAC

HSPFBase = Heating Seasonal Performance Factor of baseline heating system (kBtu/kWh) = 8.2 if replacing ASHP, 3.41 if replacing electric resistance

SEERExist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

HSPFExist = Heating Seasonal Performance Factor of existing heating system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed 6.58 if replacing ASHP, 3.41 if replacing electric resistance

SEEREE = Seasonal Energy Efficiency Ratio of efficient ASHP (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Appendix F (v5.0)

HSPFEE = Heating Seasonal Performance Factor of efficient ASHP (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Appendix F (v5.0)

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1-1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment with nameplate efficiency of 8 SEER or lower.

HF = Household factor, to adjust heating consumption for non–single family households = 100% if single family, 65% if multifamily

CF = Coincidence factor = 0.0009474181

Ductless Minisplit Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential HVAC Program ductless mini-split heat pump measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 12. Ductless Minisplit Heat Pump Energy and Demand Savings Equations (Replace on Fail)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Equation 13. Ductless Minisplit Heat Pump Energy and Demand Savings Equations (Early Replacement—First Six Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Exist}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Equation 14. Ductless Minisplit Heat Pump Energy and Demand Savings Equations (Early Replacement—Next 12 Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

where:

EFLHCool = Equivalent full load hours of air conditioning = 635

EFLHHeat = Equivalent full load hours of heating = 1,034 if ductless ASHP measure, 0 if ductless air conditioner measure

CapacityCool = Cooling capacity of heat pump (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

CapacityHeat = Heating capacity of heat pump (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

SEERBase = Seasonal Energy Efficiency Ratio of baseline cooling system (kBtu/kWh) = 14 if replacing ductless ASHP, 13 if replacing ductless AC

HSPFBase = Heating Seasonal Performance Factor of baseline heating system (kBtu/kWh)

SEERExist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

HSPFExist = Heating Seasonal Performance Factor of existing heating system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed 5.44 if replacing ductless ASHP, 3.41 if replacing electric resistance

SEEREE = Seasonal Energy Efficiency Ratio of efficient heat pump (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Appendix F (v5.0)

HSPFEE = Heating Seasonal Performance Factor of efficient heat pump (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Appendix F (v5.0)

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1-1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment with nameplate efficiency of 8 SEER or lower.

HF = Household factor, to adjust heating consumption for non–single family households = 100%

CF = Coincidence factor = 0.0009474181

Ground Source Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential HVAC Program GSHP measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 15. GSHP Energy and Demand Savings Equations (Replace on Fail)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

Equation 16. GSHP Energy and Demand Savings Equations (Early Replacement – First Six Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Exist}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

Equation 17. GSHP Energy and Demand Savings Equations (Early Replacement – Next 12 Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

where:

EFLHCool = Equivalent full load hours of air conditioning = 869

EFLHHeat = Equivalent full load hours of heating = 1,496

CapacityCool = Cooling capacity of heat pump (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

CapacityHeat = Heating capacity of heat pump (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

SEERBase = Seasonal Energy Efficiency Ratio of baseline cooling system (kBtu/kWh) = 14.1

HSPFBase = Heating Seasonal Performance Factor of baseline heating system (kBtu/kWh) = 10.58 if replacing heat pump, 3.41 if replacing electric resistance

SEERExist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed 9.06 if replacing heat pump, 6.34 if replacing CAC

HSPFExist = Heating Seasonal Performance Factor of existing heating system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed 9.55 if replacing heat pump, 3.41 if replacing electric resistance

SEEREE = Seasonal Energy Efficiency Ratio of efficient GSHP (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Appendix F (v5.0)

HSPFEE = Heating Seasonal Performance Factor of efficient GSHP (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed 15.14

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1\text{-}1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment with nameplate efficiency of 8 SEER or lower.

CF = Coincidence factor = 0.0009474181

Central Air Conditioner Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential HVAC Program CAC measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 18. Central Air Conditioner Energy and Demand Savings Equations (Replace on Fail)

$$kWh = \left[\frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}\right] \times HF$$

$$kW = kWh \times CF$$

Equation 19. Central Air Conditioner Energy and Demand Savings Equations (Early Replacement—First Six Years)

$$kWh = \left[\frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}\right] \times HF$$

$$kW = kWh \times CF$$

Equation 20. Central Air Conditioner Energy and Demand Savings Equations (Early Replacement—Next 12 Years)

$$kWh = \left[\frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}\right] \times HF$$

$$kW = kWh \times CF$$

where:

EFLHCool = Equivalent full load hours of air conditioning = 869

CapacityCool = Cooling capacity of CAC (Btu/hr) = Actual from program-tracked data; if unknown, assumed defaults from Appendix F (v5.0)

SEERExist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Ameren Missouri TRM Appendix F (v5.0)

SEERBase = Seasonal Energy Efficiency Ratio of baseline equipment (kBtu/kWh) = 13

SEEREE = Seasonal Energy Efficiency Ratio of efficient CAC (kBtu/kWh) = Actual from program-tracked data; if unknown, assumed defaults in Ameren Missouri TRM Appendix F (v5.0).

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1-1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment with nameplate efficiency of 8 SEER or lower.

HF = Household factor, to adjust heating consumption for non–single family households = 100%

CF = Coincidence factor = 0.0009474181

Advanced Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential HVAC Program advanced thermostat measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database. The ex post analysis used the field "Thermostat Controlling Unit" to determine whether the thermostat controls a heat pump or a CAC unit with either gas or electric heat. Where the controlled unit was unknown, we used data on the primary heating equipment and/or the water heater fuel type.

Where parameters were unavailable in the program tracking data, we used default inputs as described below.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 21.

Equation 21. Advanced Thermostat Energy and Demand Savings Equations

$$kWh = kWh_{Heating} + kWh_{Cooling}$$

$$kWh_{Heating} = \%ElectricHeat \times HeatingConsumption_{Electric} \times HF \times HeatingReduction \times ISR + (\Delta Therms \times Fe \times 29.3)$$

$$kWh_{Cooling} = \%AC \times \left(\frac{EFLH_{Cool} \times CapacityCool \times \frac{1}{SEER}}{1000} \right) \times CoolingReduction \times ISR$$

$$\Delta Therms = \%FossilHeat \times HeatingConsumption_{Gas} \times HF \times HeatingReduction \times ISR$$

$$kW = kWh_{Cooling} \times CF$$

where:

%ElectricHeat = Percentage of heating savings assumed to be electric = 100% if electric heating system; 0% if natural gas heating; 16% if unknown

$HeatingConsumption_{Electric}$ = Estimate of annual household heating consumption for electrically heated single family homes, in kWh

Table 8. HeatingConsumptionElectric for Advanced Thermostat Measures

Heating Equipment	HeatingConsumptionElectric
Electric Heat Pump	8,355
Electric Resistance	14,202
Natural Gas System	0
Unknown	11,456

HF = Household factor, to adjust heating consumption for non–single family households = 100% if single family, 65% if multifamily

HeatingReduction = Assumed percentage reduction in total household heating energy consumption due to advanced thermostat = 6.67%

ISR = In-service rate = 100%

ΔTherms = Therm savings if natural gas heating system, calculated using equation defined above

Fe = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

29.3 = Conversion factor of kWh per therm

%AC = Fraction of customers with thermostat-controlled air conditioning = 100%

EFLHCool = Equivalent full load hours of air conditioning = 869

CapacityCool = Capacity of air cooling system in Btu/hr = 36,000

SEER = Seasonal Energy Efficiency Ratio rating of the cooling equipment in kBtu/kWh = 13

1/1000 = Conversion factor of kBtu per Btu

CoolingReduction = Assumed percentage reduction in total household cooling energy consumption due to advanced thermostat = 8.0%

%FossilHeat = percentage of heating savings assumed to be natural gas = 0% if electric heating system; 100% if natural gas heating; 67% if unknown

HeatingConsumptionGas = Estimate of annual household heating consumption for gas-heated single family homes, in therms = 682

CF = Coincidence factor = 0.0009474181

Net Impact Methodology

The net-to-gross analysis and the development of the net-to-gross ratios (NTGRs) for the HVAC Program was conducted at the channel level.

The Downstream Channel NTGR includes channel-specific participant FR (PFR) and SO (PSO) derived from the PY2020 participant surveys. We relied on TA SO (TASO) estimated from the PY2019 TA surveys. For the PY2020 Downstream Channel, NTGR was computed as:

Equation 22. Downstream NTGR

$$NTGR_{Down} = (1 - PFR_{Down}) + PSO_{Down} + TASO_{Down}$$

The Midstream Channel's NTGR includes channel-specific PFR and PSO derived from the PY2021 participant surveys. Because of the nature of the Midstream Channel and significant role of the distributors, it also includes distributor FR (DFR) derived from the PY2021 distributor interviews. Note that for the Midstream Channel, the evaluation team did not estimate distributor SO.[1]

Since the Midstream Channel was new in PY2020, the evaluation team, in consultation with regulatory stakeholders in Missouri, established an 80%/20% weighting of PFR/DFR respectively to avoid any undue surprises in the first year of estimating Midstream NTGRs. In PY2021, we have applied the same weighting ratio thus the PY2021 Midstream NTGR was computed as:

Equation 23. Midstream NTGR

$$NTGR_{Mid} = (1 - (0.8 \times PFR_{Mid}) + (0.2 \times DFR_{Mid})) + PSO_{Mid}$$

Non-participant SO (NPSO) is also applied at the program level to derive the final net electricity and demand savings. The NPSO rates applied to PY2021 were originally derived from a large-scale (n=4,804) non-participant survey conducted as part of the PY2019 evaluation. For PY2021, we use the PY2019 NPSO rates and re-weight to account for the PY2021 ex post gross savings distribution across measures and channels. The PY2021 overall program NTGR is as follows:

Equation 24. PY2021 HVAC Program NTGR

$$NTGR = \left((NTGR_{Down} + NTGR_{Mid}) \div 2\right) + NPSO$$

Table 9 shows the elements of the channel-by-measure level NTGRs used to derive net impacts PY2021.

[1] Since contractors initiate the Midstream application, the main avenue for distributor SO would be distributors selling 18+ SEER units to *non*-participating contractors who then install units into eligible customers' homes. This type of SO is captured in the NPSO values that the evaluation team estimated for PY2019, which are applied to the PY2020 results as noted above.

Table 9. PY2021 HVAC Program NTGR

Measure/Enduse	Participant Free Ridership (PFR)	Distributor Free Ridership (DFR)	Participant Spillover (PSO)	Trade Ally Spillover (TASO)	Net-to-Gross Ratio (NTGR)
Downstream					
CACs	39.5%		0.6%	0.3%	61.4%
ASHP	37.0%				63.9%
GSHP					
DMSHP					
Advanced Thermostats	29.6%		0.6%		71.3%
Downstream Total	**38.2%**		**0.6%**	**0.3%**	**62.7%**
Midstream					
CACs	40.5%	45.0%	0.26%		58.9%
ASHP	37.1%				61.6%
DMSHP					
Advanced Thermostats	31.5%				68.8%
Midstream Total	**38.3%**	**45.0%**	**0.26%**		**60.8%**

Details of how each of the elements are computed follows.

Participant Free Ridership (Downstream and Midstream)

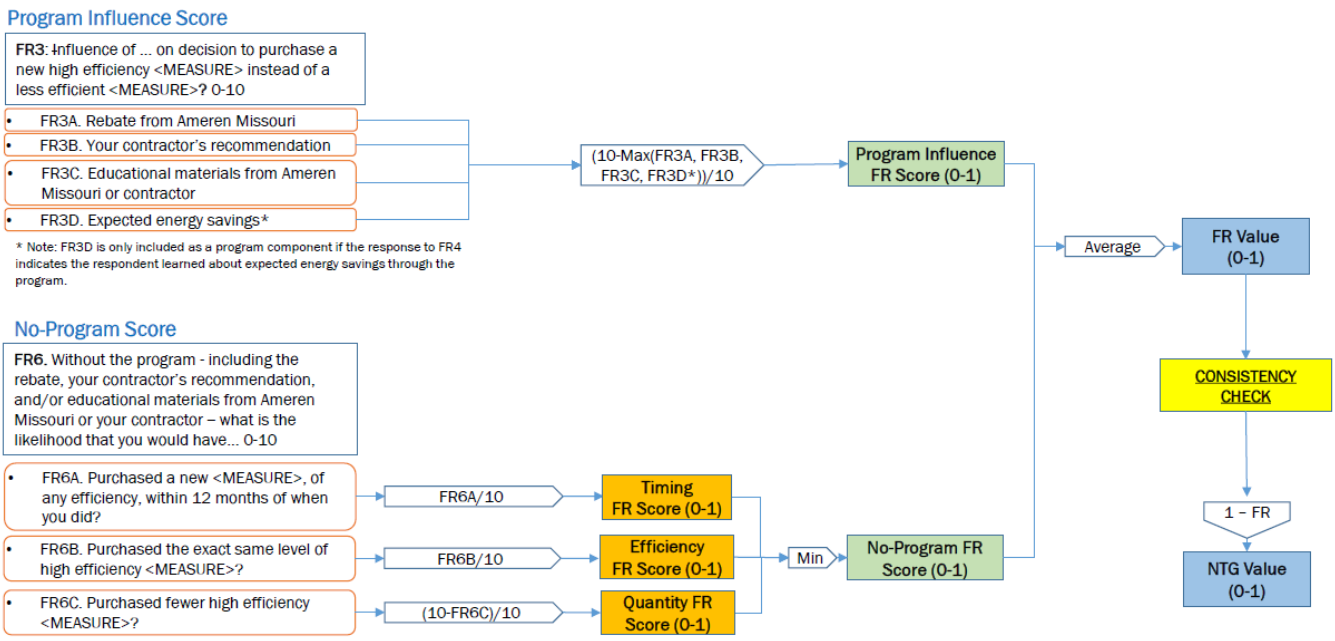
Developing individual participant-level FR scores consists of estimating two separate FR scores for each participant—both capturing different aspects of FR—which are then combined into a single FR score:

- **Program Influence FR Score:** Consists of respondents' quantification of the importance of the program factors (including the program rebate, contractor's recommendation, educational materials from Ameren Missouri or contractor, and expected energy savings[2]) on their decision to implement the energy efficiency measure.
- **No-Program FR Score:** Consists of respondents' answers to a series of counterfactual questions revealing what their intentions regarding installing high-efficiency equipment would have been in the absence of the program—includes timing, efficiency, and quantity.

When scored, each component assesses the degree of FR associated with each component on a scale of 0 to 1, where 0 means the respondent is not at all a FR for the component and a 1 means the respondent is a complete FR for the component. The two scores are then averaged to derive a combined total FR score. Figure 5 presents a diagram of the HVAC Program Participant FR algorithm, including references to survey question numbers.

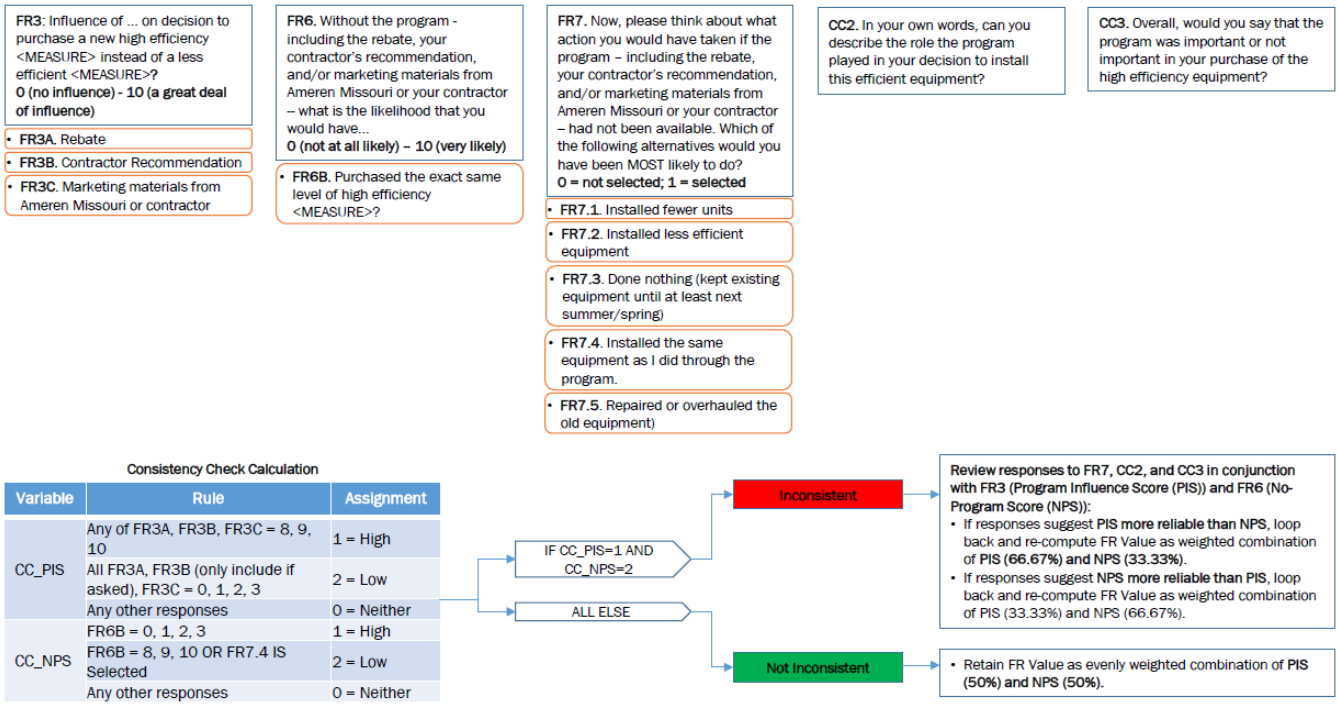
[2] Expected energy savings are only considered if the respondent learned about the expected energy savings through the program.

Figure 5. HVAC Program Participant Free Ridership Algorithm



To address the possibility of conflicting or inconsistent responses, the survey included a consistency check. The consistency check is based on the logic that if a respondent says one or more elements of the program were highly influential in their decision to purchase their new HVAC system (FR3A-C), they should not, at the same time, say that they would have purchased equipment with the exact same level of efficiency (FR6) or the exact same equipment (FR7) without the program. Figure 6 presents the process for conducting the consistency checks and recoding cases as needed.

Figure 6. Consistency Check Process



Participant Spillover

To determine if a survey respondent was eligible for SO savings, the survey contained a series of questions about additional energy efficiency home upgrades that the respondent might have taken without receiving an incentive and the degree to which the program influenced their decision to make the upgrades. The survey included two program influence questions:

- **SP1a:** How much did your experience with the Ameren Missouri Heating and Cooling Program influence your decision to make these energy efficiency improvements on your own? [SCALE 0-10; 0 means "no influence" and 10 means "a great deal of influence"]
- **SP1b:** How likely is it you would have still made these energy efficiency improvements if you had not received a rebate from the Ameren Missouri Heating and Cooling Program? [SCALE 0-10; 0 means "not at all likely" and 10 means "extremely likely"]

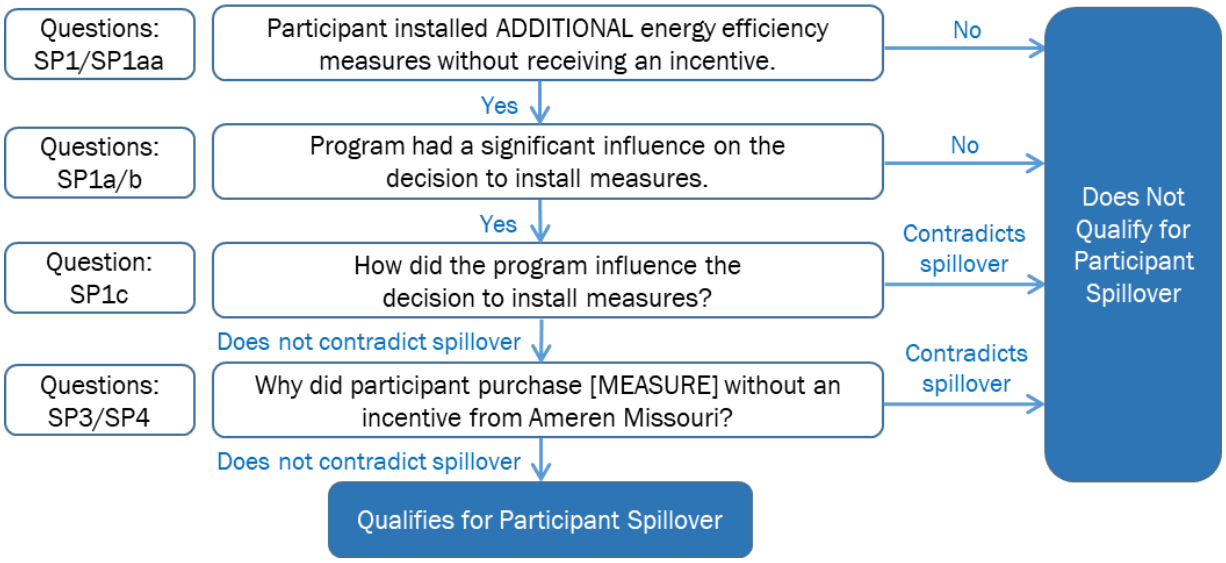
To supplement these numeric responses, the survey contained open-ended questions about how the program influenced the decision to make the upgrades and why the participant made the installations without a program incentive. A respondent's additional energy efficiency installations are deemed eligible for SO if two conditions are met: (1) the Program Influence Factor (see below) is greater than 5.0, and (2) the open-ended responses do not contradict that the installations were eligible for SO.

The Program Influence Factor is defined as follows:

$$\text{Program Influence Factor} = (\text{SP1a Response} + (10 - \text{SP1b Response})) \div 2$$

Figure 7 presents a diagram of the participant SO eligibility determination methodology used for this evaluation, including references to question numbers.

Figure 7. Participant Eligibility for Spillover



Based on results from the participant survey, we identified seven respondents who had installed measures that qualified for PSO in PY2021. Our engineering analysis of SO measures for these participants yielded total spillover savings of 1,985 kWh for the Midstream Channel (see Table 10).

Table 10. HVAC Program Midstream Participant Spillover Measures and Savings

Spillover Measure	Number of Unique Participants	Total kWh
Air Purifier	1	579
Clothes Washer	4	396
Refrigerator	5	234
Dehumidifier	1	204
Low Flow Showerhead	2	159
Tier 2 APS	1	152
Low Flow Faucet Aerator	2	87
Air Sealing	1	62
Dishwasher	4	57
Insulation	2	40
Windows	1	15
Total	**7**	**1,985**

Note: Represents total number of participants reporting spillover.

Dividing the estimated total SO in our sample (1,985 kWh) by total program ex post gross savings of the overall participant sample (771,017 kWh) yields a SO rate of 0.26% for the Midstream Channel, as shown in Equation 25.

Equation 25. PY2020 HVAC Program Midstream Channel Participant Spillover Rate

$$PSO\ \%_{Energy} = \frac{Total\ participant\ sample\ SO\ (kWh)}{Total\ participant\ sample\ savings\ (\mathrm{kWh})} = \frac{1{,}985\ kWh}{771{,}017\ \mathrm{kWh}} = 0.26\%$$

Distributor Free Ridership (Midstream)

The midstream distributor FR (DFR) score is calculated for each distributor as the average of two elements: (1) the Program Influence FR Score, and (2) the No-Program FR Score:

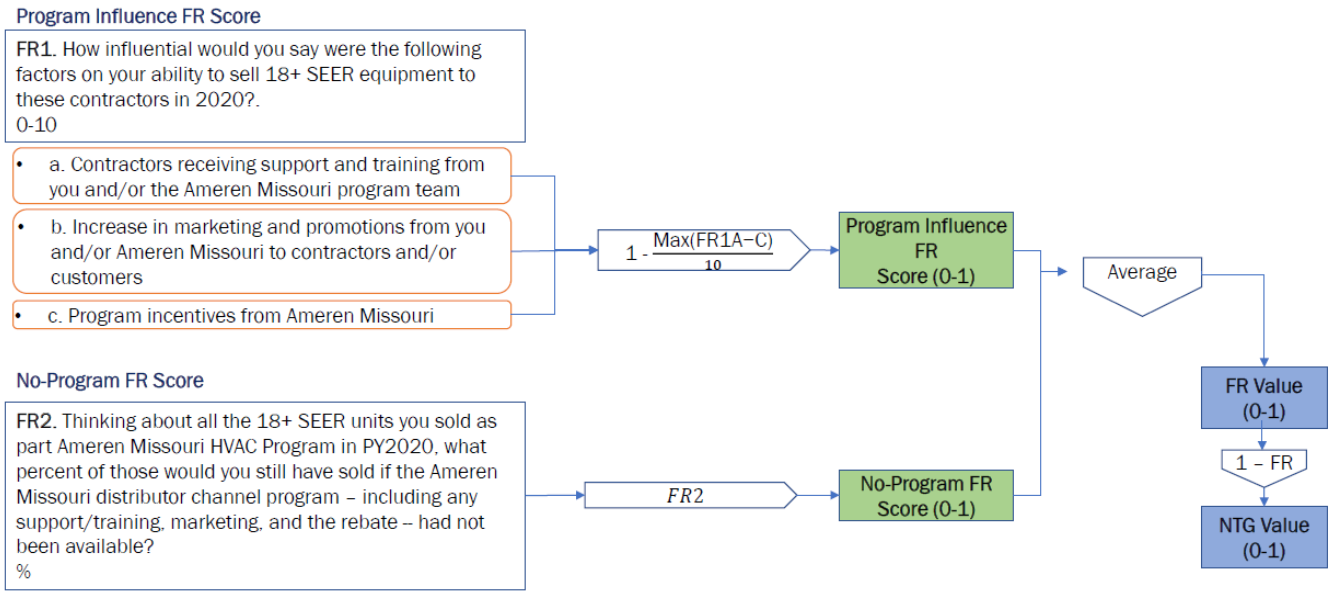
$$DFR_{Mid} = Mean(Program\ Influence\ FR\ Score,\ No\ Program\ FR\ Score_i)$$

Both elements assess the degree of FR on a scale from 0 to 1, where 0 means the respondent is not at all a FR and a 1 means that the respondent is a complete FR.

The final program-level midstream DFR is calculated as the mean of the distributor-level scores weighted by the ex post gross MWh savings associated with each interviewed distributor.

The following provides details on how each of these elements are computed. The FR algorithm is graphically depicted in Figure 8.

Figure 8. Midstream HVAC Distributor Free Ridership Algorithm



The Program Influence FR Score is assessed by asking respondents about the importance of various program elements on their ability to sell 18+ SEER equipment to contractors who account for the majority of their program-incented units. The elements include: [3]

- **FR1a:** Contractors receiving support and training from you and/or the Ameren Missouri program team

[3] Each of the three items are scored on a scale from 0 (not at all influential) to 10 (extremely influential),

- **FR1b:** Increase in marketing and promotions from you and/or Ameren Missouri to contractors and/or customers
- **FR1c:** Program incentives from Ameren Missouri

The Program Component FR Score is then computed as:

Equation 26. Program Component FR Score

$$Program\ Component\ FR\ Score = 1 - \frac{Max(FR1a, FR1b, FR1c)}{10}$$

The No Program FR Score is the counterfactual. For this component of the scoring, we ask respondents what percent of 18+ SEER units for which the distributor received an incentive in 2021 would still have been sold if the Ameren Missouri program—including training/support, marketing and promotions, and the rebate—had not been available (FR2).

Equation 27. No Program Score

$$No\ Program\ Score = FR2$$

Trade Ally Spillover

TASO was only applied to the Downstream Channel. The TASO used for PY2021 was based on the PY2019 TA interviews. The methods used for estimating PY2019 TASO are included in the PY2019 evaluation Appendix A.

Non-Participant Spillover

The NPSO rate used for the PY2021 evaluation was derived as part of a large-scale non-participant survey conducted as part of the PY2019 evaluation. For PY2021, we used the PY2019 NPSO rates and re-weighted to account for the PY2021 ex post gross savings distribution across measures and channels. The methods used for estimating the original PY2019 NPSO are included in the PY2019 evaluation Appendix A.

Demographics and Firmographics Results

The evaluation team asked participants to provide information about their household characteristics. Respondents could opt out of all demographic questions. Respondents who chose not to answer demographic questions were removed from the analysis. Table 11 provides the demographics results from the participant survey.

Table 11. HVAC Participant Survey Demographics

Characteristic	Midstream (Percent of Participants)
Age (n=191)	
Under 25	1%
26–44	12%
45–64	41%
65+	46%

Characteristic	Midstream (Percent of Participants)
Homeownership (n=197)	
Own	99%
Rent	1%
Education (n=187)	
High School or less	4%
Some College	11%
College Graduate	9%
Technical / Trade School Program or Associates Degree	43%
Graduate or Professional Degree, EG, JD, MBA, Md, PhD	34%
Income (n=140)	
Less than $50,000	11%
$50,000 to less than $100,000	23%
$100,000 to less than $150,000	24%
Greater than $150,000	29%
Housing Type (n=198)	
Single Family Detached Home	88%
Single Family Attached Home Such as a Townhouse or Row House	7%
Apartment or Condominium	3%
Mobile Home	1%
Gender (n=183)	
Female	35%
Male	64%
Non-Binary	1%
Race/ Ethnicity (n=175)	
White or Caucasian	95%
Black or African American	1%
Asian	2%
American Indian or Alaskan Native	1%
Pacific Islander	0%

Residential Efficient Products (REP)

Gross Impact Methodology

Heat Pump Water Heater Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Residential Efficient Products (REP) Program heat pump water heater measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 28.

Equation 28. Heat Pump Water Heater Energy and Demand Savings Equations

$$kWh = \left[\frac{\left(\frac{1}{EF_{Base}} - \frac{1}{EF_{EE}}\right) \times GPD \times Household \times 365.25 \times \gamma Water \times (T_{Out} - T_{In}) \times 1.0}{3{,}412} + kWh_{Cool} - kWh_{Heat}\right] * ISR$$

$$kWh_{Cool} = \left[\frac{\left(\left(1 - \frac{1}{EF_{EE}}\right) \times GPD \times Household \times 365.25 \times \gamma Water \times (T_{Out} - T_{In}) \times 1.0\right) \times LF \times WHF_C \times LM}{COP_{Cool} \times 3{,}412}\right] \times \%Cool$$

$$kWh_{Heat} = kWh_{Electric\ Resistance\ Heating} + kWh_{Heat\ Pump\ Heating}[4]$$

$$kWh_{ER\ Heating} = \left[\frac{\left(\left(1 - \frac{1}{EF_{EE}}\right) \times GPD \times Household \times 365.25 \times \gamma Water \times (T_{Out} - T_{In}) \times 1.0\right) \times LF \times WHF_H}{COP_{Electric\ Resistance} * 3{,}412}\right] \times \%ElectricHeat_{ER}$$

[4] kWh_{Heat} was calculated for an unknown electric heating system type in accordance with Appendix F (v5.0), which calculates a weighted average kWh_{Heat} value based on the percentage of homes with electric resistance heating and heat pump heating. Percentages deemed in Appendix F are based on PY2018 Efficient Products Program-tracking data.

$$kWh_{HP\ Heating} = \left[\frac{\left(\left(1-\frac{1}{EF_{EE}}\right)\times GPD \times Household \times 365.25 \times \gamma Water \times (T_{Out}-T_{In}) \times 1.0\right) \times LF \times WHF_H}{COP_{Heat\ Pump} * 3{,}412}\right] \times \%ElectricHeat_{HP}$$

where:

EF_{Base} = Energy factor of standard electric water heater according to federal standards = 0.945

EF_{EE} = Energy factor of efficient equipment = 3.44

GPD = Gallons per day = 17.6

Household = Average number of people per household = 2.65

365.25 = Days per year

γWater = Specific weight of water in pounds per gallon = 8.33

T_{Out} = Tank temperature = 125°F

T_{In} = Incoming water temperature from well or municipal system = 57.898°F

1.0 = Heat capacity of water in Btu/lb-°F

3,412 = Conversion factor from Btu to kWh

ISR = 100%

LF = Location factor = 0.81

WHF_C = Portion of reduced waste heat that results in cooling savings = 53%

COP_{Cool} = COP of CAC = 2.8

LM = Latent multiplier to account for latent cooling demand = 1.33

%Cool = Percentage of homes with central cooling = 100%

WHF_H = Portion of reduced waste heat that results in increased heating load = 43%

$COP_{Electric\ Resistance}$ = COP of electric resistance heating system = 1.0

$COP_{Heat\ Pump}$ = COP of heat pump heating system = 1.92

$\%ElectricHeat_{Electric\ Resistance}$ = Percentage of homes with electric resistance heating = 22.3%

$\%ElectricHeat_{Heat\ Pump}$ = Percentage of homes with heat pump heating = 26.9%

CF = Coincidence factor = 0.0000887318

Advanced Thermostats Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 REP Program advanced thermostat measures, the evaluation team applied Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 29.

Equation 29. Advanced Thermostat Energy and Demand Savings Equation

$$kWh = kWh_{Heating} + kWh_{Cooling}$$

$$kWh_{Heating} = \%ElectricHeat \times HeatingConsumption_{Electric} \times HF \times HeatingReduction \times ISR + (\Delta Therms \times Fe \times 29.3)$$

$$kWh_{Cooling} = \%AC \times \frac{\left(EFLH_{Cool} \times CapacityCool \times \frac{1}{SEER}\right)}{1000} \times CoolingReduction \times ISR$$

$$\Delta Therms = \%FossilHeat \times HeatingConsumption_{Gas} \times HF \times HeatingReduction \times ISR$$

$$kW = kWh_{Cooling} \times CF$$

Where:

%ElectricHeat = Percentage of heating savings assumed to be electric = 100% if electric heating system; 0% if natural gas heating; 31% if unknown[5]

$HeatingConsumption_{Electric}$ = Estimate of annual household heating consumption for electrically heated single family homes, in kWh (Table 12)

Table 12. $HeatingConsumption_{Electric}$ for Advanced Thermostat Measures

Heating Equipment	$HeatingConsumption_{Electric}$
Electric Heat Pump	8,355
Electric Resistance	14,202
Natural Gas System	0
Unknown	11,456

HF = Household factor, to adjust heating consumption for non-single family households = 100% if single family, 65% if multifamily

HeatingReduction = Assumed percentage reduction in total household heating energy consumption due to advanced thermostat = 6.67%

ISR = In-service rate = 98.8%

ΔTherms = Therm savings if natural gas heating system, calculated using equation defined above

[5] Note that the evaluation team deviated from the TRM Appendix F for this parameter. For PY2021 we applied a weighted average assumption based on available heating equipment types present in the program data.

Fe = Furnace fan energy consumption as a percentage of annual fuel consumption = 3.14%

29.3 = Conversion factor of kWh per therm

%AC = Fraction of customers with thermostat-controlled air conditioning = 100%

EFLHCool = Equivalent full load hours of air conditioning = 869

CapacityCool = Capacity of air cooling system in Btu/hr = 36,552

SEER = Seasonal Energy Efficiency Ratio rating of the cooling equipment in kBtu/kWh = 13.55

1/1000 = Conversion factor of kBtu per Btu

CoolingReduction = Assumed percentage reduction in total household cooling energy consumption due to advanced thermostat = 8.0%

%FossilHeat = percentage of heating savings assumed to be natural gas = 0% if electric heating system; 100% if natural gas heating; 69% if unknown[6]

$HeatingConsumption_{Gas}$ = Estimate of annual household heating consumption for gas-heated single family homes, in therms = 682

CF = Coincidence factor = 0.0009474181

Pool Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 REP Program pool pump measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 30.

Equation 30. Pool Pump Energy and Demand Savings Equations

$$kWh = \frac{Gallons \times Turnovers \times \left(\frac{1}{WEF_{base}} - \frac{1}{WEF_{ee}}\right) \times Days}{1000} \times ISR$$

$$kW = kWh \times CF$$

where:

Gallons = Capacity of the pool (gal) = 22,000

Turnovers = Desired number of pool water turnovers per day = 2

WEF_{base} = Weighted Energy Factor of baseline pump (gal/Wh) = 4.60

WEF_{ee} = Weighted Energy Factor of installed ENERGY STAR pump (gal/Wh) = 2.30

[6] Note that the evaluation team deviated from the TRM Appendix F for this parameter. For PY2021 we applied a weighted average assumption based on available heating equipment types present in the program data.

EF_{exist} = Energy Factor of existing single speed pump (gal/Wh) = 2.30

Days = Days per Year of Operation = 121.6

ISR = In-service rate = 100%

CF = Coincidence factor = 0.0002354459

Tier 1 Power Strips Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 REP Program Tier 1 power strip measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 31.

Equation 31. Tier 1 Power Strips Energy and Demand Savings Equations

$$kWh = \left(kWh_{Office} \times Weighting_{Office} + \ kWh_{Ent}\ x\ Weighting_{Ent}\right) \times ISR$$

$$kW = kWh \times CF$$

where:

kWh_{Office} = Estimated energy savings from using and APS in a home office = 31.0 kWh

$Weighting_{Office}$ = Relative penetration of use in home office = 36%

kWh_{Ent} = Estimated energy savings from using an APS in a home entertainment system = 75.1 kWh

$Weighting_{Ent}$ = Relative penetration of use in home office = 64%

ISR = In-service rate = 93.8%[7]

CF = Coincidence factor = 0.0001148238

Tier 2 Power Strips Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 REP Program Tier 2 power strip measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v5.0) deemed savings tables to the program-tracking database.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 32.

Equation 32. Tier 2 Power Strips Energy and Demand Savings Equations

$$kWh = (ERP \times BaselineEnergy_{AV}) \times ISR$$

$$kW = kWh \times CF$$

[7] Note that this value differs from the TRM Appendix F. For this measure, the evaluation team adopted the Tier 2 APS ISR derived from the PY2019 Efficient Products evaluation.

where:

ERP = Energy reduction percentage of qualifying Tier 2 power strip = 37.5%, average ERP of all product classes given in TRM

$BaselineEnergy_{AV}$ = Baseline audio visual (AV) energy consumption, in kWh = 432

ISR = In-service rate = 93.8%

CF = Coincidence factor = 0.0001148238

Net Impact Methodology

A NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR represents the share of *program-induced* savings.

For the PY2021 REP Program, the NTGR consists of participant free ridership (FR), participant spillover (PSO), and non-participant SO (NPSO). For the REP Program, preliminary NTGRs are computed as (1 – FR + PSO). FR is the proportion of the program-achieved ex post gross savings that would have been realized absent the program. PSO occurs when participants take additional energy-saving actions that are influenced by program interventions but that did not receive program support (Table 13).

For PY2021, the evaluation team relied on NTGR results estimated as part of the PY2019 evaluation (details on the derivation of the NTGRs can be found in the PY2019 evaluation report Appendix A). Table 13 shows the NTGRs used for the PY2021 evaluation.

Table 13. PY2021 REP Program NTGRs

Channel	Measure/Enduse	Free Ridership (FR)	Participant Spillover (PSO)	NTGR (1-FR+PSO)
Online Store	Advanced Thermostats	29.3%	2.8%	73.5%
	Tier 1 Power Strips	16.6%	2.8%	86.2%
	Tier 2 Power Strips	16.6%	2.8%	86.2%
Mail-in	Advanced Thermostats	29.3%	2.8%	73.5%
	Heat Pump Water Heaters	40.4%	2.8%	62.4%
	Pool Pumps	35.6%	2.8%	67.2%

NPSO represents the reduction in energy consumption and demand by non-participants because of the influence of the program. For PY2021, the evaluation team relied on NPSO estimates derived as part of the PY2019 evaluation (details on the derivation of the NTGRs can be found in the PY2019 evaluation report Appendix A). In general, NPSO is computed as a proportion of total ex post gross savings and is applied at the program level. Thus, NPSO is not shown in Table 13.

Multifamily Market Rate (MFMR)

Gross Impact Methodology

This appendix contains details on the savings assumptions used to estimate verified gross electric energy and electric demand savings for the Multifamily Market Rate (MFMR) Program in PY2021.

Lighting Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR lighting measures, the evaluation team used the lighting algorithms from Appendix F (v5.0) (see Equation 33). The evaluation team applied site-specific parameters from the program-tracking database and rebate approval forms (RAFs) when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 14).

Equation 33. Lighting Energy and Demand Savings Equations

$$kWh = (Watts_{Base} - Watt_{EE}) \times ISR \times (1 - LKG) \times (Hours \times WHF)/1{,}000$$

$$kW = kWh \times CF$$

Table 14. Lighting Input Values

Lighting	Enduse	Verified Inputs	Source
WattsBase	EXT Lighting BUS	Custom	Tracking Data and Rebate Approval Forms
	Lighting BUS	Custom	Tracking Data and Rebate Approval Forms
	Lighting Res	Custom	Tracking Data and Rebate Approval Forms
WattsEE	EXT Lighting BUS	Custom	Tracking Data and Rebate Approval Forms
	Lighting BUS	Custom	Tracking Data and Rebate Approval Forms
	Lighting Res	Custom	Tracking Data and Rebate Approval Forms
ISR	EXT Lighting BUS	1.00	Appendix F
	Lighting BUS	1.00	Rebate Approval Forms
	Lighting Res	0.9512	Appendix F
Hours	EXT Lighting BUS	Custom	Tracking Data, Appendix F
	Lighting BUS	Custom	Tracking Data, Appendix F
	Lighting Res	Custom	Tracking Data, Appendix F
WHF	EXT Lighting BUS	1.00	Appendix F
	Lighting BUS	1.00 (unconditioned spaces), 1.10 (conditioned spaces)	Appendix F
	Lighting Res	0.99	Appendix F
CF	Lighting Res	0.0001493	Appendix F
	EXT Lighting BUS	0.0000056	Appendix F
	Lighting BUS	0.0001900	Appendix F
Leakage	EXT Lighting BUS	0	Appendix F

Lighting	Enduse	Verified Inputs	Source
	Lighting BUS	0	Appendix F
	Lighting Res	0	Rebate Approval Forms

Hot Water Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR hot water measures (e.g., aerators, showerheads), the evaluation team used the algorithms from Appendix F described in Equation 34 and Equation 35. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 15, Table 16, and Table 17).

Equation 34. Low Flow Faucet Aerator Energy and Demand Savings Equations

$$kWh = \%ElectricDHW \times \left((GPM_{base} \times L_{base} - GPM_{low}) \times Household \times 365.25 \times \frac{DF}{FPH} \right) \times EPG_{electric} \times ISR$$

$$kW = kWh \times CF$$

Table 15. Bathroom Faucet Aerator Input Values

Bathroom Faucet Aerator	Verified Inputs	Source
%ElectricDHW	1	Appendix F
GPM_base	2.2	Tracking Data
L_base	1.6	Appendix F
GPM_low	0.5	Tracking Data
L_low	1.6	Appendix F
Household	2.1	Appendix F
DF	0.9	Appendix F
FPH	1.4	Appendix F
EPG_electric	0.06153283	Appendix F
ISR	1.00	Appendix F
CF	8.873E-05	Appendix F

Table 16. Kitchen Faucet Aerator Input Values

Kitchen Faucet Aerator	Verified Inputs	Source
%ElectricDHW	1	Appendix F
GPM_base	2.2	Tracking Data
L_base	3.7	Appendix F
GPM_low	1.5	Tracking Data
L_low	3.7	Appendix F
Household	2.1	Appendix F
DF	0.75	Appendix F
FPH	1	Appendix F

Kitchen Faucet Aerator	Verified Inputs	Source
EPG_electric	0.07897128	Appendix F
ISR	1.00	Appendix F
CF	8.873E-05	Appendix F

Equation 35. Low Flow Showerhead Energy and Demand Savings Equations

$$kWh = (\%ElectricDHW \times ((GPM_{base} \times L_{base} - GPM_{low}) \times Household \times 365.25 \times \frac{SPCD}{SPH}) \times EPG_{electric} \times ISR$$

$$kW = kWh \times CF$$

Table 17. Low Flow Showerhead Input Values

Low Flow Showerhead	Verified Inputs	Source
%ElectricDHW	1	Appendix F
GPM_base	2.5	Tracking Data
L_base	8.66	Appendix F
GPM_low	1.25	Tracking Data
L_low	7.8	Appendix F
Household	2.07	Appendix F
SPCD	0.66	Appendix F
SPH	1.4	Appendix F
EPG_electric	0.11	Appendix F
ISR	0.91	Appendix F
CF	8.873E-05	Appendix F

Learning Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR learning thermostat measures, the evaluation team used the algorithms from Appendix F described in Equation 36. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 18).

Equation 36. Learning Thermostat Energy and Demand Savings Equations

$$kWh = kWh_{Heating} + kWh_{Cooling}$$

$$kWh_{Heating} = \%ElectricHeat \times HeatingConsumption_{Electric} \times HF \times HeatingReduction \times ISR + (\Delta Therms \times Fe \times 29.3)$$

$$kWh_{Cooling} = \%AC \times \left(\frac{EFLH_{Cool} \times CapacityCool \times \frac{1}{SEER}}{1000} \right) \times CoolingReduction \times ISR$$

$$kW = kWh_{Cooling} \times CF$$

Table 18. Learning Thermostat Input Values

Learning Thermostat	Verified Inputs	Source
%ElectricHeat	1	Appendix F
HeatingConsumption_Electric	14,201.97	Appendix F
HF	0.65	Appendix F
HeatingReduction	0.088	Appendix F
Eff_ISR	1.00	Appendix F
deltaTherm	0	Appendix F; assume electric heating
%AC	1	Appendix F; assume air conditioner present
EFLH_cool	869	Appendix F
Capacity_cool	18,000, 24,000	Appendix F
SEER	8, 10, 10.3	Tracking Data
CoolingReduction	0.08	Appendix F
CF	0.000947418	Appendix F

Programmable Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR programmable thermostat measures, the evaluation team used the algorithms from Appendix F described in Equation 37. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 19).

Equation 37. Programmable Thermostat Energy and Demand Savings Equations

$$\Delta kWh_{cooling} = EFLH_{cool} * Capacity_{Cooling} * \left(\frac{1}{SEER}\right) * SBdegrees_{cooling} * SF_{cooling} * EF_{cooling}/1000$$

$$\Delta kWh_{heating} = \%ElectricResistanceHeat * EFLH_{Heat} * Capacity_{Heating} * \left(\frac{1}{HSPF}\right) * SBdegrees_{heating} * SF_{Heating} * EF_{Heating}/1000$$

$$kW = \Delta kWh_{cooling} * CF$$

Table 19. Programmable Thermostat Input Values

Programmable Thermostat	HVAC Type	Verified Inputs	Source
EFLHcool	All	869	Appendix F
Capacity_cooling	Chiller/Gas Boiler	50,909	Tracking Data, Rebate Approval Forms
SEER	All	10	Appendix F
SBdegrees_cooling	All	1.91	Appendix F
SFcooling	All	6%	Appendix F
EFcooling	All	100%	Appendix F

Programmable Thermostat	HVAC Type	Verified Inputs	Source
%ElectricHeat	Chiller/Gas Boiler	0%	Tracking Data
EFLHheat	Chiller/Gas Boiler	1,496	Appendix F
Capacity_heating	Chiller/Gas Boiler	0	Rebate Approval Forms
HSPF	Chiller/Gas Boiler	0	Rebate Approval Forms
SBdegrees_heating	All	1.8	Appendix F
SFheating	All	3%	Appendix F
EFheating	All	13%	Appendix F
CF	All	0.0009474181	Appendix F

Air Source Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR ASHP measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Central Air Conditioner Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR CAC measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Pool Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR pool pump measures, the evaluation team used the algorithms from Appendix F described in Equation 38. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 20).

Equation 38. Pool Pump Energy and Demand Savings Equations

$$\Delta kWh = \frac{kWh}{hp} \times hp \times ISR$$

$$\Delta kW = \Delta kWh \times CF$$

Table 20. Pool Pump Input Values for MFMR Measures

Input	Value	Source
kWh/hp	1,747	Tracking Data
hp	Custom	Tracking Data and Rebate Approval Forms

Input	Value	Source
CF	0.0001379439	Appendix F

Ceiling Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR ceiling insulation measures, the evaluation team used the algorithms from Appendix F described in Equation 39. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 21).

Equation 39. Ceiling Insulation Energy and Demand Savings Equations

$$kWh_{HeatingElec} = \frac{\left(\%ElecHeat \times \left(\frac{1}{R_{old}} - \frac{1}{R_{Attic}}\right) \times A_{Attic} \times (1 - FramingFactor_{Attic}) \times HDD \times 24 \times Adj_{Attic}\right)}{n_{heat} \times 3{,}412} + (1 - \%ElecHeat) \times \Delta Therms \times F_e \times 29.3$$

$$kWh_{Cooling} = \frac{\left(\%CentralCooling \times \left(\frac{1}{R_{old}} - \frac{1}{R_{Attic}}\right) \times A_{Attic} \times (1 - FramingFactor_{Attic}) \times CDD \times 24 \times DUA\right)}{n_{cool} \times 1{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

Table 21. Ceiling Insulation Input Values for MFMR Measures

Input	Value	Source
%ElectricHeat	100%	Tracking Data
R_{old}	1.32	Tracking Data
R_{Attic}	30.0	Tracking Data
A_{Attic}	Custom	Tracking Data
$FramingFactor_{Attic}$	7%	Appendix F
CDD	1,646	Appendix F
DUA	0.75	Appendix F
nCool	13	Appendix F
HDD	4,486	Appendix F
ADJ_{Attic}	0.74	Appendix F
nHeat	1.00 for Electric Heat	Appendix F
Fe	3.14%	Appendix F
CF	0.000466085	Appendix F

Electronically Commutated Motor Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR electronically commutated motor (ECM) measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when

they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Because of a July 2019 change in code requiring ECMs on all new furnaces, in PY2021 the only eligible ECMs are those included in early-replacement furnace measures or as retrofits on existing furnace equipment. For these cases, the evaluation team deemed the EUL of ECMs to be six years, which is equal to the deemed remaining useful life of the replaced equipment.

Window Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR window measures, the evaluation team used the algorithms from the 2017 Missouri Statewide Commercial TRM described in Equation 40. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in the 2017 Missouri Statewide Commercial TRM (see Table 22).

Equation 40. Windows Energy and Demand Savings Equations

$$\Delta kWh = \Delta kWh_{Heating} + \Delta kWh_{Cooling}$$

$$\Delta kWh_{Cooling} = Infiltration_{cooling} + Conduction_{cooling} + Solar_{cooling}$$

$$\Delta kWh_{Cooling} = Infiltration_{heating} + Conduction_{heating} + Solar_{heating}$$

$$Infiltration_{cooling} = \frac{(CFM_{pre} - CFM_{post}) * 60 * EFLH_{cooling} * \Delta T_{avgcooling} * 0.018 * LM}{1000 * n_{cooling}}$$

$$Conduction_{cooling} = \frac{(U_{base} - U_{Eff}) * A_{window} * EFLH_{cooling} * \Delta T\_avgcooling}{1000 * n_{cooling}}$$

$$Solar_{cooling} = \frac{(SHGC_{base} - SHGC_{Eff}) * A_{window} * \varphi_{cooling}}{1000 * n_{cooling}}$$

$$Infiltration_{heating} = \frac{(CFM_{pre} - CFM_{post}) * 60 * EFLH_{heating} * \Delta T_{avg}, heating * 0.018}{3{,}412 * n_{heating}}$$

$$Conduction_{heating} = \frac{(U_{base} - U_{Eff}) * A_{window} * EFLH_{heating} * \Delta T_{avg}, heating}{3{,}412 * n_{heating}}$$

$$Solar_{heating} = \frac{(SHGC_{base} - SHGC_{Eff}) * A_{window} * \varphi_{heating}}{3{,}412 * n_{heating}}$$

Table 22. Window Input Values

Windows	Verified Inputs	Source
CFMpre	Custom	Rebate Approval Forms
CFMpost	Custom	Rebate Approval Forms
EFLHcool	1,171	2017 AMO TRM

Windows	Verified Inputs	Source
ΔT_avgcooling	5.8	2017 AMO TRM
LM	3.0	2017 AMO TRM
ηcooling	Custom	Tracking Data
Ubase	Custom	Tracking Data
Ueff	0.27	2017 AMO TRM
A_window	Custom	Rebate Approval Forms
SHGCbase	Custom	Tracking Data
SHGCeff	Custom	Tracking Data
Ψcooling	40,996	2017 AMO TRM
EFLHheat	1,433	2017 AMO TRM
ΔT_avgheating	11.8	2017 AMO TRM
ηheating	Custom	Tracking Data
Ψheating	66,592	2017 AMO TRM
CF	0.001231928	2017 AMO TRM

Custom Measures

For HVAC Controls measures, the implementation team developed customized savings estimation methods—such as engineering analysis using metering data and binning analysis—with project-specific information about the building envelope, equipment specifications, operating schedules, and controls schemes.

To calculate verified gross energy and demand savings for these custom measures, the evaluation team collected project documentation to (1) review the methods and assumptions used to develop the ex ante savings, (2) verify the purchase/installation of the measures (e.g., through invoice or post-installation documentation), and (3) validate or update the ex post savings estimates based on evaluation findings.

Net Impact Methodology

The evaluation team relied on NTGR values from PY2020 for the PY2021 net savings estimations. No new research was conducted in PY2021. Table 23 presents the results from our NTG results from PY2020.

Table 23. PY2021 Multifamily Market Rate Program NTGR

Program	Free Ridership (FR)	Participant Spillover (PSO)	NTGR (1-FR+PSO)
MFMR Program	0.06	0.00	0.94

Multifamily Income Eligible (MFIE)

Gross Impact Methodology

This appendix contains details on the savings assumptions used to estimate verified gross electric energy and electric demand savings for the Multifamily Income Eligible (MFIE) Program in PY2021.

Lighting Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE lighting measures, the evaluation team used the algorithms described in the MFMR section of Appendix F. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available, such as baseline wattage and WHF values. For other parameters, we applied the deemed assumptions provided in Appendix F (see MFMR section). Additionally, for MFIE, an in-service rate of 98.18% was applied for all residential lighting measures in accordance with Appendix F.

Advanced Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE advanced thermostat measures, the evaluation team used the algorithms from Appendix F described in the MFMR section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available, such as cooling capacity and effective full load cooling hours. For other parameters, we applied the deemed assumptions provided in Appendix F (see MFMR section).

Programmable Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE programmable thermostat measures, the evaluation team used the algorithms from Appendix F described in the MFMR section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see MFMR section).

Air Source Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE ASHP measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Ductless Minisplit Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE ductless minisplit heat pump measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available, such as efficient and existing SEER values. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Hot Water Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE pool pump hot water measures (aerators, showerheads), the evaluation team used the algorithms from Appendix F described in the MFMR section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see MFMR section).

Pool Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE pool pump measures, the evaluation team used the algorithms from Appendix F described in the MFMR section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see MFMR section).

Refrigerator Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE refrigerator measures, the evaluation team used the algorithms from Appendix F described in Equation 41. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 24).

Equation 41. Refrigerator Energy and Demand Savings Equations

$$\Delta kWh_{unit} = kWh_{base} - \left(kWh_{new} * (1 - \%Savings)\right)$$

Table 24. Refrigerator Input Values

Refrigerator	Verified Inputs	Source
kWhBase	Custom	Rebate Approval Forms
kWhNew	Custom	Rebate Approval Forms
%Savings	10%	Appendix F
CF	0.000129	Appendix F

Clothes Washer Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE clothes washer measures, the evaluation team used the algorithms from Appendix F described in Equation 42. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 25).

Equation 42. Clothes Washer Energy and Demand Savings Equations

$$\Delta kWh = \left[\left(Capacity * \frac{1}{MEFbase} * Ncycles\right) * \left(\%CWbase + (\%DHWbase * \%Electric_{DHW}) + \left(\%Dryerbase * \%Electric_{Dryer}\right)\right)\right] - \left[\left(Capacity * \frac{1}{MEFeff} * Ncycles\right) * \left(\%CWeff + (\%DHWeff * \%Electric_{DHW}) + \left(\%Dryereff * \%Electric_{Dryer}\right)\right)\right]$$

$$\Delta kW = \Delta kWh \; x \; CF$$

Table 25. Clothes Washer Input Values

Clothes Washer	Verified Inputs	Source
Capacity	Custom	Rebate Approval Forms
MEFbase	1.66	Appendix F
Ncycles	271	Rebate Approval Forms
%CWbase	8.0%	Rebate Approval Forms
%DHWbase	3.1%	Rebate Approval Forms
%ElectricDHW	0%	Appendix F
%DryerBase	61%	Rebate Approval Forms
%ElectricDryer	0%	Appendix F
MEFeff	2.76	Rebate Approval Forms
%CWeff	8%	Rebate Approval Forms
%DHWeff	2.3%	Rebate Approval Forms
$\%Electric_{DHW}$	0%	Appendix F
%Dryereff	69%	Rebate Approval Forms
CF	0.0001379439	Appendix F

Windows Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE window measures, the evaluation team used the algorithms from the 2017 Missouri Statewide Commercial TRM described in the MFMR section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in the 2017 Missouri Statewide Commercial TRM (see MFMR section).

Electronically Commutated Motor Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFMR ECM measures, the evaluation team used the algorithms from Appendix F described in the HVAC section. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see HVAC section).

Because of a July 2019 change in code requiring ECMs on all new furnaces, in PY2021 the only eligible ECMs are those included with early-replacement furnace measures or as retrofits on existing furnace equipment. For these cases, the evaluation team deemed the EUL of ECMs to be six years, which is equal to the deemed remaining useful life of the replaced equipment.

VFD on Chilled Water Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 MFIE refrigerator measures, the evaluation team used the algorithms from Appendix F described in Equation 43. The evaluation team applied site-specific parameters from the program-tracking database and RAFs when they were available. In cases where site-specific information was not available, we applied the deemed assumptions provided in Appendix F (see Table 26).

Equation 43. VFD on Chilled Water Pump Energy and Demand Savings Equations

$$\Delta kWh = \frac{BHP}{EEFi} \; x \; Hours \; x \; ESF \; x \; HP$$

$$\Delta kW = \; \Delta kWh \; x \; CF$$

Table 26. VFD on Chilled Water Pump Input Values

Clothes Washer	Verified Inputs	Source
BHP	1.00	Appendix F
EEFi	0.93	Appendix F
Hours	3,539	Appendix F
ESF	0.3389	Appendix F
HP	Custom	Rebate Approval Forms
CF	0.000910684	Appendix F

Single Family Income Eligible (SFIE)

Gross Impact Methodology

Advanced (Learning) Thermostat Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program advanced/learning thermostat measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations, input parameters, and input values are described in the Appendix A.

Air Sealing Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program air sealing measures, the evaluation team applied one of two methods, depending on the available level of detail for the measure:

- Where actual blower door test results before and after air sealing were available (CFM50Pre and CFM50Post parameters), the evaluation team applied the "Test In / Test Out Approach" from Version 5.0 of the Ameren Missouri TRM Appendix I.
- For measures missing these data, the evaluation team applied the "Conservative Deemed Approach" defaults from Version 5.0 of the Ameren Missouri Appendix F deemed savings tables.

The team used the following equations to calculate electric and demand energy savings. Heating savings are for homes with electric heating, only:

Method 1: Test In / Test Out Approach

Equation 44. Air Sealing Test In / Test Out Approach Energy and Demand Savings Equations

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

$$\Delta kWh_{cooling} = \frac{\left(\frac{CFM50_{Pre} - CFM50_{Post}}{N_{cool}}\right) \times 60 \times 24 \times CDD \times DUA \times 0.018 \times LM}{1{,}000 \times \eta Cool}$$

$$\Delta kWh_{heating} = \frac{\left(\frac{CFM50_{Pre} - CFM50_{Post}}{N_{heat}}\right) \times 60 \times 24 \times HDD \times 0.018}{\eta Heat_{electric} \times 3{,}412}$$

$$\Delta Therms = \frac{\frac{(CFM50_{Pre} - CFM50_{Post})}{N_{heat}} * 60 * 24 * HDD * 0.018}{(\eta Heat_{gas} * 100{,}000)}$$

$$\Delta kW = \Delta kWh \times CF$$

Additional Fan Savings: $\Delta kWh_{heating} = \Delta Therms \times F_e \times 29.3$

Method 2: Conservative Deemed Approach

Equation 45. Air Sealing Conservative Deemed Approach Energy and Demand Savings Equation

$$s\Delta kWh_{cooling} = Default_{cool} \times Sq.ft.$$

$$\Delta kWh_{heating} = Default_{heat} \times Sq.ft.$$

$$\Delta kW = \Delta kWh \times CF$$

$$\Delta Therms = Default_{therms} \times Sq.ft.$$

Additional Fan Savings: $\Delta kWh_{heating} = \Delta Therms \times F_e \times 29.3$

Table 27. Air Sealing Input Values for SFIE Measures

Input	Value	Source
$CFM50_{Pre}$	Custom	Tracking Data
$CFM50_{Post}$	Custom	Tracking Data
N_{cool}	32.0	Calculated Below
CDD	1,646	Appendix I
DUA	0.75	Appendix I
LM	3.00	Appendix I
ηCool	Custom	Tracking Data
N_{heat}	22.0	Calculated Below
HDD	4,486	Appendix I
$\eta Heat_{electric}$	1.92	Appendix I
$\eta Heat_{gas}$	0.71	Appendix I
CF	0.000466081	Appendix F
Fe	3.14%	Appendix F
Sq. ft.	Custom	Tracking Data
$Default_{cool}$	0.050	Appendix F
$Default_{heat}$	0.257	Appendix F
$Default_{therms}$	0.013	Appendix F

Appendix I provides default values for the heating and cooling conversion factors N_{cool} and N_{heat}, based on the number of home stories (see Table 28). Because number of stories is not included in program-tracking data, the evaluation team calculated weighted average default values, based on 2015 Residential Energy Consumption Survey (RECS) data for the Midwest region (see Table 29).[8]

[8] US Energy Information Administration (2015). 2015 Residential Energy Consumption Survey, Table HC2.7. Number of stories, number of housing units (million), retrievable at https://www.eia.gov/consumption/residential/data/2015/hc/php/hc2.7.php

Table 28. Ameren Missouri TRM Appendix I Default Values for N_{cool} and N_{heat}

Number of Stories	N_{cool}	N_{heat}
1	34.9	24.0
2	28.3	19.5
3	25.1	17.3

Table 29. 2015 RECS Building Characteristics Data for the Midwest Region

Number of Stories	Million Homes	Weight
1	10.6	57%
2	7.5	40%
3	0.5	3%
Total	**18.6**	**100%**

The evaluation team applied this estimated mix of the number of home stories to calculate weighted average heating and cooling conversion factors, as shown in Equation 46.

Equation 46. Air Sealing Calculated Values for N_{cool} and N_{heat}

$$N_{cool} = (34.9 \times 57\%) + (28.3 \times 40\%) + (25.1 \times 3\%) = 32.0$$

$$N_{heat} = (24.0 \times 57\%) + (19.5 \times 40\%) + (17.3 \times 3\%) = 22.0$$

Air Source Heat Pump (ASHP) Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program air source heat pump (ASHP) measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 47. Air Source Heat Pump Energy and Demand Savings Equations (Early Replacement—First Six Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Exist}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Equation 48. Air Source Heat Pump Energy and Demand Savings Equations (Early Replacement—Next 12 Years)

$$kWh = kWh_{Cooling} + kWh_{Heating}$$

$$kWh_{Cooling} = \frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kWh_{Heating} = \frac{\left(EFLH_{Heat} \times Capacity_{Heat} \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{EE}}\right)\right)}{1{,}000} \times HF$$

$$kW = kWh_{Cooling} \times CF$$

Table 30. Air Source Heat Pump Deemed Input Values for SFIE Measures

Input	Value	Source
$EFLH_{Cool}$	869	Appendix F
$SEER_{Exist}$	Custom	Tracking Data
$SEER_{Base}$	13	Appendix F
Household Factor (HF)	100% for single family 65% for multifamily	Appendix F
$EFLH_{Heat}$	1,496	Appendix F
$HSPF_{Exist}$	3.41	Appendix F
$HSPF_{Base}$	3.41	Appendix F
CF	0.0009474181	Appendix F

Error! Reference source not found. shows the default values for common ASHP measures, used when measure-specific values are not available in the program-tracking data.

Table 31. Air Source Heat Pump Measure-Specific Input Values for SFIE Measures

Input	Measure Reference ID	Value	Source
$Capacity_{Cool}$	352300_2021_12_	34,556	Appendix F
$SEER_{EE}$	352300_2021_12_	15.12	Appendix F
$Capacity_{Heat}$	352300_2021_12_	34,556	Appendix F
$HSPF_{EE}$	352300_2021_12_	8.72	Appendix F
$Capacity_{Cool}$	352500_2021_12_	35,070	Appendix F
$SEER_{EE}$	352500_2021_12_	16.07	Appendix F
$Capacity_{Heat}$	352500_2021_12_	35,070	Appendix F
$HSPF_{EE}$	352500_2021_12_	9.04	Appendix F

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1-1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment for participants that received a tune-up on the existing equipment earlier in the year.

Central Air Conditioner (CAC) Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program central air conditioner (CAC) measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric energy and demand savings:

Equation 49. Central Air Conditioner Energy and Demand Savings Equations (Early Replacement—First Six Years)

$$kWh = \left[\frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{DR \times SEER_{Exist}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}\right] \times HF$$

$$kW = kWh \times CF$$

Equation 50. Central Air Conditioner Energy and Demand Savings Equations (Early Replacement—Next 12 Years)

$$kWh = \left[\frac{\left(EFLH_{Cool} \times Capacity_{Cool} \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{EE}}\right)\right)}{1{,}000}\right] \times HF$$

$$kW = kWh \times CF$$

Table 32 shows the value and source for key input parameters in the savings calculation.

Table 32. Central Air Conditioner Input Values for SFIE Measures

Input	Value	Source
$EFLH_{Cool}$	869	Appendix F
$Capacity_{Cool}$	Custom	Tracking Data
$SEER_{Exist}$	Custom	Tracking Data
$SEER_{Base}$	13	Appendix F
$SEER_{EE}$	Custom	Appendix F
Household Factor (HF)	100%	Appendix F
CF	0.0009474181	Appendix F

DR = Derating factor, to account for performance degradation of existing equipment compared to its nameplate rating. DR = $(1-1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment for participants that received a tune-up on the existing equipment earlier in the year.

Ceiling Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program ceiling insulation measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations, input parameters, and input values are described below.

Equation 51. Ceiling Insulation Energy and Demand Savings Equations

$$kWh_{HeatingElec} = \frac{\left(\%ElecHeat \times \left(\frac{1}{R_{old}} - \frac{1}{R_{Attic}}\right) \times A_{Attic} \times (1 - FramingFactor_{Attic}) \times HDD \times 24 \times Adj_{Attic}\right)}{n_{heat} \times 3{,}412} + (1 - \%ElecHeat) \times \Delta Therms \times F_e \times 29.3$$

$$kWh_{Cooling} = \frac{\left(\%CentralCooling \times \left(\frac{1}{R_{old}} - \frac{1}{R_{Attic}}\right) \times A_{Attic} \times (1 - FramingFactor_{Attic} \times CDD \times 24 \times DUA\right)}{n_{cool} \times 3{,}412}$$

$$\Delta Therms = \frac{\left(\left(\frac{1}{R_{old}} - \frac{1}{R_{Attic}}\right) \times A_{Attic} \times (1 - FramingFactor_{Attic} \times HDD \times 24 \times Adj_{Attic}\right)}{n_{heat} \times 10{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

Table 33 shows the value and source for key input parameters in the savings calculation.

Table 33. Ceiling Insulation Input Values for SFIE Measures

Input	Value	Source
%ElectricHeat	Custom	Tracking Data
R_{old}	16	Appendix F
R_{Attic}	Custom	Tracking Data
A_{Attic}	Custom	Tracking Data
$FramingFactor_{Attic}$	7%	Appendix F
CDD	1,646	Appendix F
DUA	0.75	Appendix F
nCool	11	Appendix F
HDD	4,486	Appendix F
ADJ_{Attic}	0.74	Appendix F
nHeat	0.71 for Gas Heat 1.92 for Electric Heat	Appendix F
Fe	3.14%	Appendix F
CF	0.000466081	Appendix F

Dirty Filter Alarm Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program dirty filter alarm measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations and input parameters are described in the Energy Efficiency Kits section, and input values specific to SFIE dirty filter alarm measures are described in the table below.

Table 34. Dirty Filter Alarm Input Values for SFIE Measures

Input	Value	Source
kW Motor	0.50	Appendix F
EFLH heat	1,496	Appendix F
EFLH cool	869	Appendix F
EI	15%	Appendix F
ISR	57.89%	Appendix F
Coincidence Factor (CF)	0.000466081	Appendix F

Duct Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program duct insulation measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric and demand energy savings:

Equation 52. Duct Insulation Energy and Demand Savings Equations

$$\Delta kWh = \Delta kWh_{Cooling} + \Delta kWh_{Heating}$$

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) \times Area \times EFLH_{cool} \times \Delta T_{Avg,cooling}}{1{,}000 \times SEER}$$

$$\Delta kWh_{HeatingElectric} = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) \times Area \times EFLH_{heat} \times \Delta T_{Avg,heating}}{3{,}412 \times COP}$$

$$\Delta kWh_{HeatingGas} = \Delta Therms \times Fe \times 29.3$$

$$\Delta Therms = \frac{\left(\frac{1}{R_{existing}} - \frac{1}{R_{new}}\right) \times Area \times EFLH_{heat} \times \Delta T_{Avg,heating}}{100{,}000 \times \eta Heat}$$

$$\Delta kW = \Delta kWh \times CF$$

Table 35. Duct Insulation Input Values for SFIE Measures

Input	Value	Source
$R_{existing}$	4.0	Appendix F
R_{new}	8.0	Appendix F
Area	Custom	Tracking Data
$EFLH_{cool}$	869	Appendix F
$\Delta T_{Avg,cooling}$	20.8	Appendix F
SEER	10	Appendix F
$EFLH_{heat}$	1,496	Appendix F
$\Delta T_{Avg,heating}$	71.8	Appendix F
COP	1.00	Appendix F

Input	Value	Source
Fe	3.14%	Appendix F
ηHeat	0.78	Appendix F
CF	0.000466081	Appendix F

Duct Sealing Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program electronically commutate motor (ECM) measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM and Appendix F deemed savings tables to the program-tracking database.

The TRM provides three different methods for evaluating savings. The evaluation team used Method 3 (deemed savings per linear foot) which uses the following equations to calculate electric energy and demand savings:

Equation 53. Duct Sealing Method 3 Energy and Demand Savings Equations

$$\Delta kWh = \Delta kWh_{Cooling} + \Delta kWh_{Heating}$$

$$\Delta kWh_{Cooling} = CoolSavingsPerUnit * Duct_{length}$$

$$\Delta kWh_{HeatingElectric} = HeatSavingsPerUnit * Duct_{length}$$

$$\Delta kWh_{HeatingGas} = \Delta Therms * Fe * 29.3$$

$$\Delta Therms = HeatSavingsPerUnit * Duct_{length}$$

Table 36. Duct Sealing Input Values for SFIE Measures

Input	Value	Source
CoolSavingsPerUnit	0.81 per ft	Appendix F
$Duct_{length}$	Custom	Tracking data
HeatSavingsPerUnit	4.11 per ft (Electric Heating)	Appendix F
Fe	3.14%	Appendix F
Conversion factor	29.3	Appendix F

Electronically Commutated Motor (ECM) Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program electronically commutate motor (ECM) measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

Because of a July 2019 change in code requiring ECMs on all new furnaces, the only eligible ECMs in PY2021 are those that were included with early-replacement furnace measures or as retrofits on existing furnace equipment. For these cases, the evaluation team deemed the effective useful lifetime (EUL) of ECMs to be six years, the remaining useful life of the existing equipment replaced.

The savings equations, input parameters, and input values are described in the HVAC section.

Lighting Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program lighting measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations and input parameters are described in the Energy Efficiency Kits section, and input values specific to SFIE lighting measures are described in the tables below.

Table 37. Wattage Table for SFIE Lighting Measures

Measure Description	Watts EE	Watts Base
LED - 10W (Halogen baseline) LIDI	9.1	43.0
LED - 15W Flood Light PAR30 Bulb (Halogen baseline) LI DI	14.0	55.0
Kit: LED - 10W (Halogen baseline)	9.0	43.0
LED - 15W (Halogen baseline) LIDI	10.6	53.0
LED - 18W Flood Light PAR38 Bulb (Halogen baseline) LI DI	17.0	70.0
LED - 20W (Halogen baseline) LIDI	15.0	72.0
LED - 12W Dimmable Light Bulb (Replacing Specialty Incandescent) LI DI	11.0	53.0
LED - 4W Candelabra (Replacing Specialty Incandescent) LI DI	4.5	40.4
9W A19 LED BULB	9.1	43.0

Table 38. Lighting Input Values for SFIE Lighting Measures

Input	Single Family and Mobile Homes Channels		Single Family Kits and Community Grant Channel	
	Value	Source	Value	Source
ISR	100%	Appendix F	87.95%	Appendix F
Hours Res	674.18	Appendix F	674.18	Appendix F
WHF	0.99	Appendix F	0.99	Appendix F
CF	0.0001492529	Appendix F	0.0001492529	Appendix F
%Res	100%	Appendix F	100%	Appendix F
Leakage	0%	Appendix F	0%	Appendix F

Low Flow Faucet Aerator Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program low-flow faucet aerator measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations input parameters are described in the Energy Efficiency Kits section, and input values specific to SFIE low-flow faucet aerator measures are described in the table below.

Table 39. Low Flow Faucet Aerator Input Values for SFLI Measures

Input	Bathroom Aerator	Kitchen Aerator	Source
%ElectricDHW	100% for Electric DHW; 42% for Unknown; 0% for non-electric DHW	100% for Electric DHW; 42% for Unknown; 0% for non-electric DHW	Appendix F
GPM_{base}	2.2	2.2	Appendix F
L_{base}	3.7	3.7	Appendix F
GPM_{low}	1.5	1.5	Appendix F
L_{low}	3.7	3.7	Appendix F
Household	1.56	1.56	Appendix F
DF	1.0	1.0	Appendix F
FPH	1.86	1.00	Appendix F
ISR	89% for Neighborhoods; 48% for Grants	89% for Neighborhoods; 40% for Grants	Appendix F
CF	0.0000887318	0.00008873118	Appendix F

Low-Flow Showerhead Savings Assumptions

Savings for this measure were updated in 2021.To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program low-flow showerhead measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations input parameters are described in the Energy Efficiency Kits section, and input values specific to SFIE low-flow showerhead measures are described in the table below.

Table 40. Low-Flow Showerhead Input Values for SFIE Measures

Input	Value	Source
%ElectricDHW	100% for Electric DHW; 42% for Unknown; 0% for non-electric DHW	Appendix F
GPM_{base}	2.2	Appendix F
L_{base}	8.66	Appendix F
GPM_{low}	1.5	Appendix F
L_{low}	8.66	Appendix F
Household	2.67	Appendix F
SPCD	0.66	Appendix F
SPH	2.05	Appendix F
ISR	94% for Neighborhoods; 54% for Grants	Appendix F
CF	0.0000887318	Appendix F

Pipe Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program pipe insulation measures, the evaluation team applied the Version 5.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations input parameters are described in the Energy Efficiency Kits section, and input values specific to SFIE pipe insulation measures are described in the table below.

Table 41. Pipe Insulation Input Values for SFIE Measures

Input	Value	Source
C_{base}	0.144	Appendix F
R_{base}	1.000	Appendix F
C_{EE}	0.406 for direct install; 0.458 for kits	Appendix F
R_{EE}	3.60 for direct install; 4.54 for kits	Appendix F
L	Custom	Tracking Data
ΔT	58.90	Appendix F
Hours	8,766	Appendix F
ηDHW_{Elec}	0.98	Appendix F
CF	0.0000887318	Appendix F
ISR	96%	Appendix F

Setback Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program setback thermostat measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric and demand energy savings. Heating savings are calculated only for measures with electric heating equipment.

Equation 54. Setback Thermostat Energy and Demand Savings Equations

$$\Delta kWh_{cooling} = EFLH_{cool} \times Capacity_{Cooling} \times \left(\frac{1}{SEER}\right) \times SBdegrees \times SF \times EF/1{,}000$$

$$\Delta kWh_{heating} = EFLH_{heat} \times Capacity_{Heating} \times \left(\frac{1}{HSPF}\right) \times SBdegrees \times SF \times EF/1{,}000$$

$$\Delta kW = \Delta kWh_{cooling} \times CF$$

Table 42. Setback Thermostat Input Values for SFIE Measures

Input	Value	Source
$EFLH_{cool}$	869	Appendix F
$Capacity_{Cooling}$	36,000 for single family; 20,240 for multifamily	Appendix F
SEER	Custom	Tracking Data
SBdegrees	1.91 for cooling;	Appendix F

Input	Value	Source
	1.80 for heating	
SF	6% for cooling; 3% for heating	Appendix F
EF	100% for cooling; 13% for heating	Appendix F
EFLHheat	1,496	Appendix F
$Capacity_{Heating}$	48,259 for electric heating; 0 for non-electric heating	Appendix F
HSPF	3.41	Appendix F
CF	0.0009474181	Appendix F

Refrigerator Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program refrigerator measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric and demand energy savings:

Equation 55. Refrigerator Energy and Demand Savings Equations

$$\Delta kWh = kWh_{base} - (kWh_{new} \times (1 - \%Savings))\Delta kW = \Delta kWh \times CF$$

Table Error! No text of specified style in document.-43. Setback Thermostat Input Values for SFIE Measures

Input	Value	Source
kWh_{base}	985.16	Appendix F
kWh_{new}	467.22	Appendix F
%Savings	10%	Appendix F
CF	0.0001286107	Appendix F

Room Air Conditioner Savings Assumptions

Savings for this measure were updated in 2021. To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program room air conditioner measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The team used the following equations to calculate electric and demand energy savings:

Equation 56. Room Air Conditioner Energy and Demand Savings Equations

$$\Delta kWh = \frac{FLH_{RoomAC} \times \frac{Btu}{H} \times \left(\frac{1}{CEER_{base}} - \frac{1}{CEER_{ee}}\right)}{1{,}000} \times ISR$$

Table 44. Room Air Conditioner Input Values for SFIE Measures

Input	Value	Source
FLH_{RoomAC}	860	Appendix F
Btu/H	10,322	Appendix F
$CEER_{base}$	10.83	Appendix F
$CEER_{ee}$	11.96	Appendix F
ISR	98%	Appendix F
CF	0.000947181	Appendix F

Tier 2 Advanced Power Strips Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program tier 2 advanced power strip measures, the evaluation team applied the Version 4.0 Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations, input parameters, and input values are described in the Energy Efficient Products section. For all SFIE power strip measures, the evaluation team applied an ISR of 95% as documented in Appendix F.

Tune-Up Savings Assumptions

To calculate verified gross energy and demand savings for PY2021 Single Family Income Eligible Program tune-up measures, the evaluation team applied Version 5.0 of the Ameren Missouri TRM Appendix I and Appendix F deemed savings tables to the program-tracking database.

The savings equations, input parameters, and input values are described below. Heating savings are calculated only for heat pump equipment.

Equation 57. Tune-Up Energy and Demand Savings Equations

$$kWh_{Cooling} = \frac{\left(EFLH_{cool} \times Capacity_{cool} \times \left(\frac{1}{SEER_{Test-In}} - \frac{1}{SEER_{Test-Out}}\right)\right)}{1{,}000}$$

$$kWh_{Heating} = \frac{\left(EFLH_{heat} \times Capacity_{heat} \times \left(\frac{1}{HSPF_{Test-In}} - \frac{1}{HSPF_{Test-Out}}\right)\right)}{1{,}000}$$

$$kW = kWh_{Cooling} \times CF$$

Table 45. Tune-Up Input Values for SFIE Measures

Input	Value	Source
$EFLH_{cool}$	869	Appendix F
$Capacity_{cool}$	Custom (based on measure)	Appendix F
$SEER_{Test\text{-}In}$	11.90	Appendix F
$SEER\_{}_{Test\text{-}Out}$	15.28	Appendix F
$EFLH_{heat}$	1,496	Appendix F
$Capacity_{heat}$	Custom (based on measure)	Appendix F
$HSPF\_{}_{Test\text{-}In}$	6.30	Appendix F
$HSPF_{Test\text{-}Out}$	6.72	Appendix F
CF	0.0009474181	Appendix F

1.1.1 Energy Efficient Kits Measures (Grant Channel)

Energy Efficient Kit Faucet Aerator Saving Assumption

The team used the following equations to calculate electric and demand energy savings:

Equation 58. EEK Faucet Aerator electric savings equation.

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

Equation 59. EEK Faucet Aerator demand savings equation.

$$\Delta kW = \Delta kWh * CF$$

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”

L_base = Average baseline length of daily faucet use per capita in minutes

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”

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 Home

EPG = Energy per gallon of water used by faucet supplied by electric water heater

ISR = In-service rate of faucet aerators

Leakage = Leakage rate, percent of homes in Ameren Missouri territory

Coincidence Factor = Summer peak coincidence demand (kW) to annual energy (kWh) factor

Energy Efficient Kit Low-Flow Shower Head Saving Assumption

The team used the following equations to calculate electric energy and demand savings:

Equation 60. Low Flow Shower Head Energy Savings.

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

Equation 61. Low Flow Shower Head Demand Savings.

$$\Delta kW = \Delta kWh * CF$$

Where:

ΔkWh = as calculated above

Where:

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

GPM_base = Average flow rate in gallons per minute of the baseline showerhead

L_base = Shower length in minutes with baseline showerhead

GPM_low = Average flow rate in gallons per minute of the low-flow showerhead

L_low = Shower length in minutes with low-flow showerhead

Household = Average number of people per household

SPCD = Shower per capita per day

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

EPG = Energy per gallon of hot water supplied by electric

ISR = In-service rate of showerhead

Coincidence Factor = Summer peak coincidence demand (kW) to annual energy (kWh) factor.

Leakage = Leakage rate, percent of homes in Ameren Missouri territory

Energy Efficient Kit LED – 10W (Halogen Baseline) Savings Assumption

The team used the following equations to calculate electric energy and demand savings:

Equation 62. LED Lighting Energy Savings.

$$\Delta kWh_{RES} = (Watt_{Base} - Watt_{EE}) * \%RES * ISR * (1 - LKG) * (Hours_{RES} * WHF_{RES}) / 1{,}000$$

Equation 63. LED Lighting Demand Savings

$$\Delta kW = \Delta kWh * CF$$

Where:

$Watts_{Base}$ = Wattage of the baseline bulb that was installed prior to the efficient bulb

$Watts_{EE}$ = Wattage of efficient light bulb

%Res = Percentage of light bulbs handed out to residential customers

ISR = In-service rate, percentage of units rebated that are actually in service based on estimated future installation rate trajectory

Leakage = Leakage rate, units installed outside of Ameren Missouri territory.

$Hours_{Res}$ = Average hours of use per year

WHF = Waste heat factor for energy to account for electric heating increase from the reduction of waste heat from efficient lighting

Coincidence Factor = Summer peak coincidence demand (kW) to annual energy (kWh) factor

Leakage = Leakage rate, percent of homes in Ameren Missouri territory

LED In-Service Rate

In 2019, the evaluation team estimated the ISRs for LEDs offered through the EEK Program using the installation trajectory approach recommended by the UMP.[9] Similar to our approach to estimating ISRs for the Residential Lighting Program, we developed both a first year ISR and cumulative ISR reflecting future installations over a six-year period (see Residential Lighting Gross Impact Methodology Section). The first year and cumulative ISRs for LEDs provided through the EEKs are presented in Table 46.

Table 46. First Year and Future Trajectory ISR for EEK LEDs

First Year ISR	Cumulative ISR
0.772	0.920

Energy Efficient Kit Dirty Filter Alarm Savings Assumption

The team used the following equations to calculate electric and demand energy savings:

Equation 64. Dirty Filter Alarm Energy Savings

$$\Delta kWh_{heating} = \%Heating * kW * EFLH_{heat} * EI * Utility\ Adjustment * ISR$$

$$\Delta kWh_{cooling} = \%AC * kW * EFLH_{cool} * EI * Utility\ Adjustment * ISR$$

[9] National Renewable Energy Laboratory (NREL). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Protocol. October 2017. https://www.nrel.gov/docs/fy17osti/68562.pdf.*

Equation 65. Dirty Filter Alarm Demand Savings

$$\Delta kW = \Delta kWh * CF$$

Where:

kW Motor = Average motor full load electric demand (kW)

$EFLH_{heat}$ = Equivalent full load hours heating (hours/year)

$EFLH_{cool}$ = Equivalent full load hours cooling (hour/year)

EI = Percentage of energy efficient change

ISR = In-service rate, percentage of units rebated that are actually in service

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

%Heating = Percentage of heating that used the filter

%Cooling = Percentage of cooling that uses the filter

Leakage = Leakage rate, percent of homes in Ameren Missouri territory

Energy Efficient Kit Pipe Insulation Wrap Saving Assumption

The team used the following equations to calculate electric and demand energy savings:

Equation 66. Pipe Insulation Energy Savings

$$\Delta kWh = ((C_{Base}/R_{Base} - C_{EE}/R_{EE}) * L * \Delta T * Hours)/(\eta DHW_{Elec} * 3{,}412)$$

Equation 67. Pipe Insulation Demand Savings

$$\Delta kW = \Delta kWh * CF$$

Where:

C_{Base} = Circumference (Feet) of uninsulated pipe

R_{Base} = Thermal resistance coefficient (hr-°F-ft^2)/Btu) of uninsulated pipe

C_{EE} = Circumference of insulated pipe

R_{EE} = Thermal resistance coefficient (hr-°F-ft^2)/Btu) of insulated pipe

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

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

Hours = Hours per year

ηDHW_{Elec} = Recovery efficiency of electric hot water heater

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor

ISR = In-service rate, percentage of units rebated that are actually in service

%Electric = Percentage of hot water heaters that are electric

Leakage = Leakage rate, percent of homes in Ameren Missouri territory

Non-participant Spillover (NPSO)

Ameren Missouri has been running energy efficiency programs for many years, and a key component of the residential portfolio has been a marketing and outreach campaign to promote the programs and general energy-efficiency awareness among customers. Sustained utility program and general marketing can affect customers' perceptions of their energy usage, and, in some cases, motivate them to take efficiency actions outside of the utility's program. We define NPSO as the energy savings that Ameren Missouri's program marketing activities caused but did not rebate.

As outlined in the PY2021 evaluation plan, we planned to apply the NPSO percentages that we developed in PY2019 (13.7% for MWh and 7.7% MW) to PY2021 ex-post gross savings for four applicable programs: HVAC, Energy Efficient Products, Appliance Recycling, and Energy Efficient Kits.

Summary of PY2019 NPSO Analysis

The PY2019 NPSO analysis used data we collected through a residential general population survey of a random sample of 4,804 Ameren Missouri residential customers; of which there were 3,450 non-participants for the NPSO analysis. We used a combination of survey screening techniques, survey data analysis, and follow-up phone calls to identify eligible NPSO measures amongst these respondents. NPSO savings are limited to measure installations that (1) the Ameren Missouri residential program portfolio supports (i.e., "like" measures), (2) could theoretically have been done due to Ameren Missouri's promotional efforts, and (3) are not the focus of NPSO estimation through specific program evaluations. Table 47 lists the eligible measures and their associated programs.

Table 47. PY2019 NPSO Eligible Measures

Measure	Program
Kitchen faucet aerator	Energy Efficient Kits, Appliance Recycling
Bathroom faucet aerator	Energy Efficient Kits, Appliance Recycling
Low flow showerhead	Energy Efficient Kits, Appliance Recycling
Hot water pipe insulation	Energy Efficient Kits, Appliance Recycling
Central air conditioner (CAC)	HVAC
Air source heat pump (ASHP)	HVAC
Ground source heat pump (GSHP) a	HVAC
Ductless/Minisplit Heat Pump (DMSHP)	HVAC
Furnace fan with electronic commutating motor (ECM)	HVAC
Advanced (i.e., learning or smart) thermostat	Energy Efficient Products, HVAC
Advanced power strips a	Energy Efficient Products

Measure	Program
Pool pump	Energy Efficient Products
Heat pump water heater (HPWH)	Energy Efficient Products
Recycled refrigerator	Appliance Recycling
Recycled freezer	Appliance Recycling

To qualify for NPSO, the respondent and measure needed to meet the following criteria:

- Aware that Ameren Missouri provides rebates or discounts on energy efficiency equipment or aware of at least one specific program.
- At least one element of Ameren Missouri's program marketing and outreach motivated the respondent to adopt the measure.
- The respondent had a valid reason for considering the measure to be energy efficient.
- Though aware of Ameren Missouri rebates or programs, the respondent had a valid reason for not applying for an Ameren Missouri rebate/participating.
- The respondent had a valid energy saving reason for installing the measure.
- The measure generates electric savings (thermostats or water measures that could also generate gas savings)
- For recycled appliances, the appliance was removed from the electric grid.

For more detail on PY2019 NPSO methods, analysis, and results, please refer to the Ameren Missouri PY2019 Annual EM&V Report, Volume 2: Residential Portfolio Appendices.

PY2021 NPSO Results

We allocated NPSO to each program based on the relative size of its ex-post gross savings. The specific allocations per program are in Table 48 and Table 49 below. NPSO represented 13.7% of the ex-post gross MWh savings and 7.7% of the ex-post gross MW savings among these programs.

Table 48. NPSO Allocation by Program (MWh)

Program	Ex-Post Gross Savings (MWh)	NPSO as a % of Gross Savings	NPSO Savings (MWh)
HVAC	46,823	13.7%	6,415
Energy Efficient Products	8,972		1,229
Energy Efficient Kits	4,420		606
Appliance Recycling	2,043		304
Total	**62,258**		**8,554**

Table 49. NPSO Allocation by Program (MW)

Program	Ex-Post Gross Savings (MW)	NPSO as a % of Gross Savings	NPSO Savings (MW)
HVAC	32.47	7.7%	2.50

Program	Ex-Post Gross Savings (MW)	NPSO as a % of Gross Savings	NPSO Savings (MW)
Energy Efficient Products	3.18		0.24
Energy Efficient Kits	0.85		0.07
Appliance Recycling	0.32		0.02
Total	**36.82**		**2.83**

Appendix B. Low Income Percent of Savings Analysis

Ameren Missouri and its income eligible program implementers have two unique program performance metrics that are designed to incent the pursuit of deeper savings per property and to provide a holistic assessment of the program's impact. Specifically, these metrics track the program's impact in terms of (1) a threshold criterion to spend at least 85% of the Commission-approved annual budget for administration and incentives each program year, and (2) the average percent energy savings per property. While inputs for the first metric come directly from Ameren Missouri's accounting system, evaluators provide the inputs to calculate the average percent of site savings metric. This appendix details the evaluation team's methodology and results.

Following guidance from the 2019–2021 MEEIA Energy Efficiency Plan, the evaluation team provides the two key inputs to calculating average percent energy savings for the Single Family Income Eligible (SFIE) and MFIE programs, including evaluated energy savings and total billed energy consumption for the 12-month period prior to participation (pre-period consumption). These items serve as inputs into the Earnings Opportunity Calculator and enable calculation of the average percent energy savings per property metric by dividing the program's total ex post energy savings by the total pre-period consumption for all the properties served during the program year.

Analytic Method

To calculate pre-period consumption, we used information collected from Ameren Missouri's customer billing data and from PY2021 program-tracking data. The evaluation team reviewed all datasets for accuracy and completeness. Each data source is described below.

- **Program Tracking Data:** Franklin Energy provided the evaluation team with participant tracking files for the SFIE and MFIE programs that included all PY2021 program participants through December 2021. These files contained unique customer identifiers, contact information, participation date, measures installed, and ex ante savings. Franklin Energy also provided a list of non-participating premises from properties treated through the MFIE Program.[10]
- **Customer Billing Data:** Ameren Missouri provided historic monthly electric billing data for all electric customers through December 2021. The billing data included account number, premise number, meter number, billing dates, and usage values.

As the first analysis step, we used the program-tracking data and the list of non-participating MFIE premises to compile the full list of unique premises associated with properties treated through the SFIE and MFIE programs in PY2021. We dropped any premises associated with projects initiated in PY2020 and only kept premises associated with projects initiated and completed in PY2021. We then extracted all the monthly billing data associated with all accounts and meters linked to those premises.

Next, we converted the monthly billing data into average daily consumption and used the premise participation date to identify the applicable analysis period for each premise. Per the 2019–2021 MEEA Energy Efficiency Plan, the pre-period covers the 12 months prior to the month the property was treated through either program (e.g., the pre-period for a property that was first treated in July of 2021 would cover July 2020–June 2021). Numerous premises had recorded pre-period usage across more than one associated account, particularly those included in the MFIE analysis. This could be due to tenant turnover, bill non-payment resulting in account

[10] The percent of site savings metric is calculated at the property level. Therefore, for the MFIE Program, the pre-period consumption data includes all multifamily units within a treated property, including participating and non-participating units.

conversion to a landlord, or other reasons. The guidance in the 2019–2021 MEEIA Energy Efficiency Plans advises the evaluation teams to conduct minimal data cleaning; therefore, we included all available pre-period usage from all accounts associated with each premise. We treated gaps in service (such as between one account's last bill period and another account's first bill period) as 0 usage and retained bill periods recorded in the billing data as 0 kWh usage.

Lastly, we assessed the pre-period consumption data coverage across all premises. Five premises across the two programs (0.2% of total premises) had no recorded usage in the 12-month pre-period. Additionally, 13 premises (0.6% of total premises) had fewer than six months of recorded usage. Table 50 summarizes these cases by program. Following the guidance in the 2019–2021 MEEIA Energy Efficiency Plan, we did not drop or annualize usage for the premises with fewer than 12 months of pre-period consumption data.

Table 50. Pre-Period Consumption Data Availability

	Single Family Income Eligible		Multifamily Income Eligible	
	Count	Percent	Count	Percent
No Recorded Usage	0	0%	3	0.2%
Less than 6 months of Usage	4	0.8%	8	0.6%
More than 6 months of Usage	870	99.2%	1,232	99.2%
Total Premises	**874**		**1,243**	

Based on the above, the evaluation team feels that the planned approach of retaining all consumption data as recorded in the Ameren Missouri billing database adequately represents the total annual electricity usage across all treated premises. The results in Table 51 can be input to the Earnings Opportunity Calculator as a basis for understanding the ex post annual savings from our ex post impact evaluation.

Table 51. Pre-Period Consumption

Usage	Single Family Income Eligible (n=875)	Multifamily Income Eligible (n=1,240)
Total Annual kWh	**7,631,123**	**8,914,060**

Appendix C. Data Collection Instruments

In this Appendix, the evaluation team presents data collection instruments for all primary data collection activities that contributed to the development of net program savings. In Table 54, we provide data collection instruments for the HVAC and Multifamily Programs, along with the tasks and NTGR component that each instrument contributed to.

Table 52. Residential Program Evaluation Data Collection Instruments

Program	Task	NTGR Component	File
HVAC Program	Midstream participant surveys	▪ Participant FR (midstream only) ▪ Participant SO (midstream only)	PY2021 Ameren Missouri HVAC Mids
HVAC Program	Distributor in-depth interviews	▪ Distributor FR (midstream only)	PY2021 Ameren Missouri HVAC Mids
PAYS Program	Tier 2 Participant Interview Guide	N/A	Ameren Missouri PY2021 PAYS Tier 2 P
PAYS Program	Contractor Interview Guide	N/A	Ameren Missouri PY2021 PAYS Contrac

Appendix D. Pay As You Save (PAYS)

Detailed Participation Summary

Characteristics of Participant Homes

Table 53 describes the home types of enrolled customers, catalogued by tier level. Note that tiers are not mutually exclusive. The most common home type among participants across all tiers is stick-built single family homes.

Table 53. Type of Home by Tier

Type of Home	All Enrolled	Tier 1	Tier 2	Tier 3	Tier 3 Closed Out	Tier 2 Interviewed
Stick–Built	544	426	270	60	54	11
Modular	31	21	16	6	5	0
Doublewide	7	6	4	3	3	0
Singlewide	20	15	6	3	3	0
Townhome	24	16	10	2	1	0
Duplex	12	7	5	0	0	1
Multifamily	2	0	0	0	0	0
Quadplex	2	1	1	0	0	0
Missing	406	56	38	1	0	0
Total	**1,048**	**548**	**350**	75	**66**	**12**

One of the market imperfections the PAYS Program seeks to alleviate is split incentives. By tying the program cost to the premises rather than the participant, the program is designed to include renters who may have not previously been able to make an investment on a temporary home and landlords who are not willing to take on the cost themselves. Table 54 shows the breakdown of participants across tiers who own and rent their homes. While 95% of enrolled participants and 97% of Tier 1 participants own their home, the program did attract some renters to enroll and one renter closed out a project and loan.

Table 54. Property Ownership by Tier Level

Property Ownership	All Enrolled	Tier 1	Tier 2	Tier 3	Tier 3 Closed Out	Tier 2 Interviewed
Own	993	533	343	74	65	11
Rent	53	13	6	1	1	1
Missing	2	2	1	0	0	0
Total	**1,048**	**548**	**350**	**75**	**66**	**12**

A barrier identified in the program staff and contractor interviews, was the lack of natural gas measures or savings available through the PAYS Program. Table 55 shows the breakdown of participants' primary heating fuel. Four in ten (39%) enrolled customers used natural gas as their primary heating fuel.

Table 55. Primary Heating Fuel by Tier Level

Primary Heating Fuel	All Enrolled	Tier 1	Tier 2	Tier 3	Tier 3 Closed-Out	Tier 2 Interviewed
Electric	602	308	205	56	49	7
Natural Gas	410	221	130	19	17	5
Propane	27	13	10	0	0	0
Kerosene	2	0	0	0	0	0
Wood	5	4	4	0	0	0
Missing	2	2	1	0	0	0
Total	**1,048**	**548**	**350**	**75**	**66**	**12**

Financing

Table 56 shows the breakdown of financing offers for participants that received an Easy Plan. The average financing cost of a PAYS project is ~$5,000. Almost all participants (88%) that received an Easy Plan required an additional up-front copay to continue with a project, at an average cost of ~$3,700.

Interviewed Tier 2 participants reported that among PAYS Program features, they were least satisfied with financing. The copay was identified by three participants as a significant barrier to participation. Some participants were not expecting their project to have a copay given the marketing materials they had received.

Table 56. Financing Offers

Financing Detail	Percent of Projects Requiring Copay	Average Copay	Average Amount Financed	Total Amount Financed
All Participants Who Received an Easy Plan (n=297)	88%	$3,708	-	-
Tier 3: Participants Who Moved Forward (n=75)	71%	$3,041	-	-
Closed Projects (n=66)	70%	$2,912	$5,072	$334,778

Interviewed Participant Demographics

The following tables summarize the demographic and housing characteristics of Tier 2 participants interviewed as part of the evaluation.

The interviewed participants most commonly reported an annual household size of two, and the average household size was three (Table 57).

Table 57. People Living in Home Year-Round

People living in home year-round	Frequency
1	1
2	5
3	3

People living in home year-round	Frequency
4	1
5	1
6	0
7	0
8	1
Total	**12**

Table 58 shows that most of the interviewed participants (67%) had no people under the age of 18 living in their home year-round.

Table 58. People Under the Age of 18 Living in Home Year-Round

People under the age 18 living in the home year-round	Frequency
0	8
1	1
2	1
3	1
4	0
5	0
6	1
Total	**12**

Half of the interviewed participants had been in their home for more than 11 years, and none had been in their home for less than one year (Table 59).

Table 59. Time in Residence

Time in residence	Frequency
Less than 1 Year	0
1 to 3 Years	4
4 to 10 Years	2
11 to 20 Years	3
More than 20 Years	3
Total	**12**

Interviewed participants were most commonly (42%) between 45 and 54 years old. Table 60 shows that none of the participants interviewed were below the age of 24.

Table 60. Age Distribution

Age	Frequency
18 to 24 Years Old	0

Age	Frequency
25 to 34 Years Old	1
35 to 44 Years Old	2
45 to 54 Years Old	5
55 to 64 Years Old	1
65 or Older	3
Total	**12**

Table 61 shows that 100% of interviewed participants had attained at least a high school degree or equivalent and 75% had at least some college.

Table 61. Education Level

Education level	Frequency
Less than a High School Degree	0
High School Degree	1
General Education Development or GED	1
Technical/Trade School Program	1
Associate Degree or Some College	4
Bachelor's Degree	2
Graduate / Professional Degree (e.g., J.D., MBA, MD)	3
Total	**12**

Most interviewed participants were employed full-time, with one in four retired (Table 62).

Table 62. Employment Status

Employment status	Frequency
Employed Full-Time	7
Employed Part-Time	2
Retired	3
Total	**12**

Table 63 shows that 50% of interviewed participants reported an annual household income in 2021 of over $100,000, while more than 80% reported an annual household income over $50,000.

Table 63. Annual Household Income

Household income	Frequency
$0–$50,000	2
$50,000–$100,000	4
$100,000–$200,000	3
$200,000+	3
Total	**12**

Detailed Impact Methods and Findings

The evaluation team reviewed program-tracking data to assess the energy and demand savings reported for Tier 1 and Tier 3 measures. We examined data in the Direct Install Report, the Post Retrofit Report, and the Key Assessment Data Report provided by the implementer. This Appendix provides additional details on our approach and key findings regarding (1) the reasonableness of reported savings and (2) the availability of participant and measure data for future impact evaluation.

Tier 1 Participants and Measures

The PY2021 PAYS Program included 548 unique participants who received Tier 1 Direct Install measures, which accounted for about 20% of the total adjusted ex ante energy and demand savings.[11]

The evaluation team reviewed the implementer's reports to examine the ex ante gross energy and demand savings for each Tier 1 measure:

- **The Direct Install Report provided measure-level quantity and total savings for each participant but did not provide measure-level savings for each participant.** The evaluation team examined the data to derive the per-unit savings assumptions for each Tier 1 measure type. When combined with reported measure quantities, these derived savings values (shown in Table 64) match the total reported savings for 88% of the Tier 1 participants and in aggregate equate to 97% of the total reported Tier 1 measure savings across all participants. The discrepancies indicate that the Direct Install Report uses some savings values that differ from the derived values in Table 64.
- **The Post Retrofit Report provides measure-level quantities and savings values for Tier 1 direct install measures, from which the evaluation team could discern consistent use of per unit savings values for all Tier 1 measures except LEDs.** These unit savings values in the Post Retrofit Report are shown in Table 64 and differ from the per unit savings values used for the same measures in the Direct Install Report.

The evaluation team also collected information directly from the implementer regarding deemed per unit savings values and reviewed the Ameren Missouri TRM Appendix F to identify TRM deemed savings values for comparable measures.

Table 64 shows the reported installation quantities for the six PAYS Program Tier 1 measures, and compares the per unit energy savings values derived from the Direct Install (DI) and Post Retrofit reports to per-unit savings values in the Ameren Missouri TRM Appendix F.

Table 64. Quantities Installed and Comparison of Deemed Savings Values for PAYS Tier 1 Measures

DI Measure	Total Quantity Installed	Per-Unit Energy Savings Values (kWh/unit)			
		Derived from Direct Install Report[a]	Post Retrofit Report	Implementer Email[b]	Ameren Missouri TRM Appendix F
LED	1,931	32.51	Multiple	Multiple	Multiple
Advanced Power Strip	617	31.00	42.50	42.44	31.003
WH Pipe Wrap	441	4.64	0.00	3.72	4.64

[11] The adjusted ex ante savings are the reported ex ante savings from the implementer data reports with one correction to a data entry error that overstated demand savings in the Direct Install Report.

DI Measure	Total Quantity Installed	Per-Unit Energy Savings Values (kWh/unit)			
		Derived from Direct Install Report[a]	Post Retrofit Report	Implementer Email[b]	Ameren Missouri TRM Appendix F
Bathroom Sink Aerator	166	35.17	28.00	28.14	35.17
Showerhead	112	194.58	155.50	155.66	194.72
Kitchen Sink Aerator	46	111.03	84.00	84.42	111.03
WH Wrap	41	100.55	80.00	0.00	100.55

[a] These derived per-unit savings values explain the ex ante savings for most but not all DI participants.
[b] The implementer provided these per-unit savings values in an email dated February 14, 2022.
[c] Appendix F Advanced Power Strip value is the deemed value for Tier 1 advanced power strip installed on home office equipment.

Tier 3 Participants and Measures

The PY2021 PAYS program included 66 unique Tier 3 participants with closed out projects who received Tier 3 measures, which account for about 80% of the total adjusted ex ante energy and demand savings. These Tier 3 measures include upgrades to participants' heating, ventilation, and air conditioning (HVAC) equipment, installation of smart thermostats, and implementation of attic insulation, air sealing, and duct insulation to improve the home's building shell and reduce overall heating and cooling loads.

Table 65 shows the number and percentage of Tier 3 participants who received each Tier 3 measure and the total and percentage of energy and demand savings attributed to each Tier 3 measure. Most participants received HVAC upgrades and a smart thermostat, which combined account for more than three-quarters of the total Tier 3 energy savings.

Table 65. PAYS Reported Savings by Measure, Tier 3

Tier 3 Measure	Number Tier 3 Participants (N=66)	% Tier 3 Participants	Ex Ante Gross Savings (kWh)a	% Tier 3 kWh Savings	Ex Ante Gross Savings (kW)[a]	% Tier 3 kW Savings
HVAC1	49	74%	350,505	64%	40.01	64%
Smart Thermostat	43	65%	63,444	12%	7.24	12%
Attic Insulation	31	47%	44,907	8%	5.13	8%
Air Sealing	30	45%	31,270	6%	3.57	6%
Duct Sealing	9	14%	30,337	6%	3.46	6%
HVAC2	5	8%	18,622	3%	2.13	3%
HVAC3	1	2%	6,285	1%	0.72	1%

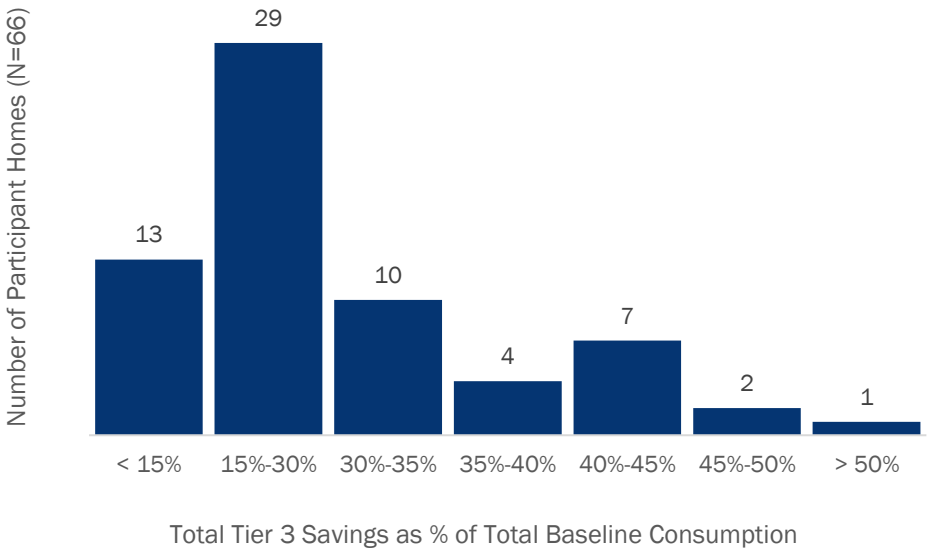
[a] Ex ante energy and demand savings as reported in the Post Retrofit Report for Tier 3 participants.

These Tier 3 measures can achieve significant energy savings because they reduce the home's heating and cooling loads and improve the efficiency of the heating and cooling equipment that serve those loads. The implementer's savings estimates predict the Tier 3 measure savings range from 1% to 51% of baseline whole home electricity consumption, with an average annual energy savings of 25% of baseline consumption.[12] The average reduction was 29% for homes with electric heating and 16% for homes with natural gas heating.

[12] The project with only 1% projected savings was in a natural gas-heated home with only one Tier 3 measure for attic insulation.

Figure 9 shows the savings distribution of Tier 3 projects based on total Tier 3 measure savings as a percentage of the home's total baseline electricity consumption. The figure shows that for most homes the implementer predicted savings to be 35% or less of baseline consumption. For 10 homes, however, the implementer predicted savings to exceed 40% of baseline consumption.

Figure 9. Tier 3 Savings as a Percentage of Total Baseline kWh Consumption



To further examine the magnitude of total reported Tier 3 savings by participant, the evaluation team used monthly baseline consumption data to predict baseline HVAC electricity consumption and calculate the total Tier 3 savings as a percentage of baseline HVAC consumption. For this high-level assessment, the evaluation team estimated baseline annual HVAC consumption as follows:

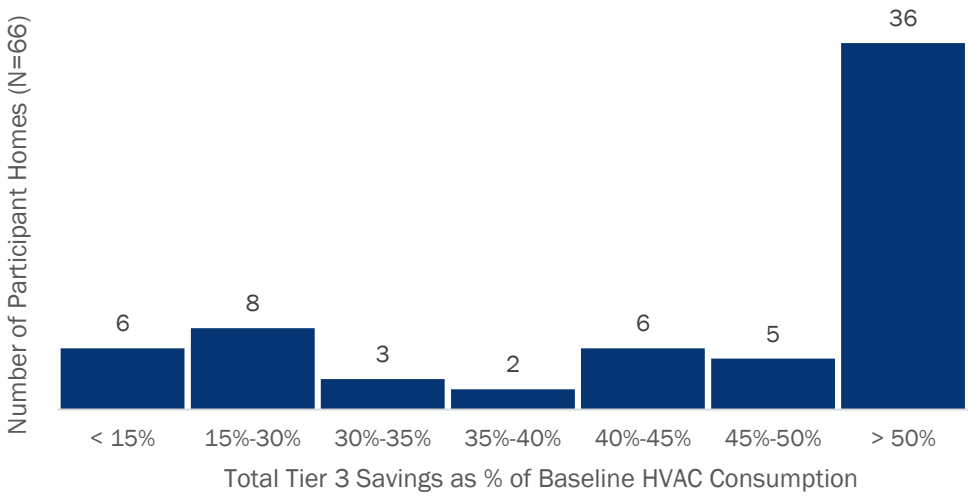
Equation 68. Baseline Annual HVAC Consumption Estimate

$$Baseline\ HVAC\ kWh\ Consumption = Total\ Annual\ kWh\ Consumption - 12 \times Monthly\ Base\ Load\ Consumption$$

We estimated Monthly Base Load Consumption as the average consumption for the two months with the lowest consumption. We then calculated the percentage baseline HVAC consumption for each participant as the ratio of the total Tier 3 savings reported for that participant to the calculated baseline HVAC kWh consumption.

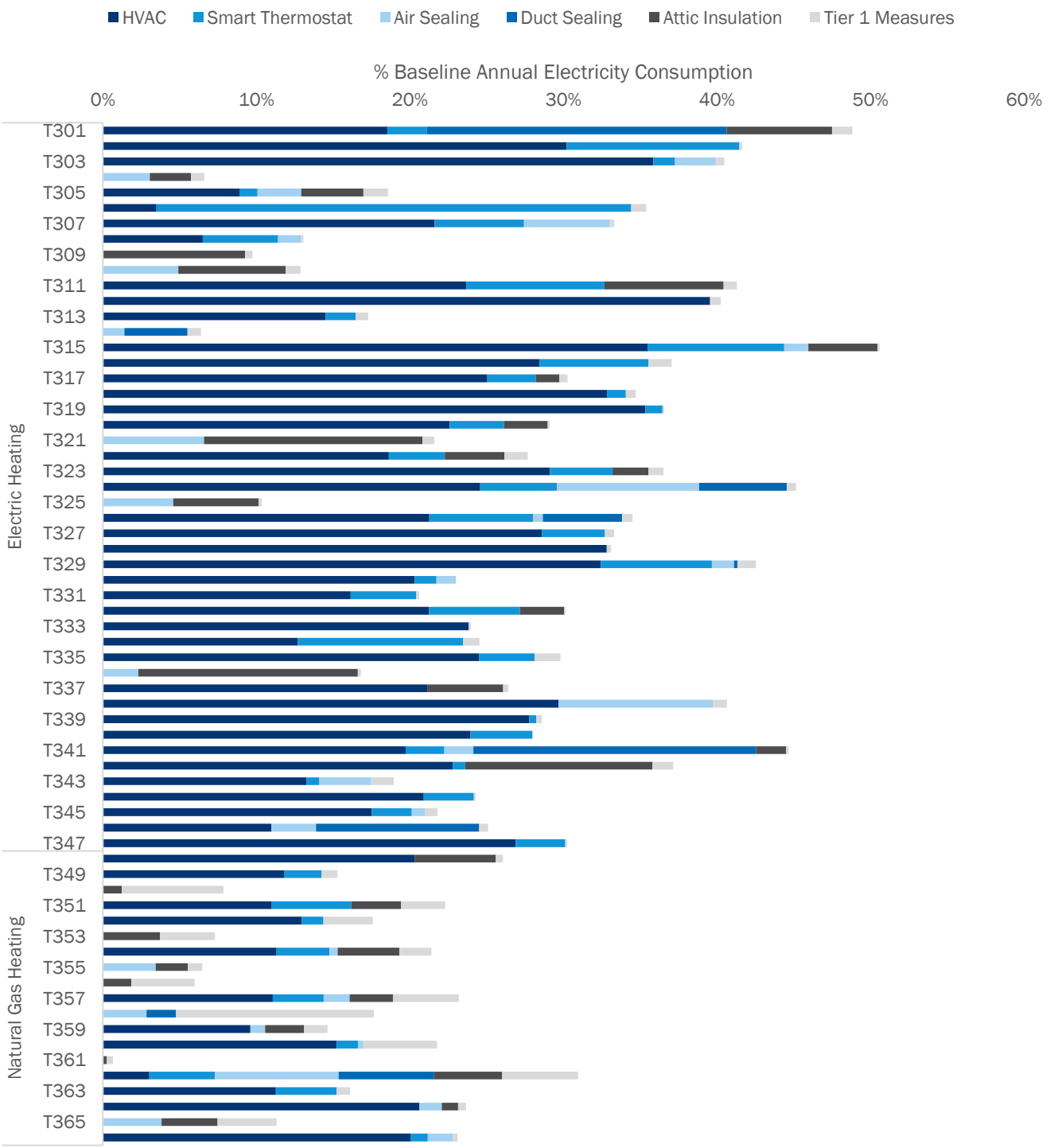
Figure 10 shows the distribution of Tier 3 participants based on total Tier 3 measures savings as a percentage of the home's estimated baseline HVAC electricity consumption. The Tier 3 savings were 40% or more of baseline HVAC consumption for 47 participants (71% of participants) and were higher than 51% of baseline HVAC consumption for 36 participants (55% of participants).

Figure 10. Tier 3 Savings as a Percentage of Estimated Baseline HVAC kWh Consumption



The evaluation team also examined the contribution of each measure to the total Tier 3 savings estimates. Figure 11 shows the relative contribution of each Tier 3 measure to the total Tier 3 savings as a percentage of total baseline consumption for each Tier 3 participant. The data confirm that, for homes with electric heat, the majority of savings are from HVAC measures.

Figure 11. Tier 3 Savings as a Percentage of Baseline Consumption [a]



[a] HVAC includes HVAC1, HVAC2, and HVAC3 measures.

To assess the reasonableness of the reported Tier 3 savings, the evaluation team calculated energy savings for each participant and measure using the relevant TRM estimation approach with participant-specific information and TRM assumptions where necessary. We calculated gross energy savings in two ways:

- **Static Baseline:** The evaluation team used TRM methods to estimate energy savings for each Tier 3 measure, using existing HVAC equipment information for all measures. This approach provides energy savings for each Tier 3 measure as a stand-alone measure but neglects the interactivity between the Tier 3 measures.
- **Adjusted Baseline:** The evaluation team used TRM methods to estimate energy savings for each Tier 3 measure, using the existing equipment information for the HVAC measure only, and then using the new HVAC equipment as the baseline for the remaining measure savings calculations. This adjusted baseline approach accounts for some of the interactivity among Tier 3 measures.

Table 66 compares the reported gross kWh savings by measure to the savings calculated using TRM methods with static and adjusted baselines. The comparison shows the reported savings overall are comparable to the calculated savings using a static baseline and are about 12% greater than the calculated savings using an adjusted baseline. This outcome suggests that the reported Tier 3 savings may overstate the total energy savings achieved by Tier 3 measures.

Table 66. Comparison of Modeled and Calculated Savings for Tier 3 Measures

Measure	Reported Gross kWh	Calculated Gross kWh - Static Baseline	Realization Rate with Static Baseline	Calculated Gross kWh - Adj Baseline	Realization Rate with Adjusted Baseline
HVAC1	350,505	348,487	99%	348,487	99%
HVAC2+HVAC3	24,907	24,764	99%	24,764	99%
Smart Thermostat	63,444	48,631	77%	24,359	38%
Attic Insulation	44,907	58,607	131%	46,766	104%
Air Sealing	31,270	39,668	127%	29,415	94%
Duct Sealing	30,337	9,995	33%	7,134	24%
Total Tier 3	**545,370**	**530,152**	**97%**	**480,925**	**88%**

The following sections provide additional details about the evaluation team's approach and findings when calculating savings using the TRM savings methods. Conducted as part of this evaluation's reasonableness assessment, this approach and the corresponding findings are not intended to represent rigorous estimations of energy savings. Rather, these simplified calculations using standard TRM algorithms and assumptions are intended to provide a benchmark for assessing the magnitude of the reported savings and for comparing the reported energy savings to standard TRM calculations.

HVAC

The evaluation team calculated total energy savings for HVAC measures as follows:

Equation 69. Total Energy Savings – HVAC Measures

$$HVAC\ kWh\ Savings\ =\ Heating\ kWh\ Savings + Cooling\ kWh\ Savings$$

$$Heating\ kWh\ Savings\ =\ Baseline\ Heating\ kWh \times (1\ -\ HSPF\_existing\ /\ HPSF\_new)$$

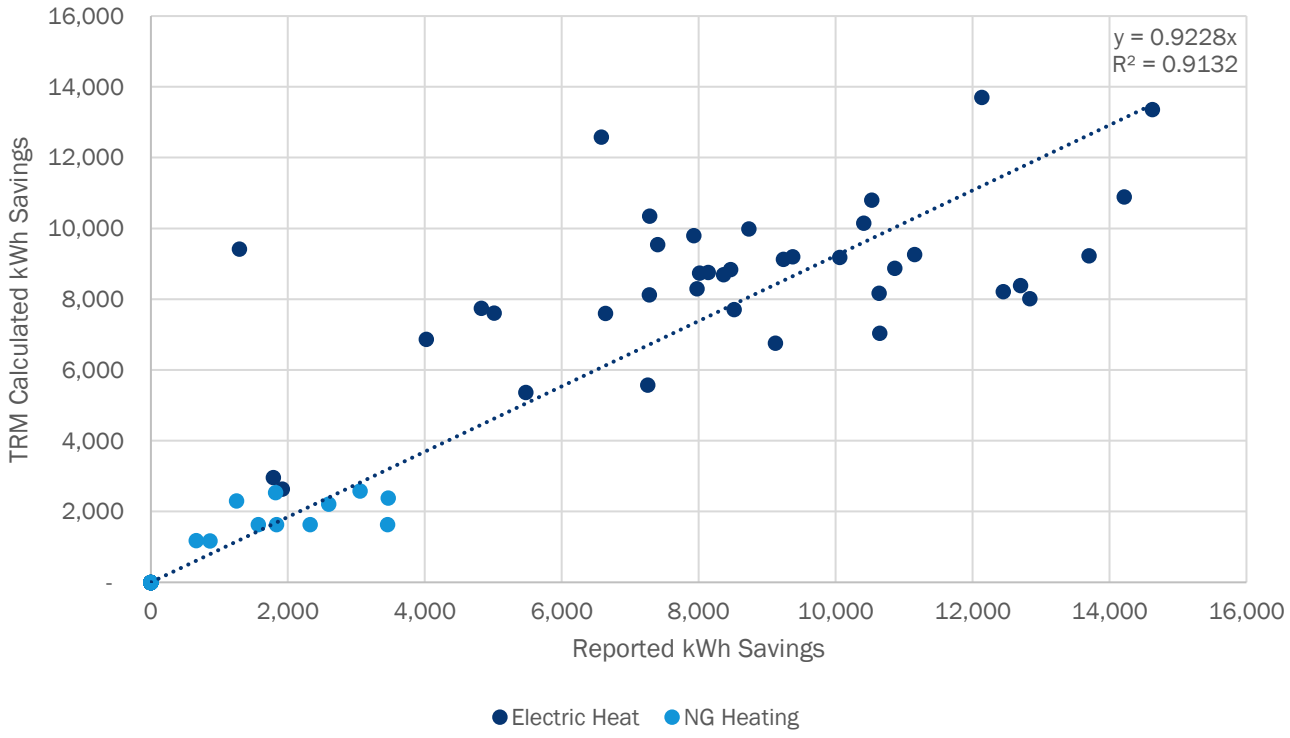
$$Cooling\ kWh\ Savings\ =\ Cooling\ Capacity\ (tons) \times 12 \times (1/SEER\_exist\ -\ 1/SEER\_base) \times EFLH\_cool$$

Where:

Baseline Heating kWh	=	30% of Total Annual kWh Consumption for homes with electric heating and zero for homes with natural gas heating.
HSPF_exist	=	Efficiency of existing heating equipment as recorded in PAYS tracking data
HSPF_new	=	Efficiency of new heating equipment as recorded in PAYS tracking data
Cooling Capacity	=	Efficiency of new cooling equipment as recorded in PAYS tracking data
SEER_exist	=	Efficiency of existing cooling equipment as recorded in PAYS tracking data
SEER_new	=	Efficiency of new cooling equipment as recorded in PAYS tracking data
EFLH_cool	=	869, based on the TRM cooling EFLH value for Residential HVAC in SF homes

Figure 12 compares the reported and calculated savings for HVAC1 measures. The figure shows a strong correlation between reported and calculated total HVAC savings for both electrically and non-electrically heated homes.

Figure 12. TRM Calculated vs. Reported kWh Savings for Tier 3 HVAC1 Measure



Thermostats

The evaluation team calculated total energy savings for thermostat measures as follows:

Equation 70. Total Energy Savings – Thermostat Measures

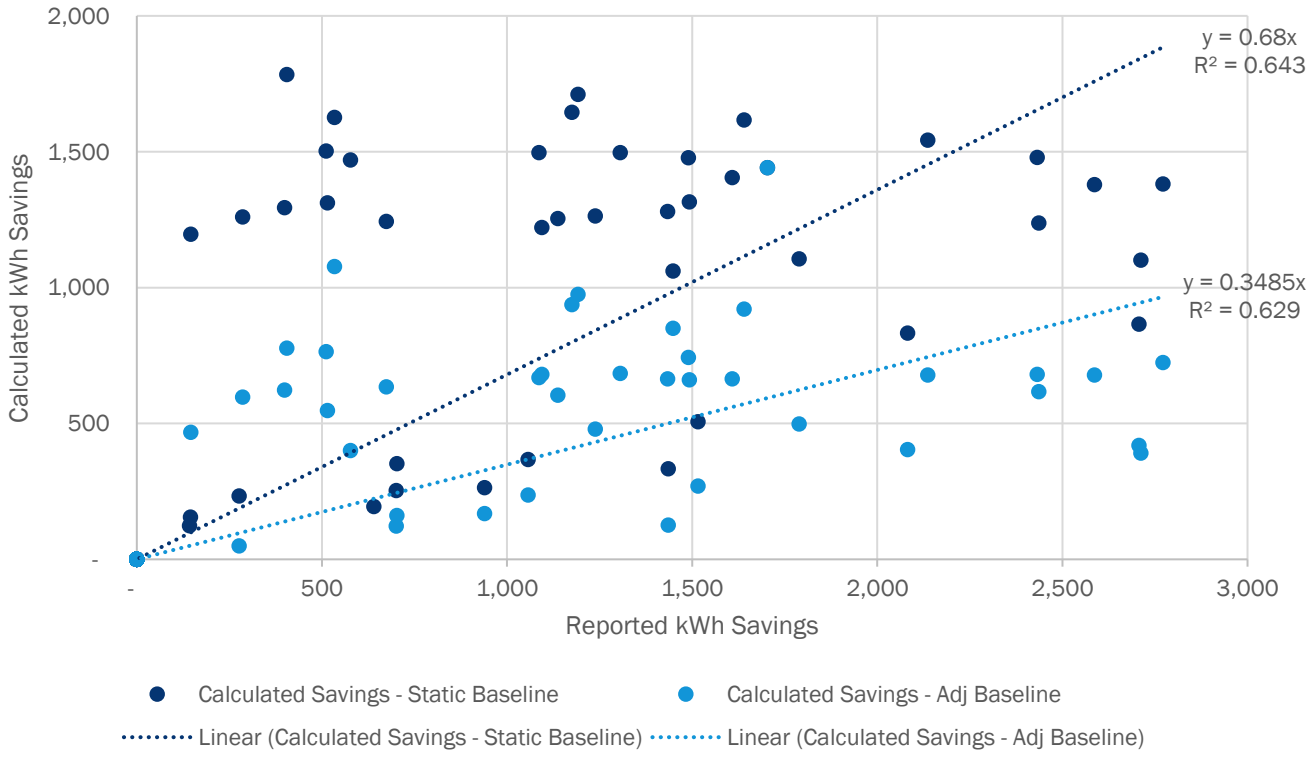
$$Thermostat\ kWh\ Savings = (Baseline\ Heating\ kWh + Baseline\ Cooling\ kWh - HVAC\ kWh\ Savings \times ESF$$

where:

Baseline Heating kWh	=	30% of Total Annual kWh Consumption for homes with electric heating and zero for homes with natural gas heating.
Baseline Cooling kWh	=	15% of Total Annual kWh Consumption
HVAC kWh Savings	=	Calculated HVAC savings as described in the previous section; value set to zero for the "Static Baseline" calculation
ESF	=	Energy Savings Factor of 8%

Figure 13 compares the reported savings for advanced thermostat measures to the calculated savings using both static and adjusted baselines. The figure shows that the calculated savings using both baselines are lower than the reported savings for thermostat measures.

Figure 13. TRM Calculated vs. Reported kWh Savings for Tier 3 Advanced Thermostats Measure



Attic Insulation

The evaluation team calculated total energy savings for attic insulation as follows:

Equation 71. Total Energy Savings – Attic Insulation

$$Attic\ Insulation\ kWh\ Savings = AI\ Heating\ kWh\ Savings + AI\ Cooling\ kWh\ Savings$$

$$AI\ Heating\ kWh\ Savings = (1/R\_old\ - 1/R\_new) \times SQFT \times (1 - FF) \times HDD\ 24 \times DUA\ /\ (341 \times Eff\_Heat)$$

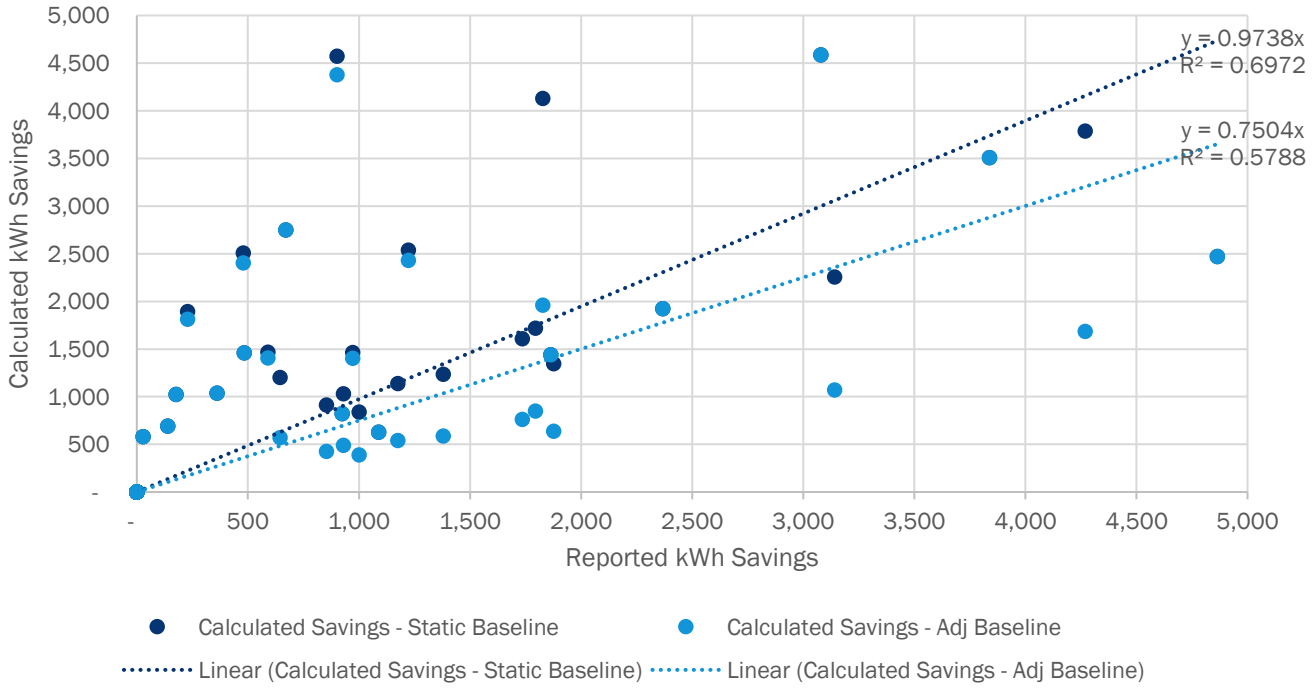
$$AI\ Cooling\ kWh\ Savings = (1/R\_old - 1/R\_new) \times SQFT \times (1 - FF) \times CDD \times 24\ \times DUA\ /\ (1000 \times Eff\_Cool)$$

where:

R_old	=	Existing insulation R-value, as recorded in PAYS tracking data
R_new	=	New insulation R-value, as recorded in PAYS tracking data
SQFT	=	Square feet of attic insulation installed, as recorded in PAYS tracking data
FF	=	7%, based on TRM Appendix F
HDD	=	4486, based on TRM
CDD	=	1646, based on TRM
DUA	=	0.74 for Heating and 0.75 for Cooling, based on TRM
Eff_Heat	=	Efficiency of heating equipment as recorded in PAYS tracking data; used existing heating equipment for static baseline and new equipment for adjusted baseline
Eff_Cool	=	Efficiency of cooling equipment as recorded in PAYS tracking data; used existing heating equipment for static baseline and new equipment for adjusted baseline

Figure 14 compares the reported and calculated savings for attic insulation measures. The figure shows the calculated savings using a static baseline are similar to the reported savings, and the calculated savings using the adjusted baseline are lower than the reported savings.

Figure 14. TRM Calculated vs. Reported kWh Savings for Tier 3 Attic Insulation Measure



Air Sealing

The evaluation team calculated total energy savings for air sealing as follows:

Equation 72. Total Energy Savings – Air Sealing

$$Air\ Sealing\ kWh\ Savings\ =\ AS\ Heating\ kWh\ Savings\ +\ AS\ Cooling\ kWh\ Savings$$

$$AS\ Heating\ kWh\ Savings = (CFMpre\ -\ CFMpost)\ /\ Nheat \times 60 \times 24 \times HDD \times 0.018\ /\ 3412\ /\ Eff\_Heat$$

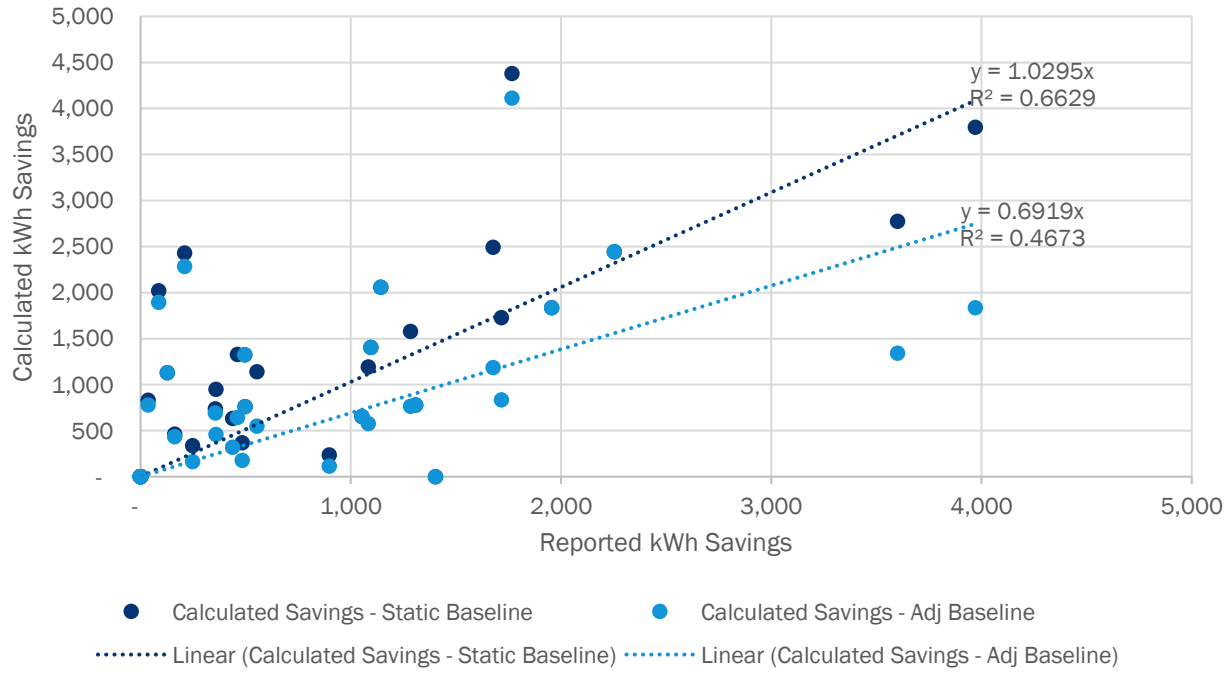
$$AS\ Cooling\ kWh\ Savings = (CFMpre\ -\ CFMpost)\ /\ Ncool \times 60 \times 24 \times CDD \times DUA \times 0.018 \times 3\ /\ 1000\ /\ Eff\_Cool$$

Where:

CFMpre	=	Baseline CFM from blower door test, as recorded in PAYS tracking data
R_new	=	Improved CFM from blower door test, as recorded in PAYS tracking data
Nheat	=	TRM values based on the number of floors recorded in PAYS tracking data
Ncool	=	TRM values based on the number of floors recorded in PAYS tracking data
HDD	=	4486, based on TRM
CDD	=	1646, based on TRM
DUA	=	0.75 for Cooling, based on TRM
Eff_Heat	=	Efficiency of heating equipment as recorded in PAYS tracking data; used existing heating equipment for static baseline and new equipment for adjusted baseline
Eff_Cool	=	Efficiency of cooling equipment as recorded in PAYS tracking data; used existing heating equipment for static baseline and new equipment for adjusted baseline

Figure 15 compares the reported and calculated savings for air sealing measures. The figure shows the calculated savings using a static baseline are similar to the reported savings, and the calculated savings using the adjusted baseline are lower than the reported savings.

Figure 15. TRM Calculated vs. Reported kWh Savings for Tier 3 Air Sealing Measure

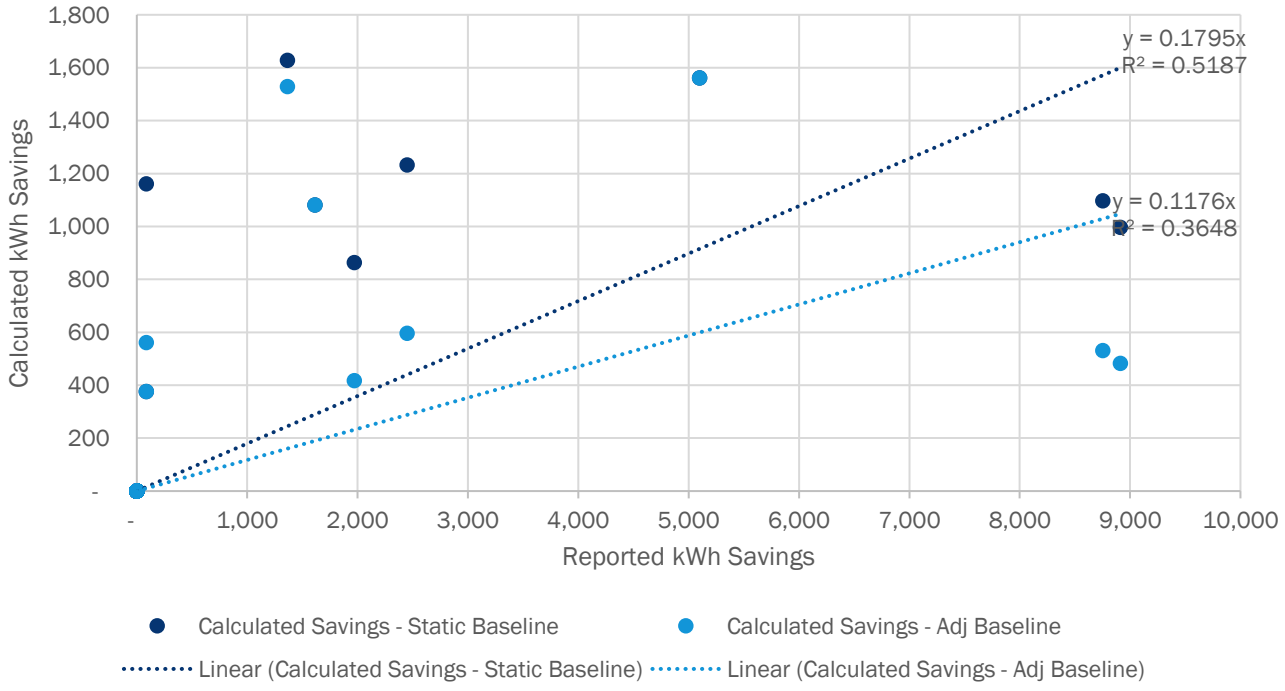


Duct Sealing

The evaluation team used the air sealing savings formulas described above to calculated savings from duct sealing combined with the CFMpre and CFMpost values from the duct leakage testing (rather than from blower door testing), as recorded in the PAYS tracking dataset.

Figure 16 compares the reported and calculated savings for duct sealing measures. The figure shows the calculated savings using both baseline approaches are significantly lower than the reported savings.

Figure 16. TRM Calculated vs. Reported kWh Savings for Tier 3 Duct Sealing Measure



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