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# Ameren Missouri Program Year 2020 Annual EM&V Report

## Volume 2: Residential Portfolio Appendices

**June 10, 2021**

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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 PY2020 Residential Lighting Program, the evaluation team applied the October 2020 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

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

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 PY2020 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 |
| WattBase | 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 | | | |
| WattEE | Actual product wattage | Looked-up for each bulb | Actual product wattage | | | |
| %RES | % of bulbs installed in residential applications, by channel | TRM Appendix F | 100% | 0% | 96% | 4% |
| LKG | % of bulbs installed outside service territory, by channel (i.e., leakage rate) | TRM Appendix F | 0% | | 4% | |

| Parameter | Description | Source of Assumption | Online Store | | Upstream Lighting | |
|---|---|---|---|---|---|---|
| | | | Residential | Commercial | Residential | Commercial |
| 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)<br>80.08% (Reflector)<br>83.92% (Specialty) | | 87.85% (Standard)<br>89.83% (Reflector)<br>92.53% (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 PY2020, 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 PY2020 program-tracking data. Table 2 shows the final NTGRs used for the PY2020 evaluation.

Table 2. PY2020 Lighting Program NTGRs

| Channel | Free-Ridership | Participant Spillover | Non-Participant Spillover | NTGR | % Ex Post Gross |
|---|---|---|---|---|---|
| | (FR) | (PSO) | (NPSO) | (1-FR+PSO+NPSO) | |
| Upstream | 42.9% | 0.0% | 7.4% | 64.5% | 98.7% |
| Online | 12.7% | 1.7% | 0.0% | 89.0% | 1.3% |
| **Overall Program** | **42.5%** | **0.0%** | **7.4%** | **64.8%** | **100.0%** |

# HVAC Program

## Gross Impact Methodology

### Air Source Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 Residential HVAC Program ASHP measures, the evaluation team applied Ameren Missouri TRM and Appendix F (v4.0) deemed savings tables to the program-tracking database.

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

Equation 5. 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 6. 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 7. 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 (v4.0)

CapacityHeat = Heating capacity of ASHP (Btu/hr) = Actual from program tracked data; if unknown, assumed defaults from Appendix F (v4.0)

Table 3. CapacityCool and CapacityHeat for Air Source Heat Pump Measures

| Measure | CapacityCool (Btu/hr) | CapacityHeat (Btu/hr) |
|---|---|---|
| ASHP SEER 15 ER Elec Resist Furnace: HVAC ER1 | 34,457 | 34,457 |
| ASHP SEER 15 ER with ASHP: HVAC ER1 | 37,222 | 37,222 |
| ASHP SEER 15 Replace on Fail Elec Resist Furnace: HVAC | 35,872 | 35,872 |
| ASHP SEER 15 Replace on Fail with ASHP: HVAC | 34,680 | 34,680 |
| ASHP SEER 16 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 35,376 | 35,376 |
| ASHP SEER 16 Replace ASHP: Early Replacement SF ER1 | 37,318 | 37,318 |
| ASHP SEER 16 Replace Electric Furnace / CAC SF | 35,429 | 35,429 |
| ASHP SEER 16 Replace ASHP: Replace on Fail SF | 39,000 | 39,000 |
| ASHP SEER 15 MF ER Replace ASHP: HVAC ER1 | 34,500 | 34,500 |
| ASHP SEER 15 MF ER Replace Elec Resist Furnace: HVAC ER1 | 33,000 | 33,000 |
| ASHP SEER 16 MF ER Replace ASHP: HVAC ER1 | 39,600 | 39,600 |
| ASHP SEER 16 Replace on Fail MF | 39,600 | 39,600 |
| ASHP SEER 16 Replace Electric Furnace / CAC: Early Replacement MF ER1 | 39,600 | 39,600 |
| ASHP SEER 15 Replace on Fail MF | 37,200 | 37,200 |
| ASHP SEER 17 Replace Electric Furnace / CAC SF | 33,600 | 33,600 |
| ASHP SEER 18 Replace Electric Furnace / CAC SF | 36,000 | 36,000 |
| ASHP SEER 18 Replace Electric Furnace / CAC MF | 48,000 | 48,000 |
| ASHP SEER 17 Replace ASHP: Early Replacement SF ER1 | 39,600 | 39,600 |
| ASHP SEER 17 Replace ASHP: Replace on Fail SF | 39,600 | 39,600 |
| ASHP SEER 18 Replace ASHP: Early replacement SF ER1 | 42,600 | 42,600 |
| ASHP SEER 18 Replace on Fail SF | 39,600 | 39,600 |
| ASHP SEER 17 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 37,200 | 37,200 |
| ASHP SEER 18 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 40,966 | 40,966 |
| ASHP SEER 19: Replace Electric Furnace / CAC SF | 33,600 | 33,600 |

| Measure | CapacityCool (Btu/hr) | CapacityHeat (Btu/hr) |
|---|---|---|
| ASHP SEER 20: Replace Electric Furnace / CAC - early replacement SF ER1 | 37,200 | 37,200 |
| ASHP SEER 20: Replace Electric Furnace / CAC SF | 38,400 | 38,400 |
| ASHP SEER 21: Replace Electric Furnace / CAC - early replacement SF ER1 | 37,200 | 37,200 |
| ASHP SEER 21: Replace Electric Furnace / CAC SF | 38,400 | 38,400 |
| ASHP SEER 19: Replace ASHP: Early Replacement SF ER1 | 39,600 | 39,600 |
| ASHP SEER 19: Replace ASHP: Replace on Fail SF | 39,600 | 39,600 |
| ASHP SEER 18: Replace Electric Furnace / CAC: Early Replacement MF ER1 | 48,000 | 48,000 |
| ASHP SEER 18: Replace ASHP: Early Replacement MF ER1 | 39,600 | 39,600 |
| ASHP SEER 19: Replace Electric Furnace / CAC: Early Replacement SF ER1 | 37,200 | 37,200 |
| ASHP SEER 20: Replace ASHP: Early Replacement SF ER1 | 39,600 | 39,600 |
| ASHP SEER 20: Replace ASHP: Replace on Fail SF | 39,600 | 39,600 |
| ASHP SEER 21: Replace ASHP: Early Replacement SF ER1 | 39,600 | 39,600 |
| ASHP SEER 21: Replace ASHP: Replace on Fail SF | 39,600 | 39,600 |

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 (October 2020)

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 (October 2020)

HSPFEE = Heating Seasonal Performance Factor of efficient ASHP (kBtu/kWh) = Actual from program tracked data; if unknown, assumed defaults in Appendix F (October 2020)

Table 4. SEERExist, SEEREE and HSPFEE for Air Source Heat Pump Measures

| Measure | SEERExist | SEEREE | HSPFEE |
|---|---|---|---|
| ASHP SEER 15 ER Elec Resist Furnace: HVAC ER1 | 7.23 | 15.13 | 8.53 |
| ASHP SEER 15 ER with ASHP: HVAC ER1 | 7.47 | 15.12 | 8.48 |
| ASHP SEER 15 Replace on Fail Elec Resist Furnace: HVAC | | 15.19 | 8.43 |
| ASHP SEER 15 Replace on Fail with ASHP: HVAC | | 15.17 | 8.70 |
| ASHP SEER 16 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 7.37 | 16.25 | 8.43 |
| ASHP SEER 16 Replace ASHP: Early Replacement SF ER1 | 7.79 | 16.35 | 8.89 |
| ASHP SEER 16 Replace Electric Furnace / CAC SF | | 16.17 | 8.78 |
| ASHP SEER 16 Replace ASHP: Replace on Fail SF | | 16.00 | 9.43 |
| ASHP SEER 15 MF ER Replace ASHP: HVAC ER1 | 7.45 | 15.13 | 9.06 |

| Measure | SEERExist | SEEREE | HSPFEE |
|---|---|---|---|
| ASHP SEER 15 MF ER Replace Elec Resist Furnace: HVAC ER1 | 7.44 | 15.25 | 8.75 |
| ASHP SEER 16 MF ER Replace ASHP: HVAC ER1 | 8.33 | 16.00 | 9.50 |
| ASHP SEER 16 Replace on Fail MF | | 16.00 | 9.80 |
| ASHP SEER 16 Replace Electric Furnace / CAC: Early Replacement MF ER1 | 8.33 | 16.50 | 7.42 |
| ASHP SEER 15 Replace on Fail MF | | 15.10 | 8.70 |
| ASHP SEER 17 Replace Electric Furnace / CAC SF | | 17.00 | 9.70 |
| ASHP SEER 18 Replace Electric Furnace / CAC SF | | 19.00 | 10.50 |
| ASHP SEER 18 Replace Electric Furnace / CAC MF | | 19.00 | 10.00 |
| ASHP SEER 17 Replace ASHP: Early Replacement SF ER1 | 8.33 | 17.00 | 9.50 |
| ASHP SEER 17 Replace ASHP: Replace on Fail SF | | 17.00 | 9.80 |
| ASHP SEER 18 Replace ASHP: Early Replacement SF ER1 | 7.90 | 18.99 | 9.68 |
| ASHP SEER 18 Replace on Fail SF | | 18.00 | 9.80 |
| ASHP SEER 17 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 8.33 | 17.00 | 9.40 |
| ASHP SEER 18 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 7.70 | 18.58 | 9.89 |
| ASHP SEER 19 Replace Electric Furnace / CAC SF | | 19.00 | 9.70 |
| ASHP SEER 20 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 8.33 | 20.00 | 9.40 |
| ASHP SEER 20 Replace Electric Furnace / CAC SF | | 20.00 | 9.70 |
| ASHP SEER 21 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 8.33 | 21.00 | 9.40 |
| ASHP SEER 21 Replace Electric Furnace / CAC SF | | 21.00 | 9.70 |
| ASHP SEER 19 Replace ASHP: Early Replacement SF ER1 | 8.33 | 19.00 | 9.50 |
| ASHP SEER 19 Replace ASHP: Replace on Fail SF | | 19.00 | 9.80 |
| ASHP SEER 18 Replace Electric Furnace / CAC: Early Replacement MF ER1 | 6.54 | 18.00 | 10.00 |
| ASHP SEER 18 Replace ASHP: Early Replacement MF ER1 | 8.33 | 18.00 | 9.50 |
| ASHP SEER 19 Replace Electric Furnace / CAC: Early Replacement SF ER1 | 8.33 | 19.00 | 9.40 |
| ASHP SEER 20 Replace ASHP: Early Replacement SF ER1 | 8.33 | 20.00 | 9.50 |
| ASHP SEER 20 Replace ASHP: Replace on Fail SF | | 20.00 | 9.80 |
| ASHP SEER 21 Replace ASHP: Early Replacement SF ER1 | 8.33 | 21.00 | 9.50 |
| ASHP SEER 21 Replace ASHP: Replace on Fail SF | | 21.00 | 9.80 |

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 PY2020 Residential HVAC Program ductless mini-split heat pump measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v4.0) deemed savings tables to the program-tracking database.

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

Equation 8. 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 9. 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 10. 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 (v4.0)

CapacityHeat = Heating capacity of heat pump (Btu/hr) = Actual from program tracked data; if unknown, assumed defaults from Appendix F (v4.0)

Table 5. CapacityCool and CapacityHeat for Ductless Minisplit Heat Pump Measures

| Measure | CapacityCool (Btu/hr) | CapacityHeat (Btu/hr) |
|---|---|---|
| Ductless Air Conditioner- ER1 SF | 18,000 | 0 |
| Ductless Air Conditioner- ROF SF | 15,750 | 0 |
| Ductless ASHP - ROF SF NC | 18,000 | 18,000 |
| Ductless ASHP - ROF SF | 18,221 | 18,221 |
| Ductless ASHP Replace Electric Resistance ER1 SF | 18,840 | 18,840 |
| Ductless ASHP Replace Electric Resistance ROF SF | 19,200 | 19,200 |
| Ductless ASHP ER1 SF | 15,375 | 15,375 |

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)

Table 6. HSPFBase for Ductless Minisplit Heat Pump Measures

| Measure | HSPFBase |
|---|---|
| Ductless Air Conditioner- ER1 SF | 0 |
| Ductless Air Conditioner- ROF SF | 0 |
| Ductless ASHP - ROF SF NC | 8.200 |
| Ductless ASHP - ROF SF | 8.200 |
| Ductless ASHP Replace Electric Resistance ER1 SF | 3.412 |
| Ductless ASHP Replace Electric Resistance ROF SF | 3.412 |
| Ductless ASHP ER1 SF | 6.580 |

SEERExist = Seasonal Energy Efficiency Ratio of existing cooling system (kBtu/kWh) = Actual from program tracked data; if unknown, assumed defaults from Appendix F (v4.0)

Table 7. SEERExist for Ductless Minisplit Heat Pump Measures

| Measure | SEERExist |
|---|---|
| Ductless Air Conditioner- ER1 SF | 6.30 |
| Ductless Air Conditioner- ROF SF | 6.30 |
| Ductless ASHP - ROF SF NC | 7.20 |
| Ductless ASHP - ROF SF | 7.20 |
| Ductless ASHP Replace Electric Resistance ER1 SF | 7.61 |
| Ductless ASHP Replace Electric Resistance ROF SF | 6.80 |
| Ductless ASHP ER1 SF | 8.02 |

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, 3.412 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 (v4.0)

HSPFEE = Heating Seasonal Performance Factor of efficient heat pump (kBtu/kWh) = Actual from program tracked data; if unknown, assumed defaults in Appendix F (v4.0)

Table 8. SEEREE and HSPFEE for Ductless Minisplit Heat Pump Measures

| Measure | SEEREE | HSPFEE |
|---|---|---|
| Ductless Air Conditioner- ER1 SF | 23.17 | 0.00 |
| Ductless Air Conditioner- ROF SF | 22.92 | 0.00 |
| Ductless ASHP - ROF SF NC | 19.00 | 10.60 |
| Ductless ASHP - ROF SF | 22.52 | 11.00 |
| Ductless ASHP Replace Electric Resistance ER1 SF | 22.43 | 9.44 |
| Ductless ASHP Replace Electric Resistance ROF SF | 23.19 | 11.23 |
| Ductless ASHP ER1 SF | 22.25 | 8.36 |

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 PY2020 Residential HVAC Program GSHP measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v4.0) deemed savings tables to the program-tracking database.

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

Equation 11. 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 12. 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 13. 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 (v4.0)

CapacityHeat = Heating capacity of heat pump (Btu/hr) = Actual from program tracked data; if unknown, assumed defaults from Appendix F (v4.0)

Table 9. CapacityCool and CapacityHeat for GSHP Measures

| Measure | CapacityCool (Btu/hr) | CapacityHeat (Btu/hr) |
|---|---|---|
| GSHP - EER 23 - replace electric furnace / CAC - Heating | 49,745 | 49,745 |
| GSHP - EER 23 - replace electric furnace / CAC ER1 - Heating | 45,750 | 45,750 |
| GSHP EER 23 ER1 - Heating | 51,319 | 51,319 |
| GSHP EER 23 Replace on Fail GSHP | 51,652 | 51,652 |

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 12 if replacing heat pump, 6.54 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 (v4.0)

Table 10. SEEREE for GSHP Measures

| Measure | SEEREE |
|---|---|
| GSHP - EER 23 - replace electric furnace / CAC - Heating | 27.75 |
| GSHP - EER 23 - replace electric furnace / CAC ER1 - Heating | 29.56 |
| GSHP EER 23 ER1 - Heating | 27.41 |
| GSHP EER 23 Replace on Fail GSHP | 27.54 |

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 = (1-1.44%)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 PY2020 Residential HVAC Program CAC measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v4.0) deemed savings tables to the program-tracking database.

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

Equation 14. 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 15. 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 16. 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 (v4.0)

Table 11. CapacityCool for Central Air Conditioner Measures

| Measure | CapacityCool (Btu/hr) |
|---|---|
| CAC - SEER 15 ER1: SF | 38,991 |
| CAC - SEER 15 ROF: SF | 39,839 |
| CAC - SEER 15 ER1: MF | 27,907 |
| CAC - SEER 15 ROF: MF | 25,000 |
| CAC - SEER 16 ER1: SF | 35,735 |
| CAC - SEER 16 ROF: SF | 36,194 |
| CAC - SEER 16 ER1: MF | 30,857 |
| CAC - SEER 16 ROF: MF | 32,571 |
| CAC - SEER 17 ER1: SF | 36,977 |
| CAC - SEER 17 ROF: SF | 38,408 |
| CAC - SEER 17 ER1: MF | 29,455 |
| CAC - SEER 17 ROF: MF | 48,000 |
| CAC - SEER 18 ER1: SF | 36,000 |
| CAC - SEER 18 ROF: SF | 36,000 |
| CAC - SEER 18 ER1: MF | 24,000 |
| CAC - SEER 18 ROF: MF | 24,000 |
| CAC - SEER 19 ER1: SF | 36,000 |
| CAC - SEER 19 ROF: SF | 36,000 |

| Measure | CapacityCool (Btu/hr) |
|---|---:|
| CAC - SEER 20 ER1: SF | 36,000 |
| CAC - SEER 20 ROF: SF | 36,000 |
| CAC - SEER 20 ER1: MF | 24,000 |
| CAC - SEER 21+ ER1: SF | 36,000 |
| CAC - SEER 21+ ROF: SF | 36,000 |

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 (v4.0)

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 (v4.0).

Table 12. SEEREE for Central Air Conditioner Measures

| Measure | SEERExist | SEEREE |
|---|---:|---:|
| CAC - SEER 15 ER1: SF | 7.53 | 15.11 |
| CAC - SEER 15 ROF: SF | | 15.12 |
| CAC - SEER 15 ER1: MF | 7.26 | 15.14 |
| CAC - SEER 15 ROF: MF | | 15.08 |
| CAC - SEER 16 ER1: SF | 7.51 | 16.03 |
| CAC - SEER 16 ROF: SF | | 16.04 |
| CAC - SEER 16 ER1: MF | 7.98 | 16.04 |
| CAC - SEER 16 ROF: MF | | 16.00 |
| CAC - SEER 17 ER1: SF | 7.55 | 17.60 |
| CAC - SEER 17 ROF: SF | | 17.55 |
| CAC - SEER 17 ER1: MF | 6.93 | 17.14 |
| CAC - SEER 17 ROF: MF | | 17.00 |
| CAC - SEER 18 ER1: SF | 8.33 | 18.00 |
| CAC - SEER 18 ROF: SF | | 18.00 |
| CAC - SEER 18 ER1: MF | 8.33 | 18.00 |
| CAC - SEER 18 ROF: MF | | 18.00 |
| CAC - SEER 19 ER1: SF | 8.33 | 19.00 |
| CAC - SEER 19 ROF: SF | | 19.00 |
| CAC - SEER 20 ER1: SF | 8.33 | 20.00 |
| CAC - SEER 20 ROF: SF | | 20.00 |
| CAC - SEER 20 ER1: MF | 8.33 | 20.00 |
| CAC - SEER 21+ ER1: SF | 8.33 | 21.00 |
| CAC - SEER 21+ ROF: SF | | 21.00 |

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

## Electronically Commutated Motor Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 Residential HVAC Program electronically commutated motor (ECM) measures, the evaluation team applied the Ameren Missouri TRM and Appendix F (v4.0) deemed savings tables to the program-tracking database. Because of a July 2019 change in code requiring ECMs on all new furnaces, in PY2020 the evaluation team deemed the EUL of ECMs to be six years, the remaining useful life of the existing equipment replaced.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 17.

Equation 17. ECM Energy and Demand Savings Equations

$$kWh = kWh_{Heating\ Mode} + kWh_{Cooling\ Mode} + kWh_{Auto\ Circulation} + kWh_{Continuous\ Circulation}$$

$$kWh_{Heating\ Mode} = (1 - \%\ with\ New\ ASHP) \times \left(400\frac{kWh}{year} \times \frac{EFLH_{Heat}}{WI\ EFLH_{Heat}}\right)$$

$$kWh_{Cooling\ Mode} = (1 - \%\ with\ New\ Central\ Cooling) \times \left(70\frac{kWh}{year} \times \frac{EFLH_{Cool}}{WI\ EFLH_{Cool}}\right)$$

$$kWh_{Auto\ Circulation} = \left(25\frac{kWh}{year} \times \frac{EFLH_{Cool}}{WI\ EFLH_{Cool}}\right) + \left(2960\frac{kWh}{year} \times RT\right) - 30\frac{kWh}{year}$$

$$kWh_{Continuous\ Circulation} = \left(25\frac{kWh}{year} \times \frac{EFLH_{Cool}}{WI\ EFLH_{Cool}}\right) + \left(2960\frac{kWh}{year} \times RT\right) - 30\frac{kWh}{year}$$

$$kW = kWh \times CF$$

Where:

% with New ASHP = 16.34%

400 = Wisconsin heating savings (kWh/year)

EFLHHeat = Effective full load heating hours = 2,009

WI EFLHHeat = Wisconsin effective full load heating hours = 2,545.25

% with New Central Cooling = 80.14%

70 = Wisconsin cooling savings (kWh/year)

EFLHCool = Effective full load cooling hours = 1,215

WI EFLHCool = Wisconsin effective full load cooling hours = 542.50

25 = Cooling savings for all systems (kWh/year)

2,960 = Wisconsin circulation savings (kWh/year)

RT = Percent additional run time factor = 8.81%

30 = Standby losses (kWh/year)

CF = Coincidence factor = 0.0004660805

### Advanced Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 Residential HVAC Program advanced thermostat measures, the evaluation team applied the Ameren Missouri TRM 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 Equation 18.

Equation 18. 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 13. 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 = 36,552

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; 84% 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 19. Downstream NTGR

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

The Midstream Channel's NTGR also includes channel specific PFR and PSO derived from the PY2020 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 PY2020 distributor interviews. Note that for the Midstream Channel, the evaluation team did not estimate distributor SO.[1]

Opinion Dynamics recommended weighting the PFR and DFR equally when deriving the channel-level NTGR. However, because the Midstream Channel was new for PY2020 and the methodology for computing Midstream NTGRs was untested—especially the DFR component—there was concern that the DFR estimates could unreasonably influence the channel-level NTGRs. To avoid surprises, in this first year of estimating Midstream NTGRs, the statewide Independent Auditor agreed to an 80%/20% weighting of PFR and DFR.[2] Thus, the PY2020 Midstream NTGR was computed as:

Equation 20. 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 PY2020 were originally derived from a large-scale (n=4,804) non-participant survey conducted as part of the PY2019 evaluation. For PY2020, we use the PY2019 NPSO rates and re-weight to account for the PY2020 ex post gross savings distribution across measures and channels. In the end, the overall program NTGR is:

Equation 21. PY2020 HVAC Program NTGR

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

Table 14 shows the elements of the channel-by-measure level NTGRs used to derive net impacts PY2020.

Table 14. PY2020 HVAC Program NTGR

<table>
<tr><th>Measure/Enduse</th><th>Participant Free Ridership (PFR)</th><th>Distributor Free Ridership (DFR)</th><th>Participant Spillover (PSO)</th><th>Trade Ally Spillover (TASO)</th><th>Net-to-Gross Ratio (NTGR)</th></tr>
<tr><td colspan="6">Downstream</td></tr>
<tr><td>CACs</td><td>39.5%</td><td rowspan="6"></td><td rowspan="4">0.6%</td><td rowspan="6">0.3%</td><td>61.4%</td></tr>
<tr><td>ASHP</td><td rowspan="3">37.0%</td><td rowspan="3">63.9%</td></tr>
<tr><td>GSHP</td></tr>
<tr><td>DMSHP</td></tr>
<tr><td>ECM[a]</td><td></td><td></td><td>68.4%</td></tr>
<tr><td>Advanced Thermostats</td><td>29.6%</td><td>0.6%</td><td>71.3%</td></tr>
<tr><td colspan="6">Midstream</td></tr>
<tr><td>CACs</td><td>36.0%</td><td rowspan="3">39.6%</td><td rowspan="4">0.1%</td><td rowspan="4"></td><td>63.4%</td></tr>
<tr><td>ASHP</td><td>39.6%</td><td rowspan="2">60.5%</td></tr>
<tr><td>DMSHP</td><td></td></tr>
<tr><td>Advanced Thermostats</td><td>28.0%</td><td></td><td>72.1%</td></tr>
</table>

[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.

[2] The evaluation team feels the approach for estimating DFR worked as designed and moving forward recommends that we apply equal weight to PFR and DFR.

| Measure/Enduse | Participant Free Ridership (PFR) | Distributor Free Ridership (DFR) | Participant Spillover (PSO) | Trade Ally Spillover (TASO) | Net-to-Gross Ratio (NTGR) |
|---|---|---|---|---|---|
| Overall Program | 37.2% | 2.4% | 0.5% | 0.3% | 63.90% |

[a] The evaluation team used PY2018 NTGR for ECMs as that was the last time that a robust ECM NTGR was estimated.

Details of how each of the elements are computed follows.

### Participant Free Ridership (Downstream and Midstream)

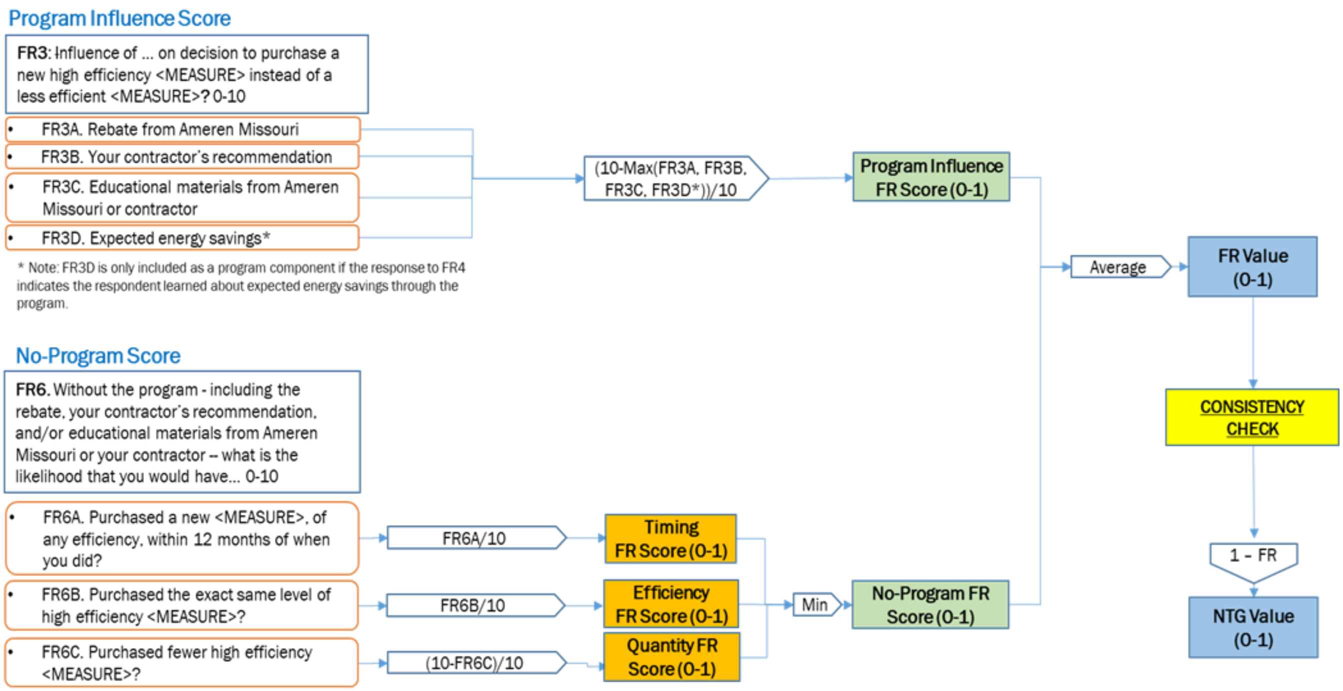
Developing individual participant-level FR scores consists of estimating two separate FR scores for each participant—both capturing different aspects of FR—which are then be combined into a single FR score:

- **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[3]) 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 1 presents a diagram of the HVAC Program Participant FR algorithm, including references to survey question numbers.

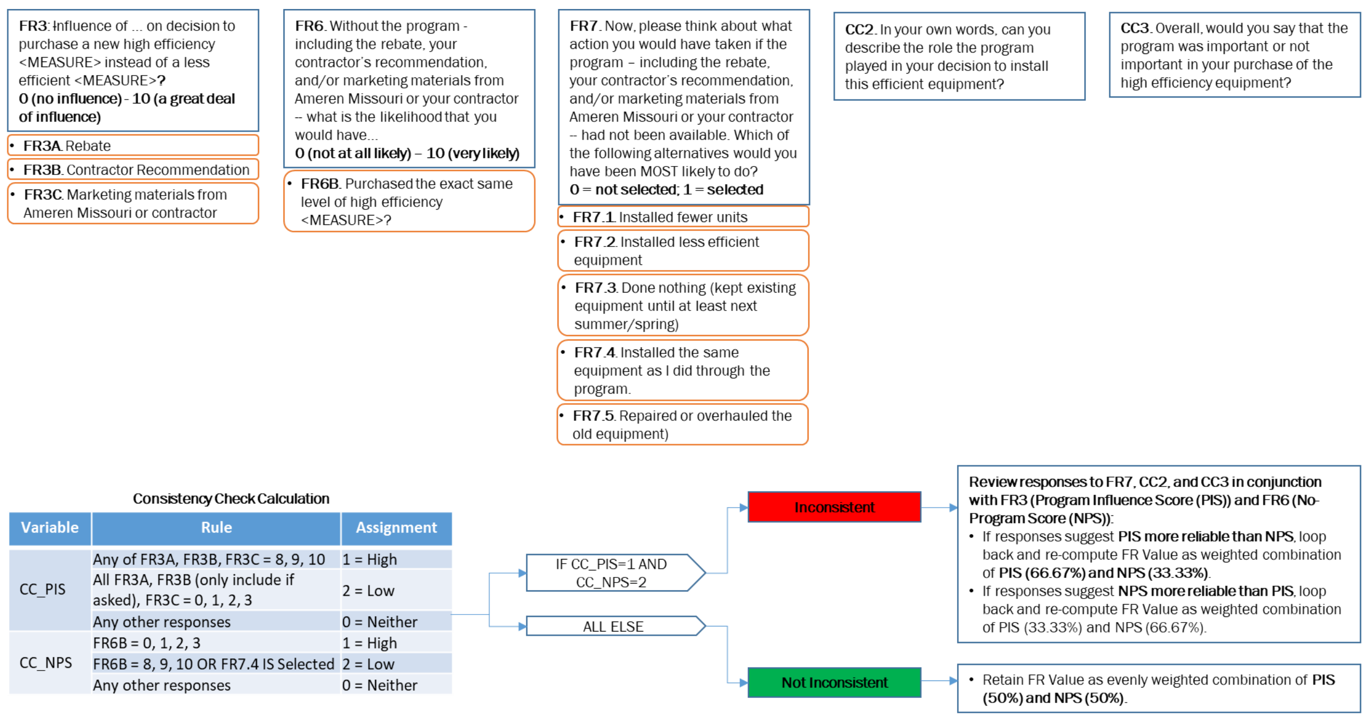
[3] Expected energy savings are only considered if the respondent learned about the expected energy savings through the program.

Figure 1. 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 2 presents the process for conducting the consistency checks and recoding cases as needed.

Figure 2. Consistency Check Process




Consistency Check Calculation

| Variable | Rule | Assignment |
|---|---|---|
| CC_PIS | Any of FR3A, FR3B, FR3C = 8, 9, 10 | 1 = High |
| | All FR3A, FR3B (only include if asked), FR3C = 0, 1, 2, 3 | 2 = Low |
| | Any other responses | 0 = Neither |
| CC_NPS | FR6B = 0, 1, 2, 3 | 1 = High |
| | FR6B = 8, 9, 10 OR FR7.4 IS Selected | 2 = Low |
| | Any other responses | 0 = Neither |

## 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 HVAC Program influence your decision to make these energy efficient improvements on your own? [SCALE 0-10; 0 means "no influence" and 10 means "greatly influenced"]
- **SP1b:** How likely is it you would have made these energy efficiency improvements if you had not received a rebate through the HVAC Program? [SCALE 0-10; 0 means "definitely would not" and 10 means "definitely would"]

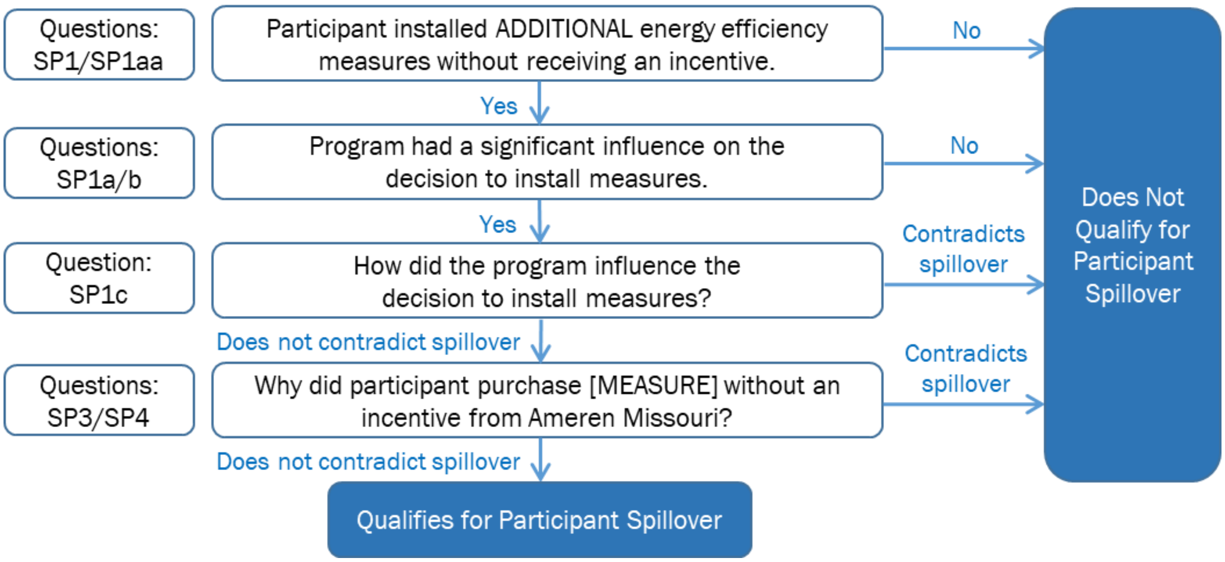
To supplement these numeric responses, the survey contained open-ended questions about how the program influenced the decision to make the upgrades and why the participant made the installations without a program incentive. A respondent's additional energy efficiency installations are deemed eligible 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 3 presents a diagram of the participant SO eligibility determination methodology used for this evaluation, including references to question numbers.

Figure 3. Participant Eligibility for Spillover




Based on results from the participant survey, we identified 20 respondents who had installed measures that qualified for PSO in PY2020. Our engineering analysis of SO measures for these participants yielded total spillover savings of 8,435 kWh for the Downstream Channel and 473 kWh for the Midstream Channel, for a total of 8,907 kWh (see Table 15).

Table 15. HVAC Program Participant Spillover Measures and Savings

| Channel | Spillover Measure | Number of Unique Participants | Total kWh |
|---|---|---|---|
| Downstream | Air Purifier | 2 | 1,230 |
| | Clothes Washer | 4 | 370 |
| | Dehumidifier | 4 | 816 |
| | Refrigerator | 3 | 167 |
| | Dishwasher | 4 | 61 |
| | Tier 1 APS | 1 | 56 |
| | Low-Flow Faucet Aerator | 3 | 178 |
| | Low-Flow Showerhead | 4 | 244 |
| | Heat Pump Water Heater | 1 | 2,640 |
| | Programmable Thermostat | 1 | 335 |
| | Pool Pump | 1 | 1,800 |
| | Air Sealing | 5 | 409 |
| | Insulation | 3 | 74 |
| | Windows | 3 | 54 |
| Midstream | Clothes Washer | 1 | 48 |
| | Refrigerator | 1 | 51 |
| | Dishwasher | 1 | 14 |
| | Air Sealing | 3 | 186 |

| Channel | Spillover Measure | Number of Unique Participants | Total kWh |
|---|---|---|---|
| | Insulation | 1 | 31 |
| | Windows | 1 | 142 |
| | **Total** | **20** | **8,907** |

Note: Represents total number of participants reporting spillover.

Dividing the estimated total SO in our sample for each program (8,435 kWh for the Downstream Channel and 473 kWh for the Midstream Channel) by total program ex post gross savings of the overall participant sample for each channel (1,459,391 kWh for Downstream; 354,284 kWh for Midstream) yields a SO rate of 0.58% for the Downstream Channel and 0.13% for the Midstream Channel, as shown in Equation 22 and Equation 23.

Equation 22. PY2020 HVAC Program Downstream Channel Participant Spillover Rate

$$PSO\ \%_{Energy} = \frac{Total\ participant\ sample\ SO\ (kWh)}{Total\ participant\ sample\ savings\ (\mathrm{k}Wh)} = \frac{8{,}435\ kWh}{1{,}459{,}391\ \mathrm{k}Wh} = 0.58\%$$

Equation 23. PY2020 HVAC Program Midstream Channel Participant Spillover Rate

$$PSO\ \%_{Energy} = \frac{Total\ participant\ sample\ SO\ (kWh)}{Total\ participant\ sample\ savings\ (\mathrm{k}Wh)} = \frac{473\ kWh}{354{,}284\ \mathrm{k}Wh} = 0.13\%$$

## 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:

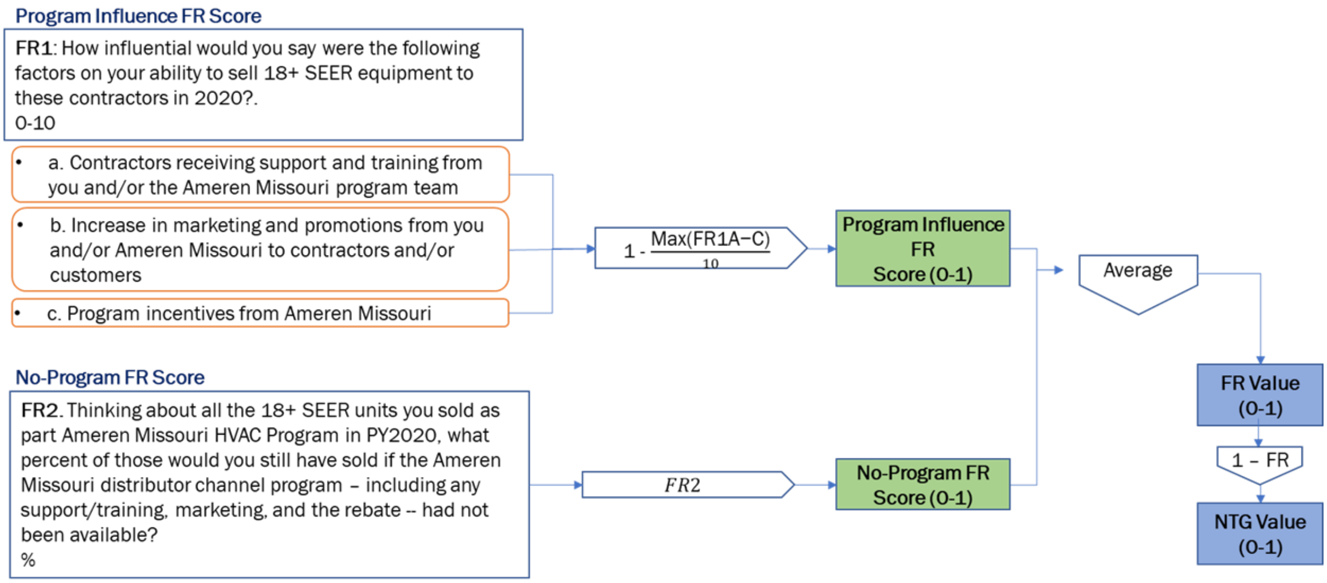
$$DFR_{Mid} = Mean(Program\ Influence\ FR\ Score,\ No\ Program\ FR\ Score_i)$$

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 4.

Figure 4. 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: [4]

- **FR1a:** Contractors receiving support and training from you and/or the Ameren Missouri program team
- **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 24. 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 2020 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 25. No Program Score

$$No\ Program\ Score = FR2$$

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

### Trade Ally Spillover

TASO was only applied to the Downstream Channel. The TASO used for PY2020 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 PY2020 evaluation was derived as part of a large-scale non-participant survey conducted as part of the PY2019 evaluation. For PY2020, we used the PY2019 NPSO rates and re-weighted to account for the PY2020 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. Participants could opt out of all demographic questions so not all percentages may add up to 100%. Table 16 provides the demographics results from the participant survey.

Table 16. HVAC Participant Survey Demographics

| Characteristic | Downstream (Percent of Participants) | Midstream (Percent of Participants) |
|---|---|---|
| **Age** | | |
| Under 25 | <1% | 0% |
| 26–44 | 20% | 23% |
| 45–64 | 43% | 42% |
| 65+ | 36% | 35% |
| **Homeownership** | | |
| Own | 99% | 100% |
| Rent | 1% | 0% |
| **Education** | | |
| High School or less | 9% | 5% |
| Some College | 14% | 13% |
| College graduate | 41% | 48% |
| Graduate or Professional Degree, e.g., JD, MBA, MD, PhD | 32% | 34% |
| **Income** | | |
| Less than $50,000 | 11% | 5% |
| $50,000 to less than $100,000 | 27% | 27% |
| $100,000 to less than $150,000 | 22% | 20% |
| Greater than $150,000 | 21% | 28% |
| **Housing Type** | | |
| Single Family Detached Home | 92% | 96% |
| Single Family Attached Home Such as a Townhouse or Row House | 5% | 2% |
| Apartment or Condominium | 3% | 2% |

| Characteristic | Downstream (Percent of Participants) | Midstream (Percent of Participants) |
|---|---|---|
| Mobile Home | <1% | 0% |
| **Gender** | | |
| Female | 43% | 28% |
| Male | 52% | 66% |
| Prefer not to answer | 5% | 6% |
| **Race/ Ethnicity** | | |
| White or Caucasian | 8% | 91% |
| Black or African American | 3% | 1% |
| Asian | 1% | 2% |
| American Indian or Alaskan Native | <1% | 1% |
| Pacific Islander | <1% | 0% |
| Prefer not to answer | 7% | 6% |

Table 17 provides the firmographic results from the TA survey.

Table 17. HVAC Trade Ally Survey Firmographics

| Characteristic | Percent of Trade Allies |
|---|---|
| **Number of Employees** | |
| Less than 10 | 64% |
| 10 to less than 20 | 7% |
| 20 to less than 50 | 14% |
| 50 to less than 100 | 7% |
| Greater than 100 | 7% |
| Don't know/ Prefer not to answer | 0% |
| **Size of Company** | |
| Local | 86% |
| Regional | 14% |
| National | 0% |
| International | 0% |
| **Years Offering Services to Residential Markets** | |
| Less than 5 | 14% |
| 5 to less than 10 | 0% |
| 10 to less than 20 | 21% |
| 20 to less than 50 | 43% |
| 50 to less than 100 | 14% |
| Greater than 100 | 7% |
| Don't know/ Prefer not to answer | 0% |

# Home Energy Reports (HERs)

The following subsections discuss the detailed methodology for estimating savings from Ameren Missouri's HERs 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 PY2020 were equivalent in terms of energy consumption (see Table 18). 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 we rely on an intent-to-treat (ITT) approach, we used the population of treatment and control customers in this equivalency analysis. 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 18. 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 | 47.02 | 46.94 |
| Wave 2 | 64.66 | 64.82 |
| Wave 3 | 41.04 | 40.98 |
| Wave 4 | 33.08 | 33.09 |

Figure 5 through Figure 8 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 5. Wave 1 Pre-Period Average Daily Consumption

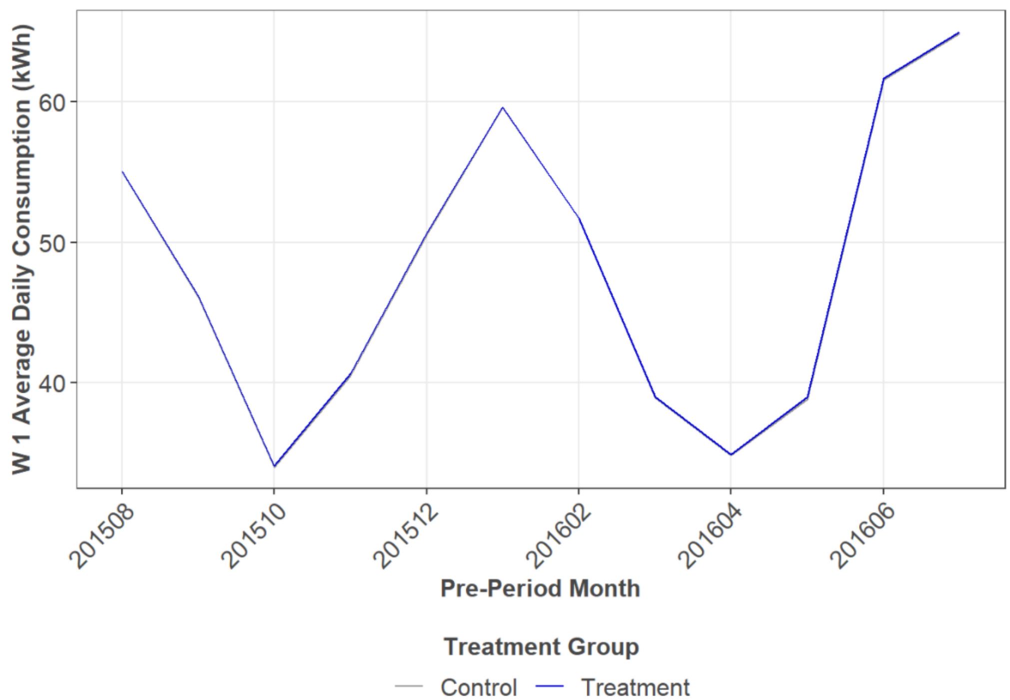



Figure 6. Wave 2 Pre-Period Average Daily Consumption

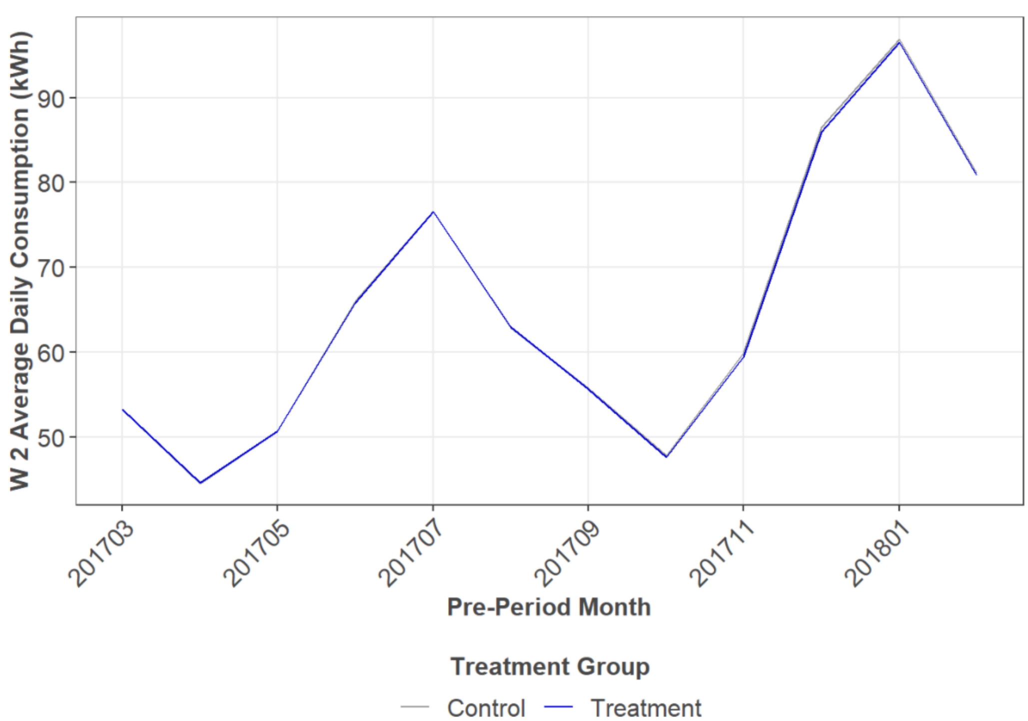


Figure 7. Wave 3 Pre-Period Average Daily Consumption

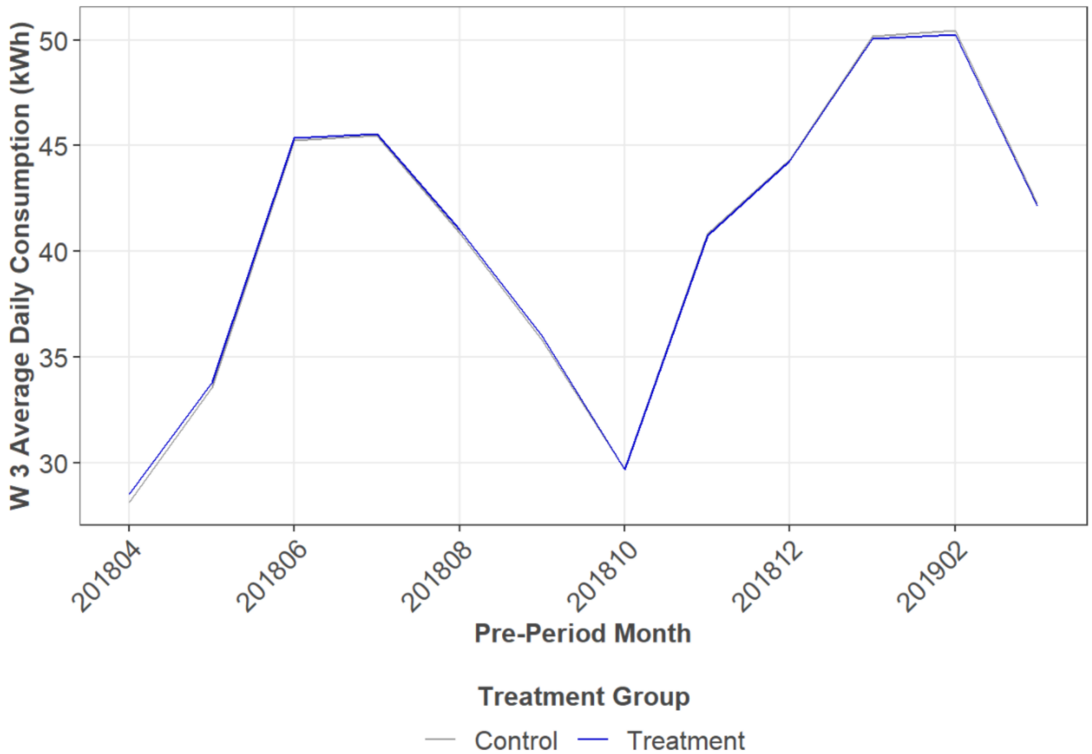
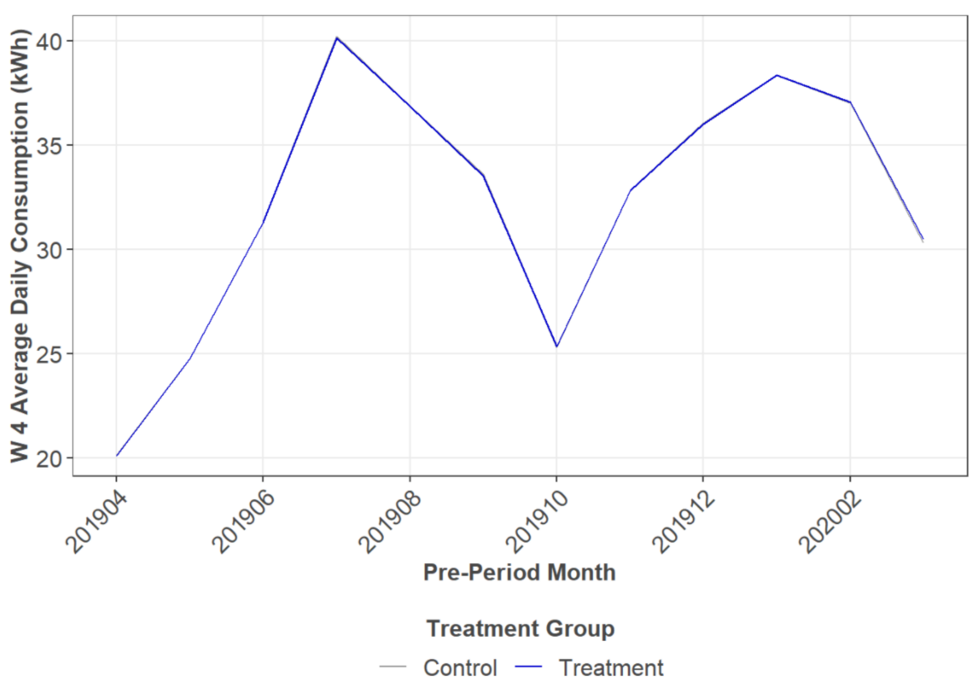



Figure 8. Wave 4 Pre-Period Average Daily Consumption



## Data Sources

Participant data and treatment/control assignments were sourced from previous program year evaluation participant tracking files for Waves 1–3, and from the participant tracking file for the pre-implementation equivalency analysis for Wave 4. Note that the evaluation team did not receive information on participants that 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 AMO 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 (see Table 19). The final customers count includes all customers that the implementation team assigned to a treatment or control group that have sufficient consumption data. 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). For Wave 4, which only received treatment from April through December 2020, a nine-month post-period sufficiency requirement would necessitate dropping a very large proportion of customers. To retain more customers for the Wave 4 analysis, the evaluation team relaxed the standard for Wave 4 to seven months of post-period data.

Table 19. Data Cleaning Results for Treatment and Control Groups by Wave

| Wave | Metric | Unique Customers | |
|---|---|---|---|
| | | Treatment | Control |
| Wave 1 | Initial | 71,903 | 24,059 |
| | Final | 70,934 | 24,052 |
| | *% Remaining* | *99%* | *100%* |
| Wave 2 | Initial | 31,680 | 8,762 |
| | Final | 31,521 | 8,760 |
| | *% Remaining* | *100%* | *100%* |
| Wave 3 | Initial | 151,203 | 60,561 |
| | Final | 129,341 | 51,907 |
| | *% Remaining* | *86%* | *86%* |
| Wave 4 | Initial | 44,882 | 24,949 |
| | Final | 30,146 | 16,807 |
| | *% Remaining* | *67%* | *67%* |

## 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 (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 PY2020, 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 PY2020. 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 26. 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*

$\alpha$ = Model intercept

$\beta_1$ = Coefficient for the change in consumption for the treatment group

$\beta_2$ = Coefficient for the average daily usage across household *i* available pretreatment meter reads

$\beta_3$ = Coefficient for the average daily usage over the months of December through March across household *i* available pretreatment meter reads

$\beta_4$ = Coefficient for the average daily usage over the months of June through September across household *i* available pretreatment meter reads

$\beta_5$ = Vector of coefficients for month-year dummies

$\beta_6$ = Vector of coefficients for month-year dummies by average daily pretreatment usage

$\beta_7$ = Vector of coefficients for month-year dummies by average daily winter pretreatment usage

$\beta_8$ = 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

$\varepsilon_{it}$ = Error

We used the LDV model to estimate the electric savings from the PY2020 HER Program. The unadjusted per household savings are shown in Table 20.

Table 20. Unadjusted Per-Household Daily Net Electric Savings

| Wave | Unadjusted Net Savings (% per household) | Unadjusted Net Savings (kWh per household) |
|---|---|---|
| Wave 1 | 0.92% | 157 |
| Wave 2 | 1.13% | 250 |
| Wave 3 | 0.70% | 92 |
| Wave 4 | 0.61% | 74 |

## Billing Analysis Model Coefficients

Table 21 provides the billing analysis model coefficients for the LDV model.

Table 21. LDV Model Billing Analysis Model Coefficients

| Wave | Term | Estimate | Standard Error |
|---|---|---|---|
| 1 | (Intercept) | 6.74 | 0.20 |
| 1 | treat | -0.43 | 0.04 |
| 1 | pre_adc | -0.42 | 0.02 |
| 1 | pre_adc_summ | 0.08 | 0.01 |
| 1 | pre_adc_win | 1.17 | 0.01 |
| 1 | my022020 | 0.49 | 0.27 |
| 1 | my032020 | 1.03 | 0.27 |
| 1 | my042020 | -0.70 | 0.27 |
| 1 | my052020 | -3.57 | 0.28 |
| 1 | my062020 | 0.82 | 0.28 |
| 1 | my072020 | 4.28 | 0.28 |
| 1 | my082020 | 2.00 | 0.28 |
| 1 | my092020 | -5.45 | 0.28 |
| 1 | my102020 | -1.30 | 0.28 |
| 1 | my112020 | 0.26 | 0.28 |
| 1 | my122020 | 0.60 | 0.37 |
| 1 | pre_adc:my022020 | 0.11 | 0.02 |
| 1 | pre_adc:my032020 | 1.02 | 0.02 |
| 1 | pre_adc:my042020 | 1.67 | 0.02 |
| 1 | pre_adc:my052020 | 1.72 | 0.02 |
| 1 | pre_adc:my062020 | 0.90 | 0.03 |
| 1 | pre_adc:my072020 | 0.58 | 0.02 |
| 1 | pre_adc:my082020 | 0.88 | 0.03 |
| 1 | pre_adc:my092020 | 1.48 | 0.02 |
| 1 | pre_adc:my102020 | 1.57 | 0.03 |

| Wave | Term | Estimate | Standard Error |
|---|---|---|---|
| 1 | pre_adc:my112020 | 1.08 | 0.03 |
| 1 | pre_adc:my122020 | 0.36 | 0.03 |
| 1 | pre_adc_summ:my022020 | -0.06 | 0.01 |
| 1 | pre_adc_summ:my032020 | -0.31 | 0.01 |
| 1 | pre_adc_summ:my042020 | -0.44 | 0.01 |
| 1 | pre_adc_summ:my052020 | -0.21 | 0.01 |
| 1 | pre_adc_summ:my062020 | 0.47 | 0.01 |
| 1 | pre_adc_summ:my072020 | 0.67 | 0.01 |
| 1 | pre_adc_summ:my082020 | 0.45 | 0.01 |
| 1 | pre_adc_summ:my092020 | 0.10 | 0.01 |
| 1 | pre_adc_summ:my102020 | -0.35 | 0.01 |
| 1 | pre_adc_summ:my112020 | -0.28 | 0.01 |
| 1 | pre_adc_summ:my122020 | -0.05 | 0.02 |
| 1 | pre_adc_win:my022020 | -0.08 | 0.01 |
| 1 | pre_adc_win:my032020 | -0.82 | 0.01 |
| 1 | pre_adc_win:my042020 | -1.31 | 0.01 |
| 1 | pre_adc_win:my052020 | -1.53 | 0.01 |
| 1 | pre_adc_win:my062020 | -1.35 | 0.01 |
| 1 | pre_adc_win:my072020 | -1.24 | 0.01 |
| 1 | pre_adc_win:my082020 | -1.35 | 0.01 |
| 1 | pre_adc_win:my092020 | -1.51 | 0.01 |
| 1 | pre_adc_win:my102020 | -1.33 | 0.01 |
| 1 | pre_adc_win:my112020 | -0.90 | 0.01 |
| 1 | pre_adc_win:my122020 | -0.35 | 0.01 |
| 2 | (Intercept) | 4.52 | 0.31 |
| 2 | treat | -0.68 | 0.07 |
| 2 | pre_adc | 0.55 | 0.03 |
| 2 | pre_adc_summ | -0.27 | 0.01 |
| 2 | pre_adc_win | 0.68 | 0.01 |
| 2 | my022020 | 0.60 | 0.43 |
| 2 | my032020 | 2.23 | 0.43 |
| 2 | my042020 | -0.23 | 0.43 |
| 2 | my052020 | -4.37 | 0.43 |
| 2 | my062020 | 0.32 | 0.43 |
| 2 | my072020 | 4.10 | 0.43 |
| 2 | my082020 | 1.95 | 0.43 |
| 2 | my092020 | -11.30 | 0.43 |
| 2 | my102020 | -0.87 | 0.44 |
| 2 | my112020 | 1.76 | 0.44 |
| 2 | my122020 | 0.40 | 0.58 |

| Wave | Term | Estimate | Standard Error |
|---|---|---|---|
| 2 | pre_adc:my022020 | 0.11 | 0.04 |
| 2 | pre_adc:my032020 | 0.74 | 0.04 |
| 2 | pre_adc:my042020 | 1.08 | 0.04 |
| 2 | pre_adc:my052020 | 0.85 | 0.04 |
| 2 | pre_adc:my062020 | -0.16 | 0.04 |
| 2 | pre_adc:my072020 | -0.46 | 0.04 |
| 2 | pre_adc:my082020 | -0.21 | 0.04 |
| 2 | pre_adc:my092020 | 0.53 | 0.04 |
| 2 | pre_adc:my102020 | 0.70 | 0.04 |
| 2 | pre_adc:my112020 | 0.65 | 0.04 |
| 2 | pre_adc:my122020 | 0.59 | 0.05 |
| 2 | pre_adc_summ:my022020 | -0.08 | 0.02 |
| 2 | pre_adc_summ:my032020 | -0.24 | 0.02 |
| 2 | pre_adc_summ:my042020 | -0.23 | 0.02 |
| 2 | pre_adc_summ:my052020 | 0.15 | 0.02 |
| 2 | pre_adc_summ:my062020 | 0.94 | 0.02 |
| 2 | pre_adc_summ:my072020 | 1.14 | 0.02 |
| 2 | pre_adc_summ:my082020 | 0.93 | 0.02 |
| 2 | pre_adc_summ:my092020 | 0.58 | 0.02 |
| 2 | pre_adc_summ:my102020 | -0.02 | 0.02 |
| 2 | pre_adc_summ:my112020 | -0.15 | 0.02 |
| 2 | pre_adc_summ:my122020 | -0.18 | 0.02 |
| 2 | pre_adc_win:my022020 | -0.06 | 0.01 |
| 2 | pre_adc_win:my032020 | -0.65 | 0.01 |
| 2 | pre_adc_win:my042020 | -0.99 | 0.01 |
| 2 | pre_adc_win:my052020 | -1.09 | 0.01 |
| 2 | pre_adc_win:my062020 | -0.81 | 0.01 |
| 2 | pre_adc_win:my072020 | -0.70 | 0.01 |
| 2 | pre_adc_win:my082020 | -0.80 | 0.01 |
| 2 | pre_adc_win:my092020 | -1.02 | 0.01 |
| 2 | pre_adc_win:my102020 | -0.90 | 0.01 |
| 2 | pre_adc_win:my112020 | -0.67 | 0.01 |
| 2 | pre_adc_win:my122020 | -0.39 | 0.02 |
| 3 | (Intercept) | 1.45 | 0.07 |
| 3 | treat | -0.25 | 0.02 |
| 3 | pre_adc | 0.58 | 0.01 |
| 3 | pre_adc_summ | -0.23 | 0.01 |
| 3 | pre_adc_win | 0.65 | 0.01 |
| 3 | my022020 | 0.29 | 0.09 |
| 3 | my032020 | 0.85 | 0.09 |

| Wave | Term | Estimate | Standard Error |
|---|---|---|---|
| 3 | my042020 | 0.26 | 0.09 |
| 3 | my052020 | -0.99 | 0.10 |
| 3 | my062020 | 1.04 | 0.10 |
| 3 | my072020 | 3.07 | 0.10 |
| 3 | my082020 | 1.78 | 0.10 |
| 3 | my092020 | -3.34 | 0.10 |
| 3 | my102020 | 0.02 | 0.10 |
| 3 | my112020 | 0.95 | 0.10 |
| 3 | my122020 | 0.37 | 0.13 |
| 3 | pre_adc:my022020 | 0.25 | 0.02 |
| 3 | pre_adc:my032020 | 0.89 | 0.02 |
| 3 | pre_adc:my042020 | 1.20 | 0.02 |
| 3 | pre_adc:my052020 | 1.02 | 0.02 |
| 3 | pre_adc:my062020 | 0.18 | 0.02 |
| 3 | pre_adc:my072020 | -0.13 | 0.02 |
| 3 | pre_adc:my082020 | 0.15 | 0.02 |
| 3 | pre_adc:my092020 | 0.96 | 0.02 |
| 3 | pre_adc:my102020 | 1.21 | 0.02 |
| 3 | pre_adc:my112020 | 0.88 | 0.02 |
| 3 | pre_adc:my122020 | 0.33 | 0.03 |
| 3 | pre_adc_summ:my022020 | -0.12 | 0.01 |
| 3 | pre_adc_summ:my032020 | -0.29 | 0.01 |
| 3 | pre_adc_summ:my042020 | -0.31 | 0.01 |
| 3 | pre_adc_summ:my052020 | -0.01 | 0.01 |
| 3 | pre_adc_summ:my062020 | 0.71 | 0.01 |
| 3 | pre_adc_summ:my072020 | 0.95 | 0.01 |
| 3 | pre_adc_summ:my082020 | 0.71 | 0.01 |
| 3 | pre_adc_summ:my092020 | 0.26 | 0.01 |
| 3 | pre_adc_summ:my102020 | -0.27 | 0.01 |
| 3 | pre_adc_summ:my112020 | -0.26 | 0.01 |
| 3 | pre_adc_summ:my122020 | -0.07 | 0.01 |
| 3 | pre_adc_win:my022020 | -0.14 | 0.01 |
| 3 | pre_adc_win:my032020 | -0.74 | 0.01 |
| 3 | pre_adc_win:my042020 | -1.09 | 0.01 |
| 3 | pre_adc_win:my052020 | -1.18 | 0.01 |
| 3 | pre_adc_win:my062020 | -0.94 | 0.01 |
| 3 | pre_adc_win:my072020 | -0.81 | 0.01 |
| 3 | pre_adc_win:my082020 | -0.93 | 0.01 |
| 3 | pre_adc_win:my092020 | -1.23 | 0.01 |
| 3 | pre_adc_win:my102020 | -1.13 | 0.01 |

| Wave | Term | Estimate | Standard Error |
|---|---|---|---|
| 3 | pre_adc_win:my112020 | -0.78 | 0.01 |
| 3 | pre_adc_win:my122020 | -0.30 | 0.01 |
| 4 | (Intercept) | 0.32 | 0.14 |
| 4 | treat | -0.20 | 0.04 |
| 4 | pre_adc | 1.57 | 0.03 |
| 4 | pre_adc_summ | -0.38 | 0.01 |
| 4 | pre_adc_win | -0.36 | 0.01 |
| 4 | my052020 | -1.09 | 0.17 |
| 4 | my062020 | 1.76 | 0.17 |
| 4 | my072020 | 4.22 | 0.17 |
| 4 | my082020 | 2.68 | 0.17 |
| 4 | my092020 | -4.65 | 0.17 |
| 4 | my102020 | 0.04 | 0.17 |
| 4 | my112020 | 1.53 | 0.17 |
| 4 | my122020 | 0.48 | 0.20 |
| 4 | pre_adc:my052020 | 0.13 | 0.04 |
| 4 | pre_adc:my062020 | -0.67 | 0.04 |
| 4 | pre_adc:my072020 | -0.90 | 0.04 |
| 4 | pre_adc:my082020 | -0.67 | 0.04 |
| 4 | pre_adc:my092020 | 0.41 | 0.04 |
| 4 | pre_adc:my102020 | 0.35 | 0.04 |
| 4 | pre_adc:my112020 | -0.23 | 0.04 |
| 4 | pre_adc:my122020 | -0.38 | 0.05 |
| 4 | pre_adc_summ:my052020 | 0.20 | 0.02 |
| 4 | pre_adc_summ:my062020 | 0.92 | 0.02 |
| 4 | pre_adc_summ:my072020 | 1.11 | 0.02 |
| 4 | pre_adc_summ:my082020 | 0.89 | 0.02 |
| 4 | pre_adc_summ:my092020 | 0.38 | 0.02 |
| 4 | pre_adc_summ:my102020 | -0.14 | 0.02 |
| 4 | pre_adc_summ:my112020 | -0.05 | 0.02 |
| 4 | pre_adc_summ:my122020 | -0.03 | 0.02 |
| 4 | pre_adc_win:my052020 | -0.23 | 0.02 |
| 4 | pre_adc_win:my062020 | 0.00 | 0.02 |
| 4 | pre_adc_win:my072020 | 0.09 | 0.02 |
| 4 | pre_adc_win:my082020 | -0.01 | 0.02 |
| 4 | pre_adc_win:my092020 | -0.44 | 0.02 |
| 4 | pre_adc_win:my102020 | -0.16 | 0.02 |
| 4 | pre_adc_win:my112020 | 0.33 | 0.02 |
| 4 | pre_adc_win:my122020 | 0.65 | 0.02 |

[a] 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 PY2020 HER demand savings is 0.000466081 kW.

## Participation Uplift and Joint Savings Analysis

We also determined whether the Ameren Missouri HER Program treatment generated participation uplift in other PY2020 programs (i.e., an increase in participation in other energy efficiency programs in PY2020 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 PY2020. We include the following residential programs in our analysis for 2020:

- Appliance Recycling
- Efficient Products
- Peak Time Savings
- Single Family Income Eligible
- Multifamily Income Eligible
- Multifamily Market Rate
- Heating, Ventilation, and Air Conditioning
- Online Retail Lighting
- Upstream Lighting

Through this analysis, we calculated the number of customers who participated in both the HER Program and other energy efficiency programs in PY2020 for each wave. To ensure the participation uplift is 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 PY2020. Any positive difference between the treatment and control population that was statistically significant 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 27:

Equation 27. 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 that, 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 28 was used to calculate participation uplift.

Equation 28. 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 of 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 and wave where at least some participation in the program occurred.

Equation 29. 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 six programs. Table 22. Program Savings Adjustments shows the uplift, per-participant savings, and savings adjustments for programs and waves that had significant and positive uplift for treatment customers in PY2020.

Table 22. Program Savings Adjustments

| Program | Wave | Per Participant Savings | Uplift | Statistical Significance (90%) | Savings Adjustment |
|---|---|---|---|---|---|
| HVAC | 2 | 1,965 | 96.89 | yes | 190,389 |
| Lighting | 1 | 698 | 46.62 | yes | 32,541 |
| MFMR | 3 | 1,602 | 46.73 | yes | 74,861 |
| RAR | 1 | 123 | 52.27 | yes | 6,429 |
| RAR | 2 | 123 | 18.07 | yes | 2,223 |
| RAR | 3 | 123 | 37.58 | yes | 4,622 |
| RAR | 4 | 123 | 20.82 | yes | 2,561 |
| REP | 3 | 496 | 204.82 | yes | 101,591 |
| REP | 4 | 496 | 98.41 | yes | 48,811 |
| RES_DR | 3 | 4 | 147.18 | yes | 589 |
| RES_DR | 4 | 4 | 96.47 | yes | 386 |

# Energy Efficient Products (REP)

## Gross Impact Methodology

### Heat Pump Water Heater Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 Residential Efficient Products (REP) Program heat pump water heater measures, the evaluation team applied the Ameren Missouri TRM 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 Equation 30.

Equation 30. Heat Pump Water Heater Energy and Demand Savings Equations

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

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

$$kWh_{Heat} = kWh_{Electric\ Resistance\ Heating} + kWh_{Heat\ Pump\ Heating}$$ [5]

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

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

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

[5] $kWh_{Haet}$ was calculated for an unknown electric heating system type in accordance with Appendix F (v4.0), 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.

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 PY2020 REP Program advanced thermostat measures, the evaluation team applied Ameren Missouri TRM 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 Equation 31.

Equation 31. 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; 33% if unknown[6]

$HeatingConsumption_{Electric}$ = Estimate of annual household heating consumption for electrically heated single family homes, in kWh (Table 23)

Table 23. $HeatingConsumption_{Electric}$ 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

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

[6] Note that the evaluation team deviated from the TRM Appendix F for this parameter. For PY2020 we applied a weighted average assumption based on available heating equipment types present in the program data.

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[7]

$HeatingConsumption_{Gas}$ = 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 PY2020 REP Program pool pump measures, the evaluation team applied the Ameren Missouri TRM 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 Equation 32.

Equation 32. Pool Pump Energy and Demand Savings Equations

$$\left(\frac{kWh}{Year}\right) = Days_{Oper} \times \left[\left(\frac{kWh_{ss}}{Day}\right) - \left(\frac{kWh_{ds}}{Day}\right)\right] \times ISR$$

$$\left(\frac{kWh_{ds}}{Day}\right) = \left(\frac{kWh_{hs}}{Day}\right) + \left(\frac{kWh_{ls}}{Day}\right)$$

$$\left(\frac{kWh_{ss}}{Day}\right) = \frac{RT_{ss} \times GPM_{ss} \times 60}{EF_{ss} \times 1000}$$

$$\left(\frac{kWh_{hs}}{Day}\right) = \frac{RT_{hs} \times GPM_{hs} \times 60}{EF_{hs} \times 1000}$$

$$\left(\frac{kWh_{ls}}{Day}\right) = \frac{RT_{ls} \times GPM_{ls} \times 60}{EF_{ls} \times 1000}$$

$$kW = kWh \times CF$$

Where:

$Days_{Oper}$ = Days per year of operation = 121.6

$RT_{ss}$ = Runtime in hours per day using single-speed (ss) pump = 11.4

$RT_{hs}$ = Runtime in hours per day in high speed (hs) using a dual-speed (ds) pump = 2.0

$RT_{ls}$ = Runtime in hours per day in low speed (ls) using a dual-speed (ds) pump = 9.8 for multi-speed pump; 10.0 for variable-speed pump

[7] Note that the evaluation team deviated from the TRM Appendix F for this parameter. For PY2020 we applied a weighted average assumption based on available heating equipment types present in the program data.

$GPM_{ss}$ = Gallons per minute using single-speed (ss) pump = 64.4

$GPM_{hs}$ = Gallons per minute in high speed (hs) using a dual-speed (ds) pump = 56.0 for multi-speed pump; 50.0 for variable-speed pump

$GPM_{ls}$ = Gallons per minute in low speed (ls) using a dual-speed (ds) pump =31.0 for multi-speed pump; 30.6 for variable-speed pump

$EF_{ss}$ = Energy factor using single-speed (ss) pump, in gallons per Watt-hour = 2.1

$EF_{hs}$ = Energy factor in high speed (hs) using a dual-speed (ds) pump, in gallons per Watt-hour = 2.4 for multi-speed pump; 3.8 for variable-speed pump

$EF_{ls}$ = Energy factor in low speed (ls) using a dual-speed (ds) pump, in gallons per Watt-hour = 5.4 for multi-speed pump; 7.3 for variable-speed pump

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 PY2020 REP Program Tier 1 power strip measures, the evaluation team applied the Ameren Missouri TRM 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 Equation 33.

Equation 33. Tier 1 Power Strips Energy and Demand Savings Equations

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

$$kW = kWh \times CF$$

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%[8]

CF = Coincidence factor = 0.0001148238

## Tier 2 Power Strips Savings Assumptions

[8] 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.

To calculate verified gross energy and demand savings for PY2020 REP Program Tier 2 power strip measures, the evaluation team applied the Ameren Missouri TRM 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 Equation 34.

Equation 34. Tier 2 Power Strips Energy and Demand Savings Equations

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

$$kW = kWh \times CF$$

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 PY2020 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 24).

For PY2020, 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 measure present in the PY2020 program-tracking data. Table 24 shows the preliminary NTGRs used for the PY2020 evaluation.

Table 24. PY2020 REP Program Preliminary 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% |

| Channel | Measure/Enduse | Free Ridership (FR) | Participant Spillover (PSO) | NTGR (1-FR+PSO) |
|---|---|---|---|---|
| | Pool Pumps | 35.6% | 2.8% | 67.2% |
| | **Total** | **30.7%** | **2.8%** | **72.1%** |

NPSO represents the reduction in energy consumption and demand by non-participants because of the influence of the program. For PY2020, 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 24.

# Energy Efficient Kits

## Gross Impact Methodology

### Energy Efficient Kit Faucet Aerator Saving Assumption

To calculate verified gross energy and demand savings for PY2020 EEK Program the faucet aerator measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.[9]

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

Equation 35. 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 36. EEK Faucet Aerator demand savings equation.

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

Table 25. Faucet Aerator Input Values

| Input | Bathroom | Kitchen | Source |
|---|---|---|---|
| %ElectricDHW | 0.42 | 0.42 | Appendix F |
| GPM_base | 2.2 | 2.2 | Appendix F |
| L_base | 1.6 | 4.5 | Appendix F |
| GPM_low | 1.5 | 1.5 | Appendix F |
| L_low | 1.6 | 4.5 | Appendix F |
| Household | 4.286 | 4.286 | Appendix F |
| DF | 0.9 | 0.75 | Appendix F |
| FPH | 2.2839 | 1.1875 | Appendix F |
| EPG | 0.0615328 | 0.0789713 | Appendix F |
| ISR | 0.48 | 0.4 | Appendix F |
| Coincidence Factor (CF) | 0.0000887318 | 0.0000887318 | Appendix F |
| Leakage | 0.72 | 0.72 | Appendix F |

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

[9] Ameren TRM Appendix F - Deemed Savings Table_Clean_2020_10_16.xlsx

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

To calculate verified gross energy and demand savings for PY2020 EEK program the low flow shower head measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 37. 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 38. Low Flow Shower Head Demand Savings.

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

Where:

ΔkWh = as calculated above

Table 26. Low-Flow Shower Head Input Values.

| Input | Value | Source |
|---|---|---|
| %ElectricDHW | 0.42 | Appendix F |
| GPM_base | 2.35 | Appendix F |
| L_base | 7.8 | Appendix F |
| GPM_low | 1.5 | Appendix F |
| L_low | 7.8 | Appendix F |
| Household | 4.286 | Appendix F |
| SPCD | 0.832 | Appendix F |
| SPH | 2.142 | Appendix F |
| EPG | 0.1089 | Appendix F |

| Input | Value | Source |
|---|---|---|
| ISR | 0.54 | Appendix F |
| Coincidence Factor (CF) | 0.0000887318 | Appendix F |
| Leakage | 0.72 | Appendix F |

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

To calculate verified gross energy and demand savings for PY2020 EEK program the 10W LED measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program tracking database.

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

Equation 39. LED Lighting Energy Savings.

$$\Delta kWh_{RES} =$$

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

Equation 40. LED Lighting Demand Savings

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

Table 27. LED Lighting Input Values.

| Input | Value | Source |
|---|---|---|
| $Watts_{Base}$ | 43 | Appendix F |
| $Watts_{EE}$ | 9 | Appendix F |
| ISR (cumulative) | 0.92 | Appendix F |
| $Hours_{Res}$ | 995.18 | Appendix F |
| WHF | 0.99 | Appendix F |
| Coincidence Factor (CF) | 0.0001492529 | Appendix F |
| %Res | 1 | Appendix F |
| Leakage | 0.28 | Appendix F |

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.[10] 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 28.

[10] 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.*

Table 28. 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

To calculate verified gross energy and demand savings for PY2020 EEK program the Dirty Filter Alarm measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 41. Dirty Filter Alarm Energy Savings

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

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

Equation 42. Dirty Filter Alarm Demand Savings

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

Table 29. Dirty Filter Alarm Input Values

| Input | Value | Source |
|---|---|---|
| kW Motor | 0.5 | Appendix F |
| $EFLH_{heat}$ | 1496 | Appendix F |
| $EFLH_{cool}$ | 869 | Appendix F |
| EI | 0.15 | Appendix F |
| ISR | 0.44 | Appendix F |
| Coincidence Factor (CF) | 0.0004660805 | Appendix F |
| %Heating | 0.9565 | Appendix F |
| %Cooling | 0.9565 | Appendix F |
| Leakage | 0.72 | Appendix F |

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

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit Pipe Insulation Wrap measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 43. Pipe Insulation Energy Savings

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

Equation 44. Pipe Insulation Demand Savings

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

Table 30. Pipe Insulation Input Values

| Input | Value | Source |
|---|---|---|
| $C_{Base}$ | .196 | Appendix F |
| $R_{Base}$ | 1 | Appendix F |
| $C_{EE}$ | 0.458 | Appendix F |
| $R_{EE}$ | 4.54 | Appendix F |
| L | 1 | Appendix F |
| ΔT | 60 | Appendix F |
| Hours | 8766 | Appendix F |
| $\eta DHW_{Elec}$ | 0.98 | Appendix F |
| Coincidence Factor (CF) | .0000887318 | Appendix F |
| ISR | 0.56 | Appendix F |
| %Electric | 0.42 | Appendix F |
| Leakage | 0.9187 | Appendix F |

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

$\eta DHW_{Elec}$ = 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

## Net Impact Methodology and Results

The evaluation team relied on NTGR values from surveys conducted in PY2019 for the PY2020 kit products (Table 31).

Table 31. PY2020 EEK Program Net-to-Gross Ratio

| Measure/Enduse | Free-Ridership (FR) | Participant Spillover (PSO) | NTGR (1-FR+PSO) |
|---|---|---|---|
| LED Light Bulbs | 63.64% | | 36.36% |
| Low-Flow Showerheads | 32.02% | 3.47% | 71.46% |
| Dirty Filter Alarm | 14.83% | 3.47% | 88.65% |
| Kitchen Faucet Aerators | 19.22% | 3.47% | 84.25% |
| Pipe Insulation (Hot Water) | 31.16% | 3.47% | 72.31% |
| Bathroom Faucet Aerators | 21.55% | 3.47% | 81.92% |
| **Overall Program Weighted Average** | **38.2%** | **2.2%** | **64.0%** |

Source: Ameren Missouri Program Year 2019 Annual EM&V Report. Volume 2: Residential Portfolio Report

# 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 from for the MFMR Program in PY2020.

### Lighting Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR lighting measures, the evaluation team used the lighting algorithm and some deemed values from Appendix F (v4.0) with project-specific values from the program-tracking database and rebate approval forms (RAFs).

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

Equation 45. 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 32. 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, 0.9818[11] | Appendix F |
| Hours | EXT Lighting BUS | Custom | Tracking Data |
| | Lighting BUS | Custom | Tracking Data |
| | Lighting Res | Custom | Tracking Data |
| WHF | EXT Lighting BUS | 1.00 | Appendix F |
| | Lighting BUS | 1.00 (unconditioned spaces_, 1.071 (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 |
| | Miscellaneous BUS | 0.0001379[12] | Appendix F |
| Leakage | EXT Lighting BUS | 0 | Appendix F |
| | Lighting BUS | 0 | Appendix F |
| | Lighting Res | 0, 0.0165 | Appendix F and Rebate Approval Forms |

## Hot Water Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR hot water measures (aerators, showerheads), the evaluation team applied Appendix F (v4.0) and actuals from the program-tracking database.

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

[11] ISR=0.9512 is for measure code 500900_2019_12_; ISR=0.9818 is for measure codes 404850_2019_12_ and 404950_2019_12.

[12] Miscellaneous BUS enduse is applied for the coincidence factor when lighting is operated 24/7.

Equation 46. 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 33. 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 34. 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 |
| EPG_electric | 0.07897128 | Appendix F |
| ISR | 1.00 | Appendix F |
| CF | 8.873E-05 | Appendix F |

Equation 47. 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 35. 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 PY2020 MFMR learning thermostat measures the evaluation team applied Appendix F (v4.0) and actuals from the program-tracking database.

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

Equation 48. Learning Thermostat Energy and Demand Savings Equations

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

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

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

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

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

Table 36. 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 | 0.067, 0.088 | Appendix F |
| Eff_ISR | 0.988 | 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 | Tracking Data |
| CoolingReduction | 0.08 | Appendix F |
| CF | 0.000947418 | Appendix F |

### Heat Pump Water Heater Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR Program heat pump water heater measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the program-tracking database and rebate approval forms.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 49.

Equation 49. Heat Pump Water Heater Energy and Demand Savings Equations

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

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

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

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

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

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

Table 37. Heat Pump Water Heater Input Values

| Heat Pump Hot Water Heater | Verified Inputs | Source |
|---|---|---|
| EFBase | Custom | Rebate Approval Forms |
| EFee | Custom | Rebate Approval Forms |
| GPD | 17.6 | Appendix F |
| Household | 2.65 | Appendix F |
| γWater | 8.33 | Appendix F |
| TOut | 125 | Appendix F |
| TIn | 57.898 | Appendix F |
| LF | 0.81 | Appendix F |
| WHFc | 53% | Appendix F |
| COPcool | Custom | Rebate Approval Forms |
| LM | 1.33 | Appendix F |
| %Cool | Custom | Rebate Approval Forms |
| WHFh | 43% | Appendix F |
| COP_Electric Resistance | 1 | Appendix F |
| COP_Heat Pump | 1.92 | Appendix F |
| %ElectricHeat_Electric Resistance | Custom | Rebate Approval Forms |
| %ElectricHeat_Heat Pump | Custom | Rebate Approval Forms |
| CF | 8.8732E-5 | Appendix F |

## Clothes Washer Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR Program clothes washer measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the rebate approval forms.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 50.

Equation 50. Clothes Washer Energy and Demand Savings Equations

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

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

Table 38. Clothes Washer Input Values

| Clothes Washer | Verified Inputs | Source |
|---|---|---|
| Capacity | Custom | Rebate Approval Forms |
| MEFbase | 1.7 | Appendix F |
| Ncycles | 2.2 | Appendix F |
| %CWbase | 2190 | Appendix F |
| %DHWbase | 6.5% | Appendix F |
| %ElectricDHW | 100% | Appendix F |
| %DryerBase | 100% | Appendix F |
| %ElectricDryer | 100% | Appendix F |
| MEFeff | 2.2 | Appendix F |
| %CWeff | 3.5% | Appendix F |
| %DHWeff | 14.1% | Appendix F |
| $\%Electric_{DHW}$ | 100% | Appendix F |
| %Dryereff | 1 | Appendix F |
| CF | 0.0001379439 | Appendix F |

## Clothes Dryer Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR Program clothes dryer measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the rebate approval forms.

The team calculated electric energy and demand savings using the algorithms outlined in Equation 51.

Equation 51. Clothes Dryer Energy and Demand Savings Equations.

$$\Delta kWh = \left(\frac{Load}{CEFbase} - \frac{Load}{CEFeff}\right) * Ncycles * \%Electric$$

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

Table 39. Clothes Dryer Input Values

| Clothes Dryer | Verified Inputs | Source |
|---|---|---|
| Load | Custom | Rebate Approval Forms |
| CEFbase | 3.1 | Appendix F |
| CEFeff | 3.9 | Appendix F |
| Ncycles | 1483 | Appendix F |
| %Electric | 100% | Appendix F |
| CF | 0.0001379439 | Appendix F |

## Wall Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR Program wall insulation measures, the evaluation team applied Version 8 of the Illinois TRM (IL TRM v8) and actuals and deemed values from the RAFs.

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

Equation 52. Wall Insulation Energy and Demand Savings Equations

$$\Delta kWh = kWh_{HeatingElec} + kWh_{Cooling} + kWh_{HeatingGas}$$

$$kWh_{HeatingElec} = \frac{\left(\left(\frac{1}{R_{old}} - \frac{1}{R_{Wall}}\right) \times A_{Wall} \times ((1 - FramingFactor_{Wall}) \times HDD \times 24)\right)}{n_{heat} \times 3412} \times ADJ_{WallHeat} \times \%ElectricHeat$$

$$kWh_{Cooling} = \frac{\left(\left(\frac{1}{R_{old}} - \frac{1}{R_{Wall}}\right) \times A_{Wall} \times ((1 - FramingFactor_{Wall}) \times CDD \times 24 \times DUA)\right)}{n_{cool} \times 1000} \times ADJ_{WallCool} \times \%Cool$$

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

$$\Delta Therms = \frac{\left(\left(\frac{1}{R_{old}} - \frac{1}{R_{Wall}}\right) \times A_{Wall} \times ((1 - FramingFactor_{Wall}) \times HDD \times 24)\right)}{n_{heat} \times 100{,}000} \times ADJ_{WallHeat} \times \%GasHeat$$

$$kW = \left(\frac{kWh_{Cooling}}{FLH_{cooling}}\right) \times CF$$

Table 40. Wall Insulation Input Values

| Wall Insulation | Verified Inputs | Source |
|---|---|---|
| %ElectricHeat | 100% | IL TRM v8[13] |
| R_old | 3.9 | IL TRM v8 |

[13] 2020 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0; https://ilsag.s3.amazonaws.com/2020_IL-TRM_Version_8.0_dated_October-17-2019_Final_Volumes_1-4_Compiled.pdf

| Wall Insulation | Verified Inputs | Source |
|---|---|---|
| R_wall | 7.6 | IL TRM v8 |
| A_wall | 1 | IL TRM v8 |
| FramingFactor | 25% | IL TRM v8 |
| CDD | Custom | Rebate Approval Forms |
| DUA | 0.75 | IL TRM v8 |
| nCool | Custom | Rebate Approval Forms |
| nHeat | Custom | Rebate Approval Forms |
| HDD | Custom | Rebate Approval Forms |
| ADJ_wall | 0.74 | IL TRM v8 |
| ADJ_WallCool | 0.80 | IL TRM v8 |
| ADJ_WallHeat | 0.60 | IL TRM v8 |
| %Cool | 100% | IL TRM v8 |
| %GasHeat | 0% | IL TRM v8 |
| Fe | 3.14% | IL TRM v8 |
| CF | 0.000466081 | IL TRM v8 |

## Windows Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFMR Program window measures, the evaluation team applied the 2017 Missouri TRM and actuals and deemed values from the RAFs.

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

Equation 53. 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 41. Window Input Values

| Windows | Verified Inputs | Source |
|---|---|---|
| CFMpre | Custom | Rebate Approval Forms |
| CFMpost | Custom | Rebate Approval Forms |
| EFLHcool | 1,171 | 2017 AMO TRM |
| ΔT_avgcooling | 5.8 | 2017 AMO TRM |
| LM | 3.0 | 2017 AMO TRM |
| ηcooling | Custom | Rebate Approval Forms |
| Ubase | Custom | Rebate Approval Forms |
| Ueff | 0.27 | 2017 AMO TRM |
| A_window | Custom | Rebate Approval Forms |
| SHGCbase | Custom | Rebate Approval Forms |
| SHGCeff | Custom | Rebate Approval Forms |
| Ψcooling | 40,996 | 2017 AMO TRM |
| EFLHheat | 1,433 | 2017 AMO TRM |
| ΔT_avgheating | 11.8 | 2017 AMO TRM |
| ηheating | Custom | Rebate Approval Forms |
| Ψheating | 66,592 | 2017 AMO TRM |
| CF | 0.001231928 | 2017 AMO TRM |

### Custom Measures

For some measures, the implemented team developed customized savings estimation methods—such as engineering analysis or building simulation model—with project-specific information about the building envelop, 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

### Participant Free Ridership

The FR assessment consists of two scores:

- A Program Influence component, based on the participant's perception of the program's influence on the decision to carry out the energy-efficient project; and
- A No-Program component, based on the participant's intention to carry out the energy-efficient project without program funds.

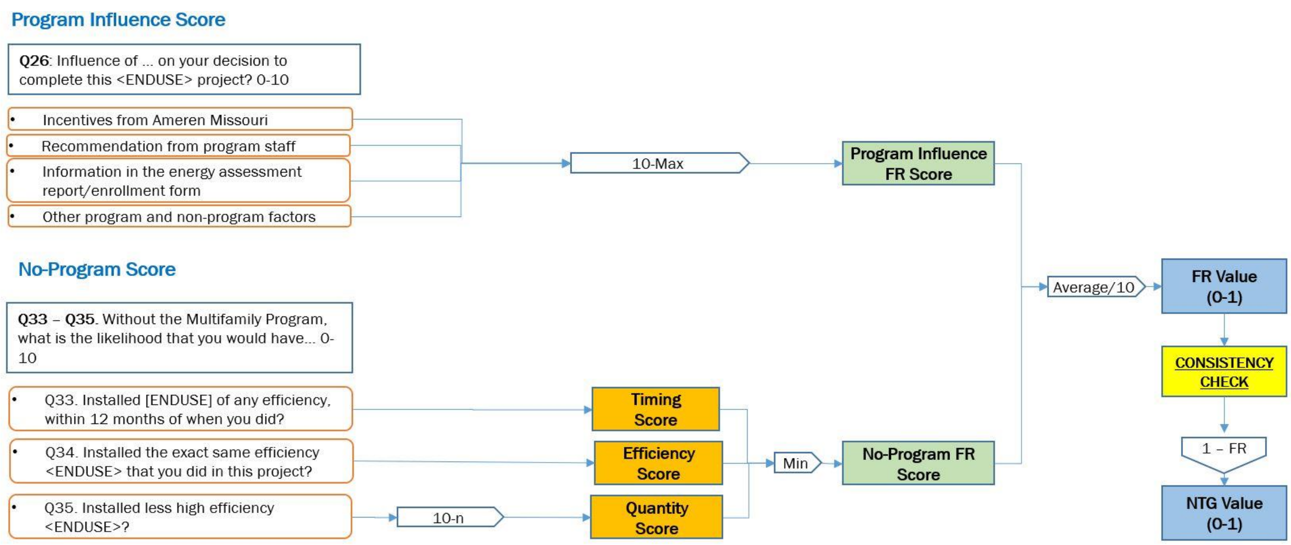
When scored, each component assesses the degree of FR associated with the project on a scale of 0 to 1, where 0 means the respondent is not at all a FR for the project and a 1 means the respondent is a complete FR for the project. The two scores are then averaged to derive a combined total FR score.

Equation 54. Free Ridership

$$Free\ Ridership\ (FR) = \ Mean(Program\ Influence, No\ Program\ Score)$$

As different and opposing biases potentially affect the two main components, the No-Program component typically indicates higher FR than the Program Influence component. Therefore, combining these decreases the biases. Figure 9 presents a diagram of the FR algorithm we will use, including references to question numbers.

Figure 9. Multifamily Market Rate Program Free Ridership Algorithm




## Calculation of the Program Influence Score

Program influence is assessed by asking respondents, on a scale from 0 (not at all influential) to 10 (extremely influential), how important they found various program elements to be on their decision to purchase the high-efficiency measure. Elements included as potential influences on customer decision-making: information; financial incentives; recommendations from contractors and program staff.

The Preliminary Program Influence Score equals the maximum influence rating for any program element rather than, for example, the mean influence rating. This is based on the rationale that if any given program element had a great influence on the respondent's decision, then the program itself had a great influence, even if other elements had less influence. An inverse relationship occurs between high program influence and FR: the greater the program influence, the lower the FR.

Equation 55. Program Influence Score

$$Program\ Influence\ Score\ (PI) = 10 - Preliminary\ Program\ Influence\ Score$$

### Calculation of the No-Program Score

The No-Program (NP) Score is based on three measures of the likelihood of a participant purchasing the exact same item(s) at the same time in the absence of the program. Each of these likelihood measures are assessed on a 0–10 scale in which 0 means “not at all likely” and 10 means “very likely.”

First, the participant is asked about their likelihood of purchasing an item of *any efficiency* within 12 months for the Timing (T) Score. A respondent stating the likelihood of purchasing an item of *any efficiency* within 12 months as a 5 on a scale of 0 to 10, is assigned a Timing Score of 5. Participants who were influenced by the program to replace still-functioning equipment will likely give a low score to this question, while participants who needed to replace burned out equipment will give a high score.

Next, the respondent is asked to gauge their likelihood of purchasing the *exact same item* (e.g., make, model, efficiency) had the program not existed. This measure forms the Efficiency (E) Score. A respondent stating the likelihood of purchasing the same exact item as a 5 on a scale of 0 to 10 is assigned an Efficiency Score of 5. Additionally, if multiple quantities of an item are purchased, the respondent is asked about the likelihood of purchasing fewer energy-efficient items. The response to this question is subtracted from 10 to compute the Quantity (Q) Score.

The No-Program Score is the minimum of the Timing, Efficiency, and (if applicable) Quantity Scores. Finally, the No-Program Score is averaged with the Program Influence Score to calculate the Final FR Value.

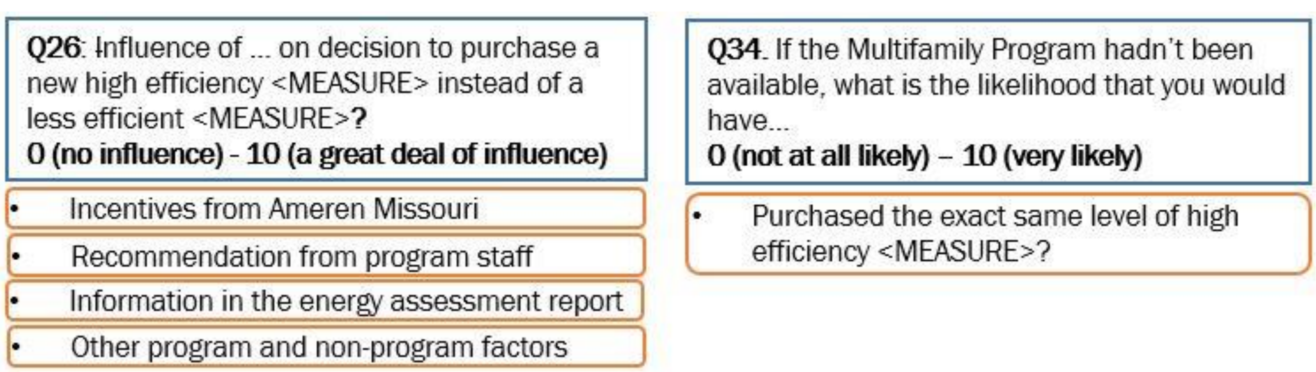
Equation 56. No Program Score

$$No\ Program\ Score\ (NP) = Min(T, E, Q)$$

### Consistency Checks

To address the possibility of conflicting or inconsistent responses, the interview 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 select and install the equipment included in their project (Q26), they should not, at the same time, say that they would have been highly likely to install equipment with the exact same level of efficiency (Q34) without the program (see Figure 10).

Figure 10. Questions Contributing to Consistency Check



To resolve any identified inconsistencies, the evaluation team assessed responses to a combination of closed-ended and open-ended questions, the first being the triggered consistency check question:

You provided a rating of <Q34> for how likely you would have been to select and install equipment with the same level of efficiency without the program, but also mentioned the <Q26 responses> were very important in the selection and installation of the efficient equipment. Can you please confirm the role the program played in your decision to select and install efficient equipment rather than a less efficient alternative? [OPEN END]

Would you like to change the 0 to 10 rating you previously gave for <Q26 responses>?

In addition, we looked at responses to the following questions in the NTG Module to provide additional context on participant decision-making:

Q30. How did the Multifamily Program change the efficiency level of the project? [OPEN END]

How did the Multifamily Program change the quantity of efficient equipment installed? [OPEN END]

How did the Multifamily Program change the timing of the project? [OPEN END]

Q37. Please think one more time about what action you would have taken if the program had not been available. Which of the following alternatives would you have been **most** likely to do?

## Participant Spillover

To determine if a respondent was eligible for SO savings, the interview guide contained a series of questions about additional energy efficiency 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 interview guide included two program influence questions:

Q41. How much did your experience with the Ameren Missouri Multifamily Program influence your decision to make these energy efficiency improvements on your own? [SCALE 0-10; 0 means “no influence” and 10 means “greatly influenced”]

How likely is it you would have still made these energy efficiency improvements if you had not received an incentive from the Ameren Missouri Multifamily Program? [SCALE 0-10; 0 means “definitely would not” and 10 means “definitely would”]

To supplement these numeric responses, the interview guide 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.

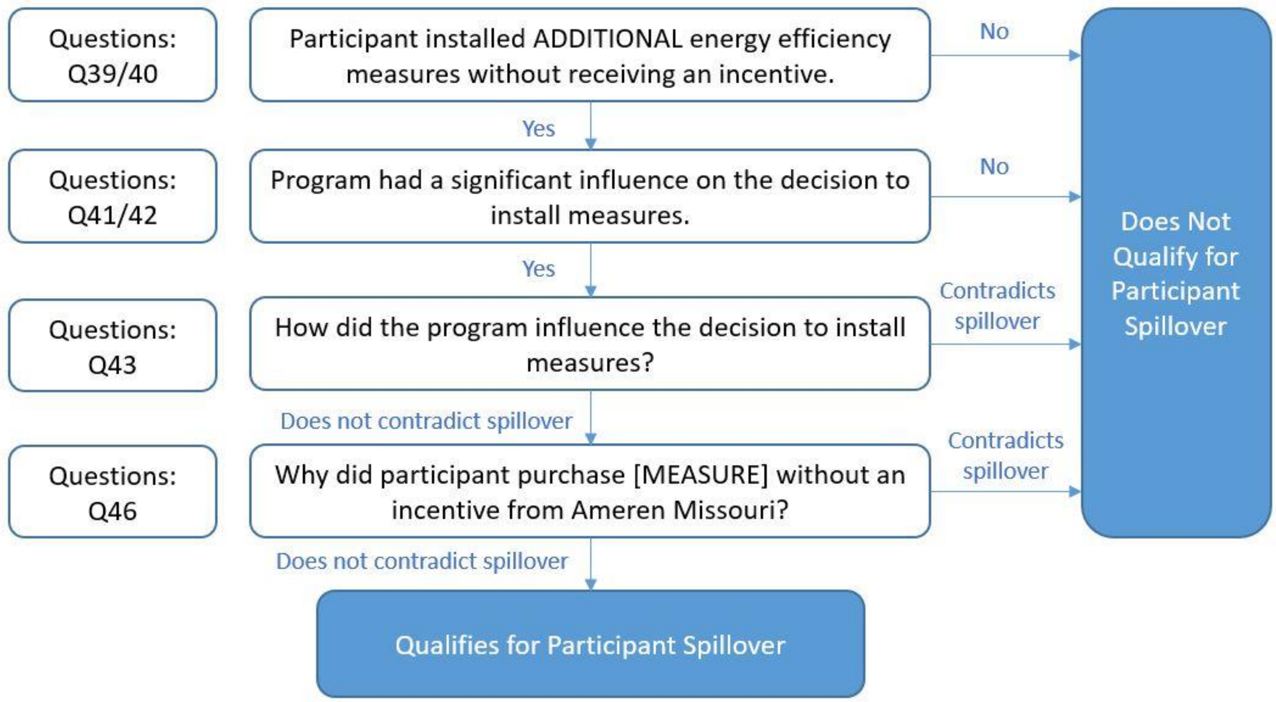
The Program Influence Factor is defined as follows:

Equation 57. Program Influence Factor

$$Program\ Influence\ Factor = (Q41\ Response + (10 - Q42\ Response)) \div 2$$

Figure 11 presents a diagram of the participant SO eligibility determination methodology used for this evaluation, including references to question numbers.

Figure 11. Participant Eligibility for Spillover




## Results

The evaluation team interviewed six MFMR participants to develop individual FR and PSO scores. Table 42 presents the results of our NTG analysis.

Table 42. PY2020 Multifamily Market Rate Program NTGR

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

Overall, the program played a key role in allowing respondents to expand the scope of their projects. Five participants noted they expanded the scope of their project as a result of engagement with the program; some added additional equipment to their project scope while others expanded the amount of equipment installed or treated more areas of the property. Additionally, three participants mentioned the program influenced the timing of their project by allowing them to replace many pieces of equipment at once, rather than through a piecemeal approach over several months or years. Lastly, two respondents reported the program influenced the efficiency level of the equipment they installed by freeing up necessary capital to select efficient technologies that are more expensive.

We found no participant spillover as part of the in-depth interviews conducted for the PY2020 evaluation.

# Appliance Recycling (RAR)

## Gross Impact Methodology

### Refrigerator Recycling Regression Analysis

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program refrigerator measure, the evaluation team applied Ameren Missouri TRM v4.0 Appendix I and Appendix F deemed savings tables to the program-tracking database .[14]

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

Equation 58. Refrigerator recycling regression-based analysis for calculating electric savings

$$\Delta kWh_{Unit} = \Big[0.5822 + (Age * 0.0269) + (Pre-1990 * 1.0548) + (Size * 0.0673) + (Side-by-side * 1.0706) + (Single-door * -1.9767) + (Primary\ Usage * 0.6046) + \left(\frac{CDD}{365} * unconditioned * 0.0200\right) + \left(\frac{HDD}{365} * unconditioned * -0.0447\right)\Big] * Days * Part\ Use\ Factor$$

Equation 59. Refrigerator recycling regression-based analysis for calculating demand savings.

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

Table 43. Refrigerator Input Values

| Input | Value | Source |
| --- | --- | --- |
| Age | Tracking data value | Tracking data |
| Pre-1990 | Tracking data value | Tracking data |
| Size | Tracking data value | Tracking data |
| Side-by-Side | Tracking data value | Tracking data |
| Single – Door | Tracking data value | Tracking data |
| Primary Usage | Tracking data value | Tracking data |
| CDD | 1678 | Appendix I |
| HDD | 4486 | Appendix I |
| Unconditioned | Tracking data value | Tracking data |
| Days | 365 | Appendix I |
| Part Use Factor (PUF) | 0.864 | Appendix F |
| Coincidence Factor (CF) | 0.000128611 | Appendix F |

Where:

Age = Age of retired unit

[14] The ex post savings were based on the Ameren TRM Appendix F - Deemed Savings Table_Clean_2020_10_16.xlsx, and the Appendix I - TRM-Vol 3_Res_2020_10_16.docx.

Pre-1990 = Designator of 1 if the unit was manufactured prior to 1990

Size = Capacity (cubic feet) or retired unit

Side – by – Side = Refrigerator specific characteristic

Single – Door = Refrigerator specific characteristic

Primary Usage = Retired unit primary or secondary unit

CDD = Cooling degree days

Unconditioned = Retired unit operated in a conditioned space

HDD = Heating degree days

Part Use Factor (PUF) = To account for the units that do not run throughout the entire year

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

### Freezer Recycling Regression Analysis

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program freezer measure, the evaluation team applied Ameren Missouri TRM v4.0 Appendix I and Appendix F to the program-tracking database.

The evaluation team would ideally use the following equations to calculate electric and demand energy savings. Due to missing data, however, the deemed savings values were used in the impact analysis for PY2020 seen at the bottom of Table 44.

Equation 60. Freezer recycling regression-based analysis for calculating electric savings.

$$\Delta kWh_{Unit} = [-0.8918 + (Age * 0.0384) + (Pre-1990 * 0.6952) + (Size * 0.1287) + (Chest\ Freezer * 0.3503) + (CDD/365 * unconditioned * 0.0695) + (HDD/365 * unconditioned * -0.0313)] * Part\ Use\ Factor$$

Equation 61. Freezer recycling regression-based analysis for calculating demand savings.

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

Table 44. Freezer Input Values

| Input | Value | Source |
|---|---|---|
| Age | Tracking data value | Tracking data |
| Pre-1990 | Tracking data value | Tracking data |
| Size | Tracking data value | Tracking data |
| Chest freezer | Tracking data value | Tracking data |
| CDD | 1678 | Appendix I |
| HDD | 4486 | Appendix I |

| Input | Value | Source |
|---|---|---|
| Unconditioned space | Tracking data value | Tracking data |
| Days | 365 | Appendix I |
| Part Use Factor (PUF) | Tracking data value | Tracking data |
| Coincidence Factor (CF) | .000128525 | Appendix I |
| kWh Deemed | 825.22 | Appendix F |
| kW Deemed | 0.139109 | Appendix F |

Where:

Age = Age of retired unit

Pre-1990 = Designator of 1 if the unit was manufactured prior to 1990

Size = Capacity (cubic feet) or retired unit

Chest Freezer = Freezer specific unit characteristic

CDD = Cooling degree days

Unconditioned = Retired unit operated in a conditioned space

HDD = Heating degree days

Part Use Factor (PUF) = To account for the units that do not run throughout the entire year

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

kWh Deemed = Deemed value of energy savings

kW Deemed = Deemed value of demand savings

## Room Air Conditioner Recycling Deemed Savings

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program room AC measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0.

The team used the following electric and demand savings values:

Table 45. Room Air Conditioner Deemed Savings Values

| | Value | Units | Source |
|---|---|---|---|
| Electric | 302.53 | kWh | Appendix F |
| Demand | 0.2866 | kW | Appendix F |

## Dehumidifier Recycling Deemed Savings

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program dehumidifier measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0.

The team used the following electric and demand savings values:

Table 46. Dehumidifier Deemed Saving Values

| | Value | Units | Source |
|---|---|---|---|
| Electric | 139 | kWh | Appendix F |
| Demand | 0.0648 | kW | Appendix F |

## Energy Efficient Kit Faucet Aerator Saving Assumption

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit faucet aerator measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 62. EE Kit 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 63. EE Kit Faucet Aerator demand savings equation.

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

Table 47. Faucet Aerator Input Values

| Input | Bathroom | Kitchen | Source |
|---|---|---|---|
| %ElectricDHW | 0.42 | 0.42 | Appendix F |
| GPM_base | 2.2 | 2.2 | Appendix F |
| L_base | 1.6 | 4.5 | Appendix F |
| GPM_low | 1.5 | 1.5 | Appendix F |
| L_low | 1.6 | 4.5 | Appendix F |
| Household | 2.65 | 2.65 | Appendix F |
| DF | 0.9 | 0.75 | Appendix F |
| FPH | 2.2839 | 1.1875 | Appendix F |
| EPG | 0.06153283 | 0.0789713 | Appendix F |
| ISR | 0.24 | 0.2 | Appendix F |
| Coincidence Factor (CF) | 0.0000887318 | 0.0000887318 | Appendix F |
| Leakage | 1 | 1 | Appendix F |

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

## Energy Efficient Kit Low-Flow Shower Head Saving Assumption

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit low flow shower head measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 64. 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 65. Low-Flow Shower Head Demand Savings.

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

Table 48. Low-Flow Shower Head Input Values.

| Input | Value | Source |
|---|---|---|
| %ElectricDHW | 0.42 | Appendix F |
| GPM_base | 2.35 | Appendix F |
| L_base | 7.8 | Appendix F |
| GPM_low | 1.5 | Appendix F |
| L_low | 7.8 | Appendix F |
| Household | 2.65 | Appendix F |
| SPCD | .832 | Appendix F |
| SPH | 2.142 | Appendix F |
| EPG | 0.1089 | Appendix F |
| ISR | 0.24 | Appendix F |
| Coincidence Factor (CF) | 0.0000887318 | Appendix F |
| Leakage | 1 | Appendix F |

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 Ameren Missouri territory

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

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit 10W LED measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 66. LED Lighting Energy Savings.

$$\Delta kWh_{RES} =$$

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

Equation 67. LED Lighting Demand Savings

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

Table 49. LED Lighting Input Values.

| Input | Value | Source |
|---|---|---|
| $Watts_{Base}$ | 43 | Appendix F |
| $Watts_{EE}$ | 9 | Appendix F |
| ISR (cumulative) | 0.88 | Appendix F |
| $Hours_{Res}$ | 995.18 | Appendix F |
| WHF | 0.99 | Appendix F |
| Coincidence Factor (CF) | 0.0001492529 | Appendix F |
| %Res | 1 | Appendix F |
| Leakage | 1 | Appendix F |

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, percent of homes in 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

## LED In-Service Rate

In 2019, the evaluation team estimated the ISRs for LEDs offered through kits component of the RAR Program using the installation trajectory approach recommended by the UMP.[15] 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 RAR are presented in Table 50.

Table 50. First Year and Future Trajectory ISR for RAR LEDs

| First Year ISR | Cumulative ISR |
|---|---|
| 0.656 | 0.879 |

## Energy Efficient Kit Dirty Filter Alarm Savings Assumption

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit Dirty Filter Alarm measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 68. Dirty Filter Alarm Energy Savings

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

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

Equation 69. Dirty Filter Alarm Demand Savings

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

Table 51. Dirty Filter Alarm Input Values

| Input | Value | Source |
|---|---|---|
| kW Motor | 0.5 | Appendix F |
| $EFLH_{heat}$ | 1496 | Appendix F |
| $EFLH_{cool}$ | 869 | Appendix F |
| EI | 0.15 | Appendix F |
| ISR | 0.09 | Appendix F |
| Coincidence Factor (CF) | 0.000466081 | Appendix F |
| %Heating | 0.9565 | Appendix F |
| %Cooling | 0.9565 | Appendix F |
| Leakage | 1 | Appendix F |

Where:

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

[15] 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.*

$EFLH_{heat}$ = 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

To calculate verified gross energy and demand savings for PY2020 Appliance Recycling Program EE Kit Pipe Insulation Wrap measure, the evaluation team applied Ameren Missouri TRM Appendix F v4.0 to the program-tracking database.

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

Equation 70. Pipe Insulation Energy Savings.

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

Equation 71. Pipe Insulation Demand Savings

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

Table 52. Pipe Insulation Input Values

| Input | Value | Source |
|---|---|---|
| $C_{Base}$ | 0.19635 | Appendix F |
| $R_{Base}$ | 1 | Appendix F |
| $C_{EE}$ | 0.458 | Appendix F |
| $R_{EE}$ | 4.54 | Appendix F |
| L | 1 | Appendix F |
| ΔT | 60 | Appendix F |
| Hours | 8766 | Appendix F |
| $\eta DHW_{Elec}$ | 0.98 | Appendix F |
| Coincidence Factor (CF) | 0.0000887318 | Appendix F |
| ISR | 0.41 | Appendix F |
| %Electric | 0.42 | Appendix F |
| Leakage | 1 | Appendix F |

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

$\eta DHW_{Elec}$ = 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

## Net Impact Methodology and Results

The evaluation team relied on NTGR values from PY2019 for the PY2020 net savings estimations. No new research was conducted in PY2020. Table 53. presents the results of our NTG analysis from PY2019.

Table 53. PY2020 Residential Appliance Recycling Program Measure-Level Net-to-Gross Ratio

| Measure/Enduse | Measure-level Respondents | Free Ridership (FR) | Participant Spillover (PSO) | NTGR (1-FR+PSO) |
|---|---|---|---|---|
| Freezer | 46 | 58.1% | 4.4% | 46.9% |
| Refrigerator | 143 | 62.6% | 4.4% | 42.3% |
| Room Air Cconditioners and Dehumidifiers (Ex Post Savings Weighted Appliance Value) | - | 61.3% | 4.4% | 43.6% |
| Bathroom Faucet Aerators | 149 | 21.6% | 1.2% | 79.6% |
| Dirty Filter Alarm | 149 | 15.7% | 1.2% | 85.5% |
| Kitchen Faucet Aerators | 149 | 21.4% | 1.2% | 79.8% |
| Low-Flow Showerheads | 149 | 28.0% | 1.2% | 73.2% |
| Pipe Insulation (Hot Water) | 149 | 34.1% | 1.2% | 67.1% |
| **Overall Program** | **338** | **56.5%** | **3.8%** | **47.7%** |

Source: Ameren Missouri Program Year 2019 Annual EM&V Report. Volume 2: Residential Portfolio Report

# Single Family Income Eligible (SFIE)

## Gross Impact Methodology

### Advanced Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program advanced thermostat measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

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

### Air Sealing Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE 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 ($CFM50_{Pre}$ and $CFM50_{Post}$ parameters), the evaluation team applied the "Test In / Test Out Approach" from Version 4.0 of the Ameren Missouri TRM Appendix I.
- For measures missing these data, the evaluation team applied the "Conservative Deemed Approach" defaults from Version 4.0 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 72. 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 73. Air Sealing Conservative Deemed Approach Energy and Demand Savings Equations

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

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

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

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

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

Table 54. 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 |
| $ηHeat_{electric}$ | 1.92 | Appendix I |
| $ηHeat_{gas}$ | 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 |

Ameren Missouri TRM Appendix I provides default values for the heating and cooling conversion factors $N_{cool}$ and $N_{heat}$, based on the number of home stories. 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 56).

Table 55. Ameren Missouri TRM Appendix I Default Values for Ncool and Nheat

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

Table 56. 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 74.

Equation 74. Air Sealing Calculated Values for $N_{cool}$ and $N_{heat}$

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

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

## Air Source Heat Pump (ASHP) Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program ASHP measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

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

Equation 75. 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 76. 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 57. 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<br>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 |

Table 58. Air Source Heat Pump Measure-Specific Input Values for SFIE Measures

| Input | Measure Reference ID | Value | Source |
|---|---|---|---|
| $Capacity_{Cool}$ | 352300_2019_12_ | 34,457 | Appendix F |
| $SEER_{EE}$ | 352300_2019_12_ | 15.13 | Appendix F |
| $Capacity_{Heat}$ | 352300_2019_12_ | 34,457 | Appendix F |
| $HSPF_{EE}$ | 352300_2019_12_ | 8.53 | Appendix F |
| $Capacity_{Cool}$ | 352500_2019_12_ | 35,376 | Appendix F |
| $SEER_{EE}$ | 352500_2019_12_ | 16.25 | Appendix F |
| $Capacity_{Heat}$ | 352500_2019_12_ | 35,376 | Appendix F |
| $HSPF_{EE}$ | 352500_2019_12_ | 8.43 | Appendix F |

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 for participants that received a tune-up on the existing equipment earlier in the year.

## Central Air Conditioner (CAC) Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program CAC measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

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

Equation 77. 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 78. 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 59. Central Air Conditioner Input Values for SFIE Measures

| Input | Value | Source |
|---|---|---|
| $EFLH_{Cool}$ | 869 | Appendix F |
| $Capacity_{Cool}$ | 35,735 for single family<br>24,000 for multifamily | Appendix F |
| $SEER_{Exist}$ | Custom | Tracking Data |
| $SEER_{Base}$ | 13 | Appendix F |
| $SEER_{EE}$ | 16.03 | 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 = $(1\text{-}1.44\%)^{Age}$, where "Age" is the age of the existing equipment in years (default = 12 years). We did not de-rate existing equipment 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 PY2020 SFIE Program ceiling insulation measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

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

Equation 79. 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 60. 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<br>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 PY2020 SFIE Program dirty filter alarm measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, 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 Table 61 below.

Table 61. 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 PY2020 SFIE Program duct insulation measures, the evaluation team applied Version 4.0 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 80. 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 62. 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 |

| Input | Value | Source |
|---|---|---|
| COP | 1.00 | Appendix F |
| Fe | 3.14% | Appendix F |
| ηHeat | 0.78 | Appendix F |
| CF | 0.000466081 | Appendix F |

## Electronically Commutated Motor (ECM) Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program electronically commutate motor (ECM) measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, Appendix F deemed savings tables to the program-tracking database.

Because of a July 2019 change in code requiring ECMs on all new furnaces, in PY2020 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, 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 PY2020 SFIE Program lighting measures, the evaluation team applied the Version 4.0 of the Ameren Missouri TRM, 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 Table 63 and Table 64.

Table 63. 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 64. 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 |

| Input | Single Family and Mobile Homes Channels | | Single Family Kits and Community Grant Channel | |
|---|---|---|---|---|
| | Value | Source | Value | Source |
| 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 PY2020 SFIE Program low flow faucet aerator measures, the evaluation team applied the Version 4.0 of the Ameren Missouri TRM, 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 Table 65.

Table 65. Low-Flow Faucet Aerator Input Values for SFIE 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 direct install; 57.2% for kits | 89% for direct install; 50.8% for kits | Appendix F |
| CF | 0.0000887318 | 0.00008873118 | Appendix F |

## Low-Flow Showerhead Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program low-flow showerhead measures, the evaluation team applied the Version 4.0 of the Ameren Missouri TRM, 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 Table 66.

Table 66. 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 |

| Input | Value | Source |
|---|---|---|
| $L_{base}$ | 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 | 89% for direct install; 58.5% for kits | Appendix F |
| CF | 0.0000887318 | Appendix F |

## Pipe Insulation Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 SFIE Program pipe insulation measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, 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 Table 67.

Table 67. 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 |
| $\eta DHW_{Elec}$ | 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 PY2020 SFIE Program setback thermostat measures, the evaluation team applied Version 4.0 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. Heating savings are calculated only for measures with electric heating equipment.

Equation 81. 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 68. 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 | Actual | Tracking Data |
| SBdegrees | 1.91 for cooling; 1.80 for heating | Appendix F |
| 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 PY2020 SFIE Program refrigerator measures, the evaluation team applied Version 4.0 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 82. Refrigerator Energy and Demand Savings Equations

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

Table 69. 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

To calculate verified gross energy and demand savings for PY2020 SFIE Program room air conditioner measures, the evaluation team applied Version 4.0 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 83. 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 70. 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 PY2020 SFIE Program tier 2 advanced power strip measures, the evaluation team applied the October 2020 Ameren Missouri TRM, 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 PY2020 SFIE Program tune-up measures, the evaluation team applied Version 4.0 of the Ameren Missouri TRM, 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 84. 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 71. Tune-Up Input Values for SFIE Measures

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

# Multifamily Income Eligible (MFIE)

## Gross Impact Methodology

This appendix contains detail on the savings assumptions used to estimate verified gross electric energy and electric demand savings from for the MFIE Program in PY2020.

### Lighting Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE lighting measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the program-tracking database and rebate approval forms (RAFs).

The evaluation team applied the rebate approval forms for the baseline wattage and WHF values. The savings equations, input parameters, and input values are described in the MFMR Program section.

### Advanced Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE advanced thermostat measures, the evaluation team applied Appendix F (v4.0) and actuals from the program-tracking database and RAFs. For measures with no thermostat type listed in the “Baseline Heating Equipment” field, “Manual” thermostat was assumed based on information in the RAFs.

The evaluation team applied the custom rebate approval forms for the heating capacity value. The savings equations, input parameters, and input values are described in the MFMR Program section.

### Programmable Thermostat Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE programmable thermostat measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the program-tracking database and RAFs.

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

Equation 85. Programmable Thermostat Energy and Demand Savings Equations

$$\Delta kWh_{cooling} = EFLH_{cool} * Capacity_{Cooling} * 2\left(\frac{1}{SEER}\right) * SBdegrees_{cooling} * SF_{cooling} * EF_{cooling}/1000$$

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

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

Table 72. Programmable Thermostat Input Values

| Programmable Thermostat | HVAC Type | Verified Inputs | Source |
|---|---|---|---|
| EFLHcool | All | 869 | Appendix F |
| Capacity_cooling | ASHP heating/cooling MF | 24,000 | Appendix F |
| | Electric furnace heating/central Air Conditioner MF | 12,000 | Appendix F |
| SEER | All | 10 | Appendix F |
| SBdegrees_cooling | All | 1.91 | Appendix F |
| SFcooling | All | 6% | Appendix F |
| EFcooling | All | 100% | Appendix F |
| %ElectricHeat | ASHP heating/cooling MF | 100% | Appendix F |
| | Electric furnace heating/central Air Conditioner MF | 100% | Appendix F |
| EFLHheat | ASHP heating/cooling MF | 1,496 | Appendix F |
| | Electric furnace heating/central Air Conditioner MF | 1,496 | Appendix F |
| Capacity_heating | ASHP heating/cooling MF | Custom | Rebate Approval Forms |
| | Electric furnace heating/central Air Conditioner MF | Custom | Rebate Approval Forms |
| HSPF | ASHP heating/cooling MF | 7.0 | Appendix F |
| | Electric furnace heating/central Air Conditioner MF | 3.41 | Appendix F |
| 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 PY2020 MFIE ASHP measures, the evaluation team applied version Appendix F (v4.0) and actuals from the program-tracking database.

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

### Ductless Minisplit Heat Pump Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE ductless minisplit heat pump measures, the evaluation team applied Appendix F (v4.0) and actuals from the program-tracking database.

The evaluation team applied the custom rebate approval forms for the existing SEER value. The savings equations, input parameters, and input values are described in the HVAC Program section.

### Air Conditioner Tune-Up Savings Assumptions

The implementer applied deemed savings values of 536 and 1,255 kWh based on the 2017 Ameren Missouri TRM algorithm and field measurements to estimate SEER, EER, and HSPF.

### Hot Water Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE hot water measures (aerators, showerheads), the evaluation team applied Appendix F (v4.0) and actuals from the program-tracking database.

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

### Refrigerator Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE refrigerator measures, the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the program-tracking database and rebate approval forms.

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

Equation 86. Refrigerator Energy and Demand Savings Equations

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

Table 73. 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 |

### Windows Savings Assumptions

To calculate verified gross energy and demand savings for PY2020 MFIE windows measures (Building Shell RES), the evaluation team applied Appendix F (v4.0) and actuals and deemed values from the RAFs.

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

### Custom Savings Assumptions

For some measures, the implemented team developed customized savings estimation methods—such as engineering analysis or building simulation model—with project-specific information about the building envelop, 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.

## 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 PY2020 evaluation plan, we planned to apply the NPSO percentages that we developed in PY2019 (13.7% for MWh and 7.7% MW) to PY2020 ex-post gross savings for four applicable programs: HVAC, Energy Efficient Products, Appliance Recycling, and Energy Efficient Kits. However, with the economic downturn due to the COVID-19 pandemic, we wanted to make sure that our plan to use the PY2019 results was still appropriate.

To make this determination, we looked to research conducted by the team in the summer of 2020. At that time, Opinion Dynamics conducted research with residential customers and HVAC contractors to assess the impact of the pandemic on Ameren Missouri residential customers and their likely program participation. Overall, our research found that the customers who are most likely to participate or make energy efficient upgrades outside a program were least impacted by the pandemic. These customers reported that the pandemic would have little impact on their purchase of energy efficient items or home improvements. For these reasons, we felt that applying the PY2019 NPSO percentage to PY2020 was reasonable despite the pandemic.

### 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 74 lists the eligible measures and their associated programs.

Table 74. PY2019 NPSO Eligible Measures

| Measure | Program |
|---|---|
| Kitchen faucet aerator | Energy Efficient Kits, Appliance Recycling |

| Measure | Program |
|---|---|
| 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 |
| 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.

### PY2020 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 75 and Table 76 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 75. NPSO Allocation by Program (MWh)

| Program | Ex-Post Gross Savings (MWh) | % Share | NPSO Allocation (MWh) | NPSO as % of Gross Savings |
|---|---|---|---|---|
| HVAC | 36,908 | 70% | 5,056 | 13.7% |
| Energy Efficient Products | 8,981 | 17% | 1,230 | |
| Appliance Recycling | 5,694 | 11% | 780 | |
| Energy Efficient Kits | 888 | 2% | 122 | |
| **Total** | **52,471** | **100%** | **7,189** | |

Table 76. NPSO Allocation by Program (MW)

| Program | Ex-Post Gross Savings (MW) | % Share | NPSO Allocation (MW) | NPSO as % of Gross Savings |
|---|---|---|---|---|
| HVAC | 21.27 | 88% | 1.79 | 7.7% |
| Energy Efficient Products | 1.57 | 7% | 0.22 | |
| Energy Efficient Kits | 0.98 | 4% | 0.07 | |
| Appliance Recycling | 0.28 | 1% | 0.01 | |
| **Total** | **27.17** | **100%** | **2.09** | |

# Appendix B. Income Eligible Pre-Period Consumption Data 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 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 2019–21 MEEIA Energy Efficiency Plan, the evaluation team provides the two key inputs to calculating average percent energy savings for the 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 PY2020 program-tracking data. The evaluation team reviewed all datasets for accuracy and completeness. The description of each data source is below.

- Program Tracking Data: Franklin Energy provided the evaluation team with participant tracking files for the SFIE and MFIE programs that included all PY2020 program participants through December 2020. 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.[16]
- Customer Billing Data: Ameren Missouri provided historic monthly electric billing data for all electric customers through December 2020. 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 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 PY2020. We dropped any premises associated with projects initiated in PY2019 and only kept premises associated with projects initiated and completed in PY2020. 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 2020 would cover July 2019–June 2020). Numerous premises had recorded pre-period usage across more than one associated account, particularly

[16] 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.

those included in the MFIE analysis. This could be due to tenant turnover, bill non-payment resulting in account 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; as such, 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. Thirty-one premises across the two programs (1.2% of total premises) had no recorded usage in the 12-month pre-period. Additionally, 24 premises (0.9% of total premises) had fewer than six months of recorded usage. Table 77 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 77. Pre-Period Consumption Data Availability

| | Single Family Income Eligible | | Multifamily Income Eligible | |
|---|---|---|---|---|
| | Count | Percent | Count | Percent |
| No Recorded Usage | 5 | 0.4% | 26 | 2.2% |
| Less than 6 months of Usage | 2 | 0.1% | 22 | 1.8% |
| More than 6 months of Usage | 1,409 | 99.5% | 1,117 | 95.9% |
| **Total Premises** | **1,416** | | **1,165** | |

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 78 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 78. Pre-Period Consumption

| Usage | Single Family Income Eligible (n=1,411) | Multifamily Income Eligible (n=1,139) |
|---|---|---|
| Total Annual kWh | 12,011,576 | 10,572,895 |

# 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 79, we provide data collection instruments for the HVAC and Multifamily Programs, along with the tasks and NTGR component that each instrument contributed to.

Table 79. Residential Program Evaluation Data Collection Instruments

| Program | Task | NTGR Component | File |
|---|---|---|---|
| HVAC Program | Downstream and midstream participant surveys | ▪ Participant FR<br>▪ Participant SO | PDF<br>Adobe Acrobat Document |
| HVAC Program | Distributor in-depth interviews | ▪ Distributor FR (midstream only) | PDF<br>Adobe Acrobat Document |
| Multifamily Market Rate | Participating property manager in-depth interviews | ▪ Participant FR<br>▪ Participant SO | PDF<br>Adobe Acrobat Document |

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