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| PY4 Appliance Recycling Program PJM Post Install M&V Demand Analysis Report  Draft |

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April 20, 2012

# I. Executive Summary

# II. Schedule/Timeline for M&V Activities

Installations (removals of equipment) occurred from June 2008 through May 2011, in three program program years.

Table . Equipment Removal Dates

|  |  |  |
| --- | --- | --- |
| **Program Dates** | **Program Year** | **Delivery Years** |
| 6/1/2008 – 5/31/2009 | PY1 | 2009, 2010, 2011 |
| 6/1/2009 – 5/31/2010 | PY2 | 2010, 2011 |
| 6/1/2010 – 5/31/2011 | PY3 | 2011 |

Metering was conducted on a staggered basis between July 2011 to March 2012.

# Summary of Changes from Original Plan

The metering period was extended. Metering began in July 2011 and ended March 2012. The original plan called for metering to be completed in January 2012, but difficulties in scheduling installations and equipment failures, required additional time in the field.

The length of metering per unit was lowered from 4 weeks to average of 3 weeks, primarily because the number of participants willing to have their appliance metered for the longer period of time was insufficient.

The final number of metered units changed slightly from original plan (Table 2) as difficulties in scheduling installations and equipment failures reduced the actual appliances with useable data.

**Table 2.** **Metered Appliances – Original Plan vs. Actual**

|  |  |  |
| --- | --- | --- |
| **Appliance Type** | **Original Plan** | **Actual** |
| Refrigerator | 100 | 102 |
| Freezer | 35 | 28 |
| Total | 135 | 130 |

# III. Equipment Specifications and Documentation

# IV. Measurement and Verification Approach

## Measurement and Verification Methodology

The evaluation approach for the Residential Appliance Recycling Program follows IPMVP Option B: Retrofit Isolation/Metered Equipment (Metering Study) & IPMVP Option D: Calibrated Simulation (Regression Analysis).

Equipment metering occurred in in situ, among appliances still in use among participating customers, and involved power, internal temperature and light loggers. Other data collection included participant self-report of space conditioning, and technician report of appliance characteristics. Verification of metered data involved assessment of appliance internal temperature, ambient (outside) temperature, and technician records. and verification of appliance characteristics using program tracking data.

Demand analysis followed a two-stage regression-based modeling process. During the first stage we estimate the relationship between observed demand and weather, peak hours and non-weekend holidays, which allows us to predict what demand would be during PJM performance hours. During the second stage we estimated the relationship between peak demand (as predicted in first-stage models) and unit characteristics. Using the coefficients from the relationships established in the second-stage model, we can estimate average per unit demand for each program year’s participant population (using summary statistics).

The part-use factor used to adjust the gross kW savings (to account for the proportion of the year that EE resources would have been in use) was estimated using participant surveys.

The evaluation approach for the Residential Appliance Recycling Program follows IPMVP Option B: Retrofit Isolation/Metered Equipment (Metering Study) & IPMVP Option D: Calibrated Simulation (Regression Analysis).

## Measurement Activity Description

Measurement activities for this EE resource include an in-situ metering study, regression analysis and telephone survey to determine part use factor.

### Measured Parameters and Variables

Table 3 below includes parameters and variables measured for this EE resource.

Table . Data Collected During Appliance Recycling Metering Study

|  |  |  |
| --- | --- | --- |
| **Data Point** | **Application** | **Data collection method** |
| Power (5 minute interval) | Energy usage and demand | Meters |
| Internal temperature (5 minute interval) | QA/QC power data (e.g., start and end dates/time of unit usage) | Meters |
| Light usage (on/off) | QA/QC power data (e.g., determine that unit was used during metering period) | Meters |
| Metering start and end dates & times | Clean power data and append weather | Technician report |
| Participant address and ZIP | Look up local weather data | Participant self-report and technician verification |
| Unit configuration | Potential association with energy consumption | Participant self-report and technician verification |
| Frost-free/manual defrost | Potential association with energy consumption | Participant self-report and technician verification |
| Through-door features | Potential association with energy consumption | Participant self-report and technician verification |
| Estimated Age | Potential association with energy consumption | Participant self-report and technician verification |
| Estimated Internal Capacity (size) | Potential association with energy consumption | Participant self-report and technician verification |
| Nameplate information | Look up additional information, if needed | Technician report |
| Primary/secondary unit | Study qualification; Potential association with energy consumption | Participant self-report |
| Location in home | Potential association with energy consumption | Participant self-report and technician verification |
| Air conditioned space (in summer) | Potential association with energy consumption | Participant self-report and technician verification |
| Heated space (in winter) | Potential association with energy consumption | Participant self-report and technician verification |
| Household occupants (#) | Potential association with energy consumption | Participant self-report |
| Occupants by age group | Potential association with energy consumption | Participant self-report |
| Part-Use Factors | Energy use and demand calculations | Participant Surveys |
| Hourly temperature and relative humidity data to calculated WTHI using PJM guidelines | Potential association with energy consumption | Rockford and O’Hare airports weather stations |

*Source: Appliance Recycling EM&V Team*

### Equipment Used in Measurement Activities

The metering study utililzed the following measurement equipment, which meet the requirements of Section 12 of PJM’s Manual 18B.

* Dent Elite power loggers – to measure power and power factor. The logger continuously samples the kW and averages it every 5 minutes.
* Hobo U12-012 temperature loggers – to measure cooling temperature inside the refrigerator. Takes a sample temperature every 5 minutes and stores it with a time stamp.
* Dent TOU light loggers – to measure door openings/closings by detecting the light going off and on.

### Metering Study Monitoring Interval

A metering study was conducted consistent with Option B: Retrofit Isolation/Metered Equipment. The Appliance Recycling metering study collected 5-minute interval demand and average kWh (from power meters), 5-minute interval internal temperature data, and light usage (on/off) from approximately 102 refrigerators and 28 freezers, between summer 2011 and winter 2012.[[1]](#footnote-1) The study team also recorded unit characteristics that have been associated with energy consumption in previous metering studies. Each unit was metered for a minimum of two weeks before being removed for recycling through the Appliance Recycling program.

### Sample Size and Statistical Accuracy

A sample size of approximately 55 refrigerators and 18 freezers is needed to estimate the unit energy consumption (UEC) of the recycled units with a one-tailed 90% confidence level (equivalent to two-tailed 80% confidence level) and 10% relative precision. However, to account for data attrition and propagation of error from the variance around part-use, and to obtain a confidence/precision level of 90/10, using a two-tailed test needed for ComEd’s energy savings analyses, we recommended a sample size of 135 (100 refrigerators and 35 freezers).

Participants were recruited and screened in a telephone survey. The evaluation team used a monetary incentive and multiple contact attempts to increase response rate and minimize non-response and selectivity bias.

Table 4 summarizes the units metered and the final metered sample after accounting for unuseable data associated with logger malfunctions.

Table . Metering Sample Frame and Final Sample

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Refrigerator** | **Freezer** | **Total** |
| **Total Metered Units** | **121** | **34** | **155** |
| Complete logger failurea | 13 | 6 | 19 |
| Partial logger failureb | 6 | 0 | 6 |
| **Units with valid power data** | **102** | **28** | **130** |

a Meter did not record any power data

b Meter either (a) recorded less than 1 day of data, or (b) recorded dates & times that could not be aligned with installation times)

A telephone survey of program participants was used to estimate part-use factors. These factors were used to adjust the annualized UEC estimates to reflect the number of months the recycled unit would have been operated absent the program. The participant telephone survey was also used for verification activity.

For the participant telephone survey, the sample size was selected to account for data attrition and propagation of error from the variance around part-use factors in each program year. The proportion of refrigerators and freezers was selected to align with recycled units. Table 5 displays sample refrigerator and freezer sample sizes used to estimate part-use factors in each year.

Table 5. Part-Use Factor Telephone Survey Sample Sizes

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Program Year 1** | **Program Year 2** | **Program Year 3** |
| **Refrigerator n** | 70 | 114 | 144 |
| **Freezer n** | 30 | 38 | 52 |
| **Total n** | **100** | **152** | **196** |

## Verification Activity Description

To verify the removal of specific refrigerators and freezers detailed in the ComEd program database, the evaluation surveyed participants each year and asked each respondent to verify their participation.

Measurement verification activities for appliance characteristics included a review of metering equipment technician records to verify that participant reported unit location and space conditioning (reported through telephone surveys) was accurate, as well as a review of the program tracking database (with implementation contractor records of appliance characteristics), to verify that technician reports were consistent with appliances that were recycled.

Measurement verification activities for power logger data included a review of each unit’s internal temperature and light logger data – in the context of ambient weather conditions and the unit’s location in the home – to verify that the unit was in use, and the power logger recorded power.

Regression modeling verification activities included model diagnostics and sensitivity analysis (of functional form and model specification) in each stage of modeling.

## Nominated EE Value Calculations

The demand savings were calculated following a two-stage modeling process. During the first stage we estimate the relationship between observed demand and weather, peak hours, and non-weekend holidays, which allows us to predict what demand would be during PJM performance hours. During the second stage we estimate the relationship between peak demand (as predicted in first-stage models) and unit characteristics. Using the coefficients from the second-stage model, we estimated demand for each year’s participant populationusing mean values of appliance characteristics. Because the demand savings are generated through the removal of existing equipment (appliances), the nominated EE value calculations utilize the “Current Load” Baseline approach. Below, we provide more detail on the calculations used in this analysis.

### First-Stage Models

Since appliance metering was staggered throughout 2011 and early 2012, not all appliances were metered during peak performance hours.[[2]](#footnote-2) Therefore we first estimated what peak demand would be for each unit in the sample. Two steps to predicting demand from first-stage

1. **Model peak demand for each unit in the meter sample:** We first established the relationship between demand and characteristics that defined “PJM performance hours” for each unit in the sample, using ordinary least squares (OLS) regressions for each unit. In these models, average hourly kW is regressed on weather (daily WTHI),a dummy variable defining peak hours, and a dummy variable for weekend/holiday days. Some appliance’s first-stage models included interaction terms among these variables to correctly specify each unit’s relationship with each of these factors.
2. **Predict average demand during PJM performance hours for each unit in the meter sample -** The models from step 1 were used to predict peak demand during PJM performance hours for each unit, assuming the WTHI value for the ComEd region posted by PJM (80.8), peak hours, and non-holiday weekends.

#### Model Specification

The goal of modeling was to best-fit the relationship between all three variables that define PJM performance hours. The basic form of each unit’s model is:

*AvekWt = WTHIt + PeakHourt + WeekendHolidayt + εt*

With parameters defined as:

*AveKWt*: Average kW at hour t, based on average of 5-minute interval kW reads across hour

*WTHIt*: Daily weighted temperature and humidity index at time t.[[3]](#footnote-3) A WTHI value of 80.8 is coincident with PJM RTO peak hour in ComEd territory.[[4]](#footnote-4)

*PeakHourt*: A dummy variable taking a value of 1 when the hour is in peak hours (1:00-5:00PM CST during standard time and 1:00-5:00PM CDT during daylight savings time)[[5]](#footnote-5)

*WeekendHolidayt*: A dummy variable taking a value of 1 when the hour falls on a weekend or holiday (a value of 0 would help define PJM performance hours)

*ε*t: Idiosyncraticerror

We tested six specifications of multivariate models for each unit in the sample, to determine whether interaction terms between the three PJM Performace criteria provided a better fit than the basic model. For the majority of units, we selected the best-fitting model (for extrapolating peak demand) primarily based on Akaike information criterion (AIC). However, for some models with very low explanatory power[[6]](#footnote-6) whose “best model” had more complex interaction terms, we defaulted to the simplest model (with only three terms). Table 6 summarizes the number of appliances whose demand was estimated with each model specification.

Table 6. Hourly Demand Models used for estimating Peak Demand

|  |  |  |
| --- | --- | --- |
| Description | Independent variables | Selected Models (n units) |
| Basic | *WTHI PeakHour WeekendHoliday* | 60 |
| With quadratic WTHI | *WTHI PeakHour WeekendHoliday WTHI2* | 27 |
| Interaction between Peak Hours and WTHI | *WTHI PeakHour WeekendHoliday Peak\*WTHI* | 11 |
| Interaction between Weekend/Holiday and WTHI | *WTHI PeakHour WeekendHoliday WeekendHol\*WTHI* | 14 |
| With quadratic WTHI and interaction between Peak Hours and WTHI | *WTHI PeakHour WeekendHoliday WTHI2 Peak\*WTHI* | 7 |
| With hourly indicators for each of four peak hours | *WTHI PeakHr1 PeakHr2 PeakHr3 PeakHr4 WeekendHoliday* | 11 |

#### Model Predictions

We retained an estimate of peak kW defined by the three PJM performance criteria explained above using the best model for each unit. The average and standard deviation of predicted peak demand is shown in Table 7. This also shows the mean and standard deviation of average hourly kW values observed through the metering period (using the average hourly kW value of each unit).

Table . Observed Average kW and Predicted Peak kW (n=130)

|  |  |  |
| --- | --- | --- |
|  | **Observed Demand[[7]](#footnote-7)** | **Peak Demand Estimates** |
| Mean Average kW | 0.109 | 0.142 |
| Coefficient of Variation | 0.67 | 0.62 |

### Second-Stage Model

We used Ordinary Least Squares (OLS) regression to model unit characteristics against peak demand impacts (n=130). The objective of the second-stage model is to use characteristics that were tracked in each of program years 1-3 (such as age, configuration, size, and location in the home). The final model generates an algorithm with a set of coefficients specific to PJM performance hours.

#### Model Specification

All relevant appliance characteristics available in program tracking data were considered for the model.[[8]](#footnote-8) We conducted sensitivity analysis (examination of model fit, multicollinearity and precision) under different specifications, such as:

1. Dummy variables for all configurations and appliance features (e.g., manual defrost and through-door features)
2. Main effects and alternate specification of continuous variables – age, cubic feet, label amps (e.g., squared term, natural log)
3. Location in home. The program tracks location in home, but does not currently track summer or winter space conditioning. Therefore location in home serves as a proxy for potential weather sensitivity – for example, units located in a garage, porch or patio may show more sensitivity to climactic conditions.
4. Interaction terms. We did not find any interaction terms to be significant at alpha level of 10% after controlling for the effects of their base additive terms.

In addition to testing alternate specifications, we conducted the following sensitivity analysis before determining that the cross-sectional model below best fits the relationship between peak demand:

* Alternative estimation of each unit’s peak demand (e.g., applying smoothing to hourly kW estimates before running models in
* Functional form of the dependent variable (natural log)
* Panel model (instead of two-step approach)
* Influential observation assessment (testing stability of estimates if low usage, or high usage, or units with large residuals are removed).
* Heteroskedasticity diagnostics and applicable corrections

#### The regression coefficients and t-statistics of the final cross-sectional model are presented below.

Table 8. Cross-Sectional Regression Coefficients

Dependent variable: Peak kW (n=130, Adjusted R2=0.26)

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Coefficient** | **Standard Error** | **t-statistic** |
| Side-by-Side (dummy) | 0.04920 | 0.01960 | 2.51 |
| Freezer (dummy) | 0.01988 | 0.01850 | 1.07 |
| Age | 0.01199 | 0.00233 | 5.15 |
| Age-squared | -0.0001443 | 0.00004 | -3.89 |
| Cubic Feet | 0.001156 | 0.00194 | 0.60 |
| Manual Defrost | -0.04503 | 0.01767 | -2.55 |
| Garage, Porch or Patio (dummy) | 0.04681 | 0.01416 | 3.31 |
| Constant | -0.09662 | 0.04661 | -2.07 |

To calculate per-unit savings in each year, we entered verified ex post participant population averages into the regression model. These values are reported in Appendix .

### Part-Use Factor

The part-use factor reflects the mean proportion of months that appliances are plugged in and in use in participants’ homes. Participants reported whether the appliance was in use for the full year prior to recycling, or whether it was in use for a portion of the year, and if so, the number of months. Therefore, the part-use factor reflects the likely proportion of the participant population (of appliances) that would have been plugged in and in use in a resource year, if the units were not recycled.[[9]](#footnote-9) Table 9 contains each year’s part-use factor and relative precision at 90% confidence in a one-tailed t-test.

### Peak Demand Savings Estimates

Peak demand savings in each year are calculated by multiplying gross kW savings per unit, the part-use factor, and the number of units recycled through the program. Precision estimates for adjusted gross savings propagate the standard errors of per unit savings estimates and part-use factor estimates.[[10]](#footnote-10)

Table 9. Nominated EE Value Calculation

|  |  |  |  |
| --- | --- | --- | --- |
|  | **PY1** | **PY2** | **PY3** |
| ***Per Unit Savings*** |  |  |  |
| Gross kW | 0.147 | 0.153 | 0.160 |
| Standard Error | 0.010 | 0.009 | 0.009 |
| Relative Precision | 8.75% | 7.52% | 7.16% |
|  |  |  |  |
| Part-Use Factor | 0.705 | 0.872 | 0.880 |
| Standard Error | 0.042 | 0.026 | 0.023 |
| Relative Precision | 7.73% | 3.79% | 3.39% |
|  |  |  |  |
| Adjusted Gross kW | 0.103 | 0.134 | 0.141 |
| Relative Precision | 11.68% | 8.42% | 7.92% |
|  |  |  |  |
| ***Total Savings*** |  |  |  |
| Number of Units | 11,513 | 25,011 | 39,983 |
|  |  |  |  |
| Adjusted Gross kW | 1,192 | 3,339 | 5,626 |
| Relative Precision | 11.68% | 8.42% | 7.92% |

Table 10 summarizes total nominated EE values by delivery year.

Table 10. Nominated Values by Resource Year

|  |  |
| --- | --- |
| **Delivery Year** | **Nominated EE value (kW)** |
| 2009 | 1,192 |
| 2010 | 4,531 |
| 2011 | 10,156 |

Appendix

Table 11. Refrigerator and Freezer Unit Characteristics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **PY1** | **PY2** | **PY3** | **PY1-PY2 Pooled** | **PY1-PY3 Pooled** | **Metering Sample** |
| Ex Post Count | 11,513 | 25,011 | 39,983 | 36,524 | 76,507 | 130 |
| % Refrigerator | 73.3% | 80.2% | 84.9% | 78.0% | 81.6% | 78.5% |
| % Freezer | 26.7% | 19.8% | 15.1% | 22.0% | 18.4% | 21.5% |
| *Refrigerator Configuration* |  |  |  |  |  |  |
| % Top Freezer | 10.3% | 46.0% | 49.1% | 34.7% | 42.2% | 52.3% |
| % Bottom Freezer | 0.7% | 2.6% | 9.6% | 2.0% | 6.0% | 4.6% |
| % Side-by-Side | 3.1% | 13.3% | 14.7% | 10.1% | 12.5% | 20.0% |
| % Single Door | 1.7% | 6.82% | 6.70% | 5.2% | 6.0% | 1.5% |
| % Unknown | 57.5% | 11.6% | 4.8% | 26.1% | 15.0% | 0.0% |
| *Freezer Configuration* |  |  |  |  |  |  |
| % Chest | 1.6% | 5.8% | 3.9% | 4.5% | 4.2% | 9.2% |
| % Upright | 2.4% | 12.7% | 8.8% | 9.4% | 9.1% | 12.3% |
| % Unknown | 22.7% | 1.3% | 2.4% | 8.0% | 5.1% | 0.0% |
| *Defrost Type* |  |  |  |  |  |  |
| % Manual | 51.3% | 38.6% | 14.4% | 42.6% | 27.8% | 28.4% |
| % Frost Free / Auto | 44.5% | 48.1% | 83.4% | 47.0% | 66.0% | 71.7% |
| % Part Frost Free | 0.1% | 2.1% | 0.7% | 1.5% | 1.1% | 0.0% |
| % Unknown | 4.1% | 11.2% | 1.5% | 9.0% | 5.1% | 0.0% |
| *Through Door Features* |  |  |  |  |  |  |
| % with Water/Ice | 17.6% | 23.0% | 25.6% | 21.3% | 23.5% | 19.7% |
| *Age* |  |  |  |  |  |  |
| Average age | 27.0 | 25.7 | 24.9 | 26.1 | 25.5 | 23.9 |
| % Age 15 years or higher | 89.6% | 86.0% | 70.5% | 87.1% | 78.4% | 84.6% |
| *Size & Amps* |  |  |  |  |  |  |
| Average size (cubic feet) | 16.8 | 17.6 | 18.0 | 17.4 | 17.7 | 18.8 |
| Average label amps | 4.8 | 5.5 | 5.9 | 5.3 | 5.6 | 7.0 |
| *Location* |  |  |  |  |  |  |
| % Garage | 45.9% | 47.85% | 45.3% | 47.2% | 46.2% | 56.2% |
| % Basement | 37.1% | 23.8% | 21.0% | 28.0% | 24.3% | 28.5% |
| % Kitchen / Other non-basement inside | 10.9% | 14.1% | 12.5% | 13.1% | 12.8% | 13.1% |
| % Porch / Patio | 0.6% | 2.0% | 3.5% | 1.6% | 2.6% | 1.5% |
| % Other or Unknown | 5.6% | 12.2% | 17.8% | 10.1% | 14.1% | 0.8% |

Table 12. Regression Relating DOE Test Annual UEC for Recycled Appliances to Explanatory Variables

| Variable Description | Coefficient | t-value |
| --- | --- | --- |
| Intercept | -422.4106 | -0.77 |
| Freezer dummy (=1 if freezer) | 169.0536 | 1.84 |
| Bottom freezer dummy (=1 if unit is bottom freezer) | 595.3794 | 2.91 |
| Side by side dummy (= 1 if unit is side-by-side) | -129.3553 | -0.34 |
| Single door dummy (= 1 if unit is single door) | -417.1026 | -4.73 |
| Frost free dummy (= 1 if unit is frost free) | -445.0348 | **-**1**.**00 |
| Natural log of unit age | 405.2134 | 2.15 |
| Cubic Feet of unit (per tracking system data) | 43.6478 | 4.59 |
| Label Amps | 104.1018 | 4.83 |
| Freezer dummy x frost free dummy | 319.1097 | 1.94 |
| Bottom freezer dummy x frost free dummy | -302.0484 | -1.28 |
| Side by side dummy x frost free dummy | 1451.3206 | 3.80 |
| Side-side dummy x amps | -126.4332 | -2.88 |
| Frost free dummy x ln(age) | 299.8206 | 2.09 |
| Dummy if unit age is 15 years or greater | 1197.8349 | 2.61 |
| Ln age x age 15 up dummy | -524.9782 | -3.08 |

1. Each unit was metered for about 2-4 weeks, therefore not all units have observations from the summer. [↑](#footnote-ref-1)
2. The metering schedule balanced needs for demand savings analysis and energy savings analysis, for which we needed more observations across winter and shoulder season to generate realistic estimates of annualized consumpAtion. [↑](#footnote-ref-2)
3. Because daily weather conditions and hourly temperature are highly correlated, we included only WTHI, because it is required for defining peak periods. Note that because PJM-defined hours are associated with higher average temperatures, the dummy variable for peak hours may capture some of the relationship between higher temperatures and demand. [↑](#footnote-ref-3)
4. WTHI standards are calculated as average of values from 1998 - 2011. Source: http://www.pjm.com/planning/resource-adequacy-planning/~/media/planning/res-adeq/load-forecast/20100308-weather-standards-for-use-in-load-management-certification.ashx [↑](#footnote-ref-4)
5. We also tested using hourly dummies for each peak hour. For most units, a single variable representing the peak period provided better model fit and statistical precision. [↑](#footnote-ref-5)
6. Indicating that the unit’s demand was minimally sensitive to weather, time of day or day of week during the metering period, and defined as having 5 or 6 of the 6 models a negative adjusted R-squared, and none or one of the three key variables significant in bivariate models. These units were examined on a case-by–case basis. [↑](#footnote-ref-6)
7. Corresponds to an average WTHI of 51.1 across units, and all hours and days of week. [↑](#footnote-ref-7)
8. We began by assessing the significance Variables and interaction terms that were significant in the original California model relating DOE test annual UEC (kWh) to explanatory variables. This model has been used to estimate ComEd ARP program savings for the past few years. Though this model is for savings and not demand, we wanted to test the multiple relationships between unit characteristics that were significant in previous studies (though not in ComEd territory) shown in Appendix Table 11. [↑](#footnote-ref-8)
9. We also examined whether the annual part-use factor would be different if calculated for summer months only, and found a minimal difference in the potential part-use factor and its standard deviation. [↑](#footnote-ref-9)
10. The standard errors used to find relative precision for savings estimates are the square root of the sum of squared standard errors divided by their respective means. [↑](#footnote-ref-10)