### Refrigerator and Freezer Recycling

###### Description

This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. Savings are provided based on a 2013 workpaper provided by Cadmus that used data from a 2012 ComEd metering study and metering data from a Michigan study, to develop a regression equation that uses key inputs describing the retired unit. The savings are equivalent to the Unit Energy Consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year. The reader should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary.

The Net to Gross factor applied to these units should incorporate adjustments that account for:

* Those participants who would have removed the unit from the grid anyway (e.g. customers replacing their refrigerator via a big box store and using the pick-up option, customers taking their unit to the landfill or recycling station);
* Those participants who decided, based on the incentive provided by the Appliance Recycling program alone, to replace their existing inefficient unit with a new unit. This segment of participants is expected to be very small and documentation of their intentions will be gathered via telephone surveys (i.e., primary data sources). For such customers, the consumption of the new unit should be subtracted from the retired unit consumption and savings claimed for the remaining life of the existing unit. Note that participants who were already planning to replace their unit, and the incentive just ensured that the retired unit was recycled and not placed on the secondary market, should not be included in this adjustment.

This measure was developed to be applicable to the following program types:  ERET.

If applied to other program types, the measure savings should be verified.

###### Definition of Efficient Equipment

n/a

###### Definition of Baseline Equipment

The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.

###### Deemed Lifetime of Efficient Equipment

The estimated remaining useful life of the recycling units is 8 years [[1]](#footnote-1).

###### Deemed Measure Cost

Measure cost includes the customer’s value placed on their lost amenity, any customer transaction costs, and the cost of pickup and recycling of the refrigerator/freezer and should be based on actual costs of running the program. The payment (bounty) a Program Administrator makes to the customer serves as a proxy for the value the customer places on their lost amenity and any customer transaction costs. If unknown assume $170[[2]](#footnote-2) per unit.

###### Loadshape

Loadshape R05 - Residential Refrigerator

###### Coincidence Factor

The coincidence factor is assumed to be 0.00012.

**Algorithm**

###### Calculation of Savings

###### Energy Savings[[3]](#footnote-3)

Refrigerators:

Energy savings for refrigerators are based upon a linear regression model using the following coefficients[[4]](#footnote-4):

|  |  |
| --- | --- |
| **Independent Variable Description** | **Estimate Coefficient** |
| Intercept | 83.324 |
| Age (years) | 3.678 |
| Pre-1990 (=1 if manufactured pre-1990) | 485.037 |
| Size (cubic feet) | 27.149 |
| Dummy: Side-by-Side (= 1 if side-by-side) | 406.779 |
| Dummy: Primary Usage Type (in absence of the program)  (= 1 if primary unit) | 161.857 |
| Interaction: Located in Unconditioned Space x CDD/365.25 | 15.366 |
| Interaction: Located in Unconditioned Space x HDD/365.25 | -11.067 |

ΔkWh = [83.32 + (Age \* 3.68) + (Pre-1990 \* 485.04) + (Size \* 27.15) + (Side-by-side \* 406.78) + (Proportion of Primary Appliances \* 161.86) + (CDD/365.25 \* unconditioned \* 15.37) + (HDD/365.25 \*unconditioned \*-11.07)] \* Part Use Factor

Where:

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Side-by-side = Side-by-side dummy (= 1 if side-by-side, else 0)

Single-Door = Single-Door dummy (= 1 if Single-Door, else 0)

Primary Usage = Primary Usage Type (in absence of the program) dummy

(= 1 if Primary, else 0)

Interaction: Located in Unconditioned Space x CDD/365.25

(=1 \* CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days

= Dependent on location[[5]](#footnote-5):

|  |  |  |
| --- | --- | --- |
| **Climate Zone**  **(City based upon)** | **CDD 65** | **CDD/365.25** |
| 1 (Rockford) | 820 | 2.25 |
| 2 (Chicago) | 842 | 2.31 |
| 3 (Springfield) | 1,108 | 3.03 |
| 4 (Belleville) | 1,570 | 4.30 |
| 5 (Marion) | 1,370 | 3.75 |

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 \* HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location:[[6]](#footnote-6)

|  |  |  |
| --- | --- | --- |
| **Climate Zone**  **(City based upon)** | **HDD 65** | **HDD/365.25** |
| 1 (Rockford) | 6,569 | 17.98 |
| 2 (Chicago) | 6,339 | 17.36 |
| 3 (Springfield) | 5,497 | 15.05 |
| 4 (Belleville) | 4,379 | 11.99 |
| 5 (Marion) | 4,476 | 12.25 |

Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used[[7]](#footnote-7).  For illustration purposes, this example uses 0.93.[[8]](#footnote-8)

For example, the program averages for AIC’s ARP in PY4 produce the following equation:

ΔkWh = [83.32 + (22.81 \* 3.68) + (0.45 \* 485.04) + (18.82 \* 27.15) + (0.17 \* 406.78) + (0.34 \* 161.86) + (1.29 \* 15.37) + (6.49 \* -11.07)] \* 0.93

= 969 \* 0.93

= 900.9 kWh

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients[[9]](#footnote-9):

|  |  |
| --- | --- |
| **Independent Variable Description** | **Estimate Coefficient** |
| Intercept | 132.122 |
| Age (years) | 12.130 |
| Pre-1990 (=1 if manufactured pre-1990) | 156.181 |
| Size (cubic feet) | 31.839 |
| Chest Freezer Configuration (=1 if chest freezer) | -19.709 |
| Interaction: Located in Unconditioned Space x CDD/365.25 | 9.778 |
| Interaction: Located in Unconditioned Space x HDD/365.25 | -12.755 |

ΔkWh = [132.12 + (Age \* 12.13) + (Pre-1990 \* 156.18) + (Size \* 31.84) + (Chest Freezer \* -19.71) + (CDDs\* unconditioned \*9.78) + (HDDs\*unconditioned \*-12.75)] \* Part Use Factor

Where:

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0)

Interaction: Located in Unconditioned Space x CDD/365.25

(=1 \* CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days (see table above)

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 \* HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days (see table above)

Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used[[10]](#footnote-10).  . For illustration purposes, the example uses 0.85.[[11]](#footnote-11)

The program averages for AIC’s ARP PY4 program are used as an example.

ΔkWh = [132.12 + (26.92 \* 12.13) + (0.6 \* 156.18) + (15.9 \* 31.84) + (0.48 \* -19.71) + (6.61 \* 9.78) + (1.3 \* -12.75)] \* 0.825

= 977 \* 0.825

= 905 kWh

###### Summer Coincident Peak Demand Savings

ΔkW = kWh/8766 \* CF

Where:

kWh = Savings provided in algorithm above

CF = Coincident factor defined as summer kW/average kW

= 1.081 for Refrigerators

= 1.028 for Freezers[[12]](#footnote-12)

For example, the program averages for AIC’s ARP in PY4 produce the following equation:

ΔkW = 806/8766 \* 1.081

= 0.099 kW

###### Natural Gas Savings

N/A

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: RS-APL-RFRC-V06-150601

1. KEMA “Residential refrigerator recycling ninth year retention study”, 2004 [↑](#footnote-ref-1)
2. The $170 default assumption is based on $120 cost of pickup and recycling per unit and $50 proxy for customer transaction costs and value customer places on their lost amenity. $120 is cost of pickup and recycling based on similar Efficiency Vermont program. $50 is bounty, based on Ameren and ComEd program offerings as of 7/27/15. [↑](#footnote-ref-2)
3. Based on the specified regression, a small number of units may have negative energy and demand consumption. These are a function of the unit size and age, and should comprise a very small fraction of the population. While on an individual basis this result is counterintuitive it is important that these negative results remain such that as a population the average savings is appropriate. [↑](#footnote-ref-3)
4. Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in July 30, 2014 memo from Cadmus: “Appliance Recycling Update no single door July 30 2014”. [↑](#footnote-ref-4)
5. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. [↑](#footnote-ref-5)
6. National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. [↑](#footnote-ref-6)
7. For example, the part-use factor that shall be applied to the current program year t (PYt) for savings verification purposes should be determined through the PYt-2 participant surveys conducted in the respective utility’s service territory, if available. If an evaluation was not performed in PYt-2 the latest available evaluation should be used.   [↑](#footnote-ref-7)
8. Most recent refrigerator part-use factor from Ameren Illinois PY5 evaluation. [↑](#footnote-ref-8)
9. Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in January 31, 2013 memo from Cadmus: “Appliance Recycling Update”. [↑](#footnote-ref-9)
10. For example, the part-use factor that shall be applied to the current program year t (PYt) for savings verification purposes should be determined through the PYt-2 participant surveys conducted in the respective utility’s service territory, if available. If an evaluation was not performed in PYt-2 the latest available evaluation should be used.   [↑](#footnote-ref-10)
11. Most recent freezer part-use factor from Ameren Illnois Company PY5 evaluation. [↑](#footnote-ref-11)
12. Cadmus memo, February 12, 2013; “Appliance Recycling Update” [↑](#footnote-ref-12)