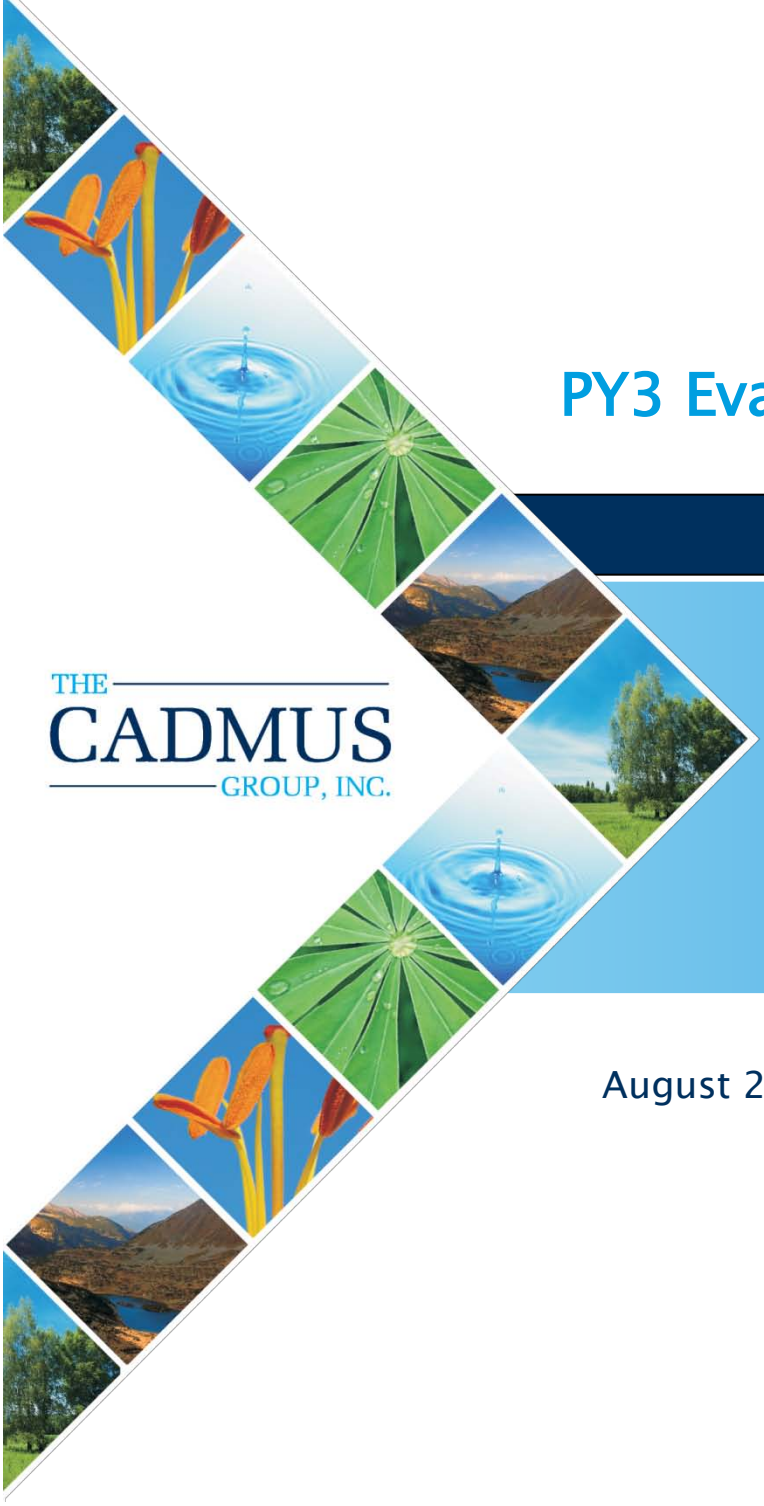


THE CADMUS GROUP, INC.

PY3 Evaluation

Appliance Recycling Program Evaluation

August 2011

Prepared by:

The Cadmus Group Inc. / Energy Services
720 SW Washington Street, Suite 400
Portland, OR 97205

503.228.2992

Prepared for:

Ameren Illinois

Prepared by:

Jane Colby

Kate Bushman

Andrew Carollo

M. Sami Khawaja, Ph.D.
Senior Vice President
The Cadmus Group Inc.

Table of Contents

1. Executive Summary 1

2. Introduction 4

Program Description 4

3. Evaluation Methods 5

Tracking Database Analysis 5

Data Sources 5

4. Program Results 6

Process Findings 6

Changes in Eligibility Requirements and Tracking 6

Participation and Marketing 7

Implementation 7

Impact Findings 7

Per-Unit Savings 7

Summary of Program Participation 10

Determination of Gross Savings 11

Determination of Net Savings 12

1. Executive Summary

The Ameren Illinois Appliance Recycling Program offers free recycling of refrigerators, freezers, and room air conditioners to residential and some commercial customers. The Cadmus Group Inc.'s (Cadmus') evaluation of Program Year 3 (PY3) consisted of reviewing and analyzing the tracking database from this program and applying savings estimates based on PY2 evaluation activities. Cadmus also interviewed program managers from Ameren Illinois and Conservation Services Group (program implementer) for a process review. Sources of savings estimates are displayed in Table ES-1.

Table ES-1. Savings Estimate Sources

Savings Estimate	Source
Recycled refrigerator per-unit energy savings	Calculated using PY2 regression model from Table 8 on page 14 of the Appliance Recycling Program Evaluation – PY2, dated September, 2010 (PY2 Report) , applying PY3 participant appliance characteristics from the PY3 tracking database.
Recycled freezer per-unit energy savings	Calculated using PY2 regression model from Table 9 on page 14 of the PY2 Report, applying PY3 participant appliance characteristics from the PY3 tracking database.
Recycled room AC per-unit energy savings	Calculated using the ENERGY STAR calculator for Peoria Illinois as described on page 17 of the PY2 Report.
NTG ratio	PY2 results from Ameren Illinois specific participant (n=159) and non-participant (n=32) surveys as described in the PY2 Report on pages 17-24.

A number of changes in program eligibility were implemented in PY3. Primary refrigerators became eligible for the program, and Ameren Illinois eliminated the minimum age requirement for appliances. These changes were implemented in January 2011 and therefore applied to only part of PY3.

Table ES-2 summarizes program participation and gross savings for each measure in the program.

Table ES-2. Program Gross Savings

Measure	Participation (units recycled)	Realized Gross Energy Savings (MWh)	Realized Gross Demand Savings (kW)
Recycled Refrigerator	7,202	7,847	977
Recycled Freezer	2,131	2,328	290
Recycled Room AC	13	12.6	5
Total - PY3	9,346	10,188	1,272

Table ES-3 summarizes the program's *ex ante* gross savings, realized gross savings, and the realization rate. The program realized 91percent of *ex ante* savings.

Table ES-3. *Ex Ante* Gross Savings, Realized Savings, and Net Savings

Measure	Ex Ante Gross Savings (MWh)	Realized Gross Savings (MWh)	Realization Rate	PY3 NTG Ratio	Net Energy Savings (MWh)	Net Demand Savings (kW)
Recycled Refrigerator	8,676	7,847	90%	0.79	6,199	772
Recycled Freezer	2,471	2,328	94%	0.82	1,909	238
Recycled Room AC	13	13	100%	1.0	13	5
Total - PY3	11,160	10,188	91%	0.80	8,121	1,015

The *ex ante* per-unit savings values used in the program tracking database were based on research performed during the PY2 evaluation, and were slightly higher than the realized per-unit savings. The new per-unit savings values calculated for PY3 reflect the characteristics of the units recycled, and the decrease in per-unit savings is a result of these characteristics.

Unit age has the greatest influence on gross savings, with older units consuming more energy than younger units. In order to mitigate the effect of changes in average unit age on realization of savings, Ameren Illinois used a tiered system of gross per-unit savings in its tracking database for PY3. Under this system, newer units were assigned lower *ex ante* savings. The tiered system differentiated between units manufactured before and after 1994 but did not account for variations in other influential characteristics such as volume. The tiered *ex ante* per-unit savings were planning estimates that approximated the expected savings associated with certain age categories; actual savings were based on the actual mix of products recycled and therefore realization rates are not 100 percent.

Program participation decreased during PY3, as shown in Table ES-4. A total of 9,333 units were recycled in PY3, a 17 percent drop from the previous year. The driver of this decreased participation was a 38 percent decrease in the number of freezers recycled in PY3 as compared to PY2. It is possible that the decrease in overall participation resulted from limited frequency of marketing, which the program manager noted as a challenge. It also may indicate that the early program years captured the existing inventory of refrigerators and freezers that consumers wanted removed, and as time goes on, the remaining number of qualifying units decreases.

Table ES-4. PY1–PY3 Participation Comparison: Refrigerators and Freezers

Measure	Number of PY1 Units	Number of PY2 Units	Number of PY3 Units	% Change from PY2 to PY3
Recycled Refrigerator	2,752	7,762	7,202	-7%
Recycled Freezer	1,096	3,422	2,131	-38%
Total	3,848	11,184	9,333	-17%

Program trends, as depicted in Figure ES-5, show that the bulk of participant units are refrigerators and that there is considerable seasonal variation in participation. These long-term

trends are similar to the patterns of participation in other appliance recycling programs elsewhere in the United States.

Figure ES-5. PY1, PY2, and PY3 Appliance Pickups by Month

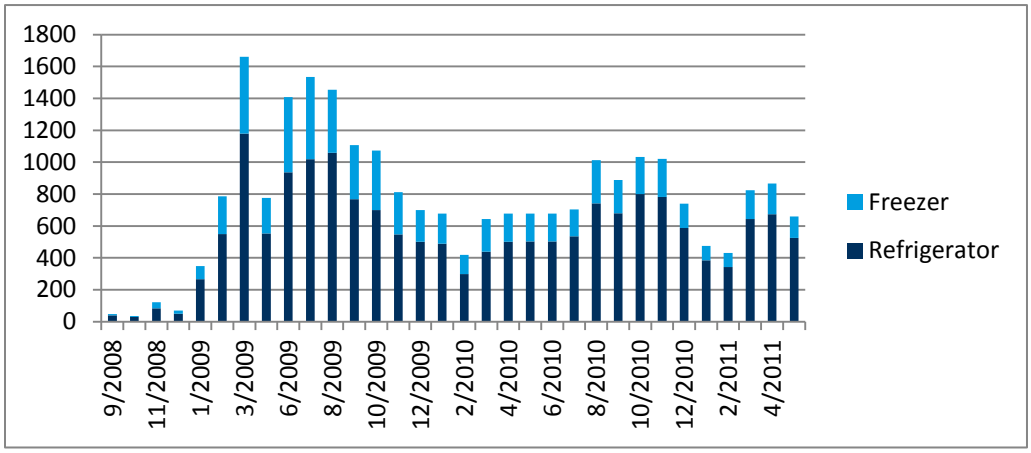


Table ES-6 summarizes and compares the PY3 results to PY1 and PY2 using NTG ratios calculated in each respective year. For PY3, Cadmus used the same NTG ratios for refrigerators and freezers as were applied in PY2. Although the addition of primary units may have affected program NTG ratios for PY3, Cadmus expects this effect is minimal since only 23 out of the 9,333 units recycled in PY3 were primary.

Table ES-6. PY1, PY2, and PY3 Appliance Recycling Program Gross and Net Results

Program Year	Gross Energy Savings MWh	Gross Demand Savings kW	Net Energy Savings MWh	Net Demand Savings kW
PY3	10,188	1,272	8,121	1,015
PY2	15,968	2,011	12,757	1,612
PY1	5,555	691	3,011	375
Total	31,711	3,975	23,889	3,001

2. Introduction

Program Description

The Ameren Illinois Appliance Recycling Program offers free recycling of refrigerators and freezers to residential and small commercial customers. Participants receive a $35 incentive payment, and the program implementer picks up and hauls the appliances to its recycling facility in Springfield, Illinois. The program not only removes older, inefficient appliances from use in Ameren Illinois' service territory, but also disposes of them in an environmentally responsible manner.[1]

Conservation Services Group (CSG) is the primary implementer for all of Ameren Illinois' residential demand-side management (DSM) programs, and Appliance Recycling Centers of America (ARCA) is the subcontractor with primary responsibility for implementing the Appliance Recycling Program.

The program is available to Ameren Illinois electric customers served under Residential Delivery Service (Rate DS-1) or Small General Delivery Service (Rate DS-2). Qualifying equipment is defined as follows:

- Appliances must be located on the account premises and must be operational at the time of pickup;
- Appliances must be full-sized units between 10 and 27 cubic feet; and
- Appliances must be household-type models (i.e., commercial refrigerators and freezers are not eligible).

As an additional service, the program will also pick up and recycle any working room air conditioners when picking up a refrigerator or freezer. No incentive is offered for air conditioners.

This report covers the program's third year (PY3).

[1] Oils, PCBs, mercury, and CFC-11 foam are properly disposed of, and CFC-12, HFC-134a, plastic, glass, steel, and aluminum are recycled.

3. Evaluation Methods

Tracking Database Analysis

CSG and ARCA track recycled appliances in a database. These files track numerous data points for each recycled unit, including the following:

- Customer name, address, and account number
- Unit type (refrigerator/freezer)
- Pickup description (first or second unit picked up from household)
- Incentive amount
- Unit characteristics including age, size, defrost type, and configuration
- Ameren Illinois' estimated energy and demand savings

Cadmus reviewed the unit data in the database, and calculated PY3 savings using the regression model developed for the PY2 evaluation. This method yielded a per-unit savings value that reflected the characteristics of the PY3 participant unit population.

Data Sources

The following data sources informed the impact and process evaluation:

- Final PY3 program database (provided by ARCA)
- Information gathered through program manager interview
- PY1 and PY2 reports and analysis

4. Program Results

Process Findings

Cadmus conducted two interviews with program staff to document changes to the program in PY3, to follow up on the status of PY2 recommendations, and to identify any challenges or successes that occurred during PY3. Table 1 shows the roles of the two individuals interviewed.

Table 1. PY3 Process Interviewees by Title

Organization	Role
Ameren Illinois	Program Manager
CSG	Operations/Program Manager

Changes in Eligibility Requirements and Tracking

Both interviewees noted a number of changes to the program in PY3. Most notably, there were two major changes to eligibility: primary refrigerators became eligible, and the minimum age requirement for refrigerators and freezers was eliminated. Beginning in January 2011, units that were being used as or had recently been used as primary refrigerators were allowed to be recycled through the program. Previously, only secondary units were eligible for participation. At the same time, the requirement that participating units be manufactured prior to 2000 was eliminated, opening up eligibility to refrigerators and freezers of any vintage.

The inclusion of primary units was the only major recommendation provided by Cadmus in the PY2 evaluation. Ameren Illinois recognized that this change could affect gross and net savings and requested further research from Cadmus to determine what these effects would be. In order to track savings accurately and account for the change in eligibility requirements, CSG made a change to the method for tracking savings in the program tracking database.

Beginning in PY3, units were assigned *ex ante* gross savings values based on their age. The values used in the tracking database, shown in Table 2, were calculated by Cadmus based on the regression model developed for the PY2 evaluation. This change addressed the fact that per-unit savings vary depending on appliance characteristics, and accounted for the influence that a different mix of appliances could have on *ex post* realized savings.

Table 2. PY3 *Ex Ante* Per-Unit Gross Savings Values Used in Tracking Database

Category	Gross Savings Per Unit (kWh)
Refrigerator – Pre-1994	1,467
Refrigerator – 1994-Plus	678
Freezer – Pre-1994	1,331
Freezer – 1994-Plus	425

Participation and Marketing

The two interviewees both stated that attempting to reach higher levels of participation was the most challenging aspect of the program during PY3. One interviewee reported that this program requires nearly constant marketing, so that when customers are ready to recycle an appliance, they remember that the program is available. The program staff members also noted that the most effective marketing tool they have is direct mail and bill inserts, but that they are limited in how frequently they can send direct mail about this program.

Both interviewees mentioned that new marketing efforts were introduced during PY3, including an effort to train trade allies in the appliance rebate program to promote the appliance recycling program. This effort, which was targeted to smaller locally owned appliance dealers, was not fully implemented until PY4.

Another new initiative during PY3, which did not lead to a large increase in participation, was an effort to partner with local nonprofit organizations including the Boys and Girls Club. Through this initiative, customers were referred to the program through the nonprofit, and an additional $10 was donated to the organization when a customer recycles an appliance. Program staff reported that customer participation in this initiative was low.

The overall marketing campaign was redesigned for PY3, and the Ameren Illinois staff member noted that it was a nice-looking campaign with a uniform look and feel. The campaign included stop-motion animation TV commercials, as well as printed materials for direct mail and online materials for the Ameren Illinois website. The program manager reported that the only challenge with the marketing campaign was that budgetary limits and limits on frequency of messaging made it difficult to reach customers as often as she would like to.

Implementation

The Ameren Illinois staff member pointed out that the implementation contractor, ARCA, does an excellent job implementing this program in the field. She noted that in the three years of program implementation, she has only received two complaints from customers, and that these were about scheduling. She also noted that ARCA contractors are extremely courteous and dedicated to serving the customer and leaving a good impression.

Impact Findings

Impact evaluation findings are presented in the following four subsections:

1. Per-unit savings
2. Summary of program participation
3. Determination of gross savings
4. Determination of net savings

Per-Unit Savings

In PY2 Cadmus independently estimated energy and demand savings for recycled refrigerators and freezers using a regression analysis, data provided in the program tracking database, and data collected in customer surveys. To develop an estimate of gross program savings for PY3, Cadmus leveraged the PY2 analysis and incorporated PY3 tracking data.

The measure-specific regression models were based on the California Energy Commission's (CEC's) energy consumption database of over 61,000 specific refrigerator and freezer makes and models manufactured between 1978 and 2008. [2] This database contains unit energy consumption (UEC) values for each appliance as reported by manufacturers, as well as the energy consumption determined using Department of Energy (DOE) appliance testing protocols. The regression model employs the DOE-based UEC as the dependent variable and various characteristics (configuration, age, size, etc.) of tested refrigerators or freezers as independent variables. The regression models are described in Table 3 and Table 4.

Table 3. PY2 Refrigerator Regression Model: Independent Variables

Refrigerators: R^2=0.83			
Independent Variable	Coefficient	Standard Error	t-value
Intercept	-1,166.6	9.59	-121.6
Age (years)	47.8	0.21	223.7
Volume (Cu. Ft.)	37.3	0.39	96.3
Dummy: Side-by-Side	227.5	3.03	75.0
Dummy: Bottom Freezer	211.4	4.91	43.0
Dummy: Automatic Defrost	429.5	5.62	76.5

Table 4. PY2 Freezer Regression Model: Independent Variables

Freezers: R^2=0.79			
Independent Variable	Coefficient	Standard Error	t-value
Intercept	-477.6	8.04	-59.4
Age (years)	30.3	0.24	125.1
Volume (Cu. Ft.)	31.2	0.25	124.4
Dummy: Upright Freezer	28.5	2.22	12.9
Dummy: Automatic Defrost	413.6	3.48	118.8

In order to apply these models to PY3 participant units, Cadmus analyzed the corresponding characteristics (the independent variables) for participating appliances (as captured in the program database by ARCA, the program implementer). Data were cleaned to eliminate outliers caused by data entry error, and PY3 averages for each independent variable (i.e., average age, average size, and proportion of each configuration) were calculated. Participant unit characteristics are summarized in Table 5 and Table 6.

An adjustment was made to the average age to account for the fact that the CEC database does not contain data on appliances manufactured prior to 1978. To prevent overstatement of consumption, any participating appliance manufactured before 1978 was assumed to have been manufactured in 1978. Without this adjustment, the average ages for participant refrigerators and freezers were 22.5 and 26.6, respectively.

[2] http://www.energy.ca.gov/appliances/database/historical_excel_files/2009-03-01_excel_based_files/Refrigeration

Table 5. PY3 Participant Unit Characteristics: Refrigerators

Independent Variable	PY3 Average
Adjusted Age (years)	21.00
Volume (Cu. Ft.)	17.74
Dummy: Side-by-Side	0.15
Dummy: Bottom Freezer	0.03
Dummy: Automatic Defrost	0.81

Table 6. PY3 Participant Unit Characteristics: Freezers

Independent Variable	PY3 Average
Adjusted Age (years)	24.24
Volume (CuFt)	16.01
Dummy: Upright Freezer	0.54
Dummy: Automatic Defrost	0.04

Next, Cadmus applied the average participant unit characteristics to the regression models to estimate annual UEC at the time of manufacture for average participating refrigerators and freezers. This approach ensures the resulting UEC is based on the specific units recycled through Ameren Illinois' program during PY3, and is not simply a secondary data source.

Next, two adjustments were made: a degradation factor was applied, and savings were adjusted for part-time use. The regression model estimates the energy consumption of units at the time of manufacture, not at the time of retirement. As a result, this consumption estimate must be adjusted for increases in energy usage that occur as refrigerators and freezers age. For this evaluation, Cadmus applied an annual degradation factor of 1.5 percent, based on DOE's National Energy Audit Tool, which uses a sliding scale of 1 to 2 percent.[3]

The part-use factor was derived from PY2 survey data and accounts for participating appliances not plugged in year-round prior to participation. Retirement of appliances not previously in operation or operated for only part of the year does not yield the full year of energy savings. To adjust annual energy consumption estimates for participating appliances not in use throughout the entire year, part-use factors were applied for refrigerators and freezers. The part-use factor is expected to differ for primary and secondary refrigerators, but since only 23 primary units were identified in the PY3 tracking database, this variation would have very little effect on total program savings. In future program years, participant survey data should be used to capture variation between primary and secondary units.

Table 7 reports estimated per-unit average annual energy consumption adjusted for degradation and shows the application of PY2 part-use factors to arrive at per-unit gross energy savings for participating refrigerators and freezers.

[3] The previous year's evaluation used slightly less conservative and now outdated degradation factors based on data from the 2004–2005 California Residential Appliance Recycling Program evaluation. A 1.5 percent degradation factor is in line with recent studies conducted by Cadmus. More information on the National Energy Audit Tool can be found on the Oakridge National Labs Website: http://weatherization.ornl.gov/assistant.shtml.

Table 7. Per-Unit Annual Energy Consumption and Per-Unit Gross Savings (PY3)

Measure	Average Unit Energy Consumption Adjusted For Degradation(kWh/Year)	PY2 Weighted Average Part-Use Factor	PY3 Per-Unit Gross Energy Savings (kWh/Year)
Recycled Refrigerator	1,239	0.88	1,090
Recycled Freezer	1,172	0.93	1,093

The PY3 per-unit gross savings estimates are substantially lower than the PY2 figures. This reflects differences in the average characteristics of units recycled in each program year. For example, the average adjusted age of PY3 refrigerators was 23 percent lower than the average adjusted age in PY2. Since age has a strong effect on unit energy consumption, this decrease (which reflects changes in program eligibility, as well as program maturation) had a downward effect on per-unit gross energy savings.

Air Conditioner Savings

In the PY2 evaluation, gross savings for room air conditioners were determined through an engineering analysis based on the ENERGY STAR® savings calculator for room air conditioning. Using Peoria, Illinois, as a reference city for weather adjustment, savings were assumed to equal a full year of energy consumption for a room air conditioner with EER 9.8. This assumption is conservative, given that older units are likely to be less efficient.[4] The gross per-unit savings value determined in PY2, shown in Table 8, was applied to the PY3 program.

Table 8. PY3 Per-Unit Gross Energy Savings for Room Air Conditioners

Appliance	Gross Energy Savings (kWh/year)
Room Air Conditioner	968

Summary of Program Participation

The program recycled 9,333 units over the course of PY3. Despite the change in eligibility requirements, only 23 refrigerators were identified as primary units in the participant database. Table 9 summarizes the number of appliances recycled and amount of incentives paid by appliance type, as reported in the program tracking database.

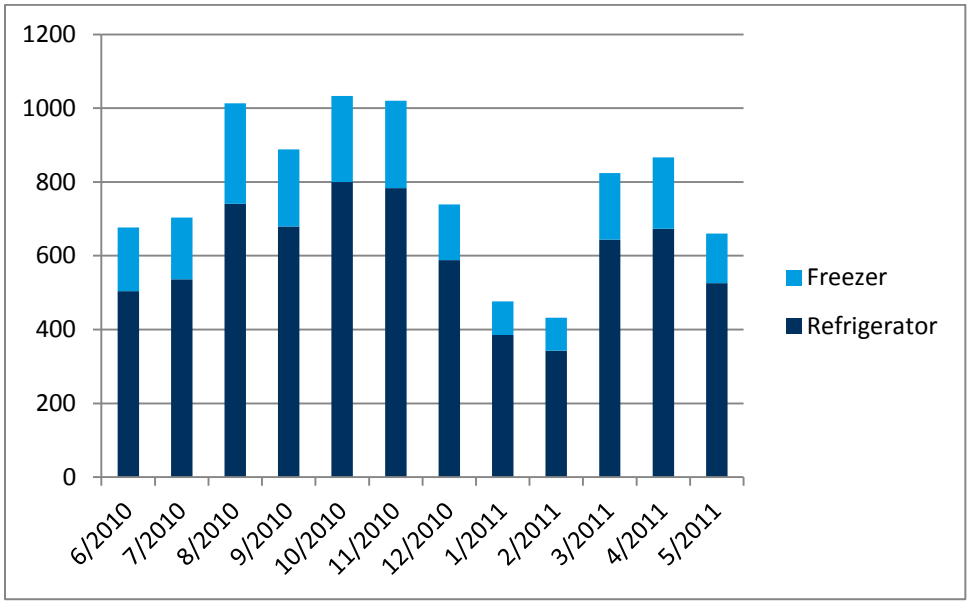
Table 9. PY3 Participation and Incentives Paid

Appliance	Quantity	Incentives $
Refrigerator - $35 incentive	7,202	$252,070
Freezer - $35 incentive	2,131	$74,585
Room Air Conditioner – No incentive	13	$0
Total	9,346	$326,655

[4] The average year of manufacture of the recycled units, according to the implementer database, was 1986.

Figure 1 shows refrigerator and freezer pickups by month for PY3. The program saw the strongest participation levels in late summer and fall, with a drop-off in December that lasted until March. These variations generally follow the pattern of seasonality established in PY2.

Figure 1. PY3 Appliance Pickups by Month



Determination of Gross Savings

Gross savings for the PY3 Appliance Recycling Program were determined from the following inputs:

- Average per-unit energy savings
- Number of appliances recycled

Realized gross energy savings are equal to per-unit energy savings multiplied by the number of appliances recycled. Demand savings for refrigerators and freezers are calculated by applying the coincidence factor determined in the PY1 cost-effectiveness evaluation.[5] For room air conditioners, a coincidence factor was determined by applying a residential cooling load shape adjusted for weather in Ameren Illinois territory. Table 10 shows the gross energy and demand savings for the program for PY3.

[5] The Cadmus Group: Ameren Illinois Utilities Portfolio Cost Effectiveness Evaluation, December 30, 2009.

Table 10. PY3 Gross Energy and Demand Savings

Measure	Participation (units recycled)	Per-Unit Gross Energy Savings (kWh)	Program Gross Energy Savings (MWh)	Program Gross Demand Savings (kW)
Recycled Refrigerator	7,202	1,090	7,847	977
Recycled Freezer	2,131	1,093	2,328	290
Recycled Room AC	13	968	13	5
Total	9,346	n/a	10,188	1,272

Determination of Net Savings

In PY2 Cadmus estimated the program's NTG ratios to be 0.79 for refrigerators and 0.82 for freezers, based on an analysis of survey response data. These same values were applied to PY3. Cadmus expects that the NTG ratio for primary refrigerators is slightly different from that for secondary refrigerators, but since only 23 primary units were identified in the PY3 tracking database, this variation would have very little effect on total program savings. In future program years, participant survey data should be used to capture variation between primary and secondary units.

As room air conditioners are picked up only as an additional service to customers already recycling another appliance, and no additional rebate is offered, a NTG ratio of 1.0 is applied for this measure. Table 11 shows *ex ante* gross savings, realized gross savings, and the application of the NTG ratios to arrive at net energy and demand savings.

Table 11. PY3 *Ex Ante* Gross Savings, Realized Savings, and Net Savings

Measure	Ex Ante Gross Savings (MWh)	Realized Gross Savings (MWh)	Realization Rate	PY3 NTG Ratio	Net Energy Savings (MWh)	Net Demand Savings (kW)
Recycled Refrigerator	8,676	7,847	90%	0.79	6,199	772
Recycled Freezer	2,471	2,328	94%	0.82	1,909	238
Recycled Room AC	13	13	100%	1.0	13	5
Total - PY3	11,160	10,188	91%	0.80	8,121	1,015

Over the three years the program has been in existence, Ameren Illinois has removed nearly 25,000 refrigerators and freezers from use. Table 12 shows the program participation and gross savings for each year in the three-year period.

Table 12. Three-Year Appliance Recycling Program Results

Measure	Program Participation			Gross Savings (MWh)		
	PY1	PY2	PY3	PY1	PY2	PY3
Recycled Refrigerator	2,752	7,762	7,202	4,188	11,387	7,847
Recycled Freezer	1,096	3,422	2,131	1,367	4,555	2,328
Recycled Room AC	0	27	13	0	26	13
Total	3,848	11,184	9,346	5,555	15,968	10,188