



Section 1. Introduction to the Program

1.1 Program Description

The Residential Appliance Recycling program was designed to achieve energy savings through the retirement and recycling of older, inefficient refrigerators, freezers, and room air conditioners. The primary objectives of the program are to:

- Decrease the retention of high energy-use refrigerators and freezers; and
- Deliver long-term energy savings.

A secondary objective is to dispose of these older refrigerators and freezers in an environmentally safe manner by offering comprehensive toxic material recycling and disposal that conforms with applicable environmental laws and regulations and permitting requirements.

The program’s primary focus is on resource acquisition, that is, cost-effective energy savings. It is **not** seeking to transform the market for recycling older appliances; for example, by developing the private sector’s capability to provide recycling as a paid-for service.

The table below shows the energy saving goals of the program in PY3 as provided by the Program Manager.

Table 1-1. ComEd Residential Appliance Recycling Program PY3 Goals

Goals	Net MWh Goal	Associated Units ¹
PY3	30,900	38,483
Estimated Achieved PY3 ²	33,093	41,024

Source: ComEd Program Staff

¹Unit Goals shift as the year goes on because refrigerators, freezers, and AC units all provide different kWh savings.

²ComEd Program Staff provided their ex ante savings estimate. The Associate Units of appliances were indeed the total number of units collected.

The Residential Appliance Recycling program began operation in June 2008. Program Year 3 (PY3) began on June 1, 2010 and ended on May 31, 2011. The program offers free pickup and recycling services for older, working refrigerators and freezers, and room air conditioners that households no longer want. Program savings are based on the accelerated removal, dismantling and recycling of these older, inefficient units.



The program is marketed through a combination of methods – bill inserts, radio ads, newspaper and newsletter advertisements, online marketing, and word-of-mouth. ComEd also used a direct mail campaign to customers from specific demographic groups who had participated in the past and were seen as likely to participate in the future.

JACO continued to implement the Appliance Recycling Program in PY3. JACO is responsible for the following functions: appliance pickups and related scheduling; processing program enrollments; deconstructing and recycling program units; responding to customer questions and complaints; and program tracking and reporting.

1.1.1 Measures and Incentives

In exchange for participating in the program, ComEd pays participants \$35 each for up to two recycled refrigerators or freezers per scheduled pickup. Operational room air conditioner (AC) units are also eligible for pick up and recycling, but they can only be picked up from sites where the recycler, JACO, is already collecting a refrigerator and/or freezer. Participants contributing these working room AC units also receive the \$35 program rebate.

1.2 Evaluation Questions

The evaluation sought to answer the following key researchable questions:

Impact Questions

1. What are the gross impacts from this program?
2. What are the net impacts from this program? What is the level of free ridership with this program? What is the level of participant spillover? How can free ridership be reduced?
3. Did the program meet its energy and demand goals? If not, why not?

Process Questions

1. Has the program as implemented changed from that in PY1? If so, how, why, and was this an advantageous change?
2. What are key barriers to participation in the program for eligible ComEd customers? How can they be addressed by the program?
3. How do customers become aware of the program? What marketing strategies could be used to boost program awareness?
4. Is the program outreach to customers and program partners effective in increasing awareness of the program opportunities?

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- a. What is the format of the outreach?
 - b. How often does the outreach occur?
 - c. Are the messages within the outreach clear and actionable?
5. How well are retail partnerships working? Are retail partner training, customer marketing and customer sign-up working well? How can the retail partnership program be improved?
 6. Are program incentive levels appropriate to encourage participation?
 - a. What is the influence of the incentive level versus the marketing effort on program participation levels?
 - b. How should the budget allocation between incentive spending and marketing spending be adjusted to maximize participation?



Section 2. Evaluation Methods

This section describes the analytic methods and data collection activities implemented as part of the PY3 process and impact evaluation of the Appliance Recycling program, including the data sources and sample designs used as a basis for the data collection activities.

2.1 Analytical Methods

2.1.1 Impact Evaluation Methods

Ex-Post Gross Program Savings

Refrigerators and Freezers. Ex-post gross energy savings are expressed in terms of Full-year Unit Energy Consumption (UECs). UEC estimates were made using a regression-based approach that models full-year energy savings as a function of unit age, size, configuration, and defrost mode. These regression equations are based on a large body of impact evaluation work that has already been completed in California, which rely on DOE lab metered results for over 2,000 units. The regression equations were applied to the characteristics of the population of units actually collected by JACO. In addition, gross savings estimates were adjusted for part-use, by applying findings from the telephone survey of program participants.

The regression equation that was used to estimate gross unit savings for recycled refrigerators and freezers is shown below in Table 2-1. This equation is from the evaluation of California's 2004-05 Appliance Recycling program⁴, and is based on a large database of over 1,600 previously metered units in California based on the DOE lab metering approach. The regression equation estimates usage as a function of unit characteristics (age, size, configuration, and defrost mode). All of the required data inputs to this equation were obtained from the program tracking data.

⁴ Although the evaluation of California's 2006-2008 Appliance Recycling program has recently been completed, the methodology for calculating impacts has been revised to be based on a relatively small database of *in situ* metered data. In addition, the regression equations based on lab-metering results were also updated. Concerns have been expressed about the validity of the new methodology and results of this evaluation, for this reason, the results have not been incorporated into this report.



Table 2-1. Regression Relating DOE Test Annual UEC for Recycled Appliances to Explanatory Variables

Independent Variables	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

These coefficients are applied to the characteristics of each of the units collected by the program in a 'bottom up' calculation, and then summed across all the units to yield the full-year Unit Energy Consumption or UEC.

Table 2-2 below lists the average value of each of these variables for the Refrigerators collected by the program in PY3.



Table 2-2. Average Refrigerator Characteristics for DOE Model Independent Variables

Independent Variables	
Freezer dummy (=1 if freezer)	0
Bottom freezer dummy (=1 if unit is bottom freezer)	11%
Side by side dummy (= 1 if unit is side-by-side)	17%
Single door dummy (= 1 if unit is single door)	8%
Frost free dummy (= 1 if unit is frost free)	28%
Average unit age in years	24.08
Natural log of unit age	3.07
Cubic Feet of unit (per tracking system data)	18.48
Label Amps	5.87
Dummy if unit age is 15 years or greater	67%

To compute energy savings for the average refrigerator, the following formula is thus applied using the coefficients from Table 2-1 and the values from Table 3-2:

$$\begin{aligned}
 \text{UEC} = & \text{intercept} + \text{freezer (FZ) dummy} + \text{bottom freezer (BF) dummy} + \text{side-by-side (SS) dummy} \\
 & + \text{single door (SD) dummy} + \text{frost free (FF) dummy} + \ln(\text{age}) + \text{size (cu.ft)} + \text{label amps} \\
 & + \text{FZ*FF} \quad \quad \quad + \text{BF*FF} \quad \quad \quad + \text{SS*FF} \quad \quad \quad + \text{SS*Amps} \\
 & + \text{FF*ln}(\text{age}) \quad \quad \quad + \text{Ln}(\text{age}>15) \text{ dummy} \quad \quad \quad + \text{Ln age} \times \text{age} \text{ 15 up}
 \end{aligned}$$

These regression values should continue to be used by ComEd to estimate and track ex-ante savings going forward into Program Year 4 until otherwise instructed.

Part-Use Adjustment. This full-year UEC value was then adjusted for part-use, based on self-reported findings from the completed telephone surveys. This adjustment pro-rates the full-year value for the proportion of the year that the unit would have been operated in the program's absence. The value of this adjustment was calculated directly from phone survey responses regarding the number of months during the year that the participant indicated the appliance would have been operated if the program had not picked it up. Average part-use factors were calculated across all respondents, separately for refrigerators and freezers.

Room Air Conditioners. The deemed savings review document (included in Section 6. Appendices) called for the energy consumption of residential room AC units to be estimated using the following equation:

$$kWh = \text{unit capacity} \times \text{load} \times \text{FLEH} / (\text{efficiency} \times 1000)$$

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where

unit capacity [BTU/h] is a nameplate value

load [dimensionless] is assumed to be 1.0 with partial loading accounted for in FLEH

FLEH (full-load equivalent hours) [hours] is basically the compressor run-time if we assume window AC units are generally a two-state device – on or off.

Efficiency [Btu out / Watts in] or Energy Efficiency Rating (EER) for equipment of this type

1000 is the conversion factor from Watts to kW

Ex-Post Net Savings Analysis

The primary objective of the net savings analysis for the Appliance Recycling program is to determine the program's net effect on customers' electricity usage. This requires estimating what would have happened in the absence of the program. Thus, after gross program impacts adjusted for part-use have been assessed, net program impacts are derived by estimating a Net-to-Gross (NTG) ratio which quantifies the percentage of the gross program impacts that can reliably be attributed to the program. A customer self-report method, based on data gathered during participant telephone surveys, was used to estimate the NTG ratio for this evaluation. This data was cross-checked against responses from surveys of used appliance haulers who provided anecdotal information regarding the disposal methods for the used appliances they process.

For PY3, the net program impacts were based solely on the estimated level of free-ridership in the program. In this program, free ridership is defined based on the percentage of program participants that would have disposed of their units absent the program in a manner that would have permanently removed the unit from the grid. This includes participants who indicated they would have otherwise:

- Sent the unit to a recycling facility, or
- Taken the unit to a landfill

Participant spillover was not assessed. For this program, because the program approach does not support a theory for how meaningful spillover might occur, and because it does seem unlikely to be significant, we have not estimated spillover.

2.1.2 Process Evaluation Methods

As in PY1 and PY2, the process evaluation consisted of in-depth interviews with the ComEd and JACO Appliance Recycling Program Managers, as well as telephone surveys with a large



sample of program participants. In addition, in-depth interviews were conducted with participating and non-participating retailers, and with two used appliance dealers, to provide a more comprehensive picture of the markets being addressed by the program.

- *Program Staff Interview.* The interview with the Appliance Recycling Program Managers at ComEd focused on changes and updates regarding the goals of the program, the program implementation, the perceived effectiveness of the program, and also verified evaluation priorities. The interviews with the JACO managers focused on the recycling process and the details of the appliance pickup.
- *Retailer Surveys.* The interviews with participating retailers focused on various processes that are unique to retailer participation including customer sign-up employee training, and program marketing. Interviews with non-participating retailers sought information on program awareness and acceptance, and general corporate policies and decision-making strategies regarding appliance recycling practices.
- *Used Appliance Hauler Surveys.* The interviews with used appliance 'haulers' sought to gauge whether owners/managers of these companies are noticing any change(s) to the secondary appliance market, as a result of consumers choosing to participate in ComEd's appliance recycling program. In addition, haulers were asked about their practices for disposing of appliances that they pick up (e.g., do they recycle, discard at land fill, or feed into secondary market, and does this vary by age or condition of the appliance).
- *Telephone Surveys.* The process evaluation component of the participant telephone survey obtained information on sources of program awareness, program satisfaction, rebate satisfaction, and awareness of program features (e.g., rebates, technical assistance, marketing materials).

In the telephone surveys, participants were asked numerous questions about satisfaction using a scale from 0 to 10, with 0 being the most dissatisfied, and 10 being the most satisfied. For the data analysis, the evaluation team grouped the responses into the following groups: 0 to 3 responses are classified as dissatisfied, 4 to 6 are classified as neutral, and 7 to 10 are classified as satisfied.



2.2 Data Sources

Table 2-3 below summarizes the key data collection activities in support of this evaluation.

Table 2-3. Data Collection Activities

Data Collection Type	Targeted Population	Sample Frame	Sample Design	Sample Size	Timing
Tracking Data Analysis	All Program Participants	Tracking Database	-	All	Ongoing
In-depth Phone Interviews	ComEd program manager	Contact from ComEd	Current and former AR PMs	2	March 29, 2011
	Implementation Contractor	Contact from ComEd	IC Retail Program Manager	2	April 8, 2011 and May 5, 2011
	Participating Retailers	Contacts from Program Implementer	Representatives from all three participating retailers	4 total – two from 1 retailer	July 1, 8 and 15, 2011
	Non-participating retailers	Internet Search – Any retailers other than the three participating retailers	Representatives from non-participating retailers	4	July 29, August 1-3
	Used Appliance Disposal and Hauling Services	Internet Search	Representatives from local haulers	2	August 3-4
CATI Phone Surveys	Program Participants	Tracking Database	Stratified Random Sample of AR Program Participants	202 Total – 151 Refrig., 51 Freezer, 30 Room AC Recyclers	August 2011

Note that the number of appliances represented exceeds the number of completed surveys. This is because some respondents interviewed had 2 or more measures.

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Below is a summary of how each of these data sources was used in the specific components of the evaluation study.

- Impact Evaluation

- *Estimation of gross savings/UECs.* All of the required data inputs to the regression equation used to develop final estimates of gross unit energy consumption for refrigerators and freezers were obtained from the program tracking database. The telephone survey also obtained several of these same characteristics. However, because they were based on self-reported information, rather than the results of a visual inspection of the units picked up by the program, they were deemed less reliable than the tracking data which was ultimately used for the calculation.
- *Estimation of the Part-use factor and Net-to-gross ratio.* Self-reported findings from the telephone survey of program participants was the primary data source for both the part-use factor and the net-to-gross ratio. For the Net-to-Gross ratio, the primary data source was the Participant survey, while it was planned that the Hauler survey findings could be used to validate the self-reported findings from the Participant survey. Because of the small sample size and the fact that those interviewed were in the business of removing appliances that were largely not working, the findings are too limited to inform the program net-to-gross ratio.

- Process Evaluation

The process evaluation relied primarily on four data sources: program staff interviews, a telephone survey of program participants, interviews with participating and nonparticipating retailers, and used appliance hauler surveys.

- *Program Staff Interviews.* The interview with the Appliance Recycling Program Managers at ComEd focused on changes and updates regarding the goals of the program, the program implementation, the perceived effectiveness of the program, and also verified evaluation priorities. The interviews with the JACO managers focused on the recycling process and the details of the appliance pickup.
- *Retailer Surveys.* The interviews with participating retailers focused on various processes that are unique to retailer participation including customer sign-up, employee training, and program marketing. Interviews with non-participating retailers sought information on program awareness and acceptance, and general corporate policies and decision-making strategies regarding appliance recycling practices.
- *Used Appliance Hauler Surveys.* The interviews with used appliance 'haulers' sought to gauge whether owners/managers of these companies are noticing any change(s) to the secondary appliance market, as a result of consumers choosing



to participate in ComEd's appliance recycling program. In addition, haulers were asked about their practices for disposing of appliances that they pick up (e.g., do they recycle, discard at land fill, or feed into secondary market, and does this vary by age or condition of the appliance).

- *Participating Customer Surveys.* The process evaluation component of the participant telephone survey obtained information on sources of program awareness, program satisfaction, rebate satisfaction, and awareness of program features (e.g., rebates, technical assistance, marketing materials).

2.3 *Sampling Plan*

Participant survey. The sample of Appliance Recycling participants was randomly selected from the Program Tracking Database provided by ComEd. Basic data cleaning steps were undertaken before the sample was pulled from the database so that for example, records with missing or invalid phone numbers were removed. A total of 1,036 participants who recycled more than one of the same type of major appliance were dropped from the survey effort for ease of survey administration. (To avoid survey fatigue, participants were only asked about one major appliance so respondents could more easily focus on a single appliance in their responses.) In addition, 1,336 participants were dropped because of duplicate or missing phone numbers or because the tracking database indicated they were a business. These records could not be included in the surveying efforts but were included in the final impact results. The final participant population from which the survey sample was drawn was 35,735 participants.

The sample was stratified by appliance type and quotas were set based on the proportion of each appliance in the general population. Each participant was assigned to one of six strata based on the type of unit or units recycled: Primary Refrigerator, Secondary Refrigerator, Primary Refrigerator and AC Unit, Secondary Refrigerator and AC unit, Freezer, and Freezer and AC Unit.⁵ Quotas were then set for each stratum. The Freezer strata were oversampled to ensure sufficient data would be available to support the impact and process analysis. Because of the oversampling, weights were then constructed for each stratum that reflect that stratum's share of the Appliance Recycling program population.

Opinion Dynamics Corporation (ODC) was then instructed to randomly select and dial participants until they had reached the following quotas – 150 Refrigerator Recyclers, 40 Freezer Recyclers, and 10 Room AC Recyclers, for a total of 200 completed surveys. Ultimately, 202 surveys were completed. Table 2-4 shows the population sizes and number of completed surveys for each of the six strata.

⁵ Participants who recycled both a refrigerator and a freezer were randomly assigned a major appliance for the survey to limit survey fatigue.



Table 2-4. PY3 Participant Survey Population and Sample Sizes by Stratum

Strata (Types of Units Recycled)	Population Size* (N)	Completed Surveys (n)
Primary Refrigerator	7,202	30
Secondary Refrigerator	24,081	99
Primary Refrigerator and AC Unit	344	4
Secondary Refrigerator and AC unit	514	11
Freezer	4,967	43
Freezer and AC Unit	143	9
Refrigerator, Freezer and AC Unit	29	0
AC Unit	7	6**
Total	38,107	202

*Source: PY3 Appliance Recycling Participant Survey Sample Frame from Program Tracking Database

**It was not part of the sample design to get AC only participants. All of these participants had a tracking database entry that showed either a refrigerator or a freezer recycled through the program. However, when we surveyed these participants about their recycled measures they stated that they only recycled AC units.

2.4 Sampling Error

Table 2-5 gives population sizes, completed interviews and the associated confidence intervals for each appliance type.

Table 2-5. PY3 Participant Survey Population, Sample Sizes and Sampling Error by Appliance Type

Strata	Population Size* (N)	Completed Surveys (n)	Sampling Error (90% CI)
Recycled Refrigerators	33,937	114	7.92%
Recycled Freezers	6,046	38	12.18%
Totals	39,983	152	6.77%

*Source: PY3 Appliance Recycling Participant Survey Sample Frame from Program Tracking Database

²This column sums to more than 200 completed surveys to meet unit type quotas and because some respondents recycled more than one appliance type. All completed surveys are included in the analysis of each subgroup.



2.4.1 Survey Disposition

Table 2-6 shows the final dispositions for the 1,369 program participants we attempted to contact for this evaluation. As the table shows, we completed interviews with 202 participants, or 15%. We were unable to reach 42% for a variety of reasons such as no one answering, an answering machine, or a busy signal. Another 10% requested to be called back later to complete the survey but did not end up doing so.⁶ There were problems with the phone number, such as a disconnected number, for 9%. Finally 16% of participants who answered refused to participate in the survey.

Table 2-6. Participant Survey Sample Disposition

Sample Disposition	Customers	%
Participants Attempted to Contact	1,369	100%
Completes	202	14.8%
Appliance not picked up	34	2.5%
Electric company not ComEd	7	0.5%
Refusal	220	16.1%
Unable to Reach	580	42.4%
Language Barrier	11	0.8%
Phone Number Issue	117	8.5%
Non-Specific Callback/Appointment Scheduled	132	9.6%
Mid Interview Terminate	66	4.6%

Source: PY3 Appliance Recycling Participant Survey

As outlined in Table 2-7, interviews were attempted with 1,369 participants and completed with 202 participants. The remaining 1,167 did not complete full surveys for several reasons including participants terminated mid-interview (n=66), the participant claimed they signed up for the program but the appliance was never picked up (n=34), or ComEd was not their electric utility (n=7). For these latter two categories, we cannot say if the participant database included some people in error or if these respondents had recall problems.

⁶ Often, participants who are not inclined to participate do not outright refuse. Instead they agree to be called back, but when called back, the time is once again inconvenient. These participants are typically called a number of times, but many never complete a survey so that their final disposition is "call back".



Table 2-7. Participant Survey Contacts Disposition

Survey Contacts Disposition	Customers	%
Customers Surveyed		
Completed Interview	202	65.4%
Appliance not picked up	34	11.0%
Electric company not ComEd	7	2.3%
Mid-Interview Terminate	66	21.4%

Source: PY3 Appliance Recycling Participant Survey



Section 3. Program Level Results

This section presents the results of the impact and process evaluations of the Appliance Recycling program.

3.1 Impact Evaluation Results

3.1.1 Verification and Due Diligence

Given modest changes in the program design, this topic was not revisited. Participant survey results continue to indicate that the program tracking database correctly records units recycled as indicated by a verification rate of 100% to the question, "our records show that you had (appliance description) picked up by ComEd's subcontractor JACO, is that correct?". Therefore the number of units by appliance type as derived from ComEd's tracking data, and shown below in Table 3-1 are valid.

Refer to the year 1 report for more information.

3.1.2 Tracking System Review

The Appliance Recycling tracking data for PY3 contained 41,024 records, one for each appliance that was picked up and recycled. This is consistent with the claimed savings estimate which was also based on this same total of recycled appliances.

Distribution by Appliance Type

About 83% of these units were refrigerators, another 15% were freezers, and the remaining 2% were room air conditioners. Table 3-1 below provides the breakdown of recycled units by measure type.

Table 3-1. Summary of Recycled Units by Appliance Type

Measure Type	Number of Units	Percent of Units
Refrigerators	33,941	83%
Freezers	6,046	15%
Room Air Conditioners	1,037	2%
Total Units Recycled	41,024	100%

Table 3-2 below provides a further breakdown of the population stratified by appliance type, of the number of appliances turned in as reported by the tracking data.



Table 3-2. Appliance Recycling Program: Appliance Type Versus Number Turned In

Refrigerators	Freezers	Room AC Units	Number of Applications	Number of Participants
		1	1	7
	1		1	4,882
1			1	30,405
	2		2	85
2			2	878
1		1	2	791
1	1		2	817
	1	1	2	141
1	1	1	3	28
	2	1	3	2
2		1	3	67
2	1		3	2
2	1	1	4	1
3	1		4	1

From these data, we observe the following patterns in terms of the distribution and count by appliance type:

- There are 38,107 unique participants, and most recycled one unit (30,405 refrigerators, 4,882 freezers, 7 room ACs).
- A total of 914 participants (2.2%) recycled 2 major units (defined as a refrigerator and/or freezer), and of these, about 10.4% also recycled a room AC unit.
- Another 5 participants recycled 3 or more major units.
- For room ACs, the majority of participants had AC units that were picked up at the same time as a refrigerator or freezer, in accordance with program procedures.

In terms of anomalies, we found one type, which did not result in any adjustment to the tracking data:

- There were 7 participants who recycled only a room AC, ComEd does not pay pick-up costs in these cases.



Problems Found

As in past evaluations, our review of the tracking data provided to the evaluation team also uncovered some problems, most notably that there were:

- Incomplete records for several tracked fields. Most fields were well-populated, and particularly the most important fields for evaluation (appliance brand, model number, size, age/year manufactured, defrost type, location at the time of pick up). Also, we commend ComEd and JACO for improving the completeness of the Room AC data fields in PY3.
- However, some of the tracked fields continued to be sparsely populated in PY3, or the entry was designated 'unknown' or 'N/A'. These included:
- **Prior Location of Recycled Unit.** A substantial number of records had 'other' or 'unknown'. Possibly these are default values in the database, but they are not useful for evaluation purposes. JACO should gather this information during the scheduling call, if at all possible.
- **Is Unit Replaced.** This, potentially, is an important field for evaluation, however, in all cases, it is populated with 'unknown'. Again, this should be gathered by JACO during the scheduling call.
- **Prior Unit Usage, Season When Used.** These fields are never populated and should be dropped from the database. They are not used by the program or by evaluation.

Although we were able to complete the evaluation without these incomplete data, it would be better if they could be more fully populated in the future. We will document our concerns in a memo to ComEd and JACO and will work closely with JACO over the next few months to ensure these fields are correct, and are being populated. Data exported for the evaluation team should also be checked for anomalies.

3.1.3 Gross Program Impact Parameter Estimates

Refrigerators and Freezers

Annualized Unit Energy Consumption (UEC)

As detailed in Section 1, regression based Unit Energy Consumption (UEC) estimates were made for both refrigerators and freezers. The regression equation estimates usage as a function of unit characteristics (age, size, configuration, and defrost mode). All of the required data inputs to this equation were obtained from the program tracking data.

Applying the regression coefficients to the full population of units collected through the program during PY3 and their associated characteristics yielded the following UECs for each type of appliance (Table 3-3).



Table 3-3. Estimated UECs

Annualized UECs	Refrigerators	Freezers
kWh	1,855	1,912

Both age (in years) and size (in cubic feet) are key explanatory variables that drive these estimates. In general, the older a unit is, the larger it is and the more electricity it uses. This is the case for 2 reasons:

1. Because of a change in standards in 1993, units built since that time are much more energy efficient and generally smaller than units made prior to the standards change.
2. There is degradation of a unit's efficiency over time, as the unit ages.

Because this is a relatively new program, the appliances collected during PY3 have been primarily older and larger units than those collected via a more established program (as in California). Table 3-4 and Table 3-5 below provide the age and size characteristics of the units collected in PY3 through ComEd's program.

Table 3-4. Age Characteristics of Recycled Appliances

Appliance Type	Age in Years									Average
	0 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40	Over 40	
Refrigerators	1%	8%	12%	18%	22%	17%	11%	4%	7%	24
Freezers	0%	2%	5%	9%	20%	21%	19%	9%	14%	26
Room Air Conditioners	1%	1%	8%	14%	25%	19%	12%	7%	12%	23

Table 3-5. Size Characteristics of Recycled Appliances

Appliance Type	10 cubic feet and smaller	11 to 15 cubic feet	16 to 20 cubic feet	21 cubic feet and larger	Average
Refrigerators	4%	20%	43%	34%	18
Freezers	11%	40%	40%	9%	15

From these data, the following observations can be made:

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- Age
- Fully 61% of refrigerators, 84% of freezers, and 76% of room AC units are over 20 years old
- Approximately 40% of refrigerators and freezers are between 21 and 30 years old
- One-fifth of refrigerators (22%) and 42% of freezers are over 30 years old
- The following percentages of appliances collected by the program were made before the 1993 standards change: 61% of refrigerators and 84% of freezers
- Note that it is a program requirement for all appliances picked up to be in working condition (even those over 30-40 years old). The truck driver tests the unit to ensure this is the case at the time of pick up.
- Size
- The majority of units collected are 16 cubic feet and larger, one third of refrigerators are larger than 20 cubic feet
- Recycled refrigerators tend to be larger on average than recycled freezers
- The size distribution of freezers collected by the program is more diverse than refrigerators. The most common freezer sizes are between 11 and 20 cubic feet, while those for refrigerators range from 16 cubic feet to over 20 cubic feet.

Since the age of recycled units is a major driver of unit energy consumption, we also looked at the trend in the age distribution of units collected through the program from PY1 to PY3. Table 3-6 provides a comparison of the age distribution of recycled refrigerators, while Table 3-7 has similar information for recycled freezers.



Table 3-6. Comparison of Age Distribution of Recycled Refrigerators

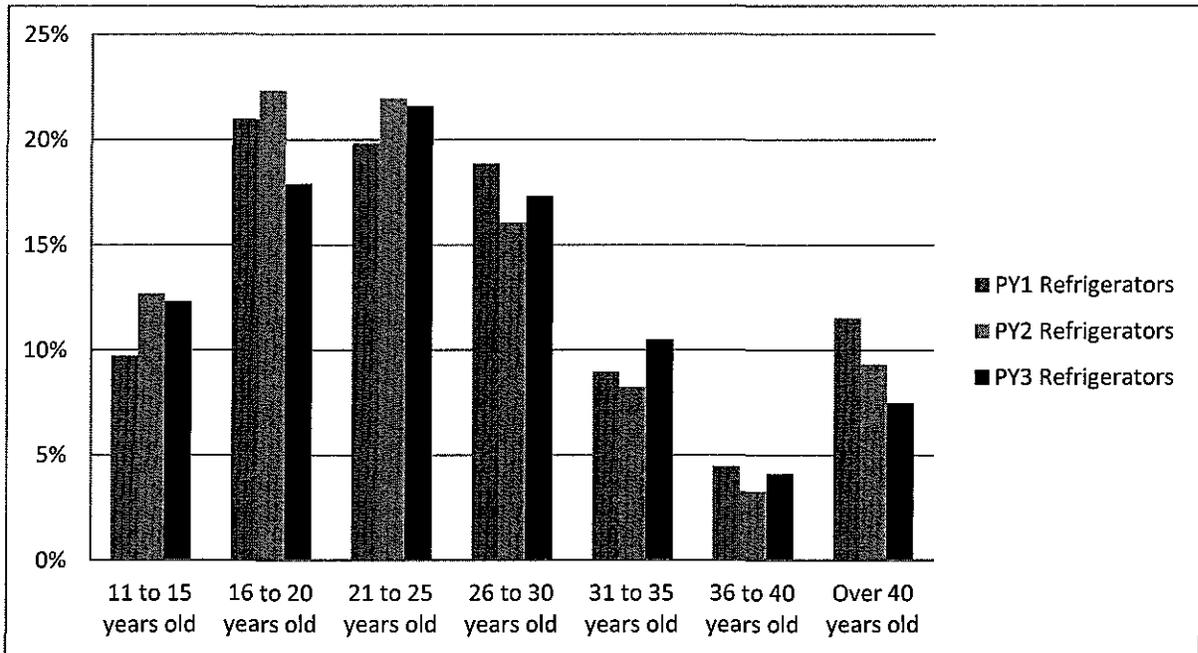
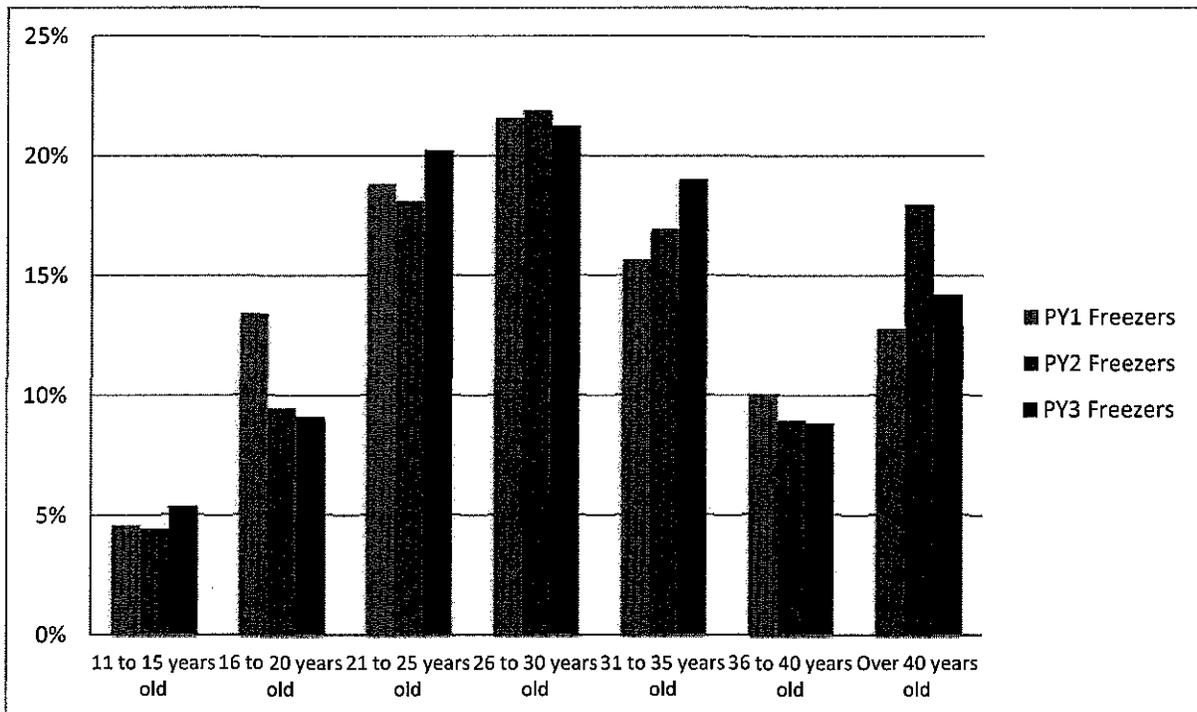


Table 3-7. Comparison of Age Distribution of Recycled Freezers





With respect to refrigerators, the PY3 program has picked up a higher proportion of older units (particularly those over 25 years old) than in PY2, comparable to that in PY1. However, the trend is the opposite for freezers. It may be that there is still a substantial 'inventory' of older units of both measure types available to the program for at least the short-term. However, over the longer term, one would expect the program to be picking up younger units as it matures, thereby decreasing per-unit energy savings.

Part-use factors. The part-use factors account for the fact that a unit that would have stayed in use would have been in use only part of the time. For example, the savings due to removal of a unit that would have been used only three months of the year is only one-quarter (3/12) the savings associated with full-year use (assuming essentially constant use over the year for a full-use unit). The part-use factor is used to adjust gross savings UECs to yield estimates of annualized gross savings that can be attributed to the program. The part-use factors are taken from the results of the telephone survey of participants.

Refrigerators. The assumption is that any refrigerator that would otherwise have been kept in use would have been used as a secondary, not as a primary refrigerator. Therefore, the part-use for all primary refrigerators that would otherwise have been kept is set at the average part-use reported by participants who disposed of a secondary refrigerator. This part-use was the number of months, divided by 12, that the participant reported the unit would have been plugged in and running had the program not picked it up. This average was determined to be 90% or 0.90. The program ex-ante gross impact estimate was based on an assumption that the part-use factor for refrigerators was 75%.

Freezers. For freezers, the average part-use factor is based on a similar question for all participants who disposed of a freezer. This average was determined to be 75% or 0.75. The supplemental data collected in the survey provide no further insight into the part-year usage, nor do the tracking data. The program ex-ante gross impact estimate was based on an assumption that the part-use factor for freezers was 65%.

Table 3-8 below reports the distribution of unit usage by appliance type and frequency of use for both refrigerators and freezers. The predominant response by participants is that they would have used the unit 'always' if the program had not picked it up.

Table 3-8. Frequency of Usage in the Absence of the Program

Appliance Type	Never	1 to 3 months	4 to 6 months	7 to 9 months	10 to 12 months	Always	N
Refrigerators	4%	6%	2%	1%	1%	85%	144
Freezers	17%	2%	4%	6%	0%	71%	52



Gross Savings (UEC) Impacts Adjusted for Part-Use

The next step is to develop gross savings estimates for each type of appliance adjusted for part use. The application of the part-use factor reduces refrigerator savings/unit to 1,674 kWh per year, and freezer savings/unit to 1,440 kWh/year. These estimates are provided in Table 3-9 below.

Table 3-9. Gross Savings (UECs) Adjusted for Part Use

Appliance Type	Gross Savings (UECs)	Part-Use Factor	Adjusted Gross Savings (kWh/unit)
Refrigerators	1,855	90%	1,674
Freezers	1,912	75%	1,440

Room Air Conditioners

The savings contribution of this measure to the program is extremely small – it accounts for only 0.1% of program savings. The deemed savings memo called for the energy consumption of residential room AC units to be estimated using an engineering algorithm. Although more data are included in the tracking database than in PY2, there still is insufficient data to do the calculation. However, since the savings contribution of this measure to the program is extremely small, we have elected to accept ComEd’s ex-ante gross savings estimates.

3.1.4 Gross Program Impact Results

Table 3-10 below provides the third-year evaluation-adjusted gross kWh savings estimates for each measure. The resulting verified total program gross savings quantity is 65,592 MWh. This value includes the application of the part-use factor. The ex-ante gross savings claimed by the program is 46,681 MWh⁷. Gross savings per unit (without adjustment for the part-use factor) are very close for the ex-ante and ex-post program-verified savings estimates, since ComEd used substantially the same approach to calculate ex-ante gross savings per unit as was used in this evaluation. Key differences are with respect to the part-use factor. In its ex-ante estimates, ComEd has assumed a part-use factor (labeled as a realization rate in their table) of 0.75 for refrigerators and 0.65 for freezers. The program verified part-use factors are 0.90 for refrigerators and 0.75 for freezers, respectively.

⁷ As reported in *PY3 Ex Ante & Plan Summary.xls* provided by ComEd.



Table 3-10. PY3 Gross Impact Parameter and Savings Estimates (MWh)

Gross and Net Impact Parameter and Savings Estimates	Refrigerators	Freezers	Room AC	Total Program
Total units recycled through the Program	33,937	6,046	1,041	41,024
Verified Annual kWh Savings Impacts				
- Verified annual Gross kWh savings per unit (full-load operating hours)	1,855	1,912	---	---
- Part-Use Factor	90%	75%	---	---
- Verified annual Gross kWh savings per unit adjusted for part-use	1,674	1,440	80	---
Verified Program Gross MWh	56,804	8,705	83	65,592

Table 3-11 below provides the third-year evaluation-adjusted gross kW savings estimates for each measure. For PY3, the kW saved by the program are based on ComEd's ex-ante planning estimates for per-unit kW savings for Refrigerators, Freezers and Room AC units.

Table 3-11. PY3 Gross and Net Impact Parameter and Savings Estimates (kW)

Gross and Net Impact Parameter and Savings Estimates	Refrigerators	Freezers	Room AC	Total Program
Total units recycled through the Program	33,937	6,046	1,041	41,024
Verified Annual kW Savings Impacts				
Annual Gross kW savings per unit (full-load operating hours)	0.30	0.26	0.04	---
Verified Program Gross kW	10,181	1,572	42	11,795

3.1.5 Net Program Impact Parameter Estimates

Once gross program impacts have been estimated, net program impacts are calculated by multiplying the gross impact estimate by the Program Net-to-Gross (NTG) ratio. The NTG ratio is equal to 1 minus the percentage of free riders plus spillover. For this program because the program approach does not support a theory for how meaningful spillover might occur, and because it does seem unlikely to be significant, we have not estimated spillover.

In this program, free ridership is defined based on the percentage of program participants that would have disposed of their units absent the program in a manner that would have permanently removed the unit from the grid. This includes participants who indicated they would have otherwise:



- Sent the unit to a recycling facility, or
- Taken the unit to a landfill

In total, 47 out of 144 refrigerator respondents (33%), 13 of 52 freezer respondents (25%), and 9 out of 30 room AC respondents (30%) revealed they would have used a method to dispose of their unit that would have permanently destroyed it, indicating they are free riders. Resulting NTG ratios are 0.67 for refrigerators, 0.75 for freezers, and 0.70 for room air conditioners. The refrigerator and freezer NTG ratios declined slightly from 0.73 and 0.82, respectively, in PY2. For its ex-ante planning estimates, ComEd has used values of 0.70 for refrigerators, 0.75 for freezers and 1.00 for room air conditioners.

Interviews with the used appliance haulers did not provide any evidence to counter these findings. The sample size was very small (n=2) and the businesses dealt largely with units that had stopped functioning. However, the haulers indicated their primary disposal methods for these types of units was either deconstruction and recycling or taking anything that cannot be recycled to a landfill.

It is recommended that a full market assessment be conducted in the PY4 evaluation. The objective is to assess the state of both the new and used appliance markets with respect to disposal and recycling of older units. Such an assessment would be comprehensive in nature, relying on facts and interview results from all major players in the market.

3.1.6 Net Program Impact Results

Table 3-12 below provides the program-level evaluation-adjusted net impact results for the PY3 Residential Appliance Recycling program. As this figure shows, the ex post program-level third-year net energy saving estimate resulting from this evaluation is 44,851 MWh, exceeding program claimed estimates by over 11,750 MWh, and resulting in a net realization rate of 136%. The difference between the ex-ante net savings and ex-post net savings is primarily due to differences in the part-use factors applied. Program verified part-use factors were 90% for refrigerators, and 75% for freezers, while the ex-ante assumption was 75% for refrigerators and 65% for freezers. The net-to-gross ratio for the ex-ante estimates was somewhat higher than ex-post for refrigerators (0.70 ex-ante vs. 0.67 for ex-post), identical for freezers, and higher for room ACs (1.00 for ex-ante vs. 0.70 for ex-post).



Table 3-12. PY3 Net Impact Parameter and Savings Estimates

Verified Annual Net MWh Savings Impacts	Refrigerators	Freezers	Room AC	Total Program
Verified Program Gross MWh	56,804	8,705	83	65,592
Net-to-Gross Ratio (1-Free Rider %)	0.67	0.75	0.70	---
Total Third-Year Evaluation-Adjusted Net MWh Savings	38,264	6,529	58	44,851
Net MWh Savings Claimed by the Program				33,093
Net MWh Realization Rate				136%
Verified Annual Net kW Savings Impacts				
Verified Program Gross kW	10,181	1,572	42	11,795
Net-to-Gross Ratio (1-Free Rider %)	0.67	0.75	0.7	0.68
Total Third-Year Evaluation-Adjusted Net kW Savings	6,821	1,179	29	8,029

3.2 Process Evaluation Results

The process evaluation component of the Residential Appliance Recycling evaluation focused on appliance usage data and satisfaction with program processes, including sign up, pickup and receipt of the refund check. Key data sources for the process evaluation include the Participant telephone survey, the Nonparticipant telephone survey, and the in-depth interviews with the ComEd Program Manager, the participating and nonparticipating retailers, and the used appliance haulers.

3.2.1 Process Themes

As indicated above, because of the way samples were drawn, participant survey results have been weighted.

Changes to Program

Program unit and savings goals increased in PY3, with unit goals increasing by a larger percentage than savings goals (47% vs. 30%) based on the expectation that the mix of units in the program may continue to shift to slightly newer or more energy efficient units.

In order to meet these increased goals, ComEd enrolled two new retailers into its program, Sears and Best Buy, and is using a combination of higher incentives and 'specials' to promote the program. ComEd increased the program incentive amount in PY3, from \$25 per unit at the beginning of the program to \$35 in November of 2010. In addition, ComEd partnered with the