Final Report
Measurement and Evaluation Study of 2002 Statewide Residential Appliance Recycling Program

Prepared for

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SECTION 1 EXECUTIVE SUMMARY 1–1
1.1 Program Background 1–1
1.2 Evaluation Objectives and Approach..1–1
1.3 Findings..1–2
1.3.1 Process Evaluation 1–2
1.3.2 Measurement and Verification..1–4
1.3.3 Verification of Program Accomplishments 1–4
1.3.4 Gross Unit Energy Consumption (UEC) Analysis 1–4
1.3.5 In Situ Literature Review..1–5
1.3.6 Net-to-Gross Analysis..1–5
1.3.7 CFL Energy Savings 1–6
1.4 Recommendations..1–6

SECTION 2 INTRODUCTION 2–1
2.1 Overview..2–1
2.2 Program Background 2–1
2.3 Evaluation Objectives and Approach..2–1
2.3.1 Impact Evaluation 2–2
2.3.2 Process Evaluation 2–3
2.3.3 Market Analysis 2–3
2.4 Report Organization..2–4

SECTION 3 PROGRAM DESCRIPTION 3–1
3.1 Background..3–1
3.2 Program Objectives..3–1
3.3 Program Approach 3–1
3.4 Goals and Budget..3–2
3.5 Accomplishments and Expectations 3–2

SECTION 4 DATA SOURCES AND DATA COLLECTION APPROACHES 4–1
4.1 ARCA's Database..4–2
4.2 Participant Survey 4–2
4.2.1 Participant Sample Distribution..4–2
4.2.2 Uses of Participant Survey Data 4–4
4.2.3 Participant Survey Implementation..4–4
4.3 Nonparticipant Survey 4–4
4.3.1 Nonparticipant Sample Distribution 4–4
4.3.2 Uses of Nonparticipant Survey Data..4–5

4.3.3 Nonparticipant Survey Implementation 4–5
4.4 Staff Interviews 4–5
4.5 ARCA Facility Tour 4–5
4.6 Statewide RASS 4–6
4.7 Prior Metering Data 4–6
4.8 New Metering Study 4–6
4.9 AHAM Data and CEC Efficiency Database 4–7

SECTION 5 PROCESS EVALUATION FINDINGS 5–1
5.1 Characterization of 2002 Program Participants 5–1
5.2 Process Evaluation Findings 5–3
5.2.1 Background 5–3
5.2.2 Program Implementation 5–4
5.2.3 Appliance Pickup and Recycling Processes 5–4
5.2.4 Program Tracking and Reporting Functions 5–7
5.2.5 Program Starting and Stopping 5–8
5.2.6 Program Marketing 5–9
5.2.7 Primary Reasons for Joining Program 5–11
5.2.8 Incentive Preferences 5–12
5.2.9 Participant Satisfaction 5–14
5.2.10 Nonparticipant Survey Findings 5–18
5.2.11 Other Process Findings 5–20
5.2.12 Suggestions for Improvements 5–21

SECTION 6 METERING STUDY AND UEC DETERMINATION 6–1
6.1 Introduction 6–1
6.2 New Metering Study Approach 6–1
6.3 Meter Study Sample 6–3
6.3.1 Sample Design 6–3
6.3.2 Sample Implementation 6–5
6.4 UEC Model 6–5
6.4.1 1998 UEC Model 6–6
6.4.2 Developing the 2002 Model 6–7
6.4.3 Population UECs from Alternative Models 6–13
6.4.4 Changes from Previous Program 6–15
6.5 UEC Difference Between New Units and Units in the Program 6–16

SECTION 7 NET-TO-GROSS ANALYSIS 7–1
7.1 Overview 7–1
7.2 Principles for Assigning Attribution Factors 7–2

7.2.1 Attribution Factors for Avoided Transfers 7–2
7.2.2 Timing of Disposal 7–3
7.3 Determining Disposition and Attribution 7–3
7.3.1 Questions Addressed by the Acquirers/Disposers Question Sequences in the Nonparticipant Survey 7–4
7.4 Quantitative Analysis 7–5
7.4.1 Framework for the Analysis 7–5
7.4.2 Assumptions for Calculating Attribution Factors 7–5
7.4.3 Part-use Factors 7–7
7.5 Net-to-Gross Estimates 7–7

SECTION 8 IN SITU LITERATURE REVIEW 8–1
8.1 Background 8–1
8.2 Key Assessment From Literature Review 8–1
8.3 Summary of Findings From Literature Review 8–3
8.4 2003 SBX1 5 Study by ICF/ADM for the California Public Utilities Commission 8–3
8.5 2003 SB5X Study by Robert Mowris for the Northern California Power Agency 8–3
8.6 LBL Study by Alan Meier (ASHRAE, August 1993) 8–4
8.7 1998 Proctor Engineering Study for PG&E 8–5
8.8 1995 Analysis of PG&E and SCE Refrigerator Load Data by Andrew Goett 8–5
8.9 1996 Barakat and Chamberlin Study for ARCA 8–6
8.10 March 1993 Study by Sacramento Municipal Utility District (SMUD) 8–7
8.11 February 1992 Study by RLW for Northeast Utilities 8–7
8.12 February 1993 study by LBL for the New York Refrigerator Monitoring Project 8–7

SECTION 9 CFL SAVINGS IMPACTS 9–1

SECTION 10 MARKET ASSESSMENT 10–1

APPENDIX A RARP PROGRAM VERIFICATION REPORT A–1
A.1 Summary of Findings A–1
A.2 Approach A–1
A.3 Findings A–2
A.3.1 Comparison of Program Tracking Data with Final Fourth Quarter 2002 Quarterly Reports A–2

A.3.2 Ridge and Associates Verification of SCE Units A–2
A.3.3 Participant Survey-based Verification A–2

APPENDIX B ARCA RECYCLING CENTER PHOTOS AND PROCESS DESCRIPTION B–1
B.1 Recycling Process B–1
B.2 Pickup Scheduling B–8

APPENDIX C PARTICIPANT SURVEY INSTRUMENT C–1

APPENDIX D NONPARTICIPANT SURVEY INSTRUMENT D–1

APPENDIX E ATTRIBUTION DETAILS E–1

APPENDIX F DETAILED PROCESS FINDINGS BY UTILITY AND HARD-TO-REACH SEGMENTS F–1
F.1 Pacific Gas and Electric F–1
F.2 Southern California Edison F–7
F.3 San Diego Gas and Electric F–13

APPENDIX G DETAILS OF NET-TO-GROSS ANALYSIS G–1

APPENDIX H ADDITIONAL MODELING RESULTS.. H–1

APPENDIX I EXTENDED NET-TO-GROSS ANALYSIS...I–1

1 EXECUTIVE SUMMARY

This document represents the draft report for the evaluation of the 2002 Statewide Residential Appliance Recycling Program (RARP), sponsored by Southern California Edison (SCE), Pacific Gas and Electric Company (PG&E), and San Diego Gas and Electric Company (SDG&E).

This executive summary provides a brief overview of the program background, discusses the evaluation objectives and approach, and presents study findings and recommendations.

1.1 PROGRAM BACKGROUND

The RARP was designed to achieve energy savings through the retirement and recycling of older, inefficient refrigerators and freezers. This program is administered by SCE on behalf of all three utilities.

The primary objectives of the RARP are to:

- Decrease the retention of high energy-use refrigerators and freezers;
- Deliver long-term energy savings and peak demand reduction; and
- Increase hard-to-reach (HTR) customer participation by strategically targeting, for example, rural areas.

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 California environmental laws and regulations and permitting requirements. The RARP is available to both owners of working primary or secondary units.

During 2002, SCE's subcontractor, Appliance Recycling Centers of America (ARCA), performed scheduling, pickup, and recycling of appliances removed by the program. ARCA also selectively marketed the program to customers of all three utilities, running ads targeted to the HTR customer populations of all three utilities, and more general awareness-building ads to the two utilities that were added to the program in 2002, PG&E and SDG&E. In exchange for participating, customers received an incentive (either $35 check or compact fluorescent light bulbs [CFLs]).

1.2 EVALUATION OBJECTIVES AND APPROACH

This evaluation verifies the program's effectiveness at achieving the objectives stated above. The specific objectives of this evaluation were to

- Measure and verify achieved levels of energy and peak demand savings through a program savings analysis;
- Provide ongoing feedback and corrective guidance regarding program implementation through a process evaluation; and
- Measure indicators of program effectiveness through a market assessment and customer behavior analysis

1.3 FINDINGS

This section presents our high-level findings from the process evaluation and the measurement and verification study.

1.3.1 Process Evaluation

The process evaluation sought to assess the program's administrative functions, determine the degree of participant satisfaction with various aspects of the program, and identify areas for program improvement. Our primary data sources were the Participant Survey, interviews with utility staff leads, and an interview and site visit with ARCA, the program's recycling service provider. Our process findings are based on a critical analysis of data from these various sources. They are as follows:

- **The RARP has changed dramatically since the last evaluation, in terms of the kinds of units it recycles.** This change was brought about by a relaxation of program rules in 1999, to allow the pickup of primary units as well as spares. Prior to this, the program only allowed spare units to be picked up. The program that has evolved is one that mostly removes recently replaced primary units, whereas in 1996 it mostly addressed working spare units. Consequences of this shift include the following:
  - The units currently being collected tend to be newer than was previously true;
  - Larger fractions of collected units would have been disposed of by some other means if not taken by the program; and
  - A substantial fraction of participants joined the program because they wanted to dispose of a unit.

  These factors, in turn, affect the energy savings achieved per unit.
- **The program is administered efficiently and well by ARCA.** ARCA administers most of the program functions. Their performance with respect to key program functions was rated very positively by utilities' program staff and by participants in the program. Participants gave very high marks to the enrollment, scheduling, pickup and incentive payment functions carried out by ARCA. Only two relatively minor areas of ARCA's responsibilities were identified as needing improvement: (1) adding certain data fields to the tracking system; and (2) scheduling of pickups to minimize customer wait times of over two weeks that occur periodically during funding lapses. Problems reported earlier

related to ARCA's reporting and communications with PG&E and SDG&E have been resolved.

- **Lapses in program funding create hardships for ARCA and lead to customer attrition.** The two-year funding cycle provided for in the California Public Utility Commission's (CPUC) draft decision for 2004–05 programs will largely solve this problem for 2004, though funding gaps may still occur as utilities approach the end of their budgets for each program year.
- **For SCE (which accounts for over two-thirds of participants), this is a mature program that is very popular and well-liked by customers.** Word of mouth is the most common way that end users learn of the program in SCE's territory. Nevertheless, marketing remains an integral program activity and allows SCE to maintain significant levels of customer participation each program year. The program uses targeted marketing to publicize the program in lesser-known areas such as SDG&E's and PG&E's territories (which were added to the program in 2002) and in HTR areas.
- **Participants are highly satisfied with all key program functions.** Very high satisfaction ratings were given for the enrollment, pickup scheduling, appliance pickup, and incentive payment functions. Participants liked the ease and convenience of the program and did not mind the requirement that they be at home during the pickup. They did not feel that the wait time for their incentive payment (an average of 3 to 4 weeks) was unreasonably long.
- **Participants come to the program mostly for reasons related to the disposal of their older unit.** While the incentive payment was the most popular reason given for joining the program, other reasons related to the appliance disposal were the predominant reason they joined.
- **The incentive is one of several important elements in the decision to recycle.** Participants gave multiple reasons for joining the program. While the program incentive was the most common reason cited, the majority of participants indicated other reasons related to the appliance disposal. This is consistent with the finding that a large fraction of participants are disposing of primary refrigerators that were recently replaced. Because the incentive has been an important element of the program, we believe this is an area that deserves further study.
- **Customers have several misconceptions about what it costs to operate older units and what it means to have units available for recycling.** Participants provided widely varying answers regarding the monthly operating cost of older units, and less than half gave answers that were realistic. In addition, nonparticipant owners of recently disposed second units did not perceive these units to be available for recycling. These findings indicate a strong need for additional education of customers in order to address these misconceptions.

1.3.2 Measurement and Verification

The measurement and verification elements of this study included verification of program accomplishments for each utility, and an evaluation of program energy-savings assumptions. The measurement and verification used new data collected from

- A new refrigerator/freezer metering study to estimate gross unit energy consumption (UEC); and
- Participant and Nonparticipant Surveys to develop the net-to-gross (NTG) factor.

Other data used in the analysis included:

- Refrigerator/freezer metering data collected in prior studies;
- California Energy Commission data on UECs of new model units; and
- Qualitative findings from previous evaluations.

1.3.3 Verification of Program Accomplishments

The purpose of this task was to present evidence to verify the program accomplishments that each investor-owned utility (IOU) claimed in its final fourth quarter report for the 2002 Statewide RARP. Overall, we found that the unit accomplishments reported by the IOUs in their final reports (specifically, in the CPUC workbook in the Program Activities Worksheet, Table A, Column S) matched the program tracking data. Using two other sources of data, we were able to validate the accuracy of data entered into the tracking database. Based on these findings, we conclude that the numbers and distribution of recycled units claimed by each utility in the fourth quarter reports for 2002 are reasonable and need no adjustments.

1.3.4 Gross Unit Energy Consumption (UEC) Analysis

This portion of the evaluation developed the annualized estimates of UECs from an analysis of metered data. Metered data for this analysis came from two sources: (1) a large database of existing lab-metered data, and (2) a new metering study reflecting a sample of 100 units recently collected by the program. Both of these data sources used the Department of Energy (DOE) lab metering protocols to collect metered data. Originally, we also planned to use AHAM data in our work but found that data were not available for many of the older models collected by the program.

The new metering study was conducted over a 6-month period, from late May to late November 2003. KEMA-XENERGY randomly selected units for metering from truck routes provided by ARCA. BR Laboratories, the contractor that performed lab metering of units for the earlier study, also conducted lab metering of units for this latest study.

To estimate UECs, we developed a model that predicted energy use as a function of key variables, such as unit age, size, configuration, and defrost mode. We then applied the fitted model to the 2002 population of units collected by the program.

Using this model, we developed estimates of UECs for refrigerators, freezers, and found that on average, UECs have dropped by about 215 kWh compared with the full-year UECs developed in the evaluation of the 1996 program. Table 1-1 reports our findings (standard errors are in parentheses).

Table 1-1
UEC Estimates and How They Compare to 1996 Program Estimates

Unit Type	2002 Program	1996 Program Evaluation	Difference
Refrigerators	1,946 (77)	2,148	-200
Freezers	1,662 (101)	2,058	-396
Overall	1,915 (77)	2,130	-215

1.3.5 In Situ Literature Review

We reviewed available literature, including many studies using in situ metering, to determine whether any adjustment to our estimates based on lab metering was warranted. In situ metering is done in the home, ideally under the same operating conditions as existed immediately prior to the unit pickup, whereas lab metering is done in a laboratory under controlled conditions.

The laboratory protocol was designed by DOE to represent average in-home usage over a 12-month period with typical refrigerator loadings. Questions remain, however, as to how well this protocol measures typical usage for current older units in particular locations.

We found that no adjustment was justified based on this review. The studies reach widely different conclusions regarding the difference between in situ and lab metering results. Moreover, none of the in situ studies reviewed reflected the combination of conditions of interest in this study, namely (1) predominantly southern California climate; (2) older, secondary refrigerators; and, (3) side-by-side comparisons of DOE lab metering and in situ metering for the same units. While we cannot conclude that the DOE laboratory procedure is unbiased for the conditions of interest, neither can we identify any firm basis for adjusting the results.

1.3.6 Net-to-Gross Analysis

The net-to-gross (NTG) analysis uses data from the Participant and Nonparticipant Surveys to estimate the credit attributable to the program for picked up units that would otherwise have been discarded. There are two components that are estimated: the attribution factor, which indicates how much credit for removal should be given to the program, and the part-use factor. The attribution factor adjusts for the percentage of participants that would have disposed of the unit anyway, and gives partial credit to the program for destroying a unit that would otherwise have been transferred to another user. The part-use factor adjusts for the fraction of the time that participants would have used the unit if they had kept it. We used the same methodology as was used in the previous evaluation to calculate and apply these two factors

The calculated NTG factor for refrigerators in this evaluation, 0.35, was substantially lower than the value in the last evaluation (0.53). The attribution factor was the primary source of the deterioration. The part-use factor developed in this study (0.88) was very similar in magnitude to that in the prior evaluation (0.86).

There were several reasons for the drop in the attribution factor:

- The dramatic increases in the shares of participants that were using the recycled unit as a primary, rather than a spare unit (79 percent in 2002 vs. 24 percent in 1996 for refrigerators);
- An increase of similar magnitude in the percentage of participants that would have disposed the unit without the program (86 percent in 2002 versus 41 percent in 1996 for refrigerators); and
- A reduction in the share of participants that would have kept the unit in use if the program hadn't picked it up (for refrigerators, 9 percent in 2002 versus 45 percent in 1996).

1.3.7 CFL Energy Savings

One of the incentives offered by the program is a 5-pack of CFLs. Only a modest share of participants (10 percent) selected the CFLs instead of the cash incentive. Because of this, the energy savings attributable to the program from CFLs is very small: less than 1 percent of program energy savings.

For this reason, we estimated CFL savings using a fairly simple formula-based approach, discussed in detail in Section 9. We found that a total of 422,316 net kWh was saved from the CFLs that all IOUs distributed through this program.

1.4 Recommendations

While the program is very highly regarded, nevertheless there are still some areas of improvement that remain. We are providing recommendations with regard to the following areas:

- customer education,
- program tracking, and
- program process changes.

Our recommendations are:

- **Develop and distribute materials to better educate customers about the high cost of operating older units.** Our findings reveal that only a minority of customers understand what these older unit are costing them to operate each month. It is recommended that the utilities work together with ARCA to develop a separate customer mailing or brochure that contains specific information on the usage and cost of operating older, less-efficient units. The brochure should also explain how a decision to recycle an older unit helps the environment and saves energy. We believe that if customers with older units were fully aware of the cost and impact on the environment of operating these units, they might be more inclined to give them up.
- **Add extra variables to the tracking database** to more completely describe the usage of the recycled unit prior to pickup. (For example, add fields to describe where the unit had been located as a primary and where it would have been located if operated as a spare.) Currently, the program only lists the location at the time of the pick-up, which may not be the same as where the unit would have been operated if retained.
- **Consider changes to the program design if cost-effectiveness becomes an issue.** If cost-effectiveness becomes an issue for RARP, the program needs to consider requirements on units to continue to cost-effectively remove inefficient units from the market. Also, consideration could be given to alternate incentives or incentive levels offered by the program for this purpose.

2 INTRODUCTION

2.1 OVERVIEW

This document is a draft report on the evaluation of the 2002 Statewide Residential Appliance Recycling Program (RARP), sponsored by Southern California Edison (SCE), Pacific Gas and Electric Company (PG&E), and San Diego Gas and Electric Company (SDG&E).

This section provides a brief overview of the program's background, discusses the evaluation objectives and approach, and presents an overview on how the report is organized. To obtain background information on the RARP, KEMA-XENERGY staff referred to utility program filings, including implementation plans and quarterly reports.

2.2 PROGRAM BACKGROUND

The RARP is designed to achieve energy savings by retiring and recycling older, inefficient refrigerators and freezers in residential homes. A rebate of either $35 or a 5-pack of CFLs is offered to customers in exchange for appliances that are in working condition at the time they are picked up.

2.3 EVALUATION OBJECTIVES AND APPROACH

The RARP's overall goals are to decrease the retention of refrigerators and freezers that require high energy use, deliver long-term energy savings and peak demand reduction; and increase hard-to-reach customer participation by strategically targeting, for example, rural areas.

The evaluation verified the program's effectiveness at achieving these goals. The specific objectives of the evaluation were to:

- Measure and verify achieved levels of energy savings through a program-savings analysis;
- Provide ongoing feedback and corrective guidance regarding program implementation through a process evaluation; and
- Measure indicators of program effectiveness through a market assessment and customer behavior analysis.

To satisfy the study objectives, our approach involved conducting a measurement and verification analyses and a process analysis. The market analysis task has been delayed because a key data source was not ready and will be completed in the spring of 2004. Two of these three study components met the evaluation objectives, as demonstrated in Table 2-1. The following subsections describe in more detail the research activities conducted to support the three study components.

Table 2-1
Study Objectives and Approach

Study Component	Study Objective	Approach
M&V Analyses	Verify and evaluate energy savings	• Perform a metering study to update energy-savings parameters • Perform an analysis of program attribution
Process Analysis	Evaluate the program's effectiveness in satisfying customers and performing administrative functions. Assess consumer behavior	• Evaluate implementation and marketing strategies • Assess participant satisfaction with the program • Identify areas for program improvement

2.3.1 Impact Evaluation

Verification of Program Units

The objective of this task was to produce evidence to verify program accomplishments that each investor-owned utility (IOU) claimed in its final report for Program Year (PY) 2002. There are two elements of these accomplishments that we found evidence to substantiate:

- The total number of units recycled by the program, as reported in the final California Public Utilities Commission (CPUC) workbook, Program Activities Worksheet, Table A, Column S; and
- The total number of units claimed by each utility for the hard-to-reach (HTR) segment, as reported in the final CPUC report narrative.

To verify the total number of recycled units, we relied upon three independent sources of evidence: (1) A comparison of program tracking data with information contained in each utility's fourth quarter reports; (2) an analysis performed for SCE by Ridge and Associates that verified information contained in two randomly drawn samples of paid and committed Appliance Turn-in Orders (ATOs), respectively; and (3) findings from the Participant Survey that verified several fields in the tracking data, including participation in the program, type of unit recycled (refrigerator versus freezer), receipt of a rebate, and other details. Our Verification Report appears in Appendix A.

Ex Post Savings Analysis

The objective of the ex post savings analysis was to develop updated estimates of refrigerator and freezer annual energy savings, making best possible use of available and new data sources.

The following approach was used to develop these new estimates:

- New metering was conducted on 100 units recently collected by the program. These units were stratified by unit type (refrigerators vs. freezers), unit configuration, age, size variables and, informally, by utility service area. The breakdown and characteristics of units collected through the 2002 program provided the basis for the stratification and allocation of units in the metering study.
- The results of this new metering were then combined with metering data collected in earlier studies, and models were run to produce estimates of gross unit energy consumption for all units collected under the current program.
- Credible new attribution and part-use estimates (net-to-gross) were developed that take into account changes in the program design since the previous program evaluation. Findings from attribution and part-use question sequences in the Participant and Nonparticipant Surveys provided the basis for the updated estimates.

2.3.2 Process Evaluation

The process evaluation objective was to provide program managers with critical feedback on the program's performance with respect to key administrative functions. The following approach was used to develop our findings.

We collected feedback on program administrative processes from three sources: (1) interviews with key utility staff involved with program administration; (2) a site visit to ARCA and a detailed interview with the ARCA recycling facility manager; (3) a survey of 547 program participants; and (4) a survey of 647 nonparticipants. From our findings, we were able to analyze critical program elements and functions in depth and to assess how these functions could be improved upon. In addition, from the Participant Survey data, we were able to separately analyze responses from participants located in HTR areas to determine the program's effectiveness and to identify changes that could be made in program delivery to increase its reach to HTR customers.

2.3.3 Market Analysis

The objectives of the market analysis were to (1) determine the market potential for recycling refrigerators and freezers; (2) characterize the traits of those likely to participate in the recycling program in the future; and (3) characterize the market for recycled appliances.

The calculation of market potential for recycled refrigerators and freezers relies on information from a number of different data sources, primarily

- information on second refrigerators provided through the Nonparticipant Survey, and
- data on the saturation of old, inefficient refrigerators and freezers and turnover/ replacement rates provided through the statewide Residential Lighting and Appliance Saturation Study (RASS).

Because the RASS data were not expected to be available until late December 2003, the market analysis task is being postponed until the spring of 2004.

2.4 Report Organization

This report is organized into 10 sections and 6 appendices. Sections 1 and 2 are the Executive Summary and Introduction, respectively. Section 3 describes the RARP program features, energy-savings goals, and program budgets for 2002. Our data sources and data collection approaches are discussed in Section 4. Section 5 presents our key findings from the process evaluation. The metering study results and our determination of UECs are presented in Section 6. Section 7 describes our detailed approach in determining the Net-To-Gross Factor based upon findings from the Participant and Nonparticipant Surveys. Our findings and conclusions from the In Situ Literature Review are discussed in Section 8. The analysis of CFL energy-savings impacts is presented in Section 9. Section 10 describes the planned approach for the Market Assessment.

3 PROGRAM DESCRIPTION

This section presents a detailed description of the Statewide RARP. First, we present program background, followed by objectives and approach. Next, we present the program's goals and its unit and savings accomplishments. Data sources for this section include interviews with program staff, utility filings, and CPUC decisions.

3.1 BACKGROUND

The RARP program is designed to achieve energy savings through the retirement and recycling of older, inefficient refrigerators and freezers. Prior to 2002, only SCE offered the RARP program to its customers. Also, prior to 1999, only spare refrigerators and freezers were eligible for pick-up and recycling through the program. Customers who had recently replaced primary units were not eligible for recycling of those units. The CPUC decision authorizing the 2002 RARP made the following changes in the program's scope and targeting:

- Increased the program scope to make it statewide, available to residential customers of all three IOUs;
- Appointed SCE as the administrator of the RARP program on behalf of the three utilities; and
- Directed the program to increase its efforts to target those customers in HTR areas who are considered to be underserved by the utilities' energy efficiency programs.

3.2 PROGRAM OBJECTIVES

The RARP's primary objectives are to:

- Decrease the retention of high energy-use refrigerators and freezers;
- Deliver long-term energy savings and peak demand reduction; and
- Increase HTR customer participation by strategically targeting, for example, rural areas.

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

3.3 PROGRAM APPROACH

SCE has been implementing its RARP for many years. In 2002, the RARP became a statewide program, available to customers of all three IOUs (SCE, PG&E, and SDG&E).

To avoid duplication of effort and cut down on administrative expenses, the CPUC directed that SCE administer the RARP on behalf of all three utilities. In this capacity, SCE oversees the recycling contractor, tracks program accomplishments, and reports program achievements to the CPUC at specified intervals.

In 2002, Appliance Recycling Centers of America (ARCA) performed scheduling, pickup, and recycling of appliances removed by the program. ARCA also selectively marketed the program to HTR customers, and more generally to customers in the PG&E and SDG&E service territories to increase participation.

Through the RARP, customers schedule an appointment to have their operating old refrigerator or freezer picked up and removed. The appliances are then taken to a recycling center where the metals, components, and refrigerants are recycled using environmentally sound procedures. During 2002, the program recycled over 43,000 used refrigerators and freezers. In exchange for participating in the RARP during 2002, customers received an incentive of either $35 cash or a 5-pack of compact fluorescent light bulbs (CFLs).

The program rules changed during 1999 to allow pickups of both working spare units and primary units. The rationale for this was to prevent replaced units from entering the secondary resale market for used appliances and the subsequent purchase and use by other consumers. Previously, the program had only allowed working spare units to be picked up and recycled.

3.4 GOALS AND BUDGET

Through the RARP, the utilities attempted to achieve over 59 million kWh of energy savings through the collection and recycling of 30,422 refrigerators and 7,605 freezers statewide. The program's budget was set at $6.68 million.

3.5 ACCOMPLISHMENTS AND EXPECTATIONS

The program ultimately collected and recycled a total of 43,170 units: 38,409 refrigerators and 4,761 freezers. Table 3-1 compares the program's performance goals with its accomplishments for each of the three utilities.

Table 3-1
Program Performance Goals Versus Accomplishments for 2002

Utility: Southern California Edison				
	Total Units		HTR Units	
Measure	Forecast Units	Actual Units	Forecast Units	Actual Units
Refrigerators	17,096	25,424	9,745	14,365
Freezers	4,274	2,407	2,436	1,360
Screw-in CFLs, 15 watts	2,137	4,070	1,218	2,300
Screw-in CFLs, 20 watts	4,274	1,985	2,436	1,122
Screw-in CFLs, 23 watts	4,274	4,070	2,436	2,300
Net kWh Savings				
- Based on planning estimates	36,901,716	48,074,251	21,033,978	27,161,952
- Based on ex-post savings		19,726,991		11,145,750
Utility: San Diego Gas and Electric Company				
	Total Units		HTR Units	
Measure	Forecast Units	Actual Units	Forecast Units	Actual Units
Refrigerators	4,372	4,567	2,317	2,284
Freezers	1,093	594	579	297
Screw-in CFLs, 15 watts	500	541	265	271
Screw-in CFLs, 20 watts	1,000	1,082	530	541
Screw-in CFLs, 23 watts	1,000	1,082	530	541
Net kWh Savings				
- Based on planning estimates	9,426,360	8,949,242	4,995,218	4,474,621
- Based on ex-post savings		3,712,994		1,856,497
Utility: Pacific Gas and Electric Company				
	Total Units		HTR Units	
Measure	Forecast Units	Actual Units	Forecast Units	Actual Units
Refrigerators	8,954	8,418	3,133	2,610
Freezers	2,238	1,760	783	546
Screw-in CFLs, 15 watts	350	1,564	123	485
Screw-in CFLs, 20 watts	700	782	245	242
Screw-in CFLs, 23 watts	700	1,760	245	546
Net kWh Savings				
- Based on planning estimates	12,880,150	11,780,932	4,506,689	3,652,089
- Based on ex-post savings		7,415,604		2,298,837

4 DATA SOURCES AND DATA COLLECTION APPROACHES

This study relied on several data sources and data collection approaches to support the impact, process, and market evaluations. Many of the sources used contributed to multiple analysis components. The data sources used and elements of the evaluation they served are summarized in Table 4-1.

Table 4-1
Data Sources and Uses

Uses in the Evaluation	Data Sources									
	ARCATS	Participant Survey	Nonparticipant Survey	Statewide Lighting and Appliance Saturation Studies	Staff Interviews	Recycling Facility Visits	Prior Metering Data	Metering Study	AHAM Data	CEC Efficiency Database
Appliance Net-to-Gross										
Units collected	x	x								
Part use	x	x								
Without program, kept or discarded	x	x								
% Discarded units transferred to new owners			x							
How second-hand units are used			x							
Analysis of program attribution	x	x	x							
UEC	x						x	x	x	x
CFL Free Ridership, Usage, and Installation Rates		x								
Process Evaluation										
Satisfaction		x								
Timeliness		x								
Adherence to Procedures		x			x	x				
Process flows					x	x				
Market Assessment										
Saturation of second refrigerators and freezers			x	x						
Willingness to give up			x							
Natural turnover rate			x							

The remainder of this section describes each data source used, the rationale for using it, its content, and the approach used to collect the data.

4.1 ARCA's Database

ARCA's database contains detailed information on each participant, including:

- Variables that describe the participation experience, including
  - the participant's name, address, and phone;
  - various dates when the pickup was scheduled, when it occurred, when callbacks for rescheduling were made, etc.;
  - the number of units collected at each site;
  - the characteristics of units collected, including manufacturer, model, size, age, defrost type, and color variables; and
  - the type of incentive received.
- Survey data collected at the time the appliance pickup is scheduled). These data include information on how customers learned about the program, how the program affected their decision to recycle, and key demographic information about their household.

SCE's ARCATS database contains program data at a less detailed level than ARCA's database. It is used to track RARP accomplishments and provide data needed for the quarterly reports to the CPUC.

4.2 Participant Survey

The Participant Survey supports both the impact and process components of the program evaluation. This survey was fielded to 545 customers who participated in the RARP program during 2002.

4.2.1 *Participant Sample Distribution*

The participant sample breakdown was based on the distribution of RARP participants during 2002. Thus, the participant sample was stratified by

- utility,
- appliance type (refrigerator/freezer),
- HTR and non-HTR populations,
- incentive type ($35 vs. CFLs), and
- language (Spanish-/non-Spanish-speaking).

Table 4-2 shows the breakdown of 2002 participants by these strata and shows how the completed participant surveys were distributed among these strata.

Table 4-2
Final Participant Survey Distribution

Freezers							
				2002 Participation Data		Completed Surveys	
Utility	Market Segment	Rebate Type	Spanish-Speaking Only	Number of Freezer Participants	% of Freezer Participants	Number of Completes	% of Completes
PG&E	HTR	$35	No	326	8.6%	6	8.8%
		CFL		45	1.2%	3	4.4%
	Non-HTR	$35		921	24.3%	11	16.2%
		CFL		113	3.0%	2	2.9%
SCE	HTR	$35		820	21.6%	11	16.2%
		CFL		72	1.9%	4	5.9%
	Non-HTR	$35		950	25.0%	17	25.0%
		CFL		55	1.4%	5	7.4%
SDG&E	HTR	$35		175	4.6%	2	2.9%
		CFL		49	1.3%	0	0.0%
	Non-HTR	$35		216	5.7%	4	5.9%
		CFL		54	1.4%	3	4.4%
			Total	**3,796**	**100.0%**	**68**	**100.0%**

Refrigerators							
				2002 Participation Data		Completed Surveys	
Utility	Market Segment	Rebate Type	Spanish-Speaking Only	Number of Refrigerator Participants	% of Refrigerator Participants	Number of Completes	% of Completes
PG&E	HTR	$35	No	2,035	5.6%	34	7.1%
			Yes	163	0.5%	0	0.0%
		CFL	No	299	0.8%	9	1.9%
	Non-HTR	$35		4,638	12.9%	62	13.0%
		CFL		800	2.2%	13	2.7%
SCE	HTR	$35		9,899	27.5%	131	27.5%
			Yes	2,422	6.7%	21	4.4%
		CFL	No	784	2.2%	8	1.7%
			Yes	252	0.7%	3	0.6%
	Non-HTR	$35	No	9,038	25.1%	124	26.0%
			Yes	628	1.7%	4	0.8%
		CFL	No	775	2.2%	9	1.9%
SDG&E	HTR	$35		1,805	5.0%	30	6.3%
		CFL		394	1.1%	3	0.6%
	Non-HTR	$35		1,712	4.7%	22	4.6%
		CFL		402	1.1%	4	0.8%
			Total	**36,046**	**100.0%**	**477**	**100.0%**

4.2.2 *Uses of Participant Survey Data*

With regard to its role in the **impact evaluation**, this survey contains a battery of attribution and usage questions that query participants on their use of the recycled unit prior to pickup, the unit location, their use or disposition of the unit in the absence of the program, and their schedule of use of the recycled appliance. Findings from this battery support the calculation of portions of the net-to-gross factor.

Another key purpose of this survey is to support the **process evaluation**. A second battery of process questions queries participants about their specific experiences with program administrative processes: marketing, enrollment, pickup scheduling, appliance pickup, and incentive selection and disbursement.

A third use of this survey is to provide data for the **market assessment** (to be completed in the spring of 2004). Findings from a battery addressing replacement of the recycled unit will support the calculation of remaining market potential. Responses from a question sequence on energy-efficient behaviors as well as a battery of questions on demographic characteristics will support the characterization of likely program participants.

4.2.3 *Participant Survey Implementation*

The Participant Survey was fielded by phone over a 4-week period from mid August to mid September 2003. Prior to this, the survey was pretested July 24–25, 2003. Following this pretest, changes were made to the questionnaire to correct awkward or ambiguous wording in a few of the questions and the order in which certain questions were asked to provide for a smoother, more logical flow.

4.3 NONPARTICIPANT SURVEY

Findings from the Nonparticipant Survey were used in both the impact evaluation and market assessment tasks. This survey was fielded to 647 nonparticipants, of which 511 were randomly selected and another 136 were exclusively disposers and acquirers of used refrigerators and freezers.

4.3.1 *Nonparticipant Sample Distribution*

The nonparticipant sample was drawn from utility billing system records. The following is the distribution of the 647 Nonparticipant Survey respondents:

- 145 (22 percent) were recent disposers of used refrigerators/freezers;
- 91 (14 percent) were recent acquirers of used refrigerators/freezers;
- The sample is further stratified by

- utility service area,
- HTR versus non-HTR, and
- housing type (single-family, multi-family, and mobile homes).

4.3.2 *Uses of Nonparticipant Survey Data*

The Nonparticipant Survey includes separate batteries of questions for fairly recent acquirers and disposers of used refrigerators and freezers. Findings from the disposer battery were used to determine what participants would have done with their unit absent the program and, thus, were particularly critical for the calculation of the net-to-gross factor. Findings from the acquirer battery will be used to help estimate the future market potential for recycled units and to determine the nature of the acquired unit's use (main versus spare). There was also a short sequence of questions that helped to determine reasons for nonparticipation in the program and to identify possible remedies.

4.3.3 *Nonparticipant Survey Implementation*

The Nonparticipant Survey was fielded by phone over an approximately 3-week period in September 2003. Since the majority of survey questions were identical to the acquirer and disposer sequences contained in the Participant Survey, there was no need to do any further pretesting of the survey instrument.

4.4 STAFF INTERVIEWS

The primary purpose of staff interviews was to support the **process evaluation**. Utility program leads and ARCA staff were interviewed at an early stage during the evaluation in order to identify process issues of concern to them. This feedback was instrumental in designing process-related question sequences for the Participant Survey. It also was a key source of evidence to support our process-related findings and recommendations.

4.5 ARCA FACILITY TOUR

Another important data source for the **process evaluation** was the ARCA facility tour conducted on March 7, 2003. This tour allowed us to verify the overall efficiency of the recycling process through direct observation and analysis of the primary workflow processes. We interviewed the lead staff, which allowed us to identify any inefficiencies and problem areas in the recycling process.

4.6 STATEWIDE RASS

Data from the RASS study will be used to support the **market assessment** task, specifically the calculation of remaining market potential. Because these data were not available during the rest of the study's timeframe, the market assessment has not yet been completed. This analysis will be completed in early 2004.

4.7 PRIOR METERING DATA

Under the previous 1996 RARP study conducted in 1998 (Study #537), lab metering was performed in two separate studies on a total of 1,313 recycled units. The largest share of these (1,173 units) were metered by ARCA in a study that involved metering of units from ARCA's various programs throughout the U.S. The remaining 140 units were metered in April 1998 based on U.S. DOE laboratory metering protocols under a study sponsored by SCE and conducted by BR Laboratories. The findings from this smaller metering effort were used to assess and correct for biases that may have emerged from either sample selection or instrumentation during the previous ARCA metering study.

In Study #537, the two metering study samples were combined and a regression including terms that assessed and corrected for any possible ARCA metering study biases was calibrated against metered consumption to obtain full-year UECs.

4.8 NEW METERING STUDY

Under this evaluation, new metering based on the same U.S. Department of Energy (DOE) lab-metering protocols as was used in the previous studies, was conducted on 100 recently recycled refrigerators and freezers. The metering of newer units allowed us to update UEC estimates for the following two effects:

1. **Changes over time in the efficiency of new units.** Because of these changes, the UEC of a unit of a given age in 2002 is not the same as a unit of the same characteristics in 1996. A particular concern is that because of a change in standards in 1993, units built since that time that are collected by the program may not be described well by the model based on older units; and
2. **Degradation of efficiency over time.** This degradation caused the UEC of a unit of a given vintage in 2002 to differ from what it was in 1996.

This current study will combine metered data results from these two prior studies with data from the new metering study to obtain updated UEC estimates.

4.9 AHAM DATA AND CEC EFFICIENCY DATABASE

Association of Home Appliance Manufacturers' (AHAM) data represent test-condition metered data at the time a unit was new. The California Energy Commission's (CEC) Efficiency Database provides similar data on additional models. We had hoped to be able to use these data sources to provide as-new UECs as a predictor in the UEC models for collected refrigerators and freezers. However, limitations in the completeness of the data available made this use impractical. While we explored alternative ways to strengthen the models with the available data, the final results did not use these data because of their limitations.

5 PROCESS EVALUATION FINDINGS

The initial part of this section provides a characterization of 2002 program participants based on our findings from the Participant Survey and analysis of 2002 tracking data. We present the current findings and compare them with those from our evaluation of the 1996 recycling program.

The remainder of this section provides the process evaluation findings. This portion of the study was designed to evaluate the program's administrative functions, assess participant satisfaction with various aspects of the program, and identify areas for program improvement. Our evidence for this portion of the evaluation comes from multiple sources: interviews with utility program managers, participant and nonparticipant surveys, a site visit to the ARCA facility, and an interview with the manager of ARCA's recycling center in Compton, CA. We also reviewed program materials provided by both the utilities and ARCA.

The process-related findings presented in this section are as follows:

- **Administration** – an overview of the program's administration and assessment of its effectiveness;
- **Appliance recycling process** – a description and assessment of each component of the appliance pickup and recycling processes;
- **Incentive preferences** – a discussion of the current incentives offered, participants' satisfaction with them, and their views of alternatives;
- **Program marketing** – a description of current program marketing activities and evaluation of their effectiveness; and
- **Participant satisfaction** – a discussion of participant satisfaction with various program processes.

Our detailed findings from the Participant and Nonparticipant Surveys are stratified by Utility Service Territory and HTR versus non-HTR (also shown in Appendix F). However, because we did not find any notable differences between HTR and non-HTR responses, our summary of survey findings is for all respondents and does not distinguish between these two groups.

5.1 CHARACTERIZATION OF 2002 PROGRAM PARTICIPANTS

Our findings from the Participant Survey reveal some significant differences in the characteristics of participants now versus those in the 1996 program. We asked participants two separate questions regarding: (1) whether the recycled unit had been replaced by a new unit or not; and (2) whether the recycled unit had been operated as a main unit or a spare. Table 5-1 provides a characterization of participants in terms of the types of units they offered to the 2002 program versus the 1996 program based on these two questions. Table 5-2 provides additional detail for those that replaced units only. Please note that these responses are not additive.

Table 5-1
Types of Units Offered by Participants

	2002	1996
Refrigerators		
replaced	85.7%	32.9%
primary	78.7%	23.9%
Freezers		
replaced	37.5%	20.5%

Table 5-2
Types of Units Offered by Replacers Only

Refrigerators		
Replaced	**2002**	**1996**
Primary	83.4%	47.1%
Secondary	16.6%	52.9%

These findings illustrate how dramatically the program has changed since the 1996 program evaluation. In 2002, most participants with refrigerators said they had acquired a new unit to take the place of the one they got rid of, whereas in 1996 only a fraction of participants had replaced their units. Further, over three-quarters of participants in 2002 said the recycled unit was their primary unit, while in 1996 the majority of recycled units were secondary units. Table 5-2 shows that the overwhelming majority of refrigerator owners (both primary and secondary units) replaced the units they got rid of in 2002, while in 1996, the percentages of those that replaced units, particularly secondary units, are much lower. This shift in the types and uses of units offered by participants has significantly reduced the net-to-gross factor, discussed in detail in Section 7.

These changes were brought about by changes in program rules in 1999 to allow the pickup of both primary units and spares (prior to this, the program only allowed spare units to be picked up). Because of this change, the program primarily consists of primary units that were replaced. Those wishing to give up true spares now comprise less than one-quarter of the participant population.

Additional findings from the ARCA's tracking data reveal significant differences in the age distribution of units collected in 2002 versus 1996. In general, units recycled in 2002 are considerably younger than those recycled in 1996. The program participant population's shift to predominantly replaced primary units has contributed towards newer units being collected now than previously. Other factors contributing to this trend toward younger units could be: greater willingness to retire inefficient units early given the drop in refrigerator prices over these years, and greater incidence of remodeling and associated unit replacement. Figures 5-1 and 5-2 compare the 2002 and 1996 age distributions of recycled refrigerators and freezers.

Figure 5-1
Age Distribution of Recycled Refrigerators

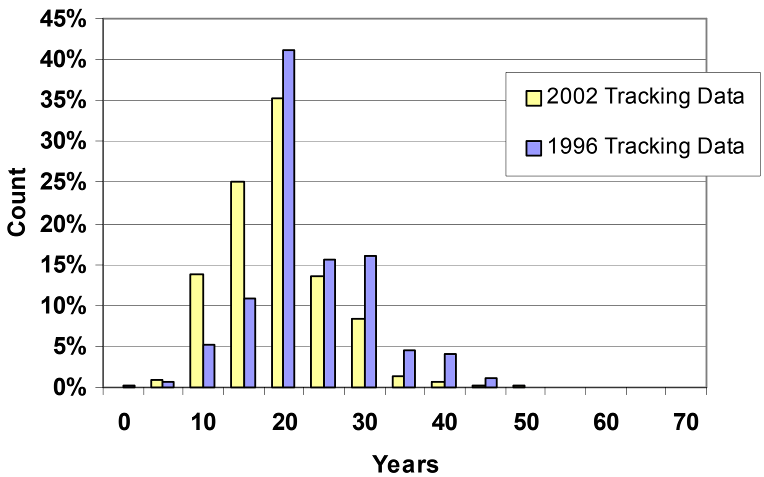
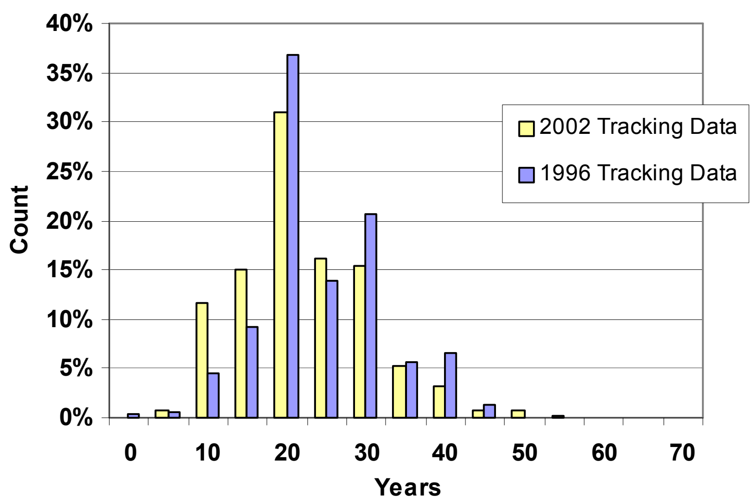


Figure 5-2
Age Distribution of Recycled Freezers



5.2 PROCESS EVALUATION FINDINGS

5.2.1 Background

During 2002, ARCA was the contractor chiefly responsible for all program functions concerning appliance recycling, marketing, and advertising. (ARCA carries out the marketing and advertising for SDG&E and PG&E only.) In 2003, the CPUC selected another contractor, Jaco Environmental, to implement these functions on behalf of PG&E while retaining ARCA for the SCE and SDG&E programs. Our discussion of process issues in this section is based on the approach used in 2002 in which ARCA was the only contractor involved with program implementation. We caveat those issues and concerns raised by PG&E that are no longer relevant under the current approach.

ARCA has been recycling unwanted appliances since 1975 at several U.S. locations. For over 10 years, ARCA has been recycling refrigerators and freezers on behalf of California's utilities. SCE is their largest utility client, accounting for over 27,000 recycled units in 2002. ARCA provides electric utilities with turnkey services to remove and recycle inefficient working refrigerators and freezers.

In certain respects, ARCA is uniquely qualified to perform refrigerator and freezer recycling services due to its use of patented, proprietary, large-scale recovery systems to recover refrigerants and other hazardous wastes. Many of these recovered nonrefrigerant materials can then be resold into the secondary market rather than going to the landfill. ARCA estimates it recycles 80 percent of refrigerator and freezer components and sends only 20 percent to landfills.

5.2.2 Program Implementation

In 2002, most RARP service functions were carried out by ARCA. These include

- customer enrollment,
- pickup scheduling,
- appliance pickups,
- appliance recycling,
- program tracking, and
- program marketing.(SDG&E and PG&E only)

Each of these functions is discussed in detail in following subsections.

As the contractor responsible for carrying out most program tasks, ARCA's work is closely managed by SCE, the utility that administered the 2002 RARP program on behalf of all three of the state's IOUs. ARCA has been SCE's contractor for over 10 years, and appears to have a very good relationship with key SCE staff responsible for managing the program.

5.2.3 Appliance Pickup and Recycling Processes

ARCA is chiefly responsible for carrying out all steps in the appliance pickup and recycling processes. These include

- Participant enrollment,
- Pickup scheduling,
- Appliance pickup, and
- Appliance recycling.

Each of these is discussed separately below.

Customer Enrollment

Customers are enrolled in the program in one of two ways: by telephone or over the Internet. Typically, both enrollment and pickup scheduling take place on the same phone call or Internet transaction.

To enroll by phone, customers call into either their utility's or ARCA's call center and a utility or ARCA employee talks them through the enrollment process. This process consists of answering a few questions to establish their eligibility for the program, obtain contact information, and determine which type of incentive they prefer.

The Internet process works similarly, except it uses a point-and-click question-and-answer process to obtain the necessary information. Customers can enroll either through their utility's or ARCA's web sites.

Pickup Scheduling

Pickup scheduling is the second part of the phone call or Internet transaction. Customers are offered the first available times. If these aren't feasible, they are asked to leave detailed information about their availability plus contact information so that the utility or ARCA can get back to them with a suitable time. Pickups are generally scheduled no more than two weeks out in order to accommodate customers' desire for speedy pickup of the units.

Appliance Pickups

The day before the scheduled pickup, ARCA develops a truck route of the next day's pickups and assigns drivers to each route. Typically, each route consists of 10 to 12 pickups. To maximize efficiency, ARCA combines its southern California routes. For example, its driver may pick up units from SCE, SDG&E, and the Los Angeles Department of Water and Power on the same day. Because PG&E is isolated geographically from the other two utilities involved in the program, ARCA schedules their pickups separately when it has a sufficient backlog of units scheduled to justify a full truck route. Units are then trucked to an intermediate location where they are loaded onto a trailer for eventual transport to ARCA's recycling facility in Compton. When the trailer is full, the units are then transported to its Compton facilities. Despite this more involved process, ARCA picked up units in PG&E's territory fairly responsively.

From ARCA's perspective, there are two elements of a successful pickup: (1) the participant is at home, and (2) the participant demonstrates that the unit is working at the time of the pickup. Before the pickup takes place, ARCA takes steps to try to ensure that each element will be met and the pickup will be successful. First, on the day before the pickup, ARCA's truck drivers call customers to confirm the next day's pick up. On the day of the pickup, ARCA's truck drivers use cell phones to report the actual pickup time and confirm the participants will be home at the time of the pickup. Second, ARCA tells participants to plug the units in the night before to confirm they are working (cooling) when the pickup occurs.

Despite these precautions, ARCA reports that about one-fourth of those scheduled pickups are either no-shows or have non-working units. ARCA reschedules the no-shows quickly, as they have found that after five days have passed since the failed pickup, there is 50 percent attrition of the no-show market because many units are then sold into the used appliance market. The longer the wait, the greater the attrition. Since ARCA gets paid for actual pickups, it is in their best interest to minimize attrition and missed opportunities.

To accommodate the schedules of those who work during the week, ARCA offers some Saturday pickup times. They do not pickup units at night, as their drivers believe some areas are unsafe after dark.

In addition to verifying the unit is working and removing it from the customer's property, ARCA's drivers have other responsibilities during the pickup. First, they must label the unit with both the ATO number and amperage. Second, they must disable the unit by cutting the cord and breaking the controls. This latter step is a precaution to ensure that the driver does not resell the unit into the used market prior to transporting it to ARCA's facility. A third responsibility is to record certain information about the unit, such as its manufacturer, color, age, size, defrost type and configuration (e.g., side-by-side).

Appliance Recycling

ARCA has been in the business of providing environmentally sound appliance recycling services for 25 years. ARCA's recycling process is comprehensive and appliance components are handled using very advanced and environmentally responsible methods. Through ARCA's recycling procedures, the company recovers and reclaims refrigerants, including CFCs, HCFs and HCFCs. To recover these refrigerants, ARCA uses patented, proprietary, large-scale recovery systems that are unique to its business. ARCA's recycling process also recovers and properly disposes of all hazardous materials, such as those containing PCBs or mercury. Where possible, components that have market value are extracted, and resold into the market. Both refrigerants and other recyclable materials, such as steel and aluminum, are reclaimed and sold as scrap. Appendix B contains photos and captions that describe the entire recycling process.

5.2.4 Program Tracking and Reporting Functions

Tracking

ARCA collects and tracks the customer and recycled refrigerator and freezer unit information. ARCA maintains its own database that contains detailed information about each participant. ARCA populates it with four main types of information:

1. **Participant data** – contains each participant's name, street and billing addresses, and phone number for primary and secondary contacts. ARCA also assigns each participant a unique identifier called an ATO number.
2. **Recycled unit information** – unit brand, model, size, age, color, defrost type, pickup location, and amperage.
3. **Pickup scheduling information** – ARCATS tracks various dates, including
   - when the original call was placed
   - pickup scheduling dates – the customer's first choice, the earliest available, the assigned pickup date, and the actual pickup date. There also is a pickup rescheduled field for the date the pickup was rescheduled in cases where that is needed.
4. **Incentive information** – ARCA tracks the type of incentive (cash or CFLs) chosen by each participant.

As the overall program administrator, SCE's program leads were able to view the program tracking data in real time so they can closely monitor program activity. The other two utilities did not have this level of access to tracking data.

ARCA also tracks dropouts, which are defined as those who schedule a pickup time, then drop out of the program prior to the pickup date.

Reporting

ARCA handles the real-time and weekly reporting of program activity to SCE, PG&E, and SDG&E. SCE is responsible for preparing content for the quarterly and annual reports to the CPUC for all three utilities. An important source of information for these reports is the program tracking system (ARCATS).

Until recently, ARCA provided reports of program activity to the utilities each month. (Reporting is now done weekly as discussed below.) These reports indicate (1) the total number of units scheduled to be picked up, (2) the total number of units picked up during the reporting period and (3) the number of cancelled pickups. Until recently, there was no separate breakdown of HTR versus non-HTR activity in these reports.

During the staff interviews, utility program leads reported some problems with ARCA's reports.

1. *The reporting was not timely enough for them to react if the news is not good*. The after-the-fact, monthly reporting of program activity did not give them enough advance warning that they are not meeting their program goals.
2. *There was no direct communication of any IOU's customer dropouts and dropout rates.*
3. *The reports did not accurately reflect program progress (because the results are lagged).*
4. *There was no separate breakout of progress versus HTR goals.*
5. *The report format was confusing.*

Program staff indicated they would like to see more frequent reporting by ARCA and direct communication of problems so they have sufficient time to ramp up program marketing, if needed.

ARCA did increase the frequency and level of detail in its reporting to the utilities. Each week, ARCA now provides all program leads with information on units scheduled, cancelled, and billed (i.e., completed) both in total and for HTR customers. This information allows each utility to monitor progress against their various goals and to stay current on their dropout rate.

5.2.5 Program Starting and Stopping

As SCE's contractor, ARCA has borne the brunt of program funding disruptions that have taken place in recent years. These have occurred primarily in between program years when the prior year's budget is spent and the next year's budget has not yet been awarded. ARCA must ramp down recycling activities during the "stop" period when no funding is available, and then quickly ramp up after funding is restored. Typically during the ramp-up period, ARCA is asked to resume to ever-higher levels than before (because of the waiting list that has developed) in order to make up for the time lost during the funding gap.

In terms of the RARP program, there are two major problems that arise during the stop period:

1. ARCA's employee turnover is higher because some of its skilled employees move on to other jobs during the down (layoff) times.
2. Customers who have requested appliance pickups are wait-listed for an indeterminate amount of time.

ARCA has diversified its operations at its Compton facility in order to provide additional work for its employees during the stop period. This has allowed some of its employees involved in recycling activities to work on other projects during the funding gap period. Nevertheless, the program start-stop does create hardships for ARCA, who must deal with funding uncertainty and wide fluctuations in work activity every year during the fourth quarter of the program year and the first quarter of the following year. ARCA's Compton recycling facility manager summarized the problems that arise from this uncertainty. They include employee turnover and difficulty in making long-term investment decisions. ARCA would prefer that the program be funded on a multi-year basis so program starting and stopping can be minimized.

Long customer waits are equally difficult. Until program funding is restored, there is no immediate solution other than for customers to find an alternative way to dispose of their unit. For many, these alternative ways include giving the unit away or selling it in the used market. During long wait periods, many units that would otherwise have been recycled find their way back into the secondary market. An added problem is that customers may become very dissatisfied with the program and decide not to use it in the future, or not recommend it to others.

The recent CPUC draft decision authorizing the 2004-05 statewide energy efficiency programs provides for a two-year funding period and, thus, eliminates the stop-start problem in 2004. .

5.2.6 Program Marketing

Primary Marketing Activities

Marketing activities vary from utility to utility. The RARP is a major residential energy efficiency program in SCE's territory, and accounts for the majority of participants (25,695 out of 39,842 participants in 2002). Marketing remains an integral program activity and allows SCE to maintain significant levels of customer participation each year. RARP's marketing activities include (1) HTR areas of all three utilities and (2) awareness building and education efforts, especially in HTR areas.

In 2002, primary marketing activities were undertaken by ARCA for SDG&E and PG&E only. ARCA used a combination of mass media (radio and TV spots and newspaper ads) to publicize the program. Within utility territories, ARCA used different approaches, but these were driven by what was available through the mass media. For example, in San Diego, cable TV was more available and ARCA could advertise on Spanish-speaking channels.

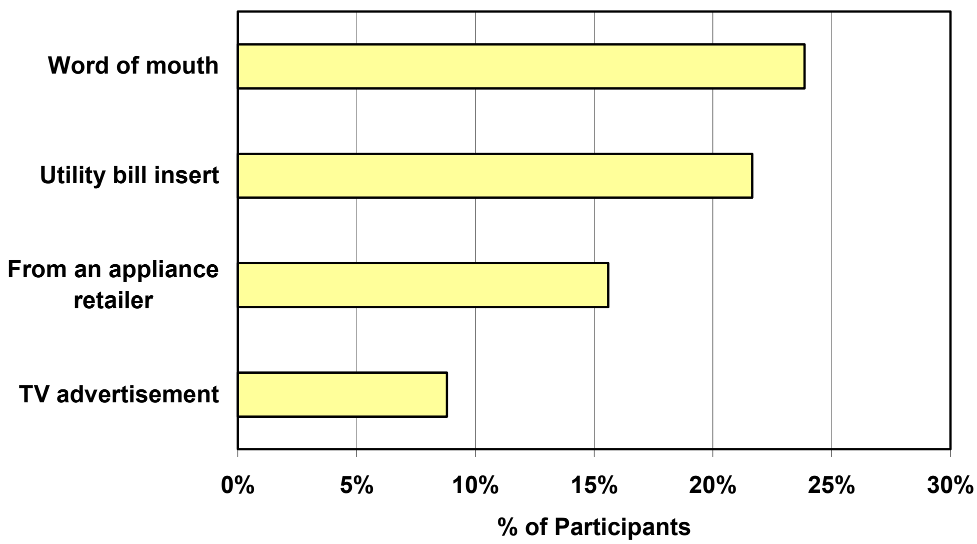
For HTR customers, ARCA used a variety of marketing approaches to publicize the RARP program. They used narrow cast spots from local cable TV companies for the HTR areas along with advertisements in local or ethnic newspapers. Specific approaches are tailored to each HTR area and are a function of the media that are available there.

Utilities' primary role in program marketing is to make basic information available to their call center staff so the call center can field customer inquiries about the program.

Participants' Feedback Regarding Program Marketing

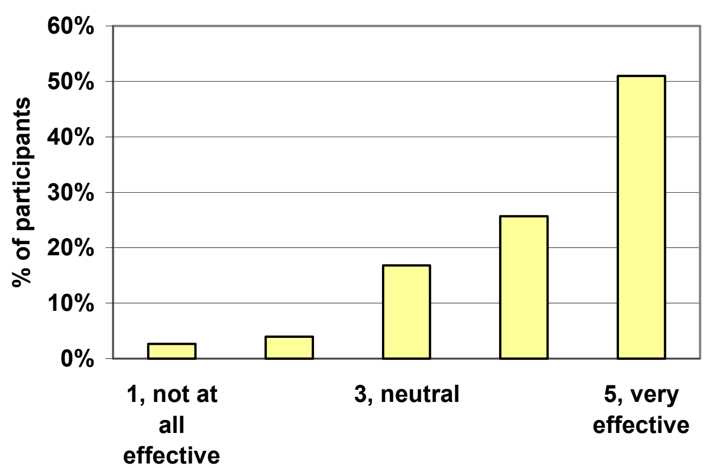
How did participants first become aware of the program? We asked them what their first sources of program information were and the most commonly reported source was word of mouth. Utility bill inserts and tips from appliance retailers were reported as other important information sources. Since the majority of participants are SCE's customers who come to the program on their own, our findings are consistent with that approach. For PG&E's customers, the appliance retailer was the most commonly reported first source of information about the program. For SDG&E, both word of mouth and TV ads were reported the most while tips from appliance retailers were reported less often. Interestingly, the utility website was only named by 2 percent of participants as their first source of information about the program. Figure 5-3 lists participants' most common first sources of information about the program.

Figure 5-3
First Sources of Program Information



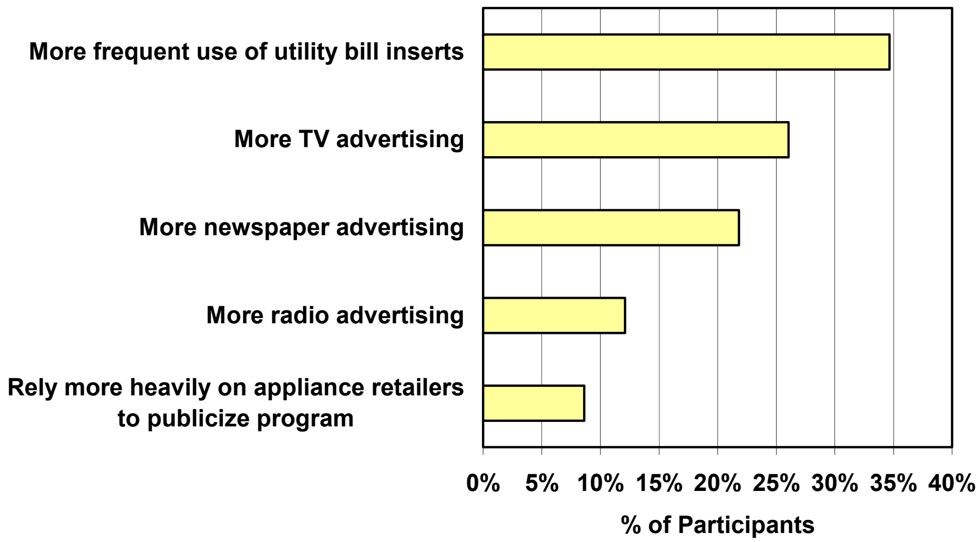
When asked to rate the program's efforts at marketing, participants' views were still quite positive, though less so than with other aspects of the program. Over 90 percent of participants gave the program's marketing efforts a score of 3, 4, or 5 as Figure 5-4 shows.

Figure 5-4
Effectiveness of Program Marketing



We also asked participants for their suggestions for raising awareness of the recycling program to other nonparticipating customers. Their ideas closely correspond to the approaches used by ARCA and the utilities now to publicize the program. Figure 5-5 lists their suggestions in descending order of popularity.

Figure 5-5
Participants' Suggestions for Raising Program Awareness



5.2.7 Primary Reasons for Joining Program

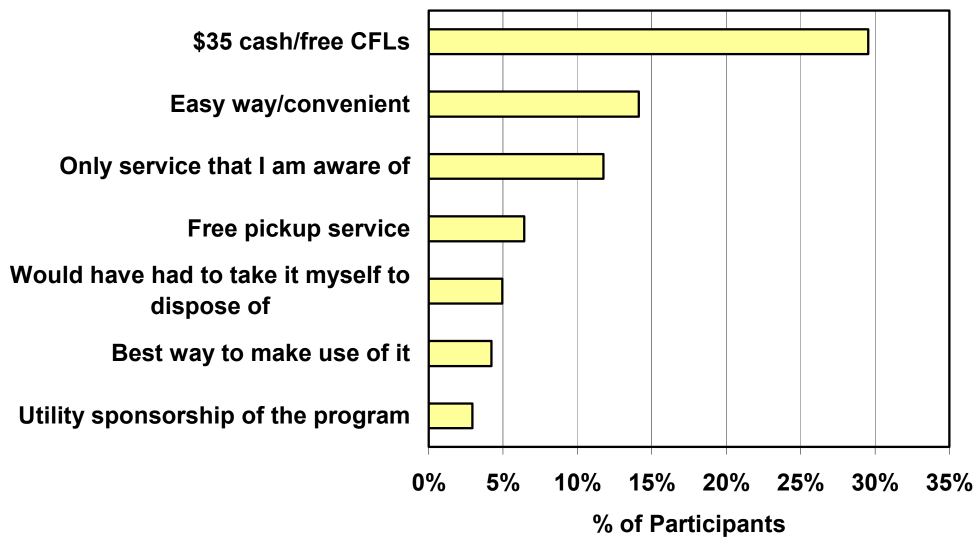
Participants were given an extensive list of possible reasons for joining the program and asked to select the main reason why they selected this program over other methods of appliance disposal available to them. The most popular responses fell into two categories:

- the ***incentive*** and
- the ***disposal service***.

While the program incentive was the most common of the 18 reasons on the list, the majority of participants (nearly 60 percent) gave a reason related to providing a disposal service for the appliance. This is consistent with the finding that a large fraction of participants are disposing of primary refrigerators that were recently replaced. However, this finding conflicts with other evidence provided by SCE that participation fell off in the past when the program offered other incentives worth less than the $35 currently being offered. The incentive is an important element of the program, and continues to be one that deserves further study.

Figure 5-6 shows our findings regarding the reasons most commonly given for joining the program.

Figure 5-6
Primary Reasons for Joining Program



5.2.8 Incentive Preferences

Through the RARP program, participants are offered a choice of incentives. They can select either $35 cash or a 5-pack of CFLs. During 2002, 90 percent of the program participants selected the cash incentive and only 10 percent chose the CFLs, most likely because the value of the cash incentive exceeds that of the CFLs, given current CFL prices. In the course of fielding the survey, we also learned that some of the participants who were given CFLs were not offered a choice of incentives. This suggests that if all participants had been given a free choice of incentives, fewer than 10 percent would have selected the CFL option.

We asked participants a series of questions in order to determine the importance of the incentive in their decision to recycle and to assess their preference for other incentive choices that the utility program managers indicated might be considered in the future.

Importance of Incentive in Decision to Recycle

Our findings regarding the importance of the incentive in one's decision to recycle were somewhat ambiguous. Nearly three-fourths of participants indicated they would still have used the program to remove their unit even if they had not received an incentive.

There are several ways this finding can be interpreted:

1. Having already pocketed their incentive, participants are now claiming that it was not an important part of their decision to give up their unit (even though it may well have been).

2. Now that they see that using the program was easy and convenient, they don't see the incentive as important, but when the program was an unknown, the incentive helped get their attention.
3. They see the program's primary value in its pickup of unwanted appliances, and the incentive is not critical in their decision to use the program.

Given the dramatic increase that has occurred since the previous evaluation in the number of primary units that are recycled, this is an issue that merits further study in future evaluation work.

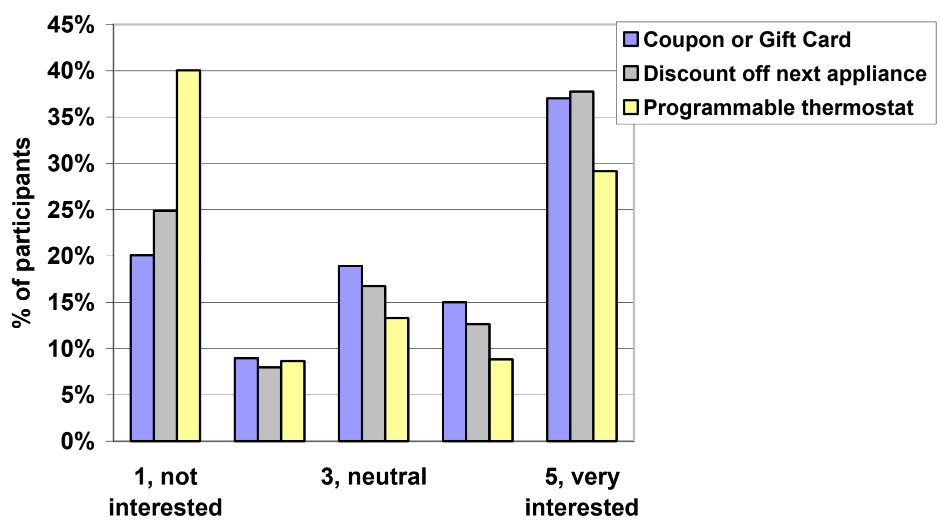
Preferences Among Alternative Incentives Offered

We also asked participants to rate their level of interest in three alternative incentive choices that the utilities might consider offering in the future. Ratings were on a scale of 1 to 5, where 1 meant they were not interested in the alternative and 5 meant they were very interested. These alternative incentives were a:

- Coupon or gift card for a local retailer,
- Discount at a local appliance dealer for their next purchase of an energy-efficient appliance, and
- Programmable thermostat.

Among these three choices, participants gave the highest ratings to the coupon or gift card incentive and the lowest ratings to the programmable thermostat. Ratings were predominantly neutral for all three choices and participants did not feel strongly about any of them. Figure 5-7 reports the distribution of ratings given for all three incentive options.

Figure 5-7
Preferences Among Incentive Choices



During 2002, CFLs accounted for 10 percent share of incentives chosen. However, this share is overstated because during part of the 2002 program year, participants in PG&E's territory were not given a choice of incentives but were required to take the CFL 5-pack. (This was done at a time when PG&E was running low on its program budget, but had an abundant supply of CFL 5-packs.) According to utility program leads, when a choice of incentives is offered, the true percentage of those taking CFLs is 5 percent, while the remaining 95 percent choose the cash incentive.

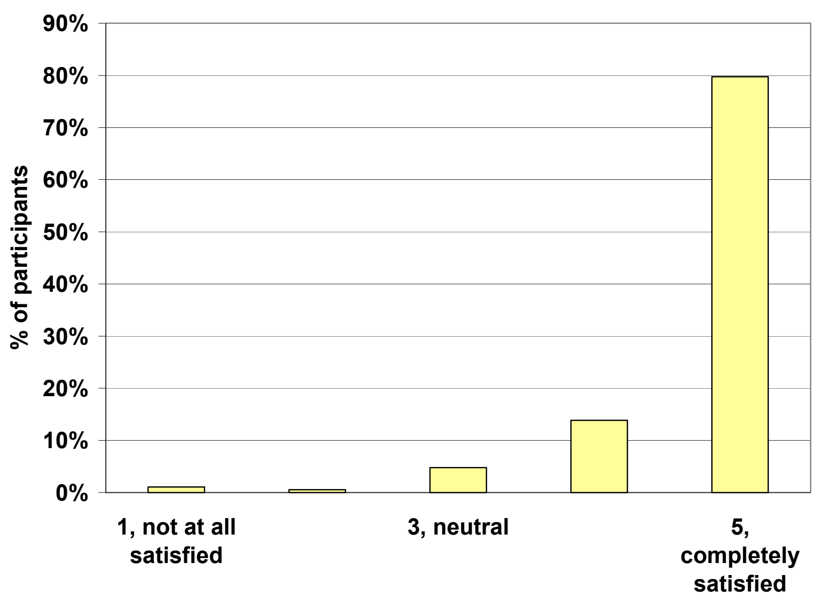
5.2.9 Participant Satisfaction

We asked participants a battery of questions designed to assess their satisfaction with the following RARP processes: enrollment, pickup scheduling, appliance pickup, and incentive processing. We also asked a general question about their overall satisfaction with the program. In each of these questions, participants were asked to rate their satisfaction on a 1 to 5 scale, where 1 meant they were very dissatisfied with the program or process, and 5 meant they were completely satisfied.

Overall Satisfaction

In general, participants were highly satisfied with the program and gave it very positive overall satisfaction ratings. Only 21 percent of participants were less than completely satisfied with the program and two-thirds of those still rated their satisfaction with the program highly, rating it a 4 on the 1–5 scale. Figure 5-8 shows these findings graphically.

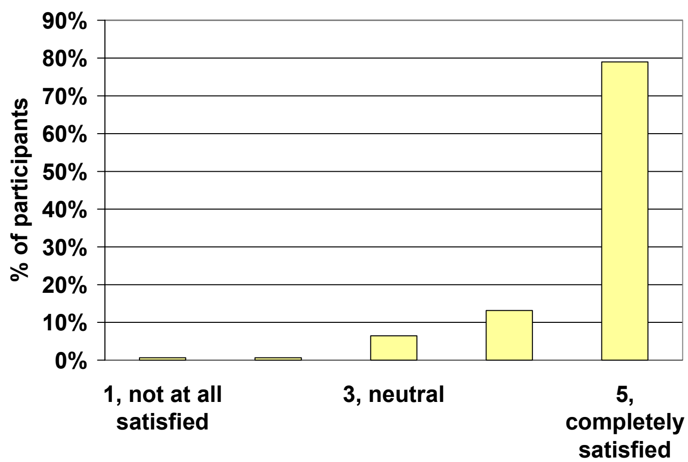
Figure 5-8
Overall Satisfaction with the Program



Enrollment

Participants as a whole were very satisfied with their enrollment experience, as Figure 5-9 shows. The majority of participants (78 percent) enrolled in the program by phone. This high level of satisfaction implies they were pleased with how they were treated during the phone call. It also indicates that those who enrolled Internet found that experience to be pleasing as well.

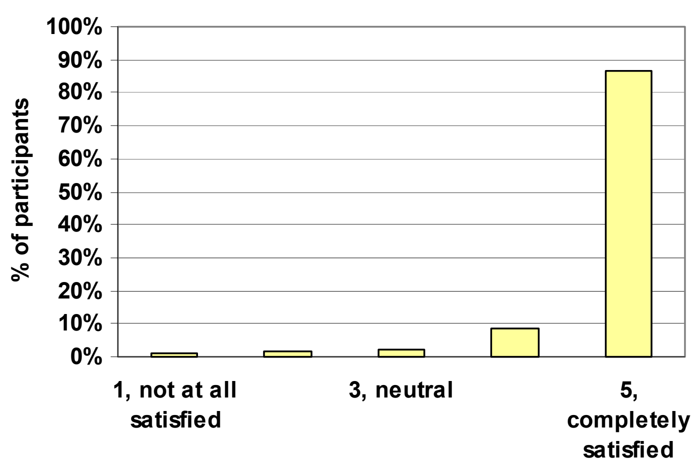
Figure 5-9
Satisfaction with Enrollment Experience



Pickup Scheduling

Participants generally gave high ratings to the process of scheduling an appliance to be picked up. From these findings, it appears they were not troubled by the program's weekday pickup times or its requirement that they be present during the pickup. As Figure 5-10 indicates, participant ratings of the pickup scheduling process generally mirror the high ratings given for other program processes.

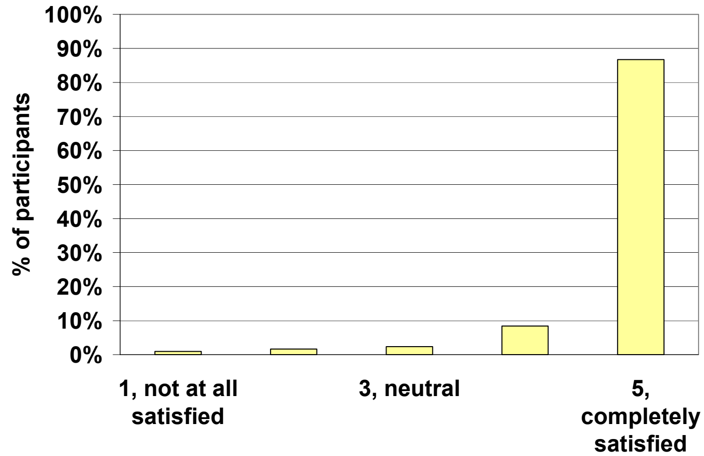
Figure 5-10
Satisfaction with Pickup Scheduling



Appliance Pickup

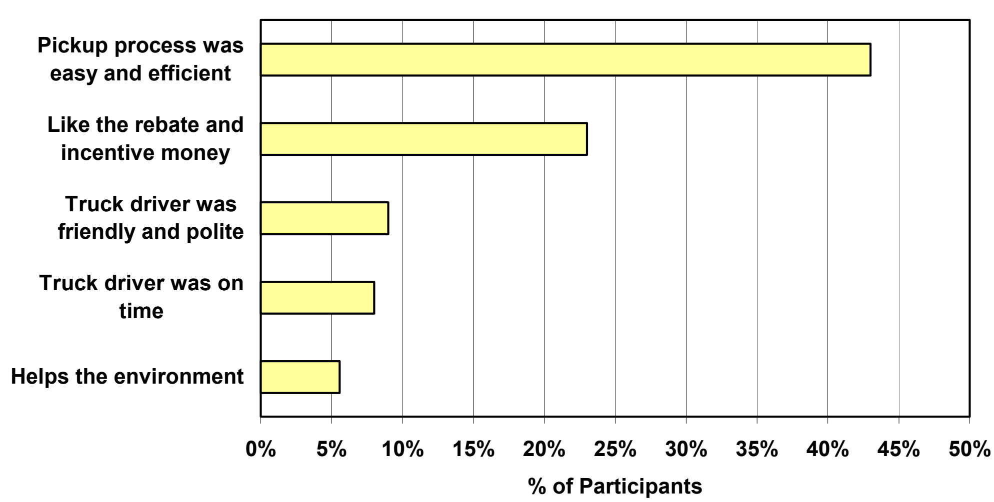
Likewise, participants rated the actual pickup experience highly, with the majority rating the program either a 4 or a 5. Figure 5-11 shows the distribution of ratings given to the appliance pickup experience.

Figure 5-11
Satisfaction with Appliance Pickup Experience



The most common reasons given for this were that the pickup process was easy and they liked having received an incentive for participating in the program. Of lesser importance were the politeness and professionalism of the truck driver and the environmental benefit of the program. Figure 5-12 below lists the primary reasons given for participants' high degree of satisfaction with the appliance pickup experience.

Figure 5-12
Reasons for High Satisfaction with Appliance Pickup



Incentive Payment Process

Participants found the incentive payment process was reasonable and most experienced wait times of four weeks or less, consistent with the two- to four-week window the utilities aim for. Average wait times reported by participants varied somewhat by utility; SCE's customers reported the lowest wait times and SDG&E's and PG&E's customers reported longer wait times. Table 5-3 reports our findings with respect to this.

Table 5-3
Average Wait Time to Receive Incentive Payment

Utility	Wait Time (in weeks)
All	3.6
Southern California Edison	3.4
Pacific Gas and Electric	4.2
San Diego Gas and Electric	3.7

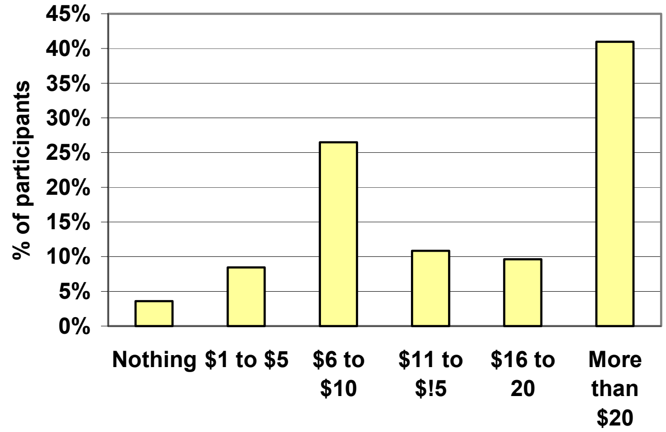
Most participants felt the wait time was reasonable, as **83 percent reporting that this amount of time was not too long.** In addition, there was agreement on this point among participants from all three utilities, despite the variations in wait time experienced. Only 20 percent of PG&E's customers felt the wait time was unreasonable, even though they reported waiting the longest to receive their program incentives.

Cost to Operate Older Units

We also asked participants what they thought it cost per month to run the older, less-efficient refrigerators and freezers that the program recycled.

As Figure 5-13 indicates, responses varied greatly, as less than half indicated operating costs that were realistic ($20 and over category). This provides further evidence of the need for increased customer education to raise awareness of the high cost of operating older, less-efficient units.

Figure 5-13
What Participants Think the Older Unit Costs to Operate Each Month (Refrigerator Owners)



5.2.10 Nonparticipant Survey Findings

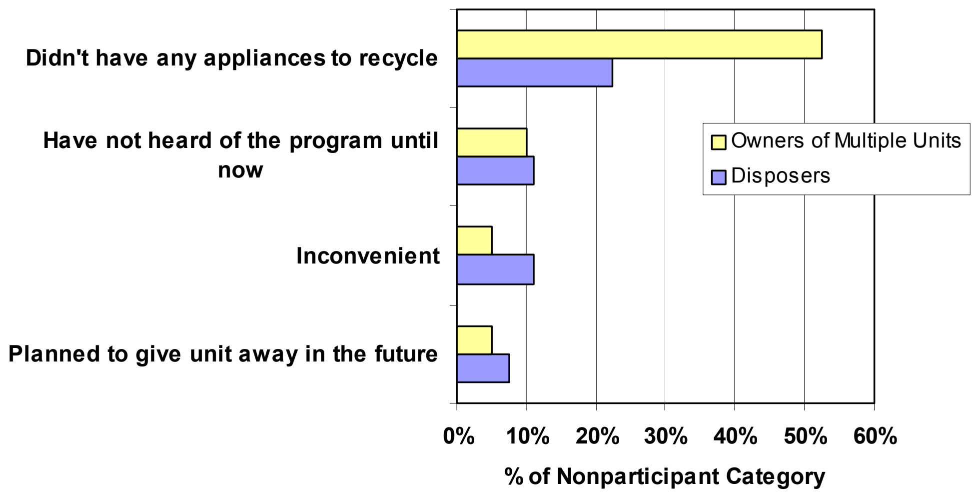
The nonparticipant survey provided us with additional insights regarding ways in which the program could be improved upon to make it more appealing to those who haven't yet participated.

We asked nonparticipants why they haven't used the program until now. We then analyzed the findings closely for two particular subgroups: recent disposers and those with multiple units. We selected these particular categories because they involve either

- those who recently disposed of a unit in some manner (recent disposer category), or
- those who own a secondary unit (multiple unit category).

Figure 5-14 lists the most common reasons given by these two nonparticipant subgroups for not using the recycling program until now.

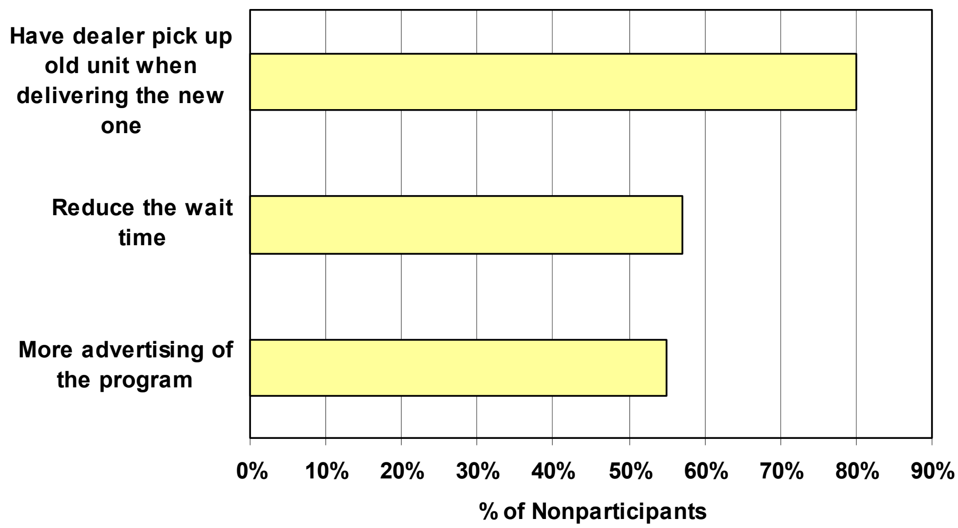
Figure 5-14
Reasons for Not Using the Recycling Program



By far, the most common response given by both subgroups was that they didn't have a unit to recycle. Even though they clearly had a unit to get rid of in some way (disposers) or a second unit, they did not regard them as units available for recycling. Other, less important reasons given were that they were not aware of the recycling program, that the program was inconvenient, and that they planned to give the unit away. These findings reveal the need for further education to make nonparticipants more aware of the significant cost of continuing to operate older, secondary units and to raise their awareness of the features of the recycling program

We also suggested a number of possible changes to the program and asked nonparticipants to indicate whether these changes would make it more or less likely to use the program or if it would make no difference. Figure 5-15 summarizes the feedback for those program changes the nonparticipants liked the most.

Figure 5-15
Changes That Would Make Nonparticipants More Likely to Use the Program



The design changes that received the most positive responses were those that would make the program more convenient to use by either immediate pickup by the dealer when the new unit is dropped off, or by otherwise reducing the wait time. Again, these findings are not surprising given that most participants are recent replacers that simply want to dispose of replaced units. Increased advertising was viewed as a third choice.

5.2.11 Other Process Findings

Additional concerns about the program were revealed during interviews with utility staff.

- *Some customers do not like the requirement that they must be home during the pickup.* Although this did not surface during the Participant Survey, it was acknowledged by SCE staff to be a problem during the interviews. They believe this requirement may discourage some customers from participating and, thus, may prevent the program from capturing its full market potential.
- *The program was very "hands off" for SDG&E and PG&E that were not directly involved in the day-to-day RARP operations.* Before ARCA instituted the more frequent and detailed reporting procedures being used now, it was hard for SDG&E and PG&E to determine when there were problems and to take a more proactive role to resolve them. The new reporting procedures have increased their level of involvement in the program, have enabled them to stay informed of program activity, and have provided them with the information they need to better manage their budget and spending decisions when funding gets tight. Therefore, this problem has been addressed.
- *PG&E program staff were skeptical of the program's claimed level of energy savings and this dampened their enthusiasm for promoting the program.* They have indicated that the

results of this study pertaining to net energy savings levels have fully addressed their concerns and that this is no longer an issue for them.

- *Customer education is needed to raise awareness of the cost of operating second refrigerators and freezers.* Currently, the program provides no information to consumers regarding the monthly cost of operating older, secondary units. The belief is that the program may be missing a large part of the target market, and that many more customers would give up their second units through the program if they knew what it cost to operate these units every month. Feedback received on the Participant Survey (discussed earlier in this section) reinforces this point.

5.2.12 Suggestions for Improvements

Most of the feedback we obtained about this program was extremely positive. Despite these positive perceptions, there are a few areas of improvement that remain based on our findings. The following are our recommendations.

- The utilities and ARCA should work together to better educate customers regarding the monthly cost of operating second refrigerators and freezers. They should provide customers with specific information regarding
  - An expected range of annual energy savings they would realize if the unit was recycled, and
  - The annual energy cost savings they would realize (given this range)

  The mailing should also contain general information on the importance of saving energy and protecting the environment, and explain how a decision to recycle a secondary unit provides benefits in these two areas. Given that the majority of RARP participants are recent replacers of older units, the mailing should go to all residential customers (since everyone will eventually fall into this category).
- **Additional variables should be added** to ARCA's tracking system (For example, add fields to describe where the unit had been located as a primary and where it would have been located if operated as a spare.) Currently, the program only lists the location at the time of the pickup, which may not be the same as where the unit would have been operated if retained.
- If cost effectiveness becomes a concern, the program should **consider changes in its design** to preserve its cost-effectiveness. For example, the utilities may wish to consider revising the incentive strategy or making other changes to how the program is delivered.

6 METERING STUDY AND UEC DETERMINATION

6.1 INTRODUCTION

This component of the evaluation develops the annualized estimates of unit energy consumption (UEC) from an analysis of metered data. Metered data for this analysis came from two sources: a large database of existing lab-metered data, plus a new metering study reflecting a sample of 100 units recently collected by the program. Both of these data sources used the Department of Energy (DOE) lab testing procedure to collect metered data.

In the evaluation of the 1996 program, the existing database of laboratory metering results, along with a new metering sample, was used to develop a model of laboratory UEC as a function of unit characteristics. This model was then applied to the population of collected units to determine the average UEC of the units collected in the program.

A key component of this evaluation was a new Metering Study. This study was needed for two reasons:

1. Because of changes over time in the efficiency of new units, the UEC of a unit of a certain age in 2002 is not the same as a unit of the same characteristics in 1996.
2. Conversely, because of degradation of efficiency over time, the UEC of a unit of a given vintage is different in 2002 than it was in 1996.

Below, we describe

- the approach of the new metering study,
- the study sample design,
- the development of the new UEC model, and
- the results of the new model applied to the 2002 population of collected units to determine the average UEC.

6.2 NEW METERING STUDY APPROACH

In developing the study plan, considerable attention was given to the question of whether to devote the metering effort to laboratory or to in situ measurement or to a combination of both.

The laboratory measurements are made according to a DOE test protocol that was designed to provide in a few days of laboratory metering results that would be similar to a full year of typical usage. The lab metering protocols represent an attempt to have a simulation of conditions (such as door openings) that reflect typical usage effects. However, this protocol was first developed in 1967 and only minor changes have been made to it since then through revisions made in 1979, 1988, and most recently in October 2003. (These changes are triggered by the expiration of the procedure approval at 10-year intervals.) It is not clear whether it still provides realistic measures of actual annual use for current refrigerators or for the particular climates served by this program.

In situ metering is also problematic. While this method measures actual use in the home, it would not be possible within this project's time and budget constraints to measure usage for more than about two weeks. Thus, it would be necessary to extrapolate from short-term to full-year usage. Moreover, since the participants have already requested removal of these units by the time they can be identified for inclusion in the sample, we would expect their operating conditions (food loading, door opening, conditioning of surrounding space) to be different in many cases from what their typical use would have been without the program. This is especially a constraint for the primary units that are being replaced. Another shortcoming of a stand-alone in situ metering sample is its limited applicability to other program years, especially if program eligibility requirements change dramatically in the future.

With any of the metering approaches, we would leverage the existing database of laboratory metering results with the new data. The leveraging approaches would be as follows:

- **In situ only:** Calculate the ratio of average annualized in situ UEC to average model estimate of laboratory UEC for the metering sample. Apply the ratio to adjust the population average model estimate of laboratory UEC.
- **Double metering (in situ plus laboratory for the same units):** Calculate the ratio of average annualized in situ UEC to average laboratory UEC for the metering sample. Apply the ratio to adjust the population average model estimate of laboratory UEC.
- **Laboratory only:** Update the model of laboratory UEC using the new metering data together with the prior metering data.

The capabilities of the different approaches, and the affordable sample sizes within the project budget, are indicated in Table 6-1. After considering the pros and cons of the different methods, the project advisory committee agreed that in this project we would conduct laboratory metering only, and would also conduct a review of the available literature comparing in situ with laboratory metering.

Table 6-1
Comparison of Alternative Metering Approaches

Approach Capability	DOE Lab Test	In Situ Only	In Situ Plus DOE Lab Test
Extending Lab Test Model & Database			
Add current-year points	X		X
Re-fit UEC model, apply to all 2002 units	X	X	X
Translating Lab to As-Operated			
Secondary sources, other regions & populations	X		
Model annualized in situ vs. modeled lab UEC		X	
Model annualized in situ vs. actual lab UEC			X
Translating to Full Year			
Weather model based on unit location in home	O	X	X
Sample Size			
Proposal	70	160	35
Add $20k + 4 weeks to data collection			
Attempted	100	216	57
Successful	93	194	46

The findings of the literature review are presented in Section 8. Based on this review, we concluded that, while uncertainty remains as to the relationship between the DOE laboratory results and typical usage in a home, the available literature offers no conclusive basis for adjusting the laboratory results in one direction or another.

6.3 METER STUDY SAMPLE

6.3.1 Sample Design

The metering sample was designed to represent the population of units collected by the 2002 program. However, since metering was conducted in 2003, only units collected in 2003 were available for metering. For this reason, the sample was designed according to the distribution of units collected as of February 26, 2003. Units were selected according to that design from units collected between May 19, 2003 and October 17, 2003. Many of these units were still included in the 2002 program, but some were in the 2003 program.

The metering sample was stratified by

- Unit type (refrigerator or freezer),
- Size (cubic feet category),
- Defrost type (manual, automatic, partial),

- Configuration (single door, side by side, top freezer, bottom freezer; chest freezer, upright freezer), and
- Age.

The 100 units of the sample were allocated to the sampling cells using Neyman allocation. This allocation takes into account both the number of units in the population and the variance of UEC within the cell. The variance of UEC by cell was determined from the existing metering data.

Some adjustments were made to the stratification and allocation to address the fact that the limited sample size would have allocated zero units to some cells. One adjustment was to collapse cells that, based on the prior metering data, had similar average UEC and variance. Another was to allocate some points to a few cells that still would have had zero allocation, but were previously unrepresented in the metering data.

The sample allocation is indicated in Table 6-2.

Table 6-2
Metering Sample Allocation

Freezer Characteristics								
			2002 Participation Data		Metering Sample			
					Target		Completes	
Type	Age (years)	Size (cubic feet)	Number of Freezer Participants	Percent of Freezer Participants	Count	Percent	Count	Percent
Frost-Free Freezer (chest or upright)	Any	10–17	860	18.2%	2	18.2%	2	20.0%
	Any	18+	1,001	21.1%	4	36.4%	2	20.0%
Manual or Partial Defrost Freezer (chest or upright)	Any	10–17	1,736	36.7%	3	27.3%	3	30.0%
	Any	18+	1,138	24.0%	2	18.2%	3	30.0%
Total Freezers			**4,735**	**100.0%**	**11**	**100.0%**	**10**	**100.0%**

Refrigerator Characteristics								
			2002 Participation Data		Metering Sample			
					Target		Completes	
Type	Age (years)	Size (cubic feet)	Number of Refrigerator Participants	Percent of Refrigerator Participants	Count	Percent	Count	Percent
Frost-Free with Bottom Freezer	Any	Any	965	2.5%	2	2.2%	2	2.2%
Frost-Free with Single Door	Any	Any	618	1.6%	2	2.2%	2	2.2%
Frost-Free with Side-by-Side Doors	≤19	10–20	1,226	3.2%	3	3.4%	5	5.6%
	>20	10–20	1,446	3.8%	3	3.4%	3	3.3%
	≤19	21+	2,938	7.7%	10	11.2%	11	12.2%
	>20	21+	3,466	9.1%	11	12.4%	11	12.2%
Frost-Free with Top Freezer	≤19	10–17	4,246	11.1%	9	10.1%	11	12.2%
	>20	10–17	3,583	9.4%	7	7.9%	7	7.8%
	≤19	18–20	7,034	18.4%	16	18.0%	15	16.7%
	>20	18–20	7,023	18.4%	15	16.9%	13	14.4%
	≤19	21+	1,166	3.1%	3	3.4%	3	3.3%
	>20	21+	848	2.2%	2	2.2%	2	2.2%
Manual Defrost with Single Door	Any	Any	1,526	4.0%	2	2.2%	1	1.1%
Manual Defrost with Two Doors (all types)	Any	Any	1,469	3.8%	2	2.2%	1	1.1%
Partial Defrost (all types)	Any	Any	656	1.7%	2	2.2%	3	3.3%
Total Refrigerators			**38,210**	**100.0%**	**89**	**100.0%**	**90**	**100.0%**

6.3.2 Sample Implementation

The targeted quotas by sampling cell had to be met by units as they were being taken from the field. The procedure to fill the sample quotas was as follows:

1. ARCA staff provided a list to KEMA-XENERGY of the trucks that were scheduled for the following one to two days' pickups. These lists contained the number, type, and location of units scheduled for pickup by each truck. The information on unit type included the main unit characteristics—configuration, age, and size.
2. KEMA-XENERGY staff randomly selected trucks from which metered units were to be pulled.
3. ARCA notified the truck drivers of the truck selection and directed them not to cut the cords off or otherwise disable the units during the pickup.
4. These trucks were driven back to ARCA and units were unloaded and placed in a trailer for insect debugging. Units were also inspected by ARCA who then finalized the unit characteristics and other information on the Appliance Turn-in Order (ATO) and emailed this information to KEMA-XENERGY.
5. KEMA-XENERGY notified ARCA of the units selected for metering. These units represented a randomly drawn sample of the units in the truck that fell into sampling cells whose quotas had not yet been met.
6. The selected units were then taken to the metering laboratory.

Units delivered to the laboratory were metered according to the DOE protocol. In some cases, a unit could not be brought to a stable temperature. These units were excluded from the final metering database.

In addition to the sampling cell identifiers, data provided for each metered unit included:

- UEC and
- Model number.

6.4 UEC MODEL

The purpose of the UEC model is to provide a basis for estimating what the laboratory UEC would have been for each unit collected under the 2002 program. This model utilizes data from 1,143 units metered by ARCA between 1992 and 1995, together with 136 units metered by Southern California Edison in 1998 and the 100 units from the new metering sample. We refer to the new metering sample as the 2002 sample since it was drawn for the 2002 program, though the metering was conducted in 2003.

The model developed in this study builds on the prior model developed in the 1998 study. This prior model is described first.

6.4.1 1998 UEC Model

The model developed by Athens Research for the 1998 metering study used the 1,143 ARCA units together with the 136 units from the 1998 sample. The model is shown in Table 6-3.

Table 6-3
1998 UEC Model

Variable	Parameter Estimate	Standard Error	T-Value
Intercept	1,138	750	1.52
Freezer Binary	-932	808	-1.15
Frost Free Defrost Binary	320	290	1.1
Single Door Binary	-541	729	-0.74
Side-by-Side Binary	-718	795	-0.9
Top Freezer Binary	-811	715	-1.13
Upright Freezer Binary	407	342	1.19
Frost Free/Bottom Freezer Binary	-673	329	-2.04
Frost Free/Side-by-Side Binary	843	430	1.96
Manual Defrost/Single Door Binary	-362	224	-1.61
Partial Defrost/Top Freezer	457	147	3.11
Square Root of Age	-37	44	-0.85
Label Amperage	109	23	4.65
Volume in Cubic Feet	30	11	2.82
Amperage/Bottom Freezer Interaction	25	135	0.18
Amperage/Side-by-Side Interaction	-65	70	-0.94
Amperage/Freezer Interaction	45	72	0.62
Square Root of Age/Frost Free Interaction	137	54	2.53
1998 Metering Sample Binary	-739	393	-1.88
1998 Metering Sample Freezer Binary	212	177	1.2
1998 Metering Sample Binary/Square Root of Age Interaction	154	89	1.74

The variables on the shaded lines in the table were considered "non-negotiable" in the Athens Research work. That is, these were kept in the model whether or not they had high statistical significance to guard against potential biases. These biases might affect either estimates for particular subgroups or the estimated average effect if particular subgroups were present disproportionately in the sample observations. A goal of the 1998 model was not only to provide a good estimate of UEC for the current program population, but also to have a model that could be used for other applications. For this reason, reducing bias for particular subgroups had higher priority than it might otherwise have had.

A dummy variable indicating that the unit was in the 1998 sample is included in the model. This variable accounts for ways that the prior metered units may be systematically different from the current population, after the other characteristics are accounted for. Reasons for differences between the prior data and the current population could include the following.

1. Both vintage (characteristics of units built in a particular time period) and age (degradation or other changes over time) could affect UEC. Thus, an age variable can have a different meaning for units observed in 1998 than the same age would indicate for units observed between 1992 and 1995.
2. Units of particular characteristics in the Edison service territory may be different from corresponding units from other areas as a result of environmental or usage factors.
3. The original data were collected by ARCA, not by an independent third party. While there was no specific reason to suspect manipulation or bias in the sample, the inclusion of the 1998 sample dummy would account for any systematic differences related to sampling or other bias.

6.4.2 Developing the 2002 Model

AHAM and CEC Data

The original plan for the 2002 analysis was to add AHAM and CEC data on manufacturers' label UECs in the analysis. These data provide the UEC for new units based on the DOE laboratory protocol. Thus, in principle, for each unit in the database of units collected by the program, we could have the UEC from the time the unit was new as well as the UEC from the time the unit was collected by the program. The as-new UEC could be used as a predictor for the UEC at pickup.

As it turned out, AHAM data were available for only a limited number of years as indicated in Table 6-4.

Table 6-4
Years of AHAM and CEC Data

Year	AHAM[a]	CEC via WAPTAC	CEC[b]
1975	X		
1976	X		
1977	X		
1978			
1979		X	
1980		X	
1981		X	
1982	0	X	
1983	0	X	

– continued –

Table 6-4 (cont)
Years of AHAM and CEC Data

Year	AHAM[a]	CEC via WAPTAC	CEC[b]
1984	0	X	
1985	0	X	
1986	0	X	0
1987	0	X	
1988		X	
1989		X	0
1990		X	0
1991	X		
1992	0	X	0
1993	0		0
1994	0		0
1995			0
1996			0
1997			0
1998	0		0
1999	0		0
2000	0		0
2001			0
2002			0

X= Used, 0= Not Used

[a] AHAM is a voluntary listing. Whirlpool opted out after 1994.

[b] 95% of the Currect CEC database units from post 1996.

An additional problem with using the AHAM and CEC data was that model numbers are not included in the ARCAT database. As a result, a model that required model number as a basis for determining as-new UEC could not be applied to the program population.

We attempted to address the latter limitation by fitting a model of as-new UEC using a similar set of predictors to that in the 1998 UEC model. However, the resulting modeled as-new UEC had limited additional explanatory power in models that included the nameplate amperage (t-statistic = 0.59).

We also considered another way to use the manufacturers' UECs. These values could be included as additional data points in the model, with age = 0. However, in investigating the manufacturers' label UECs, we learned that this UEC is not necessarily based on metering a specific model, but may be an estimate based on metering of similar models. For this reason, we were reluctant to include these data as observations in our regression model. Thus, in the end these data had no role in the UEC model.

Extending the 1998 Model

We explored a variety of forms for a model combining data from each of the three sets of metering data. The most direct extension of the 1998 model used all the same terms, plus an additional set of "new sample" terms for the 2002 sample. For each of the terms involving the 1998 sample dummy in the 1998 model, we added a corresponding term for the 2002 sample.

Alternative Specifications

We examined alternative specifications with an objective of simplifying the UEC model. A consideration in attempting this simplification was that the goal of this analysis is to evaluate a particular program, not necessarily to develop a model that will be well suited to other applications. An additional reason to simplify the model was that we now have two sampling cohorts for which effects must be estimated, both with relatively small sample size. Since the final estimates will involve the combined effects of both increments, the standard errors could become large if too many sampling cohort terms are included.

Inclusion of the age term required particular attention. There are three related effects of interest in the analysis.

1. The effect of age on UEC, controlling for other factors.
2. The effect of vintage (year of manufacture) on UEC.
3. The effect of sampling cohort on UEC.

Within any one sampling cohort, age and vintage are direct translations of one another; it is not possible to distinguish an age effect from a vintage effect. With multiple sampling cohorts, we can identify age and vintage effects separately, but only if we assume there is no sampling cohort effect. Alternatively, if we wish to estimate the sampling cohort effects, we cannot distinguish age from year.

Because we have a definite interest in estimating sampling cohort effects, we can estimate age or vintage effects, but not both. We chose to work with age, in part because the age data are somewhat more natural. At any time units are collected, their ages tend to be reported in five-year increments. The age distributions observed in the sample and population data have strong peaks at each multiple of five. Because of the different shift between age and vintage for different sampling cohorts, the vintage data would not show the same underlying clumping as the age data.

We found that the logarithm of age had slightly better explanatory power than did the square root of age, which was used in the 1998 model. We also found that, with some of the interactions with age removed, a categorical age variable did better than either continuous term. We attempted inclusion of categorical age variables in 5- and 10-year increments, but found that only the newest of these (age "around 5 years," literally age less than or equal to 7) was statistically significant.

We were reluctant to represent age by this single dummy variable for two reasons. One was the resulting lumpiness of the estimate crossing from seven to eight years old. The other was the resulting UEC estimates for younger models, which were substantially, and somewhat unrealistically, lower than with other age specifications. To address these concerns, we used a continuous age variable, but truncated it at 20 years, and took the logarithm. This final age term, natural log of truncated age, allowed the age effect to flatten out for older units, with a steep rise in the first few years, and provided nearly as good a fit as using the categorical term.

The strongest alternative model to the expanded 1998 model was developed by a combination of statistical diagnostics and a desire to have certain effects explicitly estimated, even if with low precision. We began with a simplified version of the 1998 model in which we included only a single 1998 sample dummy with no interactions. We then applied backwards elimination.

Three of the terms eliminated by this step we added back to the model.

> **1998 sample dummy.** The model estimates by subgroup were essentially unchanged whether or not this term was included. This stability is consistent with the lack of statistical significance of the term. We retained the dummy in the final model so that this model would show explicitly that there was no statistical evidence of a difference between the 1998 sample and the prior samples.
>
> **Freezer dummy.** The model estimates by subgroup, including refrigerators as a group and freezers as a group, were essentially unchanged whether or not this term was included. The term also was small in magnitude. We retained the term in the model because a separate estimate of freezer UEC was an explicit objective of the analysis. Thus, even if the effect was small, we wanted to include it.
>
> **Frost-Free dummy interacted with age:** Age is expected to affect frost-free units differently than non-frost-free. Without accounting for this interaction, we might get spurious results looking at subgroups that are one or the other.
>
> In addition, the proportion of frost-free units in the sample wasn't the same as that in the population, because of the sample design for the 1998 sample. Thus, if there is a differential effect, excluding the term could result in distorted estimates for the population on average.

As it turned out, when separate age terms were estimated for frost-free and non-frost-free units, the non-frost-free age term was small, negative, and not at all statistically significant. The age term for frost-free units (frost-free dummy interacted with log truncated age) was statistically significant. We dropped the non-frost-free age term. This decision does not mean that we believe there is no effect of age on UEC for non-frost-free units. It simply means that with the available data we are not able to estimate this effect.

The final model specification is shown in Table 6-5. We refer to this final model as the "reduced model."

Table 6-5
Model Coefficients (t-statistics) for the Reduced Model

Variable	Parameter Estimate	Standard Error	T-Value
Intercept	456	192	2.37
Frost Free Defrost Binary	-49	221	-0.22
Top Freezer Binary	-416	107	-3.89
Frost Free/Side-by-Side Binary	1,196	388	3.08
Manual Defrost/Single Door Binary	-601	128	-4.68
Partial Defrost/Top Freezer	348	126	2.77
Label Amperage	116	22	5.21
Volume in Cubic Feet	43	11	4.09
Amperage/Side-by-Side Interaction	-163	55	-2.99
Freezer Binary	24	122	0.2
Natural Log Truncated Age/Frost Free Interaction	294	68	4.35
1998 Metering Sample Binary	-41	73	-0.57
2003 Metering Sample Binary	-432	83	-5.23

n=1,378 Adjusted R^2 =0.4534

In 1998 and 2003 Final Model (green)

Added/Changed from 1998 Model (yellow)

The results for the reduced model and some alternative specifications are shown in Table 6-6.

Table 6-6
Model Coefficients (t-Statistics) for Alternative Specifications

Model Details	Athens 1998 Reported Results		Athens 1998 Model with '02 Cohort		Athens 1998 Model with '02 Cohort and '02 Cohort/Sq.Rt Age and '02 Cohort/Freezer		Athens 1998 Model with '02 Cohort and Natural Log Truncated Age		Reduced Model with Natural Log Truncated Age		Reduced Model with Frost Free/Ln Truncated age interaction	
Data Used												
ARCA 1992-1995	X		X		X		X		X		X	
SCE 1998	X		X		X		X		X		X	
Current 2002			X		X		X		X		X	
Age Variable Used	**Square Root**		**Square Root**		**Square Root**		**Natural Log**		**Ln Trunc. Age**		**Natural Log**	
Variable												
Intercept	1,138	(1.52)	1,050	(1.38)	1,066	(1.39)	1,426	(1.41)	-313	(-1.13)	456	(2.37)
Freezer Binary	-932	(-1.15)	-588	(-0.74)	-712	(-0.89)	-600	(-0.76)	25	(0.21)	24	(0.2)
Frost Free Defrost Binary	320	(1.1)	110	(0.38)	137	(0.47)	-600	(-0.82)	812	(7.16)	-49	(-0.22)
Single Door Binary	-541	(-0.74)	-378	(-0.51)	-371	(-0.5)	-443	(-0.6)				
Side-by-Side Binary	-718	(-0.9)	-626	(-0.78)	-634	(-0.78)	-663	(-0.82)				
Top Freezer Binary	-811	(-1.13)	-676	(-0.93)	-676	(-0.93)	-699	(-0.97)	-413	(-3.86)	-416	(-3.89)
Upright Freezer Binary	407	(1.19)	121	(0.48)	253	(0.88)	107	(0.43)				
Frost Free/Bottom Freezer Binary	-673	(-2.04)	-624	(-1.87)	-602	(-1.8)	-573	(-1.73)				
Frost Free/Side-by-Side Binary	843	(1.96)	880	(2.05)	877	(2.04)	894	(2.09)	1,190	(3.06)	1,196	(3.08)
Manual Defrost/Single Door Binary	-362	(-1.61)	-417	(-1.9)	-425	(-1.94)	-407	(-1.87)	-612	(-4.76)	-601	(-4.68)
Partial Defrost/Top Freezer	457	(3.11)	395	(2.73)	394	(2.72)	396	(2.75)	353	(2.8)	348	(2.77)
Label Amperage	109	(4.65)	105	(4.42)	105	(4.45)	103	(4.38)	116	(5.21)	116	(5.21)
Volume in Cubic Feet	30	(2.82)	41	(3.86)	40	(3.8)	42	(4.05)	42	(3.96)	43	(4.09)
Amperage/Bottom Freezer Interaction	25	(0.18)	42	(0.31)	38	(0.28)	35	(0.26)				
Amperage/Side-by-Side Interaction	-65	(-0.94)	-68	(-1.06)	-66	(-1.03)	-69	(-1.08)	-161	(-2.96)	-163	(-2.99)
Amperage/Freezer Interaction	45	(0.62)	52	(0.72)	46	(0.64)	51	(0.71)				
Square Root of Age/Frost Free Interaction	137	(2.53)	163	(2.97)	156	(2.84)						
Natural Log Truncated Age/Frost Free Interaction											294	(4.35)
Natural Log of Age/Frost Free Interaction							505	(2.04)				
1998 Metering Sample Binary	-739	(-1.88)	-691	(-1.71)	-746	(-1.83)	-1,978	(-2.49)	-32	(-0.44)	-41	(-0.57)
1998 Metering Sample Freezer Binary	212	(1.2)	143	(0.82)	180	(0.99)	138	(0.8)				
2003 Metering Sample Binary			-421	(-5.11)	-928	(-2.03)	-428	(-5.21)	-423	(-5.13)	-432	(-5.23)
2003 Metering Sample Freezer Binary					255	(0.84)						
Square Root of Age	-37	(-0.85)	-59	(-1.33)	-61	(-1.36)						
Log Truncated Age							-225	(-0.93)	267	(4.12)		
1998 Metering Sample Binary/Square Root of Age Interaction	154	(1.74)	139	(1.52)	151	(1.65)						
1998 Metering Sample Binary/Log Truncated Age							667	(2.38)				
2003 Metering Sample Binary/ Square Root of Age Interaction					116	(1.09)						
R-Squared	0.4931		0.4607		0.4614		0.4640		0.4526		0.4534	

(green)	In 1998 and 2003 Final Model
(yellow)	Added/Changed from 1998 Model
(orange)	In 1998 Model, Not in Final Model
(white)	Tried but not used in Final Model

The reduced model results indicate the following:

- The coefficients of the 1998 dummy and its interactions are not statistically significant. This result indicates that there is no systematic difference between the 1998 sample and the earlier ARCA samples once the other characteristics are controlled for.
- The 2002 sampling cohort dummy is statistically significant. Thus, there is a difference between the units being turned in for the 2002 program compared with those turned in for earlier programs, even after the other characteristics are accounted for.

6.4.3 Population UECs from Alternative Models

For each of the models shown in Table 6-6, we applied the model to the 2002 program population to determine the program average UEC. We also calculated these averages by unit characteristics. For each group average, the standard error is calculated from the regression results. Results are shown in Table 6-7.

Table 6-7
Program Average UEC (Standard Error) for Alternative Models

Model Details			'02 Weighted Average		Athens 1998 Model		Athens 1998 Model with '02 Cohort		Athens 1998 Model with '02 Cohort and '02 Cohort/Sq.Rt Age and '02 Cohort/ Freezer Interactions		Athens 1998 Model with '02 Cohort and Natural Log Truncated Age		Reduced Model with Only Frost Free/Ln Trunc age interaction	
Data Used to Fit Model														
ARCA 1992-1995					X		X		X		X		X	
SCE 1998					X		X		X		X		X	
Current 2002			X				X		X		X		X	
Age Variable Used					Square Root Age		Square Root Age		Square Root Age		Natural Log Truncated Age		Natural Log Truncated Age	
Subgroup														
Overall			1,980	(82)	2,255	(67)	1,907	(76)	1,928	(78)	1,906	(75)	1,915	(77)
Freezer			1,817	(207)	2,126	(138)	1,638	(127)	1,857	(245)	1,627	(126)	1,662	(101)
Refrigerator			2,000	(88)	2,272	(74)	1,941	(77)	1,936	(81)	1,941	(77)	1,946	(77)
Defrost	Freezer	Frost-Free	1,575	(362)	2,797	(164)	2,276	(156)	2,481	(255)	2,255	(155)	2,234	(129)
		Manual Defrost	1,973	(248)	1,688	(142)	1,217	(129)	1,448	(251)	1,212	(127)	1,286	(103)
		Partial Defrost			1,722	(141)	1,294	(127)	1,499	(249)	1,287	(126)	1,338	(104)
	Refrigerator	Frost-Free	2,052	(97)	2,393	(74)	2,065	(77)	2,056	(80)	2,067	(77)	2,074	(77)
		Manual Defrost	1,421	(0)	1,023	(104)	672	(103)	714	(119)	655	(102)	642	(98)
		Partial Defrost	1,907	(90)	1,586	(99)	1,187	(99)	1,240	(121)	1,181	(98)	1,155	(99)
Configuration	Freezer	Chest	1,967	(376)	1,818	(310)	1,525	(252)	1,653	(279)	1,525	(248)	1,632	(101)
		Upright	1,643	(207)	2,300	(134)	1,701	(110)	1,973	(283)	1,684	(109)	1,679	(102)
	Refrigerator	Bottom Freezer	2,553	(258)	2,548	(129)	2,167	(143)	2,205	(154)	2,178	(142)	2,196	(123)
		Single Door	1,471	(279)	1,315	(122)	919	(111)	977	(135)	878	(109)	908	(92)
		Side by Side	2,428	(207)	2,891	(89)	2,566	(88)	2,562	(91)	2,569	(87)	2,603	(88)
		Tog Freezer	1,868	(105)	2,118	(77)	1,793	(80)	1,781	(83)	1,795	(80)	1,788	(80)
Size	Freezer	< 18 cu. ft.	1,888	(264)	1,930	(137)	1,419	(123)	1,642	(250)	1,404	(122)	1,452	(105)
		18 to 20 cu. ft.	2,008	(305)	2,275	(150)	1,807	(140)	2,024	(245)	1,799	(139)	1,827	(103)
		> 20 cu. ft.	1,331	(88)	2,570	(165)	2,129	(158)	2,344	(255)	2,126	(158)	2,128	(118)
	Refrigerator	< 18 cu. ft.	1,702	(83)	1,862	(78)	1,500	(83)	1,507	(88)	1,490	(82)	1,486	(83)
		18 to 20 cu. ft.	1,962	(158)	2,276	(75)	1,950	(78)	1,941	(82)	1,955	(78)	1,962	(79)
		> 20 cu. ft.	2,488	(193)	2,797	(86)	2,495	(85)	2,486	(87)	2,501	(84)	2,514	(85)
Agebins	Freezer	1-5 yrs			1,997	(285)	1,902	(173)	1,843	(310)	1,860	(191)	1,787	(128)
		2-10 yrs	1,444	(0)	1,878	(210)	1,629	(147)	1,682	(261)	1,632	(156)	1,609	(106)
		3-15 yrs	1,897	(398)	2,011	(161)	1,639	(131)	1,775	(244)	1,637	(129)	1,651	(103)
		4-20 yrs	1,906	(243)	2,072	(141)	1,616	(127)	1,816	(242)	1,602	(126)	1,654	(101)
		5-25 yrs			2,226	(139)	1,686	(130)	1,945	(255)	1,670	(130)	1,715	(101)
		6-30 yrs	1,555	(0)	2,311	(156)	1,628	(123)	1,980	(294)	1,615	(120)	1,664	(101)
	Refrigerator	1-5 yrs			1,761	(192)	1,729	(98)	1,508	(211)	1,624	(107)	1,596	(106)
		2-10 yrs	1,952	(215)	1,997	(121)	1,830	(83)	1,707	(128)	1,812	(82)	1,801	(82)
		3-15 yrs	1,653	(106)	2,208	(83)	1,941	(78)	1,891	(86)	1,956	(77)	1,956	(77)
		4-20 yrs	2,032	(157)	2,343	(75)	1,995	(78)	2,003	(83)	2,020	(78)	2,031	(78)
		5-25 yrs	2,261	(164)	2,464	(95)	2,035	(81)	2,103	(114)	2,014	(78)	2,027	(78)
		6-30 yrs	2,753	(486)	2,335	(134)	1,807	(85)	1,946	(167)	1,754	(79)	1,765	(79)

In addition to the estimates for the alternative model specifications, the table also shows the results using the weighted average of the current data alone. This is the result using the current sample as a stand-alone without leveraging the existing data.

The weighted average is an unbiased estimate for the current population. However this estimate does not leverage the larger data set. As a result the standard errors are somewhat higher than for most of the leveraged model estimates, particularly for freezers. There are only 10 freezers in the 2002 sample. Hence, this stand-alone sample is not a very sound basis for estimating typical freezer UECs.

The 1998 model does not utilize the 2002 data. Thus, to the extent there has been a change from the relationships estimated from the earlier data, that change is not reflected in the results of the 1998 model. This model by itself is not an appropriate basis for estimating the 2002 program UEC.

With the addition of the 2002 sample data and a dummy term for inclusion in that sample, the 1998 model can provide an appropriate estimate. The resulting estimates are slightly lower than for the weighted average and have smaller standard errors, particularly for freezers.

When three terms are added to the 1998 model to account for the 2002 effect (2002 dummy alone and interacted with age and with freezer dummy) the standard error for freezers exceeds that of the stand-alone weighted average.

The final model gives similar results to the 1998 model with single 2002 sampling cohort term for both refrigerators and freezers. The standard errors are also similar, though somewhat better, for freezers. (Results for some of the other specifications tested are displayed in Appendix H.)

Results are similar across the model specifications within each of the subgroups. The 1998 model with single 2002 sampling cohort term and log truncated age replacing square root of age has the lowest standard error for the overall population average, by a slight amount, but higher standard error for freezers alone than the reduced model.

Final Estimates

Based on the observations above, we recommend use of the reduced model for the final estimates. These models give the following UECs (and standard errors), in kWh/year:

Refrigerators:	1946 (77)
Freezers:	1662 (101)

6.4.4 Changes from Previous Program

The 2002 model results indicate that the units being collected in the current program tend to have lower UEC than units of similar characteristics collected in earlier programs. Alternative ways of calculating the magnitude of this difference are presented in Table 6-8. The table shows that the current program UEC is on the order of 300 kWh lower than would have been predicted for these units based on the earlier sample data alone.

Table 6-8
Alternative Estimates of the UEC Reduction

Measure of Difference	Estimate of Difference	Standard Error
Weighted 2002 Sample Mean vs. Athen's 1998 UEC Estimate	-268	106
Final 2002 Model UEC Estimate vs. 1998 Athens Model	-333	
Athens Model with vs. without '02 Cohort Term	-341	
Athens Model incremental '02 Cohort Term	-421	82
Final Model '02 Cohort Term Minus '98 Cohort Term	-390	110

6.5 UEC Difference Between New Units and Units in the Program

A component of the net-to-gross analysis presented in Section 7 requires an estimate of the average UEC of a new unit compared to the average unit in the program. The average UEC of units in the program is given above. The average UEC of a new unit is calculated as the simple average of all models listed in the CEC database for 2000 through 2002.

The CEC does not have market shares associated with each model. We assume that the number of different models listed roughly reflect the prevalence of broad types of units in the market.

We take models back to 2000 for two reasons. First, models are listed in the database only in the first year they appear. Models that were first produced in 2000 and were still produced in 2002 are listed only in 2000. Second, units sold in a particular year may have been produced in earlier years and held in inventory.

Table 6-9 compares the new-unit UEC from the CEC data with the program UEC determined from the modeling described above. Also provided in the table is the savings associated with replacing an old unit from the program by a new unit, as a fraction of the full UEC for a unit in the program.

Table 6-9
New and Old Unit UECs (kWh/year)

UEC	Refrigerators	Freezers
2002 program	1,946	1,662
New (CEC, 2000 to 2002 models)	583	458
Difference	1,363	1,204
Percent of in-program UEC	70%	72%

7 NET-TO-GROSS ANALYSIS

7.1 OVERVIEW

The UEC, as described in Section 6, is estimated to be 1,946 kWh/year for refrigerators and 1,662 kWh/year for freezers. These UECs represent the energy consumed in a full year of operations for the average refrigerator or freezer collected by the 2002 Statewide RARP. This consumption level is the gross savings associated with removing an average unit that was running for a full year from use. The net savings is the reduction in energy use that can be attributed to the program. This net savings differs from the gross savings number for two reasons:

1. The unit might have been taken out of use at about the same time even without the program.
2. A unit removed may have operated less than a full year in the absence of the program. As a result, its removal lowers energy use by less than the full-year UEC.

For this evaluation, net savings is determined by multiplying the gross, full-year UEC by a net-to-gross factor (NTG). This factor consists of two components:

- the attribution factor; and
- the part-use factor.

The attribution factor accounts for what the disposition of a recycled unit would have been in the absence of the program. The part-use factor accounts 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 NTG factor is thus given by

$$NTG = A*U,$$

where

A = the attribution factor, and
U = the part-use factor.

The Participant Survey is used to determine the part-use factor. That survey also provides the fractions of units that would otherwise have been kept in use, stored, and discarded. The attribution factor utilizes these fractions. The attribution factor also utilizes information on the disposition of discarded units developed from the supplemental survey of acquirers and disposers.

7.2 PRINCIPLES FOR ASSIGNING ATTRIBUTION FACTORS

For a unit that would otherwise have been destroyed, we assign an attribution factor of zero; no credit for removal of this unit is attributed to the program. For a unit that would otherwise have been kept by its owner, the attribution factor is one; full credit for removal is attributed to the program. A third possibility is that the unit would otherwise have been transferred to another owner by being sold, given away, or left in place when the original owner moved. For these units, the attribution factor is a fraction between zero and one; the program is given partial credit for removing the unit.

The rationale for giving part credit for removal of units that would otherwise have been transferred is that preventing this transfer results in some savings on average. How much savings can be attributed to transfer cases depends on what proportions of different types of transfers occur.

7.2.1 Attribution Factors for Avoided Transfers

If a unit collected by the program would otherwise have been transferred to another customer who would have used it for a second refrigerator or freezer and would not otherwise acquire a second unit, the savings are the same as if the unit would otherwise have stayed in place and been used as a second refrigerator or freezer; in this case, the attribution factor would be one. In other cases, the recipient of the transfer would have used the refrigerator or freezer as a primary unit. Preventing this transfer by recycling the unit means that the would-be recipient must acquire a different unit. If the different unit is a new or newer one, the removal from the original customer has resulted in effectively moving the would-be recipient from an older unit to a newer one. In this case, the program deserves credit for the accelerated replacement of an older, less efficient unit by a new, more efficient one. The different possible dispositions and corresponding attribution factors are indicated in Table 7-1.

In the case of accelerated replacement, the attribution factor can be computed as the difference in UEC between a new unit and the average unit picked up by the program, expressed as a fraction of the program's average UEC. Assuming a program average UEC for refrigerators of 1,946 kWh per year and a newer-unit UEC around 580 kWh per year, the accelerated replacement factor would be around 70 percent.

Table 7-1
Attribution Factor for Disposed Units

How Discarded	Percent	Transferred	Destroyed
gave/sold privately	57%	X	
gave/sold/traded to dealer	5%	X	
picked up by dealer	13%	X	
paid someone to take away	6%		X
collected by trash	6%		X
recycled/utility program	13%		X
TOTAL	**100%**	**75%**	**25%**

The program participant who would otherwise have given away or sold the recycled unit typically cannot know how the would-be recipient would have used it, and often would not know who that recipient would have been. Thus, we cannot determine from the Participant Survey what the mix of attribution factors is among the transfer cases. This information is instead determined from the survey of nonparticipant acquirers and disposers discussed below.

7.2.2 Timing of Disposal

If the unit would not have been discarded until a year or more from the time of program participation, the disposition of the unit without the program is considered to be “kept” instead of discarded. This classification makes sense for a first-year impact analysis. Moreover, if the planned disposition is that far in the future, it is questionable whether it would have occurred even as soon as reportedly planned.

The analysis above uses the Participant Survey information to determine the fractions of units picked up by the program that would otherwise have been kept in use, stored, or discarded. The Participant Survey is also the basis for estimating the fraction of the year the units would have been used if they were kept.

7.3 DETERMINING DISPOSITION AND ATTRIBUTION

The determination of how units would otherwise have been disposed of based on customers’ reports of what they would have done is open to question. Customers who have not had to give serious thought to how to dispose of a unit may not give realistic responses. However, it is reasonable to assume that participants do know whether they would have kept a unit or disposed of it.

Supplemental data were collected to determine how units would otherwise have been disposed of, and the corresponding program credit for avoided transfers to other users. The analysis presented below uses this additional information. The questions addressed in this empirical study and the bases for answering those questions follow.

7.3.1 Questions Addressed by the Acquirers/Disposers Question Sequences in the Nonparticipant Survey

1. For units that have been disposed of outside the program, what fractions have been disposed of by what means? Specifically, what fractions are destroyed, and what fractions are transferred to another user?
2. For those customers who acquire used units, what fractions are acquired for use as spares and what fractions for use as main refrigerators?
3. For those customers who acquired new units, what fraction would have acquired a new one, a similar one, or none if that particular unit had been unavailable?

Background from Qualitative Findings

As a background to interpreting the survey results for these questions, qualitative findings developed in the previous evaluation of this program were considered. These qualitative findings were based primarily on interviews with used appliance dealers, scrap and recycle dealers, and local governments. Because there was no indication that conditions were changed from the time of these interviews, this data collection was not repeated. The key qualitative findings were:

1. Regulatory requirements regarding CFC disposal are not an impediment to refrigerator recycling.
2. The dealer surveys indicated that the final disposition of the unit generally matches the initial disposition. That is, units that were taken by used appliance dealers are resold. Units given to recyclers and junk dealers are taken out of service. Based on this result, we can assume that the disposal means reported by customers who discarded a unit reflects the final disposition of the unit.
3. Dealers also indicated that there was little movement of refrigerators in and out of regions. Thus, transfers outside the three California IOUs service territories are not a major factor. Likewise, there is likely to be little influx of used units from outside the territory to replace the supply removed by the program.
4. Dealers reported that utility appliance recycling programs have had little effect on the market for used refrigerators and freezers. These programs are seen as disposing of older, low-value units. Dealers rarely take units more than 20 years old. (In fact, 52 percent of refrigerators and 67 percent of freezers collected by the program were over 20 years old.) Thus, it is reasonable to assume that an alternative unit would have been available to an acquirer if a particular one had been taken out of service.

An additional finding re-confirmed by the acquirers/disposers survey conducted for the present evaluation is that there are no substantial barriers to disposal of used refrigerators and freezers outside the program. The survey of discarders indicates that disposing of a refrigerator or freezer is not at all difficult. Only 6 percent of the discarders had to pay someone to take the unit away. The majority of the discarded working units, 57 percent, were privately transferred either as gifts to a known recipient or through a private sale. Another 18 percent went to dealers.

7.4 Quantitative Analysis

The NTG analysis uses the quantitative data collected in the original Participant Survey along with the supplemental data collected in the acquirers/disposers question sequences in the Nonparticipant Survey. The qualitative information summarized above is used to guide the interpretation of the quantitative survey data.

The supplemental survey instrument had separate question sequences for acquirers and disposers. Some respondents were in both categories and answered both sets of questions. For convenience, we refer to the portion of the survey related to acquisition of used units as the acquirers survey and the portion related to disposals as the disposers survey.

7.4.1 Framework for the Analysis

The NTG analysis consists of the following steps.

1. Determine the fraction of units that would be kept or discarded in some way. These fractions are determined from the Participant Survey.
2. For units that would have been discarded in the absence of the program, determine the fractions that would have been destroyed and the fractions that would have been transferred. These fractions are determined from the supplemental survey of discarders.
3. Determine what fraction would have been used as a main unit and what fraction as a spare. Also, for both refrigerators and freezers, determine the proportions of alternate actions that took place because the transfer did not occur. These determinations are based on the survey of customers who acquired used units in some way.
4. Assign attribution factors to the various possible dispositions and compute the weighted average attribution based on the proportions determined in Steps 1 through 3.
5. Combine the attribution factor with the part-use factor for each group to determine the NTG factor.

7.4.2 Assumptions for Calculating Attribution Factors

Proportions That Would Have Been Kept Versus Discarded

We recognize that participants may not have a good idea how they would have discarded a unit. However, we do consider it reasonable to think that they know whether or not they would have discarded it. Moreover, based on the qualitative findings discussed above, it is reasonable to assume that anyone who wanted to dispose of a unit could have. We therefore take the proportions of units that would have been kept or discarded from the Participant Survey classifications.

Effect of Preventing Transfers

We assume that the proportion of transferred units that would have been used as main and as spare refrigerators is the same as the proportions that were used in these ways for customers who actually did acquire used units. We also assume that what actually took place because the program prevented the transfer follows the proportions of what these customers reported they would have done if the unit they acquired had not been available.

Attribution Factors

The following attribution factors are assigned to the various disposition possibilities.

Table 7-2
Attribution Factors

Classification	Attribution
What would have been done with unit?	
Keep	1
Discard—how?	
Taken out of service	0
Transferred within CA—how used and what happened instead?	
Main refrigerator or freezer	
Bought new	*a*
Bought or fixed similar	0
Bought worse	0
Acquired none	1
Spare refrigerator	
Bought new	*a*
Bought or fixed similar	0
Bought worse	0
Acquired none	1

The attribution factor *a* for an avoided transfer that resulted in the would-be acquirer's buying a new unit is the difference between the average UEC for collected units and the average UEC of a new unit. This fraction was calculated as approximately 70 percent, as described in Section 6.

Summary of Assumptions for Attribution Factors

The assumptions for the analysis are summarized as follows.

1. The fraction of participants who would have discarded the unit in some way without the program is well estimated by the fraction who reported on the Participant Survey that they would have discarded the unit within a year without the program.
2. The fraction of discarded units that would have been transferred versus taken out of service is well estimated by the fractions in each category in the supplemental survey of discarders.
3. The distribution of alternate actions taken because these units were not transferred is well estimated by what customers who did acquire used units report what they would otherwise have done if that particular unit had been unavailable.
4. The savings from accelerated replacement is equal to 70 percent of the savings from full removal.

7.4.3 Part-use Factors

The part-use factors assigned in the NTG analysis are taken from the results of the Participant Survey. 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 in the past year, divided by 12, the unit had been plugged in and running. This average was determined to be 0.88.

For freezers, the average part-use is based on a similar question for all participants who disposed of a freezer. This average was determined to be 0.77.

The supplemental data provide no further insight into the part-year usage. The Participant Survey collected good information on this question for a large sample of customers. The part-use factors are based on the results of the Participant Survey.

7.5 NET-TO-GROSS ESTIMATES

Tables 7-3 and 7-4 summarize the attribution assignments and resulting average attribution for refrigerators and freezers, respectively. These calculations show an average attribution factor of 41 percent for the refrigerator analysis and 73 percent for the freezer analysis.

For transfers avoided by the program, the acquirers survey included the alternate action of buying a lower-quality unit. If removing the unit forces the would-be recipient to acquire a worse unit rather than a new one, the effect is actually an increase in energy usage rather than a decrease. Thus, we would in principle assign a negative attribution factor to this outcome. The assignment of zero attribution in this case is a simplifying assumption, and has negligible effect on the results.

Along with the attribution calculation, Tables 7-3 and 7-4 show the average part-use and the resulting overall NTG. The NTG for refrigerators is 0.35 compared with 0.54 for freezers. Further details of the net-to-gross analysis are provided in Appendix G.

Table 7-3
Net-to-Gross Calculations for Refrigerators

Refrigerators – Base Case											
	What Participants Would Have Done with Unit without Program	Percent of Units in Program	How Would Have Discarded	Percent of Discarded Units	How Transferred Unit Would Have Been Used	What Was Done Because Transfer Wasn't Available	Percent of Units Trans-ferred within SCE	Attribution Assigned	Average Attribution A	Usage Factor U	Net-to-Gross
Basis	Participant Survey		Disposers Survey		Acquirers Survey	Acquirers Survey				Participant Survey	A x U
All Units									0.41		0.35
	Kept Unused	4.6%						1	1.00	0.00	0.00
	Kept in Use	9.0%						1	1.00	0.88	0.88
	Discarded	86.4%							0.32		0.31
			Destroyed	24.8%				0	0.00		
			Transferred	75.2%					0.43		0.41
					Main				0.37	1.00	0.37
						Bought New	33.8%	0.70	0.70		
						Bought or Fixed Similar	35.1%	0	0.00		
						Bought Worse	5.2%	0	0.00		
						Acquired None	6.5%	1	1.00		
					Spare				0.65	0.88	0.57
						Bought New	5.2%	0.70	0.70		
						Bought or Fixed Similar	3.9%	0	0.00		
						Bought Worse	1.3%	0	0.00		
						Acquired None	9.1%	1	1.00		
		100%		100%			100%				

Table 7-4
Net-to-Gross Calculations for Freezers

Freezers – Base Case											
	What Participants Would Have Done with Unit without Program	**Percent of Units in Program**	**How Would Have Discarded**	**Percent of Discarded Units**	**How Transferred Unit Would Have Been Used**	**What Was Done Because Transfer Wasn't Available**	**Percent of Units Transferred within SCE**	**Attribution Assigned**	**Average Attribution A**	**Usage Factor U**	**Net-to-Gross**
Basis	**2003 Participant Survey**		**2003 Disposers Survey**		**2003 Acquirers Survey**	**2003 Acquirers Survey**				**Participant Survey**	**A x U**
All Units									0.73		0.54
	Kept Unused	2.6%						1	1.00	0.00	0.00
	Kept in Use	20.8%						1	1.00	0.77	0.77
	Discarded	76.6%							0.64		0.50
			Destroyed	23.8%				0	0.00		
			Transferred	76.2%					0.84		0.65
									0.84		0.65
						Bought New	20.0%	0.72	0.50		
						Bought or Fixed Similar	10.0%	0	0.00		
						Bought Worse	0.0%	0	0.00		
						Acquired None	70.0%	1	1.00		
		100%		100%			100.0%				

8 IN SITU LITERATURE REVIEW

8.1 BACKGROUND

Over the past decade, there has been extensive debate centered around the approach to use to meter refrigerator and freezer energy consumption. There are two main approaches available: (1) metering using the DOE protocols ("lab metering"), and (2) metering in situ (that is, under the same operating conditions as existed immediately prior to unit pickup). Each approach has its own merits and drawbacks. Lab metering has the advantage of a controlled environment and a specific set of consistently applied testing procedures. In situ metering has the advantage of reflecting actual unit operating conditions. The testing environment is not controlled, but "real world."

Extensive lab metering has already been performed by ARCA and SCE. This has resulted in a large database that contains results from over 1,200 metered units. Based largely on this consideration, the Project Advisory Committee for the SCE 2002 Residential Appliance Recycling Program Measurement and Evaluation Study elected to use a lab-metering approach to meter recycled units for the new metering study conducted under this project.

In order to shed further light on the relationship between lab and in situ metering results, KEMA-XENERGY was directed to perform a literature review of various metering studies performed to date. This section provides our findings and conclusions from these various studies.

8.2 KEY ASSESSMENT FROM LITERATURE REVIEW

KEMA-XENERGY reviewed the findings from nine studies that used various metering methodologies under varying situations. These studies were completed between February 1992 and March 2003 for refrigerators only. Predominant themes that emerge from a review of these studies are as follows.

- There is no significant trend between lab results and in situ results. Therefore, there is no definitive basis present at this time for making an adjustment to the lab-metered estimates of UEC. The results of these studies point in different directions. Some studies found that lab tests overpredicted actual energy consumption; others were inconclusive.
- None of the studies reviewed involved conditions similar to those of the statewide RARP, namely:
  - Predominantly southern California climate,
  - Old and secondary refrigerators, and
  - DOE and in situ metering for the same units.

- A just-published study that evaluates the SBX1 5 program by ICF/ADM found an average consumption of 1,024 kWh per year for on-site-metered units. However, the study had several limitations: (1) small, nonstatistical sample size (22 units); (2) units predominantly from the Bay area; (3) units not all from the recycling program; and (4) relied on short-term measurement extrapolated to a full year. In addition, the comparisons were limited because the authors did not have the current lab rating for a given unit and relied on the 1998 model of lab UECs instead. Because of these limitations, the study's authors stated this evidence was not enough to serve as the basis for a definitive estimate of UECs but that this area merited further study.
- A recently completed in situ study, conducted by Robert Mowris for the Northern California Power Agency (NCPA), concluded there is only a 5 percent difference overall between AHAM-rated usage and in situ metering. This study also had many of the same problems as the ICF study: (1) very small sample (2) units from Bay area; (3) relatively newer units (two were under 10 years old); (4) relied on short-term measurement extrapolated to a full year; and (5) widely varying results;
- This review reveals that the basis for the adjustment between lab and in situ metering must rely on a carefully developed in situ sample that includes wide variation in climate, seasonality, household size, appliance configuration, appliance age and appliance status as secondary/primary. Such a sample can then be used to model the relationship between appliance use in a controlled situation versus appliance use in kitchens or garages as in a program like RARP.

Table 8-1 provides a summary of our findings from these various studies.

Table 8-1
Literature Review Summary

Source	Year	DOE / In Situ	Context	Use	# Units
ADL	1982	20% low	Florida	primary	
Barakat & Chamberlin	1996	15% - 22% high	cite of Esource report		
Meier and Jansky	1993	10% - 14% high	cold climates, relatively new	primary	209
RLW	1992	inconclusive	Northeast, frost-free and manual	secondary	58
Meier et al.	1993	13% high overall low in summer	Rochester, mostly frost-free	secondary	20
Bos	1993	low	SMUD turn-in program	secondary	79
Quantum Consulting	1994	slightly high	SCE refrigerator rebate program	primary	
Dutt et al.	1995	high	new	primary	256
Goett	1995	nearly the same	PG&E and SCE new	primary	
Miller and Pratt	1998	28% low to 11% high	New York multi-family public housing	primary	324
ICF/ADM	2003	90% high	CA Bay Area ("DOE" = model from previous evaluation)	mix - some empty	22
Mowris	2003	6% low but highly variable	6 cities in Northern California	primary	8

8.3 SUMMARY OF FINDINGS FROM LITERATURE REVIEW

Summary-level information for each of the nine studies reviewed is provided below.

8.4 2003 SBX1 5 STUDY BY ICF/ADM FOR THE CALIFORNIA PUBLIC UTILITIES COMMISSION

- Study performed "due diligence" review of ARCA program assumptions.
- As a first step, ICF worked with Athens Research to reapply a statistical model and data used in a prior evaluation to the characteristics of units collected under the current program. Based on this approach, and without ruling out program cohort effects, per-unit energy consumption was found to be 2,166 kWh for refrigerators and 2,162 kWh for freezers.
- The study also performed in situ metering on a sample of 40 units collected predominantly from the Bay area; units from the Central Valley were preferred but not provided. This metering was intended to provide a comparison against UEC estimates drawn from earlier studies that used the lab metering approach.
- UEC estimates based on this in situ monitoring were found to be much lower than those generated in prior studies and currently used in California to assess program impacts. Per-unit consumption for refrigerators was found to be 1,204 kWh/year, or about half the level generated by the statistical model and data from lab metering.
- The study also questioned the NTG factor generated through prior studies, especially given the recent expansion of the program to allow for collection of primary units in addition to secondary units. The higher the share of primary units collected, the lower the NTG ratio.
- The study re-analyzed cost-effectiveness, substituting the in situ-measured UECs and the low end of the NTG ratio in the literature, and still found the program to be cost-effective, with benefit-cost ratios of 1.45 for refrigerators and 3.63 for freezers.

8.5 2003 SB5X STUDY BY ROBERT MOWRIS FOR THE NORTHERN CALIFORNIA POWER AGENCY

- In situ metering was performed on a sample of units from six municipalities located in northern California.
- Two municipalities with the largest numbers of participants were Santa Clara with 747 participants and Lodi with 541 participants. The remaining four municipalities had under 70 participants each.
- The study was based on field measurements of 107 units total—91 refrigerators (85 percent) and 16 freezers (15percent).

- Each unit was measured for several days in order to obtain 15-minute average kW measurements during a 2 PM to 6 PM timeframe. Daily kWh measurements were extrapolated to develop average measurement and verification (M&V) full-year UEC values.
- AHAM/DOE methodology was criticized for
  - not providing kW ratings,
  - addressing new units only, and
  - being based on 90°F ambient conditions rather than on actual operating conditions.
- The study found that average full-unit UECs (90 percent confidence level) were
  - Refrigerators – 1,682 kWh/year ± 122 kWh/year and 0.362 kW ± 0.02 kW
  - Freezers – 2,009 kWh/year ± 241 kWh/year and 0.348 kW ± 0.06 kW.
- The average difference between field-metered and AHAM/DOE UECs were found to be 5 percent overall. However, much larger differences were found for specific models.
- Participant Survey question responses were used to determine attribution and NTG factors (appears to be same methodology as SCE).
- The kW NTG ratios were 0.76 for Santa Clara and 0.79 for Lompoc, and the kWh NTG ratio was 0.61 (same for both).

8.6 LBL Study by Alan Meier (ASHRAE, August 1993)

- Field consumption of 432 refrigerators was monitored and collected. However, only 209 met preset requirements for further analysis. Of these, 72 percent were top freezers and 23 percent side by sides. The remaining 5 percent were bottom freezers and single-door units.
- Nearly all of the units were located in northern climates and the majority were in the Pacific Northwest.
- Mean energy use of the 209 units was 1,010 kWh/year. The mean labeled (lab-tested) energy use of these same units was 1,160 kWh/year, which implies the labels overpredict the field test results by 15 percent.
- Field-tested top freezers were found to use 18 percent less than the label predicted.
- Kitchen temperature was found to be the most significant determinant of variation in a unit's energy usage.
- Relatively modest ambient temperature variations caused 50 percent variations in energy use. Even when data among 20 units were combined, the ambient temperature appeared to explain nearly all of the variation in energy use.

8.7 1998 Proctor Engineering Study for PG&E

- PG&E wanted to compare consumption estimates on labels (based on lab metering) with metered actual consumption in people's homes (in situ). The company wanted to study whether these labels are an accurate basis for estimating the differences in electricity consumption between refrigerators of different efficiencies.
- A multivariate regression approach was used to estimate annualized consumption.
- Three different models were developed to predict usage from metered data:
  - Model 1 (Analysis of Consumption of Individual Refrigerators) – Modeled annualized consumption against daily average outside temperature and several static variables.
  - Model 2 (Analysis of Consumption Based on Temperature Only) – Model 1 with temperature variables only.
  - Model 3 (Analysis of Averaged Consumption Data) – An aggregated regression of annualized consumption versus daily average outside temperature. The model is limited to days when there are data for at least 75 refrigerators in the group.
- The study found that
  - The lab-test procedure overpredicted the actual consumption of new refrigerators in the PG&E service territory by 10–14 percent. Labeled consumption should be reduced by about 10 percent for projecting differences in annual consumption or diversified load.
  - The estimated difference in UECs between the standard and efficient models of 181 kWh (based on lab metering) lies within the confidence bounds of the UECs estimated in this study.
  - UECs increased by
    - 100–125 kWh by anti-sweat heater, and
    - 75–105 kWh by automatic icemaker.

8.8 1995 Analysis of PG&E and SCE Refrigerator Load Data by Andrew Goett

- The purpose of this analysis was to (1) verify certain findings from the earlier analysis of PG&E's new refrigerator data; and (2) research the transferability of refrigerator loads between service territories.
- The study concludes that DOE test-based estimates of usage are reliable for estimating gross impacts of the utility's new refrigerator rebate programs (i.e., estimates of usage between models of differing efficiency levels are reliable).

- The study finds that new refrigerators use a higher percentage of annual consumption during the summer on-peak period than older models.
- The study finds moderate differences in loads for new refrigerators between SCE and PG&E. During summer weekday afternoons, these differences are about 5 percent, while during the evening hours, they increase to almost 14 percent. The differences are statistically significant and can only be partially explained by differences in weather or average household size across the two utilities' samples.

8.9 1996 Barakat and Chamberlin Study for ARCA

- This study combined refrigerator characteristics (from AHAM data) with the results of a regression model to estimate UECs. An average UEC of 1,490 kWh/year was estimated, which is slightly less than the UEC reported in the program evaluation of 1,593 kWh/year.
- The study used a second technique in which the AHAM models were categorized into 12 clusters with similar energy-use characteristics based on size, model, and age variables.
- Consumption data provided by ARCA were significantly higher than the AHAM-supplied historical consumption estimates in almost every cluster where data were available. This was true despite the fact that both were based on the same DOE test approach.
- There were two contributing factors to this discrepancy:
  - Degradation of refrigerator performance was higher than previously thought.
  - ARCA and AHAM tested refrigerators at different voltage levels (the study acknowledges that this can only account for a small part of the discrepancy).
- The study reviewed Planergy's numbers and also found that estimated UECs (based on AHAM) were much lower than measured consumption. Planergy's measured results were found to be similar to ARCA's measured results.
- The study found that it was likely that significant degradation had occurred, so that the tested refrigerators after many years of operation consumed significantly more energy than they had when new (when AHAM estimates were made).
- By accounting for the impact of degradation, the savings were much greater than previously thought (i.e., unadjusted ARCA values of GreenPlus— 2,693 kWh/year—and Energy Monitoring—2,276 kWh/year. When reduced by 18 percent to account for overprediction from the lab approach, savings were still much higher than previously thought: GreenPlus—2,208 kWh/year—and Energy Monitoring—1,866 kWh/year).
- The study re-estimated realization rates and concluded with the following rates: refrigerators – 53.2 percent and freezers – 40.2 percent.

8.10 March 1993 Study by Sacramento Municipal Utility District (SMUD)

- A total of 79 refrigerators were tested using the DOE lab-test procedure.
- Average annual UECs were found to be considerably higher than when the refrigerators were new.
- When the sample was divided into two vintages (pre and post 1982), energy consumption for two classes was found not to differ.
- The study found that consumption averaged 2,100–2,600 kWh/year, depending on size. This contrasted with an assumed annual consumption of 1,600 kWh at the time of program design.
- Units with coil cleaning were found to use moderately less energy than others without. Estimated energy savings was 75 kWh/year (about 3 percent).
- Average vintage of the 79 units was "significantly earlier than 1979."
- (Note – No attribution or part-use factors applied in this study.)
- No significant correlation was found between label- and test-usage values.

8.11 February 1992 Study by RLW for Northeast Utilities

- The main purpose of this study was to generate gross estimates of energy and demand used by refrigerators and freezers picked up by the program.
- Free ridership and attribution were not addressed.
- kWh per year by model type were found to be:
  - Frost-free refrigerators – 1,565 (25 units sampled),
  - Manual refrigerators – 649 (22 units sampled), and
  - Freezers – 1,289 (11 units sampled).
- The study used in situ metering in a warehouse environment.
- Four groups (representing 4 truckloads) were tested. Each group was monitored in a warehouse. The first two groups were monitored in heated conditions over 2 winter weeks, and the second two groups were monitored over 2 summer weeks without air-conditioning.

8.12 February 1993 study by LBL for the New York Refrigerator Monitoring Project

- RG&E monitored a total of 26 refrigerators for one year in the home. Average age was 16 years.

- In the first year (prior to maintenance), the average UECs were 2,100 kWh/year for field-tested models.
- After cleaning coils, replacing gaskets, and performing other needed repairs, the same units were monitored a second year. No net savings were observed from these changes.
- Nearly all of the variation in energy use between units could be attributed to changes in kitchen temperature.
- After participants in the program were given a new refrigerator (vintage 1990) to replace the older unit, the new unit was monitored in the field. The field energy use was found to be 13 percent less than that labeled. The new refrigerators used an average of 790 kWh per year.

In addition, another 24 refrigerators were metered using the DOE lab-test procedure. LBL also performed Japanese Institute of Standards test-metering procedures and found the test results averaged 15 percent less than the DOE lab test.

9 CFL SAVINGS IMPACTS

This section presents our findings on the energy savings associated with the 5-pack CFL incentive provided by the Program. We first calculate the net energy savings for each bulb size based upon findings from the Participant Survey. We then calculate the total energy saved from CFLs distributed through the Program.

9.1 METHODOLOGY

CFL bulb savings represent less than 1 percent of total Program energy savings. Because the share of savings is very small, we elected to use a simple formula-based approach to derive annualized net savings per bulb type.

To calculate net energy savings per bulb, we used the following three simple formulas:

1. Gross kilowatt-hours (kWh) saved = (Δ watts[1]) * average hours use;
2. Installed gross kWh saved = gross kWh * installation rate; and
3. Net kWh saved = Installed gross kWh * free rider %.

Our primary input data source for these calculations was findings from the Participant Survey. We asked participants a separate battery of questions regarding their use of CFLs provided by the Program. These questions collected the following types of quantitative data:

- Number and percentage of CFLs installed;
- Hours per day of use for the two bulbs they used the most; and
- Percent of CFLs provided by the Program that replaced CFLs already installed.

From the CFL manufacturer, we also had the number of watts replaced for each bulb category. From this basic information, we were able to calculate net energy savings for each of the bulb sizes provided.

We calculated the variables in the formulas in the following manner:

- Δ **watts** equaled the difference between watts replaced (from the manufacturer) and the CFL bulb wattage, as shown in Table 9-1.

[1] (Δ watts = (Wattage of Replaced Bulb) minus (Wattage of CFL bulb).

Table 9-1
Calculation of Δ watts for Various CFL Bulb Sizes

CFL Wattages	Replaced Wattages	Δ watts
15 watts	60 watts	45 watts
20 watts	75 watts	55 watts
23 watts	90 watts	67 watts

- **Average hours used** – (1) To develop estimates of bulb use (hours) per day, we took the self-reported data for the two bulbs used the most, then performed a simple trend analysis to derive estimates of the three remaining bulbs. We then computed annual hours of use by multiplying daily use by 365 days. (2) From the installation data, we then computed, for each bulb category, weights that represent the fractions of bulbs installed for that category. (3) Finally, we applied these weights to the hours of use per year to obtain a weighted average number of hours per year across all bulbs. Our analysis is shown in Table 9-2.

Table 9-2
Computation of Average Annual Hours of Use

Bulb Identifier	Hours Used		% of Bulbs Installed	Annual Average Hours of Use
	Per Day	Per Year		
CFL #1	4.71	1,719	28%	
CFL #2	2.51	916	27%	
CFL #3	1.34	488	21%	
CFL #4	0.71	260	15%	
CFL #5	0.38	139	10%	
				879

The percent of bulbs installed in Table 9-2, which is the category weight, is the fraction of installed bulbs that were a first, second, third, fourth, or fifth bulb. These fractions were determined from the survey data that gave the distribution of the number of bulbs installed. For example, a first bulb exists for all customers who installed any bulbs; a fifth bulb exists only for those who installed 5. The distribution of number of bulbs installed is shown in Table 9-3.

Table 9-3
Number of Bulbs Installed

Number of Bulbs Installed	Number of Participants	% of Participants
0	0	0%
1	2	5%
2	8	20%
3	9	23%
4	7	18%
5	14	35%

From the Δ watts and average hours of use data, we calculated gross kWh saved per bulb, as shown in Table 9-4.

Table 9-4
Computation of Gross kWh Saved per CFL Bulb

CFL Wattages	Δ Watts	Annual Hours of Use	Gross kWh Saved
15 watts	45 watts	879	39.53
20 watts	55 watts	879	48.32
23 watts	67 watts	879	58.86

Next, from the self-reported installation data, we computed an average installation rate of 64 percent and applied it to the gross kWh saved for each bulb category to yield a figure for installed gross kWh saved. The results are shown in Table 9-5.

Table 9-5
Calculation of Installed Gross kWh Saved per CFL Bulb

CFL Wattages	Gross kWh Saved	Installation Rate	Installed Gross kWh Saved
15 watts	39.53	64%	25.13
20 watts	48.32	64%	30.71
23 watts	58.86	64%	37.41

We then used self-reported information on the number of CFLs that would be replaced with Program-provided CFLs to estimate a free rider rate of 21 percent. (In this case, we defined free rider as anyone who indicated that Program-provided CFLs would be used to replace existing CFLs.) This gave us a NTG factor for the CFLs of 0.79. We then applied this factor to the installed gross kWh saved to obtain net kWh saved. Table 9-6 shows this derivation of net kWh saved for each bulb category.

Table 9-6
Calculation of Net kWh Saved per CFL Bulb

CFL Wattages	Installed Gross kWh Saved	Net to Gross Factor	Net kWh Saved
15 watts	25.13	0.79	19.95
20 watts	30.71	0.79	24.38
23 watts	37.41	0.79	29.70

Last, we estimated the total energy saved by all of the bulbs distributed through this Program by multiplying the net kWh per bulb times the total number of bulbs distributed. Table 9-7 shows the results of this computation.

Table 9-7
Calculation of Net kWh Saved by CFLs from this Program

CFL Wattages	Number of Bulbs Distributed	Net kWh Saved per Bulb	Net kWh Saved by CFLs
15 watts	6,175	19.95	123,191
20 watts	3,849	24.38	93,839
23 watts	6,912	29.70	205,286
Total Net kWh Saved			**422,316**

10 MARKET ASSESSMENT

Our original work plan called for us to conduct an assessment of the market for used refrigerators and freezers. This analysis was to include

- an estimation of program penetration and remaining market potential for recycled units; and
- an assessment of how the program influences ownership of second, older, and less-efficient units.

Important data sources for this assessment include the Participant and Nonparticipant Surveys and the Statewide Residential Appliance Saturation Study (RASS).

Because the RASS results will not be available until early next year, this analysis has been deferred until 2004.