RLPNC 18-1 Appliance Recycling Report

FINAL

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SUBMITTED TO:
Massachusetts Program Administrators
Energy Efficiency Advisory Council Consultants

SUBMITTED BY:
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MA Appliance Recycling

Evaluating the Energy Savings and Participant Experience from an Appliance Recycling Program

NMR conducted a study to update gross, adjusted gross, and net energy savings for the MassSAVE Refrigerator and Freezer Recycling Initiative. The study also examined participant satisfaction and overall experiences with the program. Participant satisfaction with the program is high, driven by both personal and environmental benefits.

■ Refrigerators ■ Freezers

Net-to-gross Ratio	Gross Energy Savings	Adjusted Gross Savings	Net Energy Savings
44%	**1,019 kWh**	**897 kWh**	**398 kWh**
56%	**718 kWh**	**488 kWh**	**275 kWh**

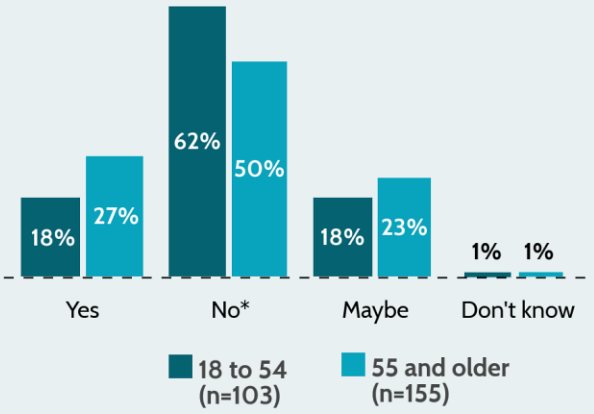
Who is willing to pay for appliance removal?

The program provides a valuable service to those who otherwise might have been unable to physically move or have access to transportation to dispose of old and unwanted units. As shown in the figure to the right, the survey found that the bulk size of the old refrigerators or freezers presented a greater disposal obstacle for older respondents than younger respondents.

About one-half of participants said they would have been willing to pay $25 for the removal service. However, younger respondents were more likely to say they were unwilling to pay any amount for removal services.

* Respondents aged 18 to 54 are significantly different than respondents aged 55 or above at the 90% confidence level

Appliance Removal Hindered by Physical Removal and Transportation



Participant Experience

97% program satisfaction

98% easy application process

93% easy pick-up scheduling

Drivers of Satisfaction

86%
Smooth process

80%
Positive environmental impact

74%
Convenient pick-up

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Executive Summary

The Massachusetts Program Administrators (PAs) currently sponsor a refrigerator and freezer recycling program (the Program) through the Residential Consumer Products Core Initiative. The program pays participants an incentive of $50, or $100 during special promotions, to recycle secondary refrigerators and stand-alone freezers. In 2017, the program provided 18,300 rebates: 15,637 for recycled refrigerators and 2,663 for recycled freezers.

The PAs and Energy Efficiency Advisory Council Consultants (EEAC Consultants) asked NMR Group, Inc. (NMR) to estimate gross, adjusted gross, and net energy savings (and a net-to-gross ratio) based on the characteristics and alternative outcomes for refrigerators and freezers currently recycled through the program. This report summarizes that research and addresses participants' experiences with the program.

Study Terminology

Appliance recycling programs pay customers to get rid of a product. This logic stands in contrast to more typical energy efficiency programs that pay incentives to increase adoption of a product or behavior. Likewise, appliance recycling programs come with their own set of terminology and savings assumptions that diverge from standard practices in the industry. NMR created Table 1 to crosswalk the appliance recycling terminology with that more typically used by the PAs. This report strives to use the terminology that aligns with the MA Technical Resource Manual and reporting needs, but, at times we default to the common industry terminology for the sake of clarity and documentation should the PAs repeat this study in the future.

Table 1: Key Terms Used in this Report

Common Industry Recycling Program Terminology	Equivalent Terminology for MA TRM and Reporting	Definition
Unit Energy Consumption (UEC)	Gross savings	How much energy the unit used based on its age, size, configuration, and other characteristics
Part-use Adjustment	Realization Rate	Adjustment for the portion of the year the unit was plugged in
Part-use Adjusted Savings	Adjusted Gross Savings	Savings after the application of the realization rate
Net savings	Net savings	Savings achieved after applying realization rate and accounting for free ridership and likely appliance outcomes in the absence of the program. Net savings for appliance programs does not consider spillover
Net-to-gross Ratio	Net-to-gross Ratio	Net savings / Adjusted Gross Savings

STUDY APPROACH

As described in more detail in Section 1.2, NMR used the approach advocated in the Uniform Methods Project (UMP) to guide the estimation of gross and net energy savings.[1] The UMP developed algorithms for estimating the UEC – equivalent to gross energy savings – of refrigerators and freezers by developing regression models from data collected in prior metering appliance studies. When evaluation resources preclude metering (as is the case for this study), the protocol suggests applying the regression coefficients to the characteristics of units currently recycled through the program to estimate UEC. The UMP then directs evaluators to apply a part-use adjustment factor (the percentage of time units were plugged in prior to recycling) to the UEC. The part-use adjustment serves as a realization rate, and its application yields adjusted gross energy savings. Net energy savings considers what would have happened to the unit had it not been recycled through the program. The UMP approach accounts for free-ridership (the units would have been removed from service), transferred use (someone other than the participant or their acquaintance would have used the unit), and non-free ridership (the participant would have kept the unit or given it to an acquaintance).

[1] Keeling, J.; Bruchs, D. 2017. "Chapter 7: Refrigerator Recycling Evaluation Protocol." *The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures.* Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68563. http://www.nrel.gov/docs/fy17osti/68563.pdf.

In following the UMP approach, NMR used a combination of program tracking data provided by ARCA, the program implementer, and a survey of 365 participants (236 refrigerator recyclers and 129 freezer recyclers) to gather most of the necessary inputs to estimate gross and net energy savings (summarized in Table 2). We also used the ENERGY STAR Appliance Calculator[2] to estimate the energy use of newly manufactured refrigerators and freezers with characteristics that match those of appliances recycled through the program. This was supplemented with data from the Residential Energy Consumption Surveys (RECS)[3] for 2005, 2009, and 2015 on the proportion of refrigerators with through-the-door ice and freezers with manual defrost (characteristics not currently tracked by the program implementer). This information factors into the calculation of net savings, as discussed more in Section 1.3.2.

Table 2: Data Sources and Approaches for Energy Savings

Algorithm Inputs	Savings Type[1]	Data Source
UMP Regression Inputs		
Appliance Age	Gross	Program Tracking
Manufactured before 1990	Gross	Program Tracking
Appliance Size	Gross	Program Tracking
Door Configuration	Gross	Program Tracking
Primary / Secondary (Refrigerator Only)	Gross	Both
Unconditioned Space	Gross	Survey
Post-regression Adjustments		
Realization Rate (% of Year Plugged In)	Adjusted Gross	Survey
Free-Ridership	Net	Survey
Transferred Use	Net	Survey[2]

[1] Gross energy savings (pre-adjusted) equals the UEC. Realization rate equals the part-use factor. Net savings is applied to adjusted gross savings.
[2] Transferred use identified from the survey. Calculation of savings for transferred use based on a combination of adjusted gross savings, characteristics of units recycled through the program (via program tracking data), RECS data, and the ENERGY STAR appliances calculator, as described more in Sections 1.2.3 and 1.3.2.

The participant study also asked a series of questions that allowed NMR to explore the feasibility of alternative appliance outcomes in more detail. Although the responses to these questions do not affect the gross and net savings algorithms, they provide useful context for understanding the results. The survey also addressed participants' experiences and satisfaction with the program.

KEY FINDINGS

Impact Factors

Table 3 presents the a gross energy savings estimates for 2017, developed through application of the UMP algorithm. Section 2 lists the values that served as inputs to the algorithm and

[2] https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[3] https://www.eia.gov/consumption/residential/

compares them to the inputs and adjusted savings estimates reported in a 2011 study of the program.[4] Based on the characteristics of units recycled in 2017, the UMP regression algorithm suggests that the current **gross energy savings** is 1,019 kWh for refrigerators and 718 kWh for freezers. On average, survey respondents reported that they had their refrigerators plugged in 88% of the year prior to recycling and their freezer for 68% of the year; these percentages serve as the **realization rates**. Their application yields an **adjusted gross energy savings** of 897 kWh for refrigerators and 488 kWh for freezers.

Table 3: Derivation of Gross Energy Savings

Algorithm	Refrigerator	Freezer
Gross Energy Savings (kWh)	1,019	718
Realization Rate (% of Year Plugged In)	88%	68%
Adjusted Gross Energy Savings (kWh)	**897**	**488**

To estimate the net-to-gross ratio, survey respondents self-reported what they believe they would have done with their recycled appliances in the absence of the program. Based on survey questions, and in line with UMP guidance, recycled units were categorized into three groups:

1. The unit would have remained in service in the same household or that of a close acquaintance (non-free rider)
2. The unit would have been discarded by a method leading to its permanent removal from service (free riders)
3. The unit would have been transferred directly or indirectly to another customer (not a close acquaintance of the participant) for continued use (outcome unknown)[5]

While the outcome of units in the first two groups are known, the outcomes of units in the third group are not, as this study did not survey prospective purchasers. NMR followed UMP recommendations by assuming that units in group three (transferred units) fell into three categories:

A. 50% of transferred units assume full savings (non-free riders: the potential purchaser would not purchase a used or new appliance if they did not purchase the one recycled through the program)

B. 25% of transferred units assume zero savings (free rider: potential purchaser would find a similar unit to the one that was recycled)

C. 25% of transferred units assume partial savings (potential purchaser buys a new unit instead, so savings equal the difference in energy use between a new unit and the recycled unit)

[4] NMR conducted the research, resulting in three separate reports delivered to the PAs and EEAC consultants in June 2011. Impact evaluation http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-Final-Report.pdf, Participant survey results http://ma-eeac.org/wordpress/wp-content/uploads/Participant-Survey-Results-Final-Report.pdf, and Secondary market review (with Cadmus) http://ma-eeac.org/wordpress/wp-content/uploads/Secondary-Market-and-Appliance-Disposal-Report.pdf.

[5] See Section 5 of the UMP protocols. *Ibid*.

Finally, the PAs and EEAC Consultants also directed NMR to assume that units older than ten years that would have been given to a retailer be treated as free riders since retailers are not likely to resell older units.

Table 4 summarizes the application of the algorithm. The free rider and non-free rider estimates in this table include transferred units (see Section 2.2 for detailed breakdowns). The algorithm categorized 54% of recycled refrigerators and 40% of recycled freezers as free riders. Conversely, 43% of refrigerators and 56% of freezers were categorized as non-free riders. The remaining units were assigned the delta watts between a new and recycled unit. This yields a net-to-gross ratio of 44% for refrigerators and 56% for freezers, or net savings of 398 kWh and 275 kWh, respectively.

Table 4: Derivation of Net Energy Savings

Algorithm	Refrigerator		Freezer	
	% of Respondents	Savings (kWh)	% of Respondents	Savings (kWh)
Free Riders	54%	0	40%	0
Non-free Riders	43%	897	56%	488
Transferred, Delta Watts	3%	465	4%	134
Net Savings (kWh)		**398**		**276**
Net as % of Adj. Gross		**44%**		**56%**

Additional Findings

The study also explored issues related to the physical and financial feasibility of program alternatives, program satisfaction, and demographic differences in the participant experience. Some of the highlights, explored in more detail in the body of this report, include the following:

- Most participants (76% for refrigerators and 72% for freezers) had not tried to get rid of their appliance prior to program participation. The most common alternative to the program was to simply keep the unit.
- About one-half of participants generally voiced a willingness to pay for removal that fell in line with the fees charged by municipal recycling programs (about $25), but below those charged by hauling companies (about $100).
- Most refrigerator participants believed they could have overcome the challenges of physically removing the appliance from their home if the program had not existed (61% said it would not have been a hindrance), but freezer respondents voiced greater concern about the physical hindrance of removal (53% said it would or may have been a hindrance).
- The three most common drivers of program participation included the ease of recycling through the program (77% of refrigerators respondents; 79% of freezer respondents), benefits to the environment (72%; 65%), and the incentive (73%; 64%).
- More than one-half of respondents for both appliances (56% for refrigerators; 64% for freezers) said they were 55 years or older. Participants aged 55 or older voiced greater

concerns about the physical hindrances of removal (50% said it would or may have been a hindrance compared to 36% of respondents aged 18 to 54). Older respondents also seemed more open to the idea of paying for removal.

- Older respondents were more likely to say they required assistance from a hauler or retailer to remove their appliances. Older respondents were also more likely to recycle units over ten years old. Since appliances older than ten years picked up by a hauler or retailer were considered free riders, a greater proportion of older respondents met the criteria for free-ridership. The net savings algorithm designated 51% of older respondents as free riders compared to 39% of younger respondents.

RECOMMENDATIONS, CONSIDERATIONS, AND GUIDANCE

In this section, NMR offers recommendations, considerations, and guidance for future study planning based on the findings discussed in this report. For each recommendation, consideration, or point of guidance, we offer a rationale based on the findings from evaluation activities conducted as part of this study.

Recommendations

Recommendation #1: NMR recommends that the PAs adopt the gross energy savings estimates, realization rates, and net-to-gross ratios reported in Table 5. The net-to-gross ratio should be applied to adjusted gross energy savings.

Rationale: The exploration of impact factors concluded that partial use (captured by the realization rate) and free-ridership means that the appliance recycling program achieves adjusted gross energy savings and net energy savings that fall below the gross energy use of recycled units. Partial use has a greater impact on freezers, while free-ridership has a greater impact on refrigerators, but both factors affect both appliances.

Table 5: Recommended Updates to Impact Factors

Appliance	Per Unit Gross Savings Energy (kWh)	Per Unit Realization Rate	Per Unit Adjusted Gross Savings Energy (kWh)	Net-to-Gross Ratio
Refrigerators	1,019	88%	897	44%
Freezers	718	68%	488	56%

Considerations

Consideration #1: The PAs and program implementers should consider conducting experiments to identify the optimal incentive level.

Rationale: The program incentive – $50, or $100 during special promotional events – served as one of the top three drivers of program participation, yet more than one-half of participants said they would have taken part in the program even without the incentive. This suggests that the program could potentially retain high participation rates at lower incentive levels. Conducting small experiments, in which the implementer varies

incentives over time or across areas, could help to identify the optimal incentive level. If the PAs pursue this consideration, the evaluation team would be happy to work with the PAs and implementation contractor to advise on the experimental design and analysis.

Consideration #2: NMR suggests that the implementation contractor collect email addresses from program participants and use them for program communication when appropriate.

Rationale: Email represents a widespread method of communication, and people of all ages increasingly tend to communicate via email. Many households no longer have landlines, and individuals will often ignore landline or cellular phone calls from numbers they do not recognize. In addition, NMR has found that being able to send emails with unique links for individual respondents increases response rates and reduces respondent burden since they only have to click the link to answer the survey. It also limits confusion and errors associated with respondents having to type in website address and unique identification numbers. Therefore, ARCA may want to consider collecting email addresses from willing web and phone applicants, using those emails together with other methods (phone calls, texts) to confirm pick-ups and communicate with participants, and include these addresses in the tracking database to aid in program evaluability.

Consideration #3: NMR suggests that the implementation contractor consider collecting information on the presence of through-the-door ice for refrigerators.

Rationale: The program tracking database does not currently list whether units have through-the-door ice. Yet, refrigerator energy use varies considerably by the presence or absence of this feature. Currently, accounting for through-the-door ice has little impact on the final estimates of net energy savings. However, the prevalence of this feature has increased over time and will continue to do so given the popularity of side-by-side and bottom-mounted freezer models. In the future, the PAs may find it useful to account for through-the-door ice in estimating net energy savings. Note that the percentage of freezers with automatic defrost has remained stable over time, and we do not suggest that the implementer track this characteristic.

Guidance for Future Study Planning

Guidance #1: The PAs should consider updating the refrigerator and freezer gross savings annually using program tracking data applied to the UMP algorithm. These updates would also use information on appliance location (conditioned vs. unconditioned space) as well as the realization rates and net-to-gross ratios from this RLPNC 18-1 survey effort.

Rationale: Updating gross savings based on program tracking data is a low-cost approach that tailors reported annual energy savings to the characteristics of appliances recycled through the program in a specific year. Therefore, the PAs may want to treat updates as a standard evaluation task (like the annual updates to lighting market indicators). However, the current program year provides an additional argument in favor of an update. The recycling program ceased operation for most of 2016 after the prior implementation contractor suddenly went out of business (in December 2015). The program gap year may have affected the nature of appliances recycled in 2017, arguing for a truing up with 2018 program data.

Guidance #2: Based on the results of the current study, NMR believes that there would be minimal benefit in conducting future research into the secondary appliance or appliance removal markets.

Rationale: Sensitivity analyses conducted for this study found minimal impact of varying assumptions about the savings associated with units that survey respondents self-reported would have been transferred to another user. Among the factors explored, the sensitivity analysis identified the assumed unit age at which a retailer could resell a recycled appliance and have the greatest impact on savings. In the current study, we assumed that all units ten years or younger could be resold and categorized them as non-free riders. Raising the cut-off to 15 years increased refrigerator savings by about 28 kWh and freezer savings by six kWh. All other sensitivity analyses (e.g., varying the assumptions used to estimate the energy use of a newly manufactured unit) adjusted savings by no more than one kWh per unit. The study also found that municipalities in Massachusetts generally charge little or nothing for refrigerator recycling, although older participants may find it challenging to get the units to the curb or city yard. Thus, while NMR recognizes that additional research into the secondary appliance and appliance hauling markets could firm up some savings assumptions, the application of the adjustments would have minimal impact on estimated net savings. Therefore, we do not believe the PAs should fund a secondary appliance market or appliance hauling study.

Section 1 Introduction

The Massachusetts Program Administrators (PAs) currently sponsor a refrigerator and freezer recycling program (the Program) through the Residential Consumer Products Core Initiative. Marketed under the Mass Save® umbrella, the program collects unwanted refrigerators and freezers and pays an incentive of $50, or $100 during special promotions, to customers who recycle their appliances through the program. In 2017, the program provided 18,300 rebates. Of these 18,300 rebates, 15,637 were for recycled refrigerators and 2,663 were for recycled freezers.

The last impact, process, and secondary market study performed on this program was completed in June 2011.[6] It is likely that the characteristics – and thus the energy use – of recycled units has changed since 2011. Therefore, the PAs and Energy Efficiency Advisory Council Consultants (EEAC Consultants) asked NMR Group, Inc. (NMR) to conduct research that would update gross energy savings, adjusted gross savings, and net savings for refrigerators and freezers. The PAs selected a new program implementer in 2017, so the research also addresses the participants' experiences with the program.[7] This report summarizes the results of both efforts.

1.1 Study Objectives

The objectives of this research were as follows:

- Identify the current characteristics of refrigerators and freezers being recycled through the program and compare them to those identified in the 2011 study
- Update estimates of unit energy consumption (UEC), partial use (how often recycled units were plugged in, which serves as the realization rate), and net-to-gross ratios (NTG)
- Calculate per-unit gross savings, adjusted gross savings, and net energy savings based on UEC, realization rates, and free ridership rates.
- Explore the role of the incentive and ease of disposal on customer participation
- Examine possible alternative outcomes for units in the absence of the program
- Describe participants' experiences with the program

Research questions included the following:

- How do current energy use and energy savings for recycled refrigerators and freezers compare with those stated in the 2016 to 2018 Technical Resource Manual (TRM)?
- What drives changes in energy use and energy savings?
- What do participants think they would have done with the recycled appliance in the absence of the program, and how realistic is it that they would have been successful at following through on alternatives to the program?

[6] NMR conducted the research, resulting in three separate reports delivered to the PAs and EEAC consultants in June 2011. Impact evaluation http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-Final-Report.pdf, Participant survey results http://ma-eeac.org/wordpress/wp-content/uploads/Participant-Survey-Results-Final-Report.pdf, and Secondary market review (with Cadmus) http://ma-eeac.org/wordpress/wp-content/uploads/Secondary-Market-and-Appliance-Disposal-Report.pdf.

[7] The PAs and EEAC Consultants decided against updating secondary market research.

- How important is the program to the decision to recycle the unit?
- How satisfied are participants with their experience with the program?

1.2 DATA SOURCES

The study relied primarily on two data sources: program tracking data and responses from a participant survey. NMR supplemented these sources with estimates of energy use for newly manufactured refrigerators and freezers (estimated using the ENERGY STAR Appliances Calculator),[8] and data on the prevalence of through-the-door ice for refrigerators and manual defrost for freezers (not currently tracked by the program implementer) as reported in the Residential Energy Consumption Surveys (RECS)[9] for 2005, 2009, and 2015.

1.2.1 Program Tracking Data

ARCA, the program implementer, provided 2017 program tracking data to NMR. The dataset included records for 18,300 recycled appliances (15,637 refrigerators and 2,663 freezers – recycled by 17,015 unique customers). Prior to calculating the program averages and proportions for estimating gross energy savings, NMR reviewed the data, plotting distributions and identifying outliers. This review flagged units older than 40 years as outliers. Given this characteristic's importance to the calculation of gross energy savings (which contains inputs for both age and date of manufacture), we took a closer look at the records for appliances over 40 years. We excluded six freezers and 125 refrigerators because we could not confirm the age through use of the model number (using a mixture of web lookups and examination of other records in the database). The final estimation of gross energy savings relied on the remaining 15,512 refrigerators and 2,657 freezers. NMR then calculated average values and proportions of units for the necessary regression model inputs (Section 1.3.1). Appendix A contains a data description for the most critical factors used to calculate gross energy savings.

1.2.2 Participant Survey

NMR addressed the following topics in a survey of 2017 program participants:

- Verified the primary/secondary status of recycled refrigerators
- Determined whether participants had used recycled units in conditioned space in the summer and the winter
- Explored what respondents would have done with the unit in the absence of the program, including probing deeper on the feasibility of their stated alternatives
- Gathered the participants' experiences with the program

To pull the sample for the participant survey, we randomly selected 1,250 participants that had recycled a refrigerator and 750 that had recycled a freezer. We verified that the sample accurately reflected the population on key inputs (e.g., appliance age and primary/secondary status).

NMR sent potential respondents an advance letter with a pre-paid incentive and a link to the web-only survey. The letter explained the purpose of the survey and provided phone numbers to call

[8] https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
[9] https://www.eia.gov/consumption/residential/

for more information. We administered a $5 pre-paid incentive to survey respondents as this has been found to be a cost-effective approach to boosting response rates with minimal risk of biasing responses. The survey was fielded from June 12, 2018 through June 19, 2018, and yielded a total of 365 responses, including 236 refrigerator respondents and 129 freezer respondents. The overall response rate was 19%. The number of responses exceeded the study's quotas of 125 refrigerator respondents and 75 freezer respondents. Table 6 presents the sampling error for both absolute and relative precision, using the 90% confidence level (errors become even smaller at the 80% level), and the proportion of respondents identified as free riders (44% for refrigerators and 56% for freezers, see Section 2.2) through their responses or algorithm decisions.[10]

Table 6: Sample Design and Sampling Error

Appliance	Population	Final Sample	Sampling Error	
			Absolute	Relative
Refrigerators	15,637	236	5.3%	9.8%
Freezers	2,663	129	6.9%	17.4%
Total	**18,300**	**365**	**4.6%**	**9.3%**

Some participants recycled more than one appliance with the program. In these cases, the survey asked respondents to provide responses for one of the appliances (randomly assigned). The survey named the targeted appliance, which was especially helpful if they recycled both a refrigerator and a freezer, and provided the date of pickup to help the respondents differentiate between the units they recycled. In addition, some respondents recalled recycling a different type of appliance than listed in the program tracking database. In these cases, the survey rerouted the respondent to the survey questions for the appliance they recalled recycling.

1.2.3 ENERGY STAR Appliances Calculator and Residential Energy Consumption Surveys

As described in Section 1.3.2, the UMP algorithm for net savings requires estimation of the energy use of brand new (i.e., recently manufactured) refrigerators and freezers. NMR turned to the ENERGY STAR Appliances Calculator and RECS to develop this estimate. We first identified the size and configurations (door for refrigerators and upright/chest for freezers) for the most common appliances recycled in the program, accounting for 94% of refrigerators and 84% of freezers (see Appendix B for a listing of these appliances). We then used the ENERGY STAR Appliances calculator to estimate the use of new units with similar configurations, weighting the results by recent shipments of ENERGY STAR and non-ENERGY STAR models.

One difficulty we encountered is that the ENERGY STAR calculator reports different energy usage for through-the-door ice for side-by-side and bottom-mounted-freezer refrigerators and manual defrost for upright freezers, but the program tracking database does not list these characteristics. NMR obtained the percentages of through-the-door ice and manual defrost for New England from

[10] See Section 2.2 for free-ridership estimates. NMR typically uses the 90% confidence interval and 50% break in responses for sample design and planning purposes. Using the evaluated results on one of the more important findings presents a more accurate description of sampling error.

RECS. We pulled data from 2005, 2009, and 2015 and then weighted the estimated use of new units by the average percentage of values across the three years.[11,12]

1.3 ANALYSIS

NMR calculated three estimates of energy savings: gross, adjusted gross, and net. Table 7 provides a summary of the approaches and data sources used to estimate each. Hyperlinks refer to the appropriate section describing the approach.

Table 7: Types of Savings Estimate, Approaches, and Data Sources

Savings Estimate	Approach	Data Source
Gross Energy Savings	UMP Regression Coefficients (Section 1.3.1)	Program Tracking, Participant Survey
Adjusted Gross Energy Savings	Application of realization rate, equivalent to a part-use factor (Section 1.3.1)	Participant Survey
Net Energy Savings	Application of UMP free-ridership algorithm (Section 1.3.2)	Participant Survey ENERGY STAR Appliance Calculator RECS

1.3.1 Gross Energy Savings: Unit Energy Consumption

NMR estimated **gross energy savings** – equivalent to the UEC – for both refrigerators and freezers and applied the average values of the units recycled through the Massachusetts program in 2017 to the following UMP regression equations for refrigerators and freezers:

$$
\begin{aligned}
&Refrigerator\ UEC \\
&\quad = 365.25 * (0.582 + \ 0.027(average\ appliance\ age) \\
&\quad + 1.055(\%\ manufactured\ before\ 1990) + 0.067(average\ size\ in\ cuft) \\
&\quad + \ -1.977(\%\ single - door) + 1.017(\%\ side - by - side\ door) \\
&\quad + 0.605(\%\ primary\ use) \\
&\quad + \ .020(interaction\ \%\ in\ unconditioned\ space\ and\ CDD) \\
&\quad + \ -0.045(interaction\ \%\ in\ unconditioned\ space\ and\ HDD)
\end{aligned}
$$

[11] We decided to use the average because we have no data on whether prospective purchasers forced into the new appliance market (because they could not find a suitable used appliance) would buy a unit that exactly matched one recycled through the program (when through-the-door-ice and automatic defrost were less common) or would buy units similar to all purchasers of new units.

[12] The Department of Energy is only now releasing 2015 RECS data. As of August 2018, they have not released information on manual defrost freezers. Therefore, the current calculations use only 2005 and 2009 data.

$$Freezer\ UEC = 365.25 * (-0.955 + 0.045(average\ appliance\ age) + 0.543(\%\ manufactured\ before\ 1990) + 0.12(average\ size\ in\ cuft) + 0.298(\%\ chest\ configuration) + .082(interaction\ \%\ in\ unconditioned\ space\ and\ CDD) + -0.031(interaction\ \%\ in\ unconditioned\ space\ and\ HDD)$$

Table 8 shows the data sources for each variable.

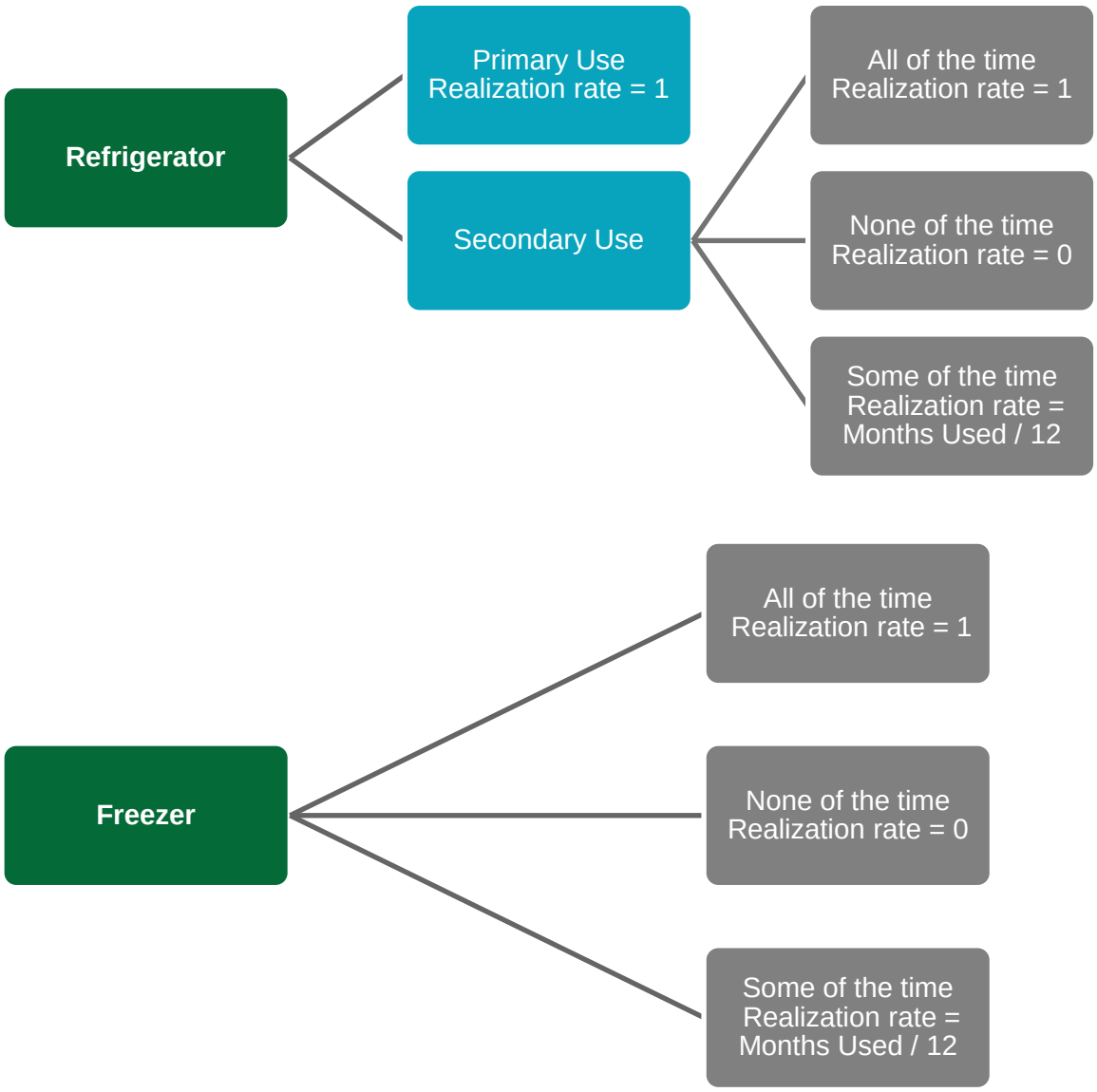
Table 8: Data Sources for Gross Energy Savings (UEC)

Algorithm Inputs	Appliance	Data Source
Appliance Age	Both	Program Tracking
Manufactured Before 1990	Both	Program Tracking
Appliance Size	Both	Program Tracking
Single-door Configuration	Refrigerator	Program Tracking
Side-by-side Door Configuration	Refrigerator	Program Tracking
Chest Configuration	Freezer	Program Tracking
Primary Use	Refrigerator	Both
Unconditioned Space Summer	Both	Survey
Unconditioned Space Winter	Both	Survey
Cooling Degree Days	Both	TMY3[1]
Heating Degree Days	Both	TMY3[1]

[1] https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.

Adjusted gross energy savings equals gross savings multiplied by a realization rate, operationalized as the part-use factor. This is a measure of the portion of the year the household had the unit plugged in the year prior to recycling. The fact that households may not be using the unit continuously or at all makes it necessary to apply a realization rate to create a more accurate estimate of energy savings. NMR took the approach in Figure 1 to develop the realization rate. We assumed all primary refrigerator users had their unit plugged in the entire year, while secondary users needed to indicate the portion of the year they had their refrigerator plugged in. The survey asked every freezer recycler to indicate the portion of the year they had the unit plugged in, as the primary/secondary distinction does not apply to stand-alone freezers. The final realization rate reflected the average score for all refrigerators or freezers recycled by survey respondents.

Figure 1: Realization Rate (Part-use Factor) Algorithm



1.3.2 Net Energy Savings

NMR utilized the participant survey to ascertain free-ridership (and a net-to-gross ratio).[13] For recycling programs, free-ridership occurs when the participant would have disposed of the unit in such a way that, like the program, would have permanently removed it from service. Evaluation best practices suggest conducting participant and non-participant surveys and secondary market research to estimate and understand program free-ridership. Due to time constraints, NMR

[13] The nature of recycling programs – that someone gets rid of an appliance rather than adding a measure to the home – means they are unlikely to induce the spillover associated with traditional rebate or direct install programs.

conducted only the participant survey and followed the guidance in the UMP for calculating free-ridership in the absence of non-participant surveys and secondary market research.

NMR asked respondents to explain what they would have done with the refrigerator or freezer in the absence of the program. There are three possible scenarios for what would have happened to a program-recycled unit in the absence of the program.

1. The household would have kept the unit or given it directly to a close acquaintance.
2. The unit would have been transferred directly or indirectly to a customer (other than a close acquaintance) for continued use.
3. The unit would have been discarded by a method that would lead to its permanent removal from service.

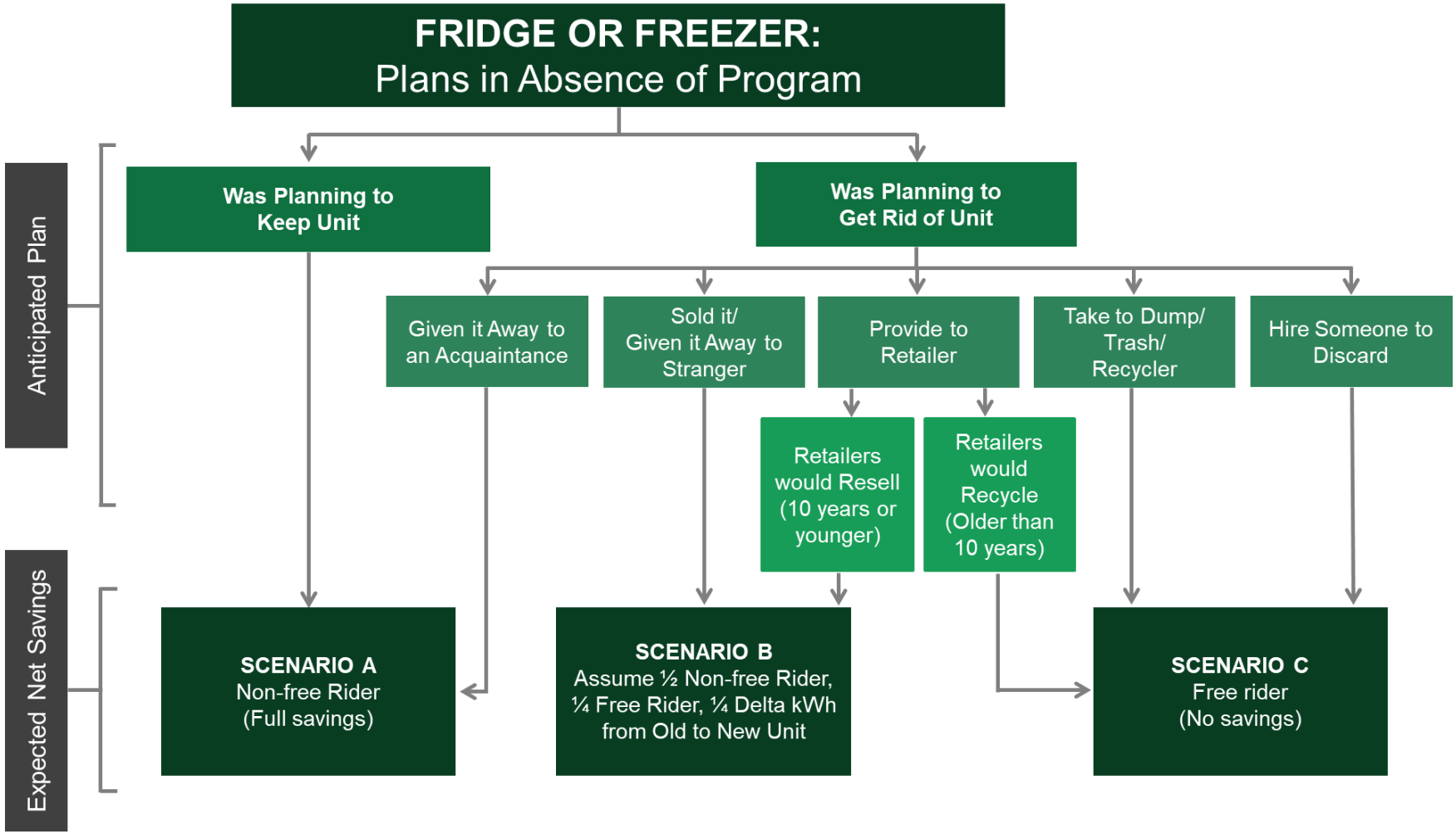
The last scenario constitutes program free-ridership. To estimate free-ridership, evaluators typically rely on self-reported responses from participants on what they would have done with the unit if the program did not exist. Unfortunately, as the UMP explains, participant intentions may not always match reality. Likewise, participants may not fully understand what happens to units picked up by municipalities, junk haulers, or retail stores. Best practices suggest that evaluators dig a little deeper to probe respondents on alternatives to the program, but this can create respondent fatigue. To balance between additional probing and respondent fatigue, NMR assigned program free-ridership based on the scheme described in Table 9. The savings adjustments in Column 3 corresponds to the algorithm in Figure 2.

Table 9: Free Rider Scheme

Self-reported Alternatives to the Program	Decision	Savings Adjustments (Figure 2)
Kept by the household	Not a free rider	Scenario A
Given away for free to an acquaintance	Not a free rider	Scenario A
Sold/given to charity, classified ads, internet, etc.	See algorithm below	Scenario B
Provided to retailer (new or used)	If older than 10 years, free rider;	Scenario C
	if 10 years or younger see algorithm below	Scenario B
Given to municipality / hired a hauler	Free rider	Scenario C
Other outcomes	Treated on case-by-case basis, per survey responses	Scenario A, B, or C

To determine net savings, NMR followed the algorithm depicted visually in Figure 2. This algorithm was developed based on UMP guidance. The algorithm assigns respondents who planned to keep their units or give them for free to acquaintances as non-free riders; these respondents receive full savings (Scenario A). Free-riders include anyone who planned to trash, recycle, or discard the unit, or to provide an older unit to a retailer (Scenario C). For those participants who planned to transfer the unit to another user by selling it, giving it away to charity or stranger, or providing younger units to retailers (Scenario B), we assumed that one-half of the units got full savings and one-quarter of the units were free riders. The remaining quarter of transfers was assigned the difference in savings between the adjusted gross energy savings (Section 1.3.1) and the weighted average consumption of newly manufactured units (delta watts), as described below the figure.

Figure 2: Free-ridership and Secondary Market Savings Adjustment Algorithm[1,2]



[1] Visual depiction of UMP recommendations provided by Scott Dimetrosky

[2] Application of the algorithm relied on adjusted gross savings calculated from the UMP regression coefficients and survey-derived part-use factors; survey responses on likely outcomes for appliances in the absence of the program; and the calculation of savings of newly acquired units based on characteristics of recycled units obtained from program tracking data, the Residential Energy Consumption Survey (2005, 2009, and 2015), and the ENERGY STAR calculator. See text for more details.

For one-quarter of the transferred units, Scenario B requires the calculation of the delta in usage between a new unit and the recycled one. NMR took the following steps to estimate the energy use of new units, which fed into the calculation of the delta watts between newly manufactured and recycled units:

1. Identified the most common refrigerator and freezer configurations and sizes recycled through the program, accounting for 94% of refrigerators and 84% of freezers (see Appendix B).
2. Used the ENERGY STAR Appliances Calculator to extract the energy use of new units (both conventional and ENERGY STAR-qualified models), including estimates for refrigerators with and without through-the-door ice and freezers with manual or automatic defrost.
3. Estimated the proportion of refrigerators with through-the-door ice for side-by-side and bottom-mounted models, and the proportion of upright freezers with manual defrost, using the average of their prevalence as reported in RECS for 2005, 2009, and 2015.[14] The program tracking database does not note whether recycled units had through-the-door ice or manual or automatic defrost, but these features greatly affect energy use.
4. For both conventional and ENERGY STAR qualified new appliances, weighted the average energy use for each new appliance type by the total number of units of similar sizes and configuration recycled through the program, or assumed from RECs data.
5. Calculated a single weighted average energy use for new refrigerators and freezers using national market share of ENERGY STAR qualified refrigerators and freezers (48% and 35%, respectively).[15]

The final delta used to estimate net energy savings equals the difference between the adjusted gross energy use for appliances recycled in the program in 2017 and the new unit energy use.

1.3.3 Additional Analysis

NMR conducted additional analysis based on participant survey questions designed to further understand what would have happened to the recycled units in the absence of the program and to gather information about the participants' program experiences. Questions focused on what attempts respondents had made to get rid of the appliances (if any), the degree to which physical or financial considerations may have placed limits on alternatives to the program for removing appliances, participation drivers, and participant satisfaction. The report presents a subset of findings by respondent demographics.

[14] As noted earlier, we rely on the average for three years because of the uncertainty regarding whether prospective purchasers would buy units that match those recycled through the program or that reflect the general purchase of new units in the broader market. Manual defrost freezer information is not available for 2015; the percentage remained nearly the same between 2005 and 2009.

[15] ENERGY STAR. 2016. ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2016 Summary.
https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2016_USD_Summary_Report.pdf?8fd5-1967

Section 2 Energy Consumption and Savings

The primary objectives of this study involved updating gross energy savings and net energy savings for the Appliance Recycling Program, as discussed in this section of the report. We compare these estimates to current TRM values. This section also provides a deeper look at the role the program plays in the decision to recycle the unit, the range of alternative appliance outcomes, and the degree to which financial and physical considerations may limit alternative ways of removing the appliance.

Key findings include the following:

- Refrigerator impact factors:
  - Gross energy savings (UEC) = 1,019 kWh
  - Realization rate (part-use factor) = 88%
  - Adjusted gross energy savings = 897 kWh
  - Net-to-gross ratio = 44%
- Freezer impact factors:
  - Gross energy savings (UEC) = 718 kWh
  - Realization rate (part-use factor) = 68%
  - Adjusted gross energy savings = 488 kWh
  - Net-to-gross ratio = 56%
- Most respondents had not tried to get rid of their units prior to program participation. The most frequently assumed program alternative was to simply keep the unit.

2.1 Gross and Adjusted Gross Energy Savings

This section presents the results of the gross energy savings calculations and adjusted gross energy savings calculations.

2.1.1 Gross Energy Consumption (UEC)

Table 10 and Table 11 summarize the calculation of gross energy savings for refrigerators and freezers, respectively. The first column shows the UMP-recommended regression inputs and the second shows the regression coefficients. The third column lists the 2011 values for those inputs, while the fifth column lists the 2017 values. The fourth and sixth columns show the effect each input has on energy use. The daily use sums across the individual inputs, while the annual gross energy savings multiplies daily use by 365.25.[16]

The results in Table 10 suggest that gross energy savings for refrigerators fell by 14%, from 1,179 kWh to 1,019 kWh. This somewhat modest decrease reflects changes in the characteristics of

[16] The model is a linear regression, so to figure out the effect of any single input, one multiplies the coefficient by the value. For example, the impact of appliance size on daily energy use is *0.07 x age*. For 2011, the result was 1.13. For 2017, it was 1.28, with the larger size refrigerators recycled in 2017 leading to increased daily energy use.

units recycled through the program. Participants recycled younger units in 2017, which tend to use less energy than older ones due to efficiency standards increases. However, unit size and the prevalence of side-by-side door configuration also increased over the years. Both factors are associated with increased energy use, offsetting the gains made by the improved energy efficiency of younger units.

In contrast to refrigerators, the gross energy savings for freezers decreased by 30% (Table 11), from 1,022 to 718 kWh. Efficiency gains stemming from the younger age and smaller size of freezers recycled in 2017 caused gross savings to decrease compared to 2011.

Table 10: Calculation of Gross Energy Savings (UEC) for Refrigerators[1]

Input	UMP	2011 MA Data		2017 Results	
	Coefficient	Value	UEC[2]	Value	UEC
Intercept	0.58	1.00	0.58	1.00	0.58
Appliance Age (years)	0.03	26.60	0.72	19.22	0.52
Manufactured Pre-1990	1.06	0.82	0.87	0.19	0.20
Appliance Size (cubic feet)	0.07	16.80	1.13	19.15	1.28
Single-door Configuration	-1.98	0.00	0.00	0.03	-0.07
Side-by-side Configuration	1.07	0.12	0.13	0.19	0.20
Primary Usage Type[3]	0.61	0.22	0.13	0.48	0.29
Located in Unconditioned Space * CDDs[4]	0.02	0.31	0.01	0.31	0.01
Located in Unconditioned Space * HDDs[5]	-0.05	7.37	-0.33	5.13	-0.23
Daily Use (kWh)			**3.23**		**2.79**
Annual Gross Energy Savings (kWh)			**1,179**		**1,019**

[1] Results subject to rounding error.
[2] This calculation applies values reported in the 2011 study to the UMP algorithm. The 2011 study used a different methodology that arrived at a UEC of 1,292 kWh (after weighting for primary and secondary use and replacement). See NMR Group, Inc., June 2011 Impact evaluation http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-Final-Report.pdf and Participant survey results http://ma-eeac.org/wordpress/wp-content/uploads/Participant-Survey-Results-Final-Report.pdf.
[3] The program tracking database lists this value as 47%, while survey respondents indicated the value was 48%.
[4] 230 respondents indicated that 71% of refrigerators had been in spaces that lacked summer cooling.
[5] 229 respondents indicated that 31% of refrigerators had been in spaces that lacked winter heating.

Table 11: Calculation of Gross Energy Savings (UEC) for Freezers[1]

Input	UMP	2011 MA Data		2017 Results	
	Coefficient	Value	UEC[2]	Value	UEC
Intercept	-0.96	1.00	-0.96	1.00	-0.96
Appliance Age (years)	0.05	30.94	1.39	25.52	1.06
Dummy: Manufactured Pre-1990	0.54	0.86	0.47	0.39	0.21
Appliance Size (cubic feet)	0.12	17.27	2.07	15.27	1.83
Dummy: Chest Configuration	0.30	0.19	0.06	0.27	0.08
Located in Unconditioned Space * CDDs[3]	0.08	0.36	0.03	0.40	0.03
Located in Unconditioned Space * HDDs[4]	-0.03	8.55	-0.26	9.52	-0.30
Daily Use (kWh)			**2.80**		**1.97**
Annual Gross Energy Savings (kWh)			**1,021**		**718**

[1] Results subject to rounding error.
[2] This calculation applies values reported in the 2011 study to the UMP algorithm. The 2011 study used a different methodology that arrived at a UEC of 1,126 kWh (after weighting for whether the unit was replaced). See NMR Group, Inc., June 2011 Impact evaluation http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-Final-Report.pdf and Participant survey results http://ma-eeac.org/wordpress/wp-content/uploads/Participant-Survey-Results-Final-Report.pdf.
[3] 125 respondents indicated that 91% of refrigerators had been in spaces that lacked summer cooling.
[4] 127 respondents indicated that 57% of refrigerators had been in spaces that lacked winter heating.

2.1.2 Realization Rates and Adjusted Gross Energy Savings

As explained in Section 1.3.1, NMR estimated realization rates based on partial use – the portion of the year survey respondents had appliances plugged in the year prior to participation. We assumed respondents used primary refrigerators the entire year but probed respondents who recycled secondary refrigerators or any freezers about how often they had the units plugged in. Figure 3 compares the results for 2011 to those for 2017. On average, respondents used refrigerators 88% of the year in 2017 compared to 72% of the year in 2011.[17] The increased prevalence of primary units recycled (22% in 2011 versus 48% in 2017, Table 10) drives this result. On average, respondents in 2011 and 2017 had their freezers plugged in for similar portions of those years (65% and 68%, respectively).[18]

Figure 3: Percentage of the Year Units were Plugged In (Realization Rate)

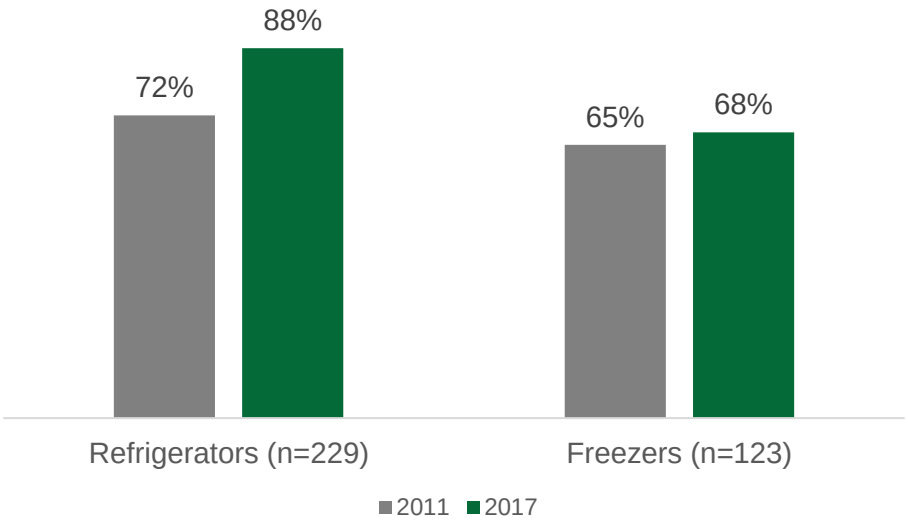


Table 12 applies the realization rates to gross energy savings, yielding adjusted gross energy savings of 897 kWh for refrigerators and 488 kWh for freezers. This table also compares the results to the values derived from the 2011 study (adjusted for primary and secondary use and replacement).

[17] The realization rate in 2011 reflects the weighted average of primary, secondary replaced, and secondary not replaced units, as derived from that study.
[18] The realization rate in 2011 reflects the weighted average of secondary replaced and secondary not replaced units, as derived from that study.

Table 12: Calculation of Adjusted Gross Energy Savings[1]

	Refrigerators		Freezers	
	2011[2]	2017	2011[2]	2017
Gross Energy Savings (kWh)	1,292	1,019	1,126	718
Realization Rate (Part-use Factor)	72%	88%	65%	68%
Adjusted Gross Savings (kWh)	**930**	**897**	**734**	**488**

[1] Results subject to rounding error.
[2] As derived from the methodology used in that study, so the values differ from the UMP-derived estimates in Table 10 and Table 11 (but see the footnotes to those two tables).

2.2 Net Savings Estimates

The net savings algorithm, described in Section 1.3.2, classifies each recycled appliance as a free rider, non-free rider, or transferred unit. Lacking an in-depth exploration of the secondary market, we followed the UMP guidance to treat one-half of transferred units as non-free riders and one-quarter as free riders. The remaining one-quarter of transferred units are assigned energy savings equal to the difference (delta) between units recycled through the program in 2017 and similar newly manufactured units.

Table 13 summarizes the application of this algorithm for refrigerators based on participant survey responses. The algorithm classifies 51% of refrigerators as free riders based on customer responses, and another 3% of transferred units are assigned as free riders, bringing total free-ridership to 54%. Freezers exhibited less free-ridership than refrigerators because higher proportions of respondents indicated that they would have kept the unit or given it away to an acquaintance (Table 14). A total of 40% of freezers are classified as free riders, 36% based on survey responses and 4% assigned from the transfer group. The following section expands on the alternative outcomes for the units recycled through the program, including a breakdown of the responses that informed the assignment of units to free rider, non-free rider, or transfer.

Table 13: Refrigerator Net Savings Estimation[1]

Participant Assignment[2]	% of Refrigerators (n=225)	Net Savings (kWh)
Scenario A: Pure Non-free Riders (includes units ≤ 10 years)[3]	36%	897[4]
Scenario B: Transfer Non-free Riders (50% of transfer group)	7%	897
Scenario C: Pure Free Riders (includes units > 10 years)[3]	51%	0
Scenario B: Transfer Free Riders (25% of transfer group)	3%	0
Scenario B: Transfer Other (25% of transfer group)[5]	3%	465
Net Savings (kWh)		**398**
Net as Percentage of Gross[3]		**44%**

[1] Results subject to rounding error. Original calculations based on additional decimal places.
[2] Scenarios refer to those in Table 9 and Figure 2.
[3] Adjusting this to a 15-year cut off increases savings by about 7%.
[4] Equivalent to adjusted gross savings.
[5] Average new unit = 432 kWh, difference between new and old = 465 kWh. Accounts for the average prevalence in New England of through-the-door ice/water in 2005, 2009, and 2015 as reported by RECs (19%) and national ENERGY STAR market share (48%). Sensitivity analysis yielded no noticeable difference in savings if based solely on non-ES unit or if using the percentages reported by any individual RECS.

Table 14: Freezer Net Savings Estimation[1]

Net Savings Assignment[2]	% of Refrigerators (n=124)	Net Savings (kWh)\
Scenario A: Pure Non-free Riders (includes units ≤ 10 years)[3]	47%	488[4]
Scenario B: Transfer Non-free Riders (50% of transfer group)	8%	488
Scenario C: Pure Free Riders (includes units > 10 years)[3]	36%	0
Scenario B: Transfer Free Riders (25% of transfer group)	4%	0
Scenario B: Transfer Other (25% of transfer group)[5]	4%	134
Net Savings (kWh)		**276**
Net as Percentage of Gross[3]		**56%**

[1] Results subject to rounding error. Original calculations based on additional decimal places.
[2] Scenarios refer to those in Table 9 and Figure 2.
[3] Adjusting this to a 15-year cut off increases savings by about 2%.
[4] Equivalent to adjusted gross savings.
[5] Average new unit = 354 kWh, difference between new and old = 134 kWh. Accounts for the average prevalence in New England of manual defrost in 2005 and 2009 as reported by RECs (57%) national ENERGY STAR market share (35%). Sensitivity analysis yielded no difference in savings if based solely on non-ES unit.

2.3 DIGGING DEEPER: PROGRAM IMPORTANCE AND ALTERNATIVES

The net savings approach summarized above determines program free-ridership based on respondents' best guess of what they would have done with their unit absent the program. However, as mentioned in the UMP, participant intentions may not always match what actually would have happened if they had not taken part in the program. Determining free-ridership for appliance recycling differs from other programs, even those that rely on self-reported methods. In most programs, free-ridership captures whether a participant would have bought/installed an efficient measure or adopted an efficient behavior in the absence of the program. In recycling programs, while the respondent makes the initial decision on how the unit is disposed, their decision also involves the state of the market and the decision of others. If the respondent hires a hauler or has a retailer take it away, then the decision to scrap the unit or sell the unit in a second-hand market changes hands to the hauler or retailer. When this occurs, evaluators are unable to determine definitively, based on the responses of participants, whether the unit would have been removed from service.

To unravel this information, the team asked respondents a battery of questions to gauge whether the unit would ultimately be removed from service (including transfers to other users). The initial question asked respondents what they would have done with the unit in the absence of the program, and their responses informed the net savings calculations in Table 13 and Table 14. We followed up with additional questions about whether respondents had attempted to get rid of the unit prior to participation and what they had tried. We also asked about the physical and financial challenges associated with removing a bulky item that could contain banned chlorofluorocarbons (CFCs). These follow-up questions did not factor into the estimation of net savings, but they add to our understanding of alternatives to program participation.

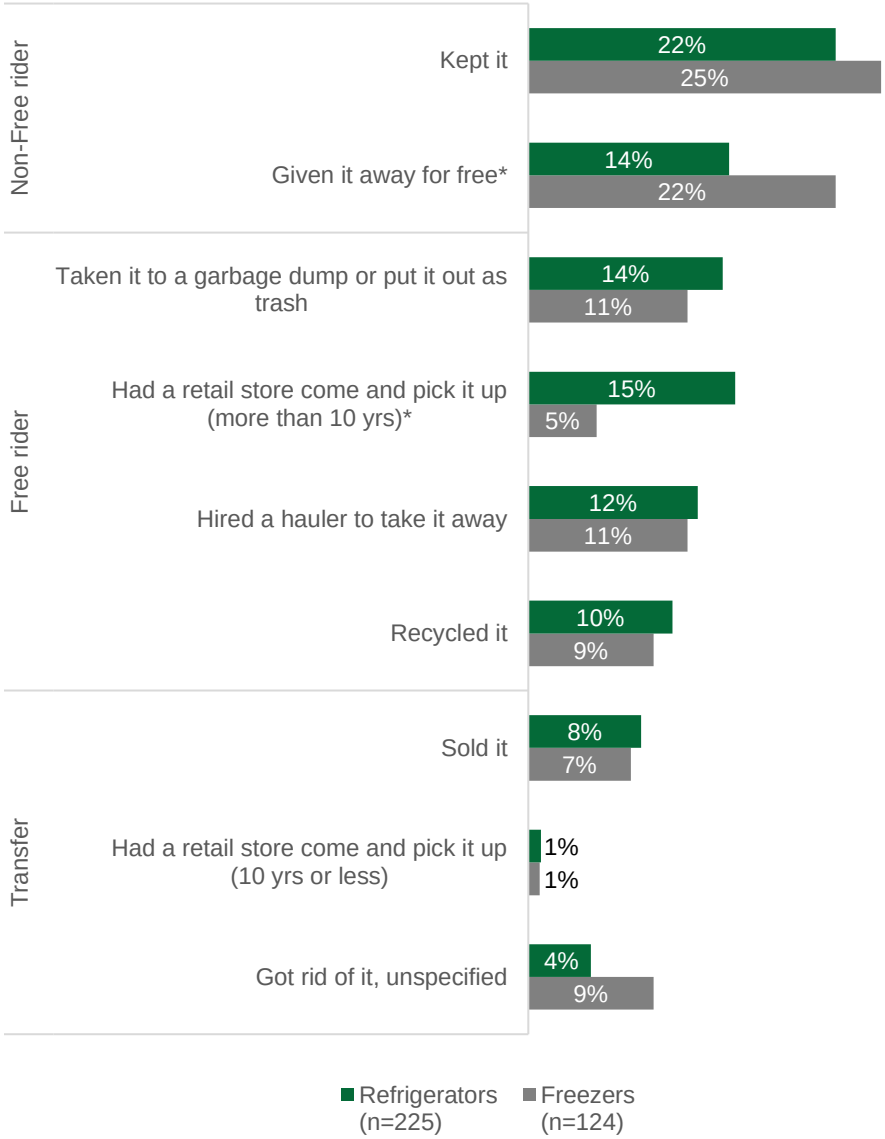
2.3.1 Likely Actions in the Absence of the Program

The information in Figure 4 presents the actions respondents think they would have taken if they hadn't recycled the unit through the program and represents the more detailed responses that informed the net savings calculations in Table 13 and Table 14. Figure 4 groups responses according to the non-free rider, free rider, and transfer designations. While the results indicate some variation between freezers and refrigerators, only two of the findings differ statistically: (1) freezer respondents reported that they would have given a greater proportion away to acquaintances for free, and (2) a greater proportion of refrigerators than freezers get designated as free riders because of their age. The remainder of this section focuses on the subset of respondents who said that they would still have gotten rid of their appliance if they had not recycled the unit through the program.

Three-fourths of respondents (76% for refrigerators and 72% for freezers) who wanted to get rid of their appliance never attempted to dispose of their unit prior to participating in the program. This draws into question whether the respondents could or would have actually removed their appliance in the stated non-program

manner because circumstances may have made it difficult or even prevented the respondent from following through on their intentions.

Figure 4: Likely Actions in the Absence of the Program



* Refrigerator respondents are significantly different than freezer respondents at the 90% confidence level.

NMR further explored the question of alternative appliance outcomes by asking respondents if they had tried to get rid of the recycled unit prior to program participation. **We urge the reader to remember that this study did not include a non-participant survey. Therefore, everyone we spoke with successfully recycled their unit with the program**. When we probed about program drivers (see Figure 7), no respondents reported that they could not get rid of it outside the program – although a few did say they did not want to pay to have it removed. Therefore, we cannot conclude that people who tried another disposal method were unsuccessful. We can only say that they chose the program over other methods.

Keeping the caveat in mind, Table 15 breaks down the previous actions taken by respondents who wanted to dispose of their appliances, including those who had and had not tried to do so. For refrigerators (6%) and freezers (11%), respondents had most commonly tried to give it away for free. About one-in-ten freezer respondents tried to sell the unit (9%), as had 3% of refrigerator recyclers. Other removal attempts included having a retailer or hauler pick it up, recycling it, or putting it out for the trash. Some of the respondents cannot remember what they tried to do. **Importantly, most respondents never tried to get rid of their units, we have no information on the success rates for non-participants who wanted to remove appliances, and the small number of respondents who tried to get rid of their units exhibit no bias towards or away from free-ridership.** Therefore, while NMR agrees that respondents may not have been able to follow-through with their stated alternative for the unit, the evidence does not suggest that this biases the net savings estimates.

Table 15: Actions Taken Prior to Program Participation[1]

Prior to signing up for the Mass Save Appliance Recycling Program, had you tried to do any of the following to get rid of the refrigerator? (Multiple response)	Refrigerators (n=176)	Freezers (n=93)
I had not tried to get rid of it	78%	73%
Give it away for free	6%	11%
Sell it	1%	9%
Take it to a garbage dump or put out as trash	1%	2%
Have a retail store come and pick it up	5%	1%
Recycle it	3%	1%
Hire a hauler to take it away	2%	1%
Don't know	8%	9%

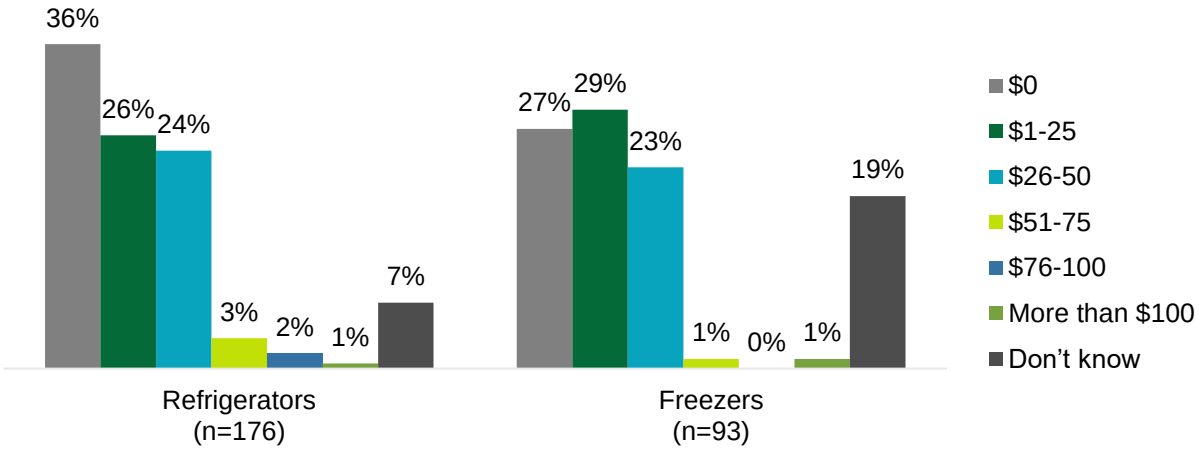
[1] Base = respondents who wanted to get rid of the unit in the absence of the program. Sample sizes for those who tried to get rid of the appliance are 42 for refrigerators and 26 for freezers, multiple responses allowed.

2.3.2 Physical and Financial Challenges for Alternative Disposal

The survey questionnaire also asked respondents who wanted to get rid of their appliance their willingness to pay to have someone else remove their refrigerators and freezers. Approximately one-half of respondents (56% for refrigerators and 54% for freezers) were willing to pay someone to remove their unit, with stated amounts between $1 and $50 being the most common (Figure 5). NMR conducted high-level research to understand how reasonable their willingness-to-pay was, given common program alternatives. Municipal fees average about $15 to $25 (some even

offer it for free), thus curbside pick-up could be a viable alternative to some program participants, but some participants may have found it difficult or impossible to get the bulky heavy appliance to the curb without assistance. In contrast, hiring a hauling company or having a retailer take the unit away costs more than municipal pick-up. Our inquiries suggest that hauling companies charge about $100 (depending on appliance characteristics), and retailers often require the purchase of a new unit (and sometimes a $25 fee) to remove an unwanted unit. Only 2% of respondents indicated they were willing to pay $100 to have someone remove their appliance. Approximately one-third of respondents (33%) were not willing to pay any amount to have their appliance removed (36% for refrigerators and 27% for freezers). Respondents unwilling to pay any amount would have had to remove and transport the units themselves, found someone else – perhaps a buyer/recipient – to remove it, or simply decided to keep it.

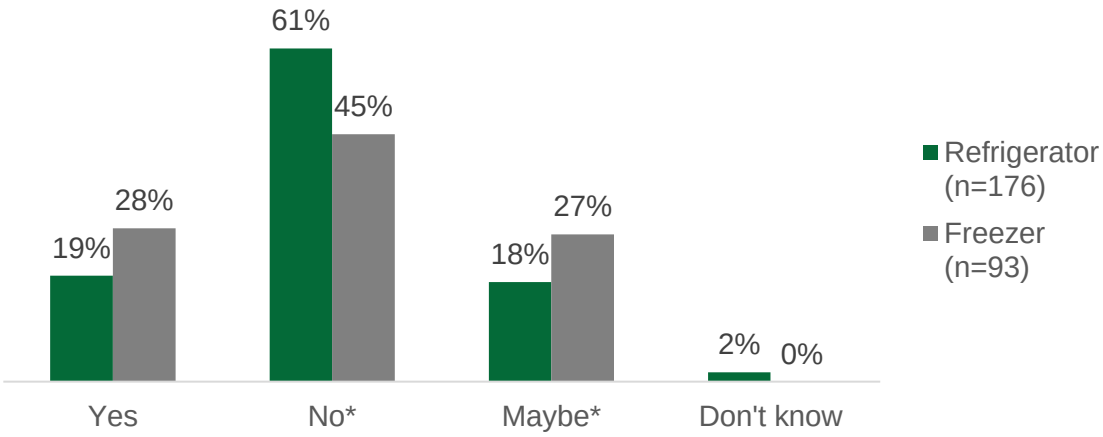
Figure 5: Willingness to Pay for Unit Removal in the Absence of the Program



The last question in the series assessing alternative outcomes specifically addressed the physical challenges of removing unwanted refrigerators and freezers. The survey asked respondents, *"If the Mass Save Appliance Recycling Program had **not** been available, would the need to physically move the refrigerator out of your house and transport it have prevented you from getting rid of it?"* Figure 6 shows the responses. Most refrigerator respondents (61%) said that the physical challenges would not have hindered their ability to get rid of the appliances, significantly higher than the 45% who responded similarly for freezers. In contrast, freezer respondents more often reported that the physical challenges would have (28% for freezers versus 19% for refrigerators) or may have (27% for freezers versus 18% for refrigerators) hindered their ability to get rid of the appliance.

In summary, financial and physical considerations may create challenges for some households looking to unload unwanted freezers or refrigerators outside of the program, but other households seem willing and able to pay or remove the appliances themselves. We revisit this question in Section 3.3 by comparing a subset of these questions for certain demographic groups.

Figure 6: Appliance Removal Hindered by Physical Removal and Transportation



* Refrigerator respondents are significantly different than freezer respondents at the 90% confidence level.

Section 3 Participant Experience

The study also addressed some process evaluation elements, including drivers of program participation and program satisfaction. We additionally examined whether participation, free-ridership, and other factors differed by participant demographics.

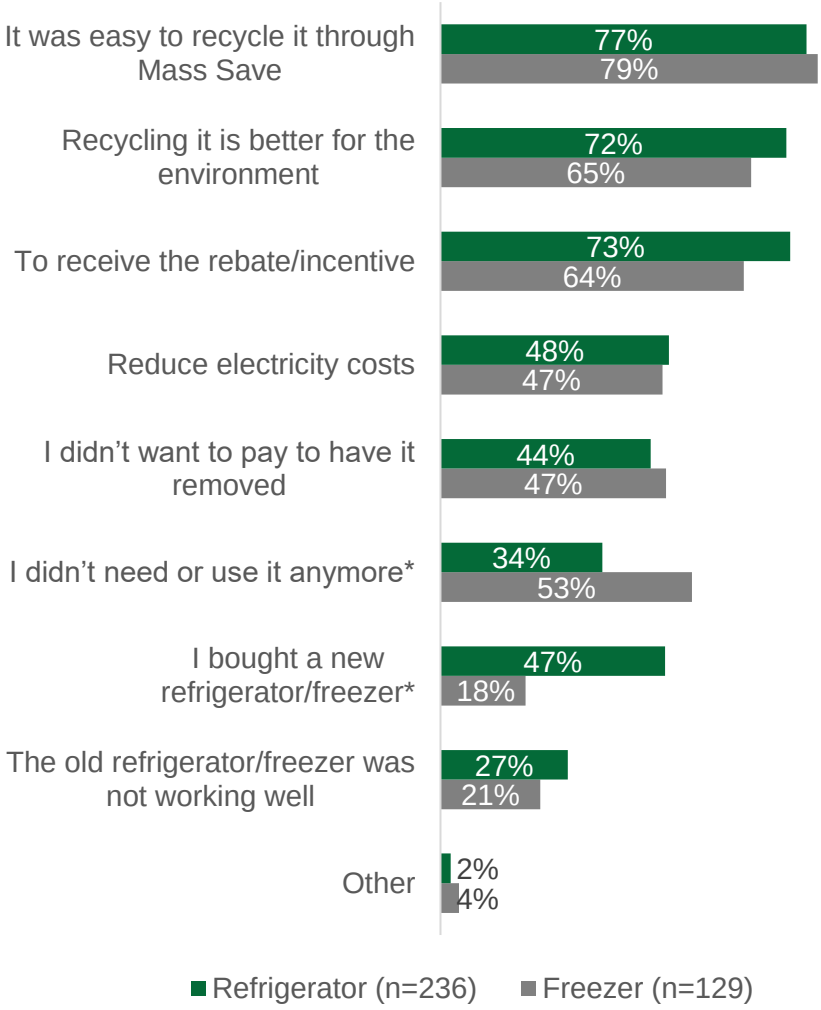
Key findings include the following:

- The three most common drivers of program participation included the ease of recycling through the program (77% of refrigerators respondents, 79% of freezer respondents), benefits to the environment (72%, 65%), and the incentive (73%, 64%).
- Nearly all respondents found it easy to sign up for the program online or by phone. Roughly three-fourths of respondents are satisfied with the program, mainly because of how smoothly the process went, its positive environmental impact, and the convenience.
- Program participants tend to be 55 years of age or older, which increases the physical challenges they may have faced if having to remove the appliance on their own. Older respondents also voiced greater openness to paying for removal and exhibited higher free-ridership rates (mainly because the appliance was older than ten years).

3.1 Participation Drivers

The survey asked respondents why they decided to recycle the appliance through the MassSAVE program (Figure 7). The survey allowed them to provide multiple responses. About three-quarters of respondents cited three main reasons for both appliances: (1) ease of recycling, (2) environmental benefit, and (3) rebate. About one-half of respondents for each appliance also wanted to reduce energy costs. Likewise, about one-half of respondents wanted to avoid having to pay to have it removed. A majority of freezer recyclers reported that they did not need the unit anymore, while in contrast refrigerator recyclers often had purchased a new unit.

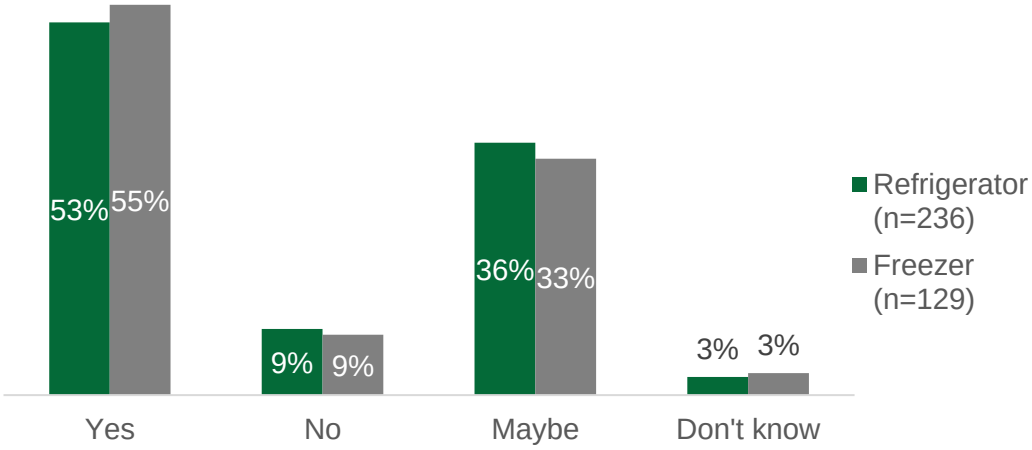
Figure 7: Drivers of Program Participation



*Refrigerator respondents are significantly different than freezer respondents at the 90% confidence level.

Although the rebate was among the top three drivers of participation, a little over one-half of respondents (53% for refrigerators and 55% for freezers) would have participated in the program even if the rebate had not been offered (Figure 8). In comparison, only 9% of respondents for either appliance would not have participated without the incentive, and another one-third were uncertain if they would have participated without the rebate. Coupled with the information on drivers of participation, it appears that the incentive is important, but participants also appreciate how easy the program makes it to recycle their appliance in an environmentally safe manner.

Figure 8: Program Participation Without Rebate



3.2 PARTICIPANT SATISFACTION

The survey asked respondents how they signed up for the program, the ease of the enrollment process, and their satisfaction with the program overall. One-half of respondents recalled signing up online, and 44% said they signed up over the phone. The remainder could not remember which approach they used to sign up. Using a five-point scale, in which one was extremely difficult and five was extremely easy, most respondents (98% overall, 99% online, and 96% over the phone) found the enrollment process easy. Most of the respondents (93%) felt that scheduling a time for the pick-up was easy. Using a similar five-point scale, in which one was extremely dissatisfied and five was extremely satisfied, nearly all respondents (97%) were satisfied with the recycling program overall (indicating satisfaction with a four or five).

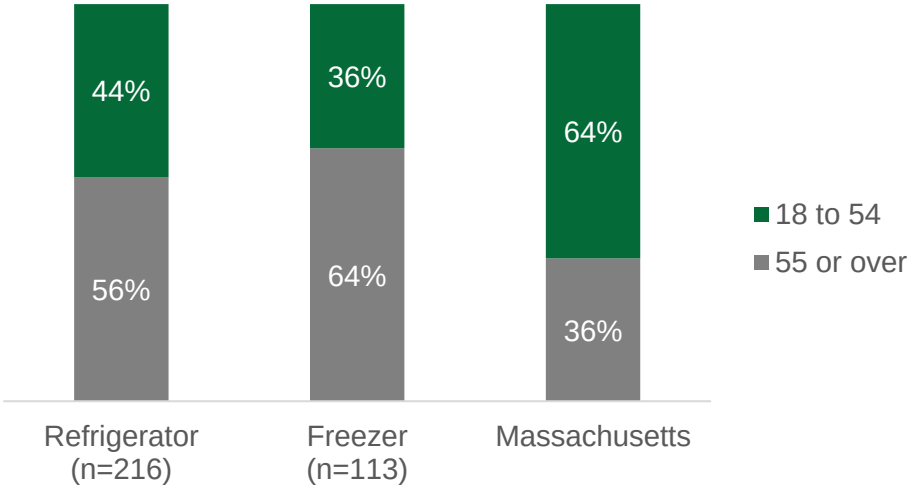
When asked to name reasons for satisfaction, respondents indicated the smooth process (86%), positive environmental impact (80%), and convenient pick up (74%) as the top reasons. The five respondents who indicated lower levels of satisfaction (three or lower on a five-point scale, in which one indicated low satisfaction and five indicated high satisfaction) had issues with the hauler/contractor's professionalism and punctuality or the size of the incentive. One respondent said that the hauler/contractor did not show up for their first scheduled appointment.

3.3 Participation and Free-ridership by Select Demographics

As documented in the 2011 study, recycling programs often serve an older and less affluent population than other market-rate programs.[19] Therefore, we assessed participation and other issues by age, income, owner-renter status, educational attainment, and building type. This section reports the subset of results found to have important programmatic implications.

As found in 2011, the current study concludes that the program disproportionately serves an older population. While about one-third of Massachusetts householders are 55 years or older, 56% of refrigerator and 64% of freezer respondents were 55 years or older.

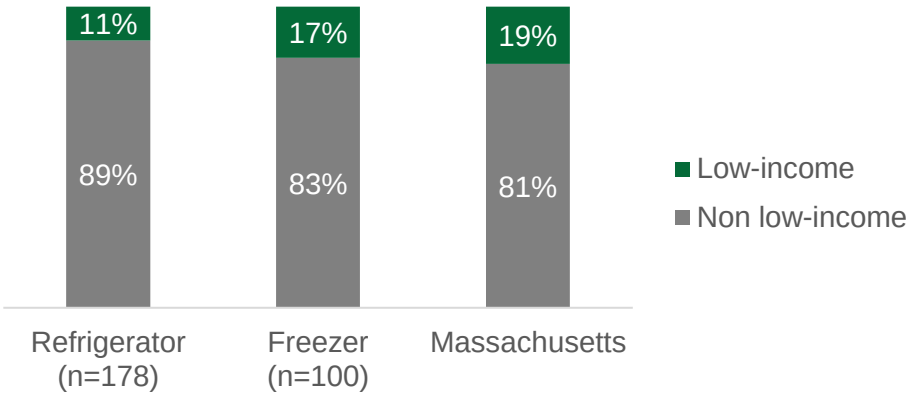
Figure 9: Respondent Age by Appliance



[19] NMR Group, Inc. 2011. *The Massachusetts Appliance Turn-in Program-participant Survey Results*. http://ma-eeac.org/wordpress/wp-content/uploads/Participant-Survey-Results-Final-Report.pdf.

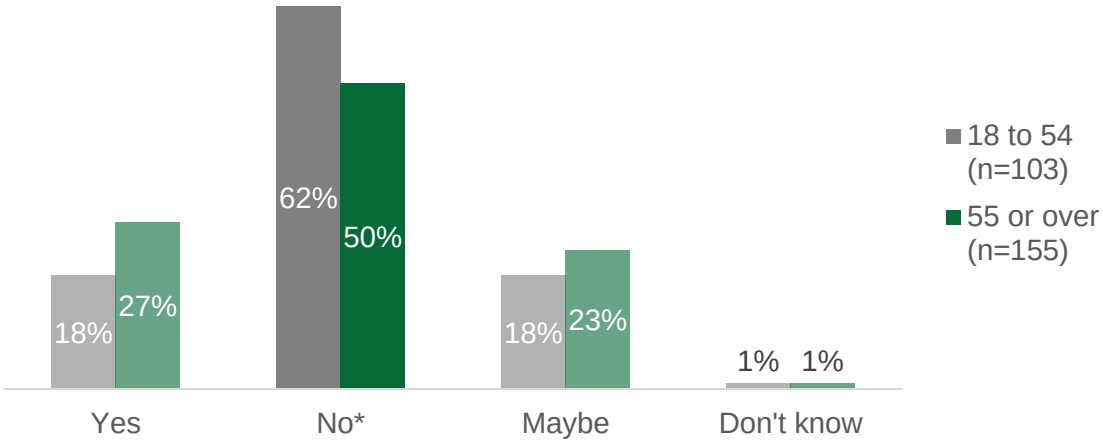
Three-fourths of respondents elected to provide income information on the survey. Of the respondents who provided income information, 11% of refrigerator and 17% freezer respondents qualified as low-income households, defined as making no more than 60% of the state median income for a household of their size. Combined, low-income families account for 13% of the sample, slightly lower than the 19% for the state of Massachusetts, shown in Figure 10. The income finding in part reflects the age of respondents, some of whom likely exist on fixed retirement incomes.

Figure 10: Low-income Status



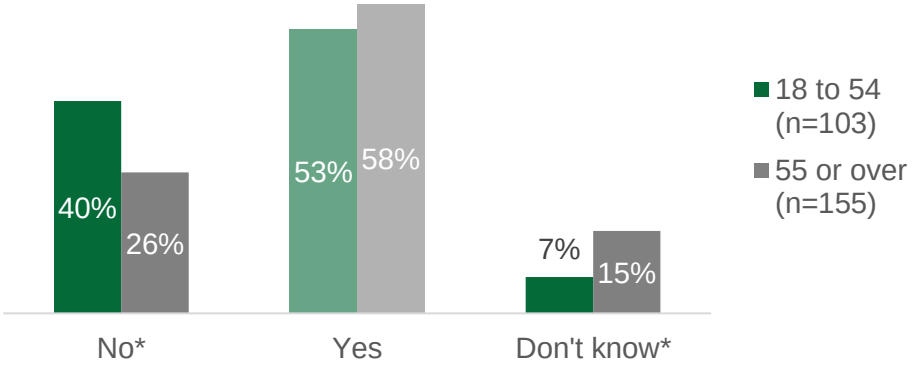
Given the findings on age and income, it is not surprising to find that the program provided a valuable service to the elderly, who otherwise might have been unable to move the unit on their own or to have access to transportation to dispose of old and unwanted units. The survey found that the bulk size of the old refrigerator or freezer presented a greater disposal obstacle for older respondents than younger respondents (Figure 11). Older respondents also more frequently reported that they would have hired a hauler if the program had not been available (19% of 55 and older respondents versus 6% of 18 to 54-year-old respondents [not shown]). Finally, compared to older respondents (26%), younger respondents (40%) more frequently said that they were unwilling to pay any amount for someone to remove the unit (Figure 12).

Figure 11: Appliance Removal Hindered by Physical Removal and Transportation



* Respondents aged 18 to 54 are significantly different than respondents aged 55 or above at the 90% confidence level.

Figure 12: Willingness to Pay for Appliance Removal



* Respondents aged 18 to 54 are significantly different than respondents aged 55 or above at the 90% confidence level.

Older respondents also reported having older appliances. The average age of appliances recycled by respondents 55 years and older was 24 years, compared to 19 years for respondents younger than 55, a statistically significant difference. Application of the algorithm for alternative methods of disposal and age of units resulted in a larger percentage of older participants (51%) than younger participants (39%) being designated as free riders. Thus, the program provides a valuable service to a potentially vulnerable group of customers, but the age of both the participants and the appliances they recycle serves to increase free-ridership.

Appendix A Additional Findings

The following tables and graphs describe the inputs in the calculation of gross energy savings (UEC). Note that the sample sizes change due to missing data for some inputs.

Figure 13. Distribution of Recycled Refrigerator Age (Count = 15,512)

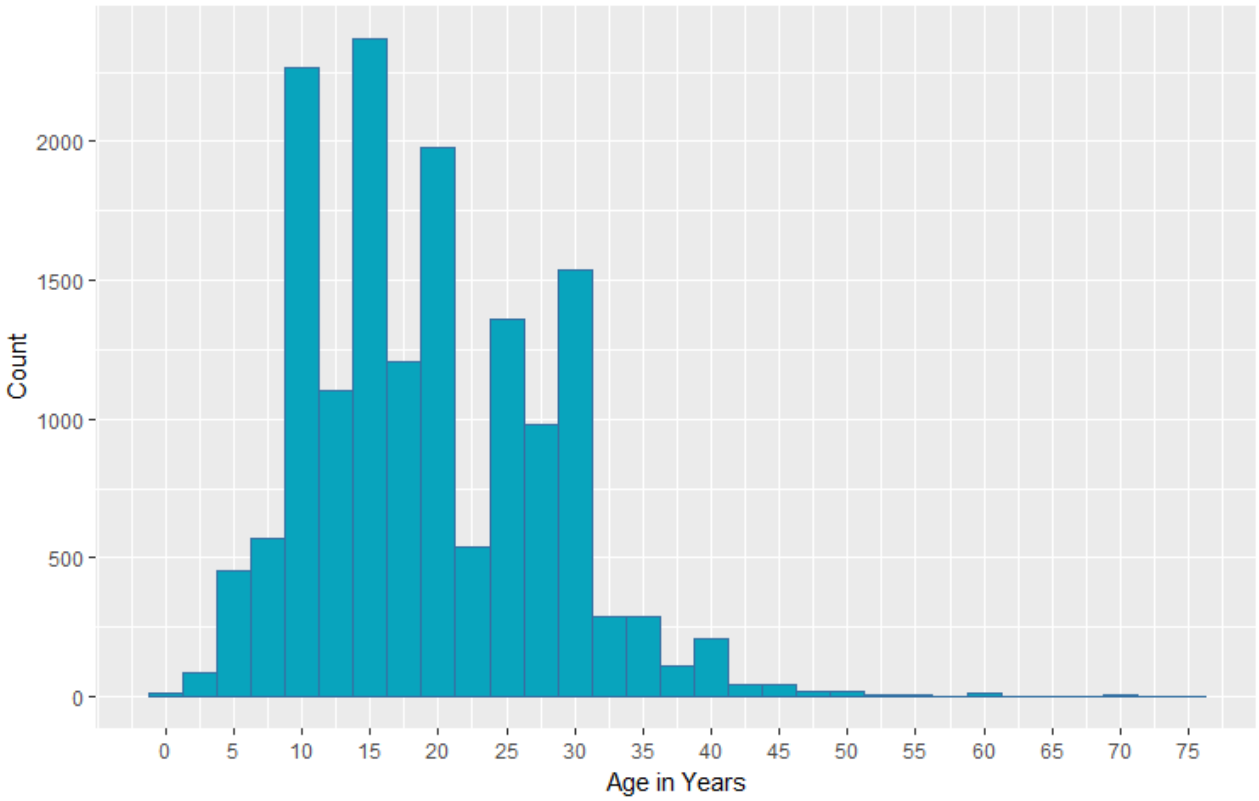


Figure 14. Distribution of Recycled Freezer Age (Count = 2,657)

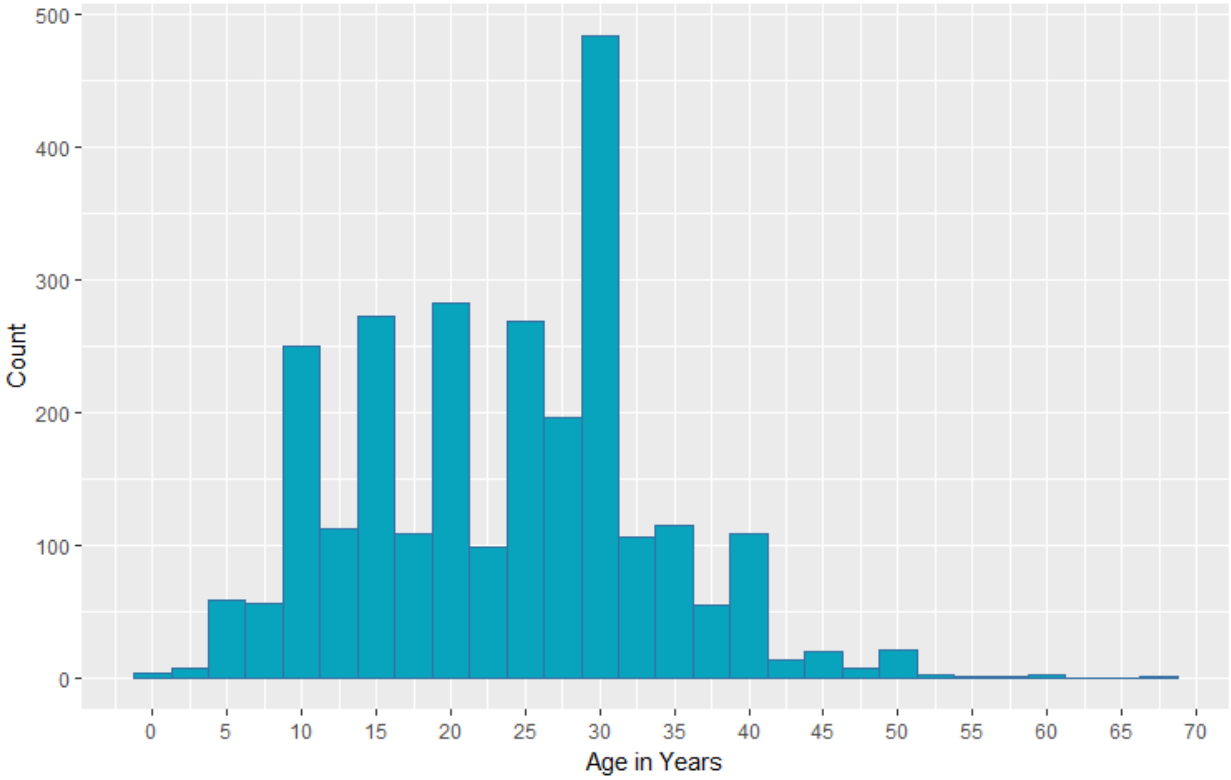


Figure 15. Distribution of Recycled Refrigerator Size (Count = 15,637)

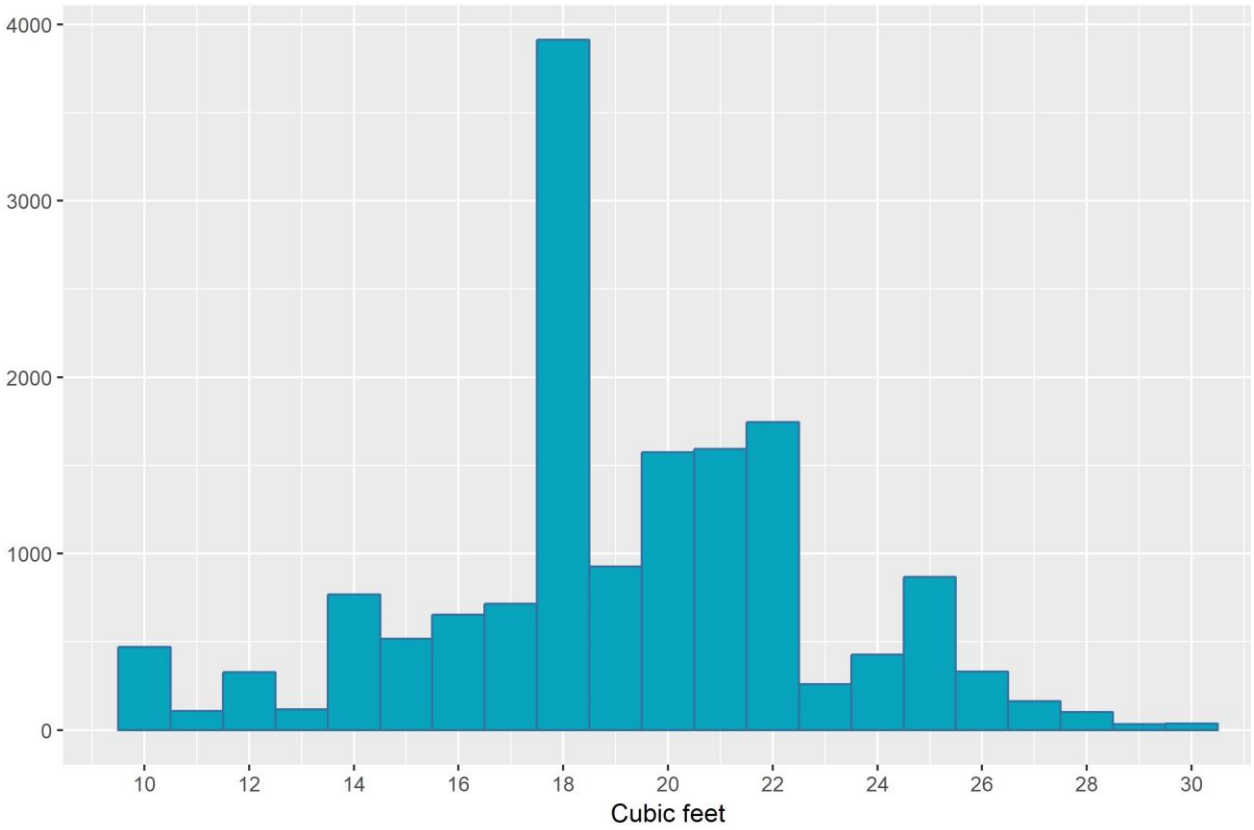


Figure 16. Distribution of Recycled Freezer Size (Count = 2,663)

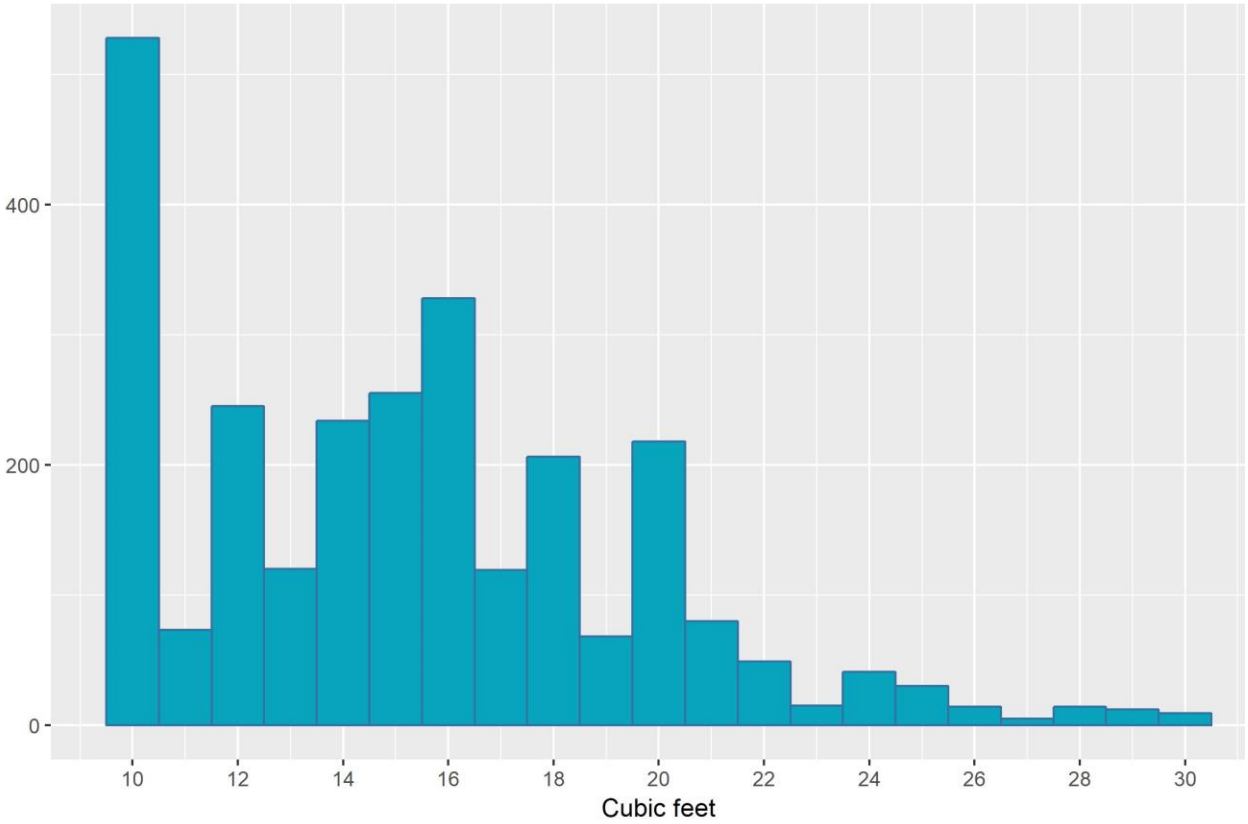


Table 16. Recycled Unit Year of Manufacture

Year of Manufacture	Refrigerators	Percentage	Freezers	Percentage
Pre-1990	3,014	19%	1,037	39%
1990 and later	12,498	81%	1,620	61%
Total	15,512		2,657	

Table 17. Recycled Unit Configuration

Unit Type	Door Configuration	Count	Percentage
Refrigerators	Bottom Freezer	1,120	7%
	Side-by-side	2,970	19%
	Single Door	537	3%
	Top Freezer	11,010	70%
	Total Refrigerator	**15,637**	
Freezers	Chest	726	27%
	Upright	1,937	73%
	Total Freezer	**2,663**	

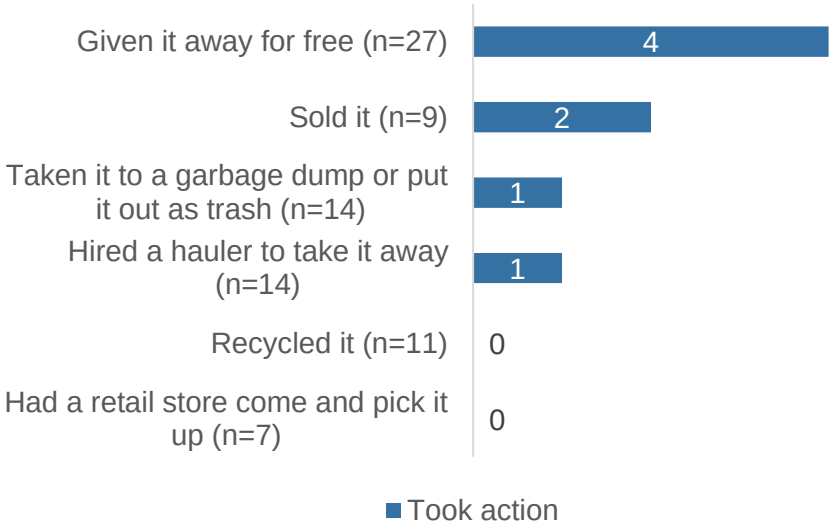
Table 18. Recycled Unit Use

Unit Use	Refrigerators	Percentage	Freezers	Percentage
Primary	7,325	47%	464	17%
Secondary	8,311	53%	2,199	83%
Total	**15,636**		**2,663**	

Figure 17 and Figure 18 explore respondents' experiences with alternative appliance outcomes by comparing the actions they would have taken without the program and whether they had previously attempted the action. The sample sizes on the left-hand side reflect the number of people who said they would have taken that action if they had not recycled the unit through the program. The bars and sample sizes on the right show the subset of the same people who had attempted the action. For example, five of the 32 people who said they would have given away the refrigerator for free had tried to do it before participating in the program. The figures emphasize that very few respondents have first-hand knowledge with the stated program alternative, at least for the appliances recycled through the program (i.e., they may have disposed of previous appliances through a non-program method).

Figure 17: Likely Actions in the Absence of the Program that were Previously Attempted - Refrigerators

Figure 18: Likely Actions in the Absence of the Program that were Previously Attempted - Freezers



Appendix B Appliance Configurations Used in New Unit Energy Use Estimation

The UMP algorithm for net savings estimation suggests that one-quarter of transferred units be assigned savings equal to the difference between the energy use of a newly manufactured unit and units recycled through the program. The ENERGY STAR Appliances Calculator[20] provides estimates of energy use for newly manufactured refrigerators and freezers, but the use varies by size, door location (for refrigerators), upright or chest style (for freezers), presence of through-the-door ice (for refrigerators), and manual or automatic defrost type (for freezers).

NMR created a weighted estimate of use based on the most common refrigerator and freezer configurations recycled through the program, while also making certain to have ample representation of each configuration.[21] Program tracking data included size, door location, and upright and chest style. Table 19 lists the configuration used to estimate new unit energy use. These configurations account for 94% of the refrigerators and 84% of the freezers recycled through the program.

Table 19: Appliance Configurations Used in Estimation of New Unit Energy Use

Refrigerator		Freezer	
Size (ft^3)	Number	Size (ft^3)	Number
≤15	1,976	≤12	773
16 to 20	7,580	13 to 15	590
21 to 25	4,716	16 to 18	643
>25	386	>18	218
Total Included	14,658	Total Included	2,224
Total Recycled	15,637	Total Recycled	2,663
% Included	**94%**	**% Included**	**84%**

The program tracking data do not include through-the-door ice or defrost type. The main body of the report discusses treatment of these factors (Section 1.3.2).

[20] https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

[21] That is, like with the estimation of lumen bins and sales weights for the Lighting Market Adoption Model (http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_176_MAMMEMO_24APR2018.pdf), NMR first selected for the most common configurations of appliances, both overall and within types (e.g., refrigerators with top- or bottom-mounted freezers).

Appendix C Survey Questionnaire

C.1 APPLIANCE RECYCLING (RLPNC 18-1) PARTICIPANT SURVEY

KEY

[ ] = Instructions for programmer

Introduction

[NOTE TO PROGRAMMER: WE NEED AT LEAST 125 REFRIGERATOR RESPONDERS AND 75 FREEZER RESPONDERS. WE CAN ACCEPT COMPLETIONS BEYOND THOSE QUOTAS]

Thank you for taking the time to complete this survey. This survey asks questions about your household's participation in the Mass Save Appliance Recycling Program. We are contacting customers who used the program to remove and recycle refrigerators and freezers in 2017. Please have the person who made the decision to participate in this program complete the survey. Answer the questions to the best of your ability. All your responses will remain confidential. The survey should take about 15 minutes to complete.

Verification and Recall

V1. Just to confirm, are you the person who made the decision to recycle the appliance(s)?

1. Yes [GO TO V2]
2. No [TERMINATE]
98. Don't know [TERMINATE]

V2. Our records indicate that your household participated in the Mass Save Appliance Recycling Program. Someone would have come to your home and picked up your old refrigerator or freezer to recycle it. You would have received a rebate for each unit you recycled. Our records indicate that you had the program remove:

[IF TOT.UNITS = 1 AND…]
[…IF NUM.RF = 1] one refrigerator.
[…IF NUM.FZ = 1] one freezer.

[IF TOT.UNITS = 2 AND ...]
[IF NUM.RF = 2] two refrigerators.
[IF NUM.FZ = 2] two freezers.
[IF NUM.RF = 1 AND NUM.FZ = 1] one refrigerator and one freezer.

Is this correct?

Yes **[GO TO P1]**
1. No, do not recall participating **[THANK AND TERMINATE]**
98. No, different quantities or appliances **[GO TO V3]**
Don't know **[THANK AND TERMINATE]**

V3. Thinking only about any appliances that were picked up through the Appliance Recycling program, please enter the number of refrigerators and freezers you recycled through the program. Enter zero if you did not recycle the appliance.

1. Refrigerators [ENTER QUANTITY, MUST BE ZERO OR GREATER]
2. Freezers [ENTER QUANTITY, MUST BE ZERO OR GREATER]

[IF V3 1=0 AND V3 2=0, TERMINATE]

[IF V3.1 > 0 AND V3.2 = 0, REASSIGN APPTYPE1 = REFRIGERATOR]
[IF V3.1 = 0 AND V3.2 > 0, REASSIGN APPTYPE1 = FREEZER]
[IF V3.1 AND V3.2 > 0, REASSIGN APPTYPE1 = FREEZER]

Program Information and Satisfaction

P1. How did you find out about this program? Select all that apply **[RANDOMIZE 1-8, MULTIPLE RESPONSE]**

1. Utility bill insert
2. Utility/Mass Save website
3. Online or email advertisement
4. Print advertisement
5. Radio advertisement
6. Social media (Facebook, LinkedIn, Twitter, Instagram)
7. Co-worker, family or friend
8. Appliance dealer or store employee

97. Other **[OPEN END]**
98. Don't know

P2. How did you initially sign up for the program?

1. Over the phone
2. Online
98. Don't know

P3. Using a scale from 1 to 5, where 1 is "extremely difficult" and 5 is "extremely easy," how difficult or easy was it for you to…

1. **[IF P2=1]** Sign up over the phone
2. **[IF P2=2]** Sign up online
3. **[IF P2=98]** Sign up for the program
4. **[ASK ALL]** Schedule the time for the appliance pickup

P4. **[IF P3-1 ≤ 3]** What challenges did you have signing up over the phone? Select all that apply. **[RANDOMIZE 1-3, MULTIPLE RESPONSE]**

1. Did not have all the information I needed
2. Put on hold/long wait time
3. Technical difficulties with the automated phone system
97. Other **[OPEN END]**

P5. **[IF P3-2 ≤ 3]** What challenges did you have signing up online? Select all that apply. **[RANDOMIZE 1-3, MULTIPLE RESPONSE]**

1. Did not have all the information I needed
2. Website was confusing
3. Technical difficulties with computer/Internet service
97. Other **[OPEN END]**

P6. **[IF P3-3 ≤ 3]** What challenges did you have signing up for the program? Select all that apply. **[RANDOMIZE 1-5, MULTIPLE RESPONSE]**

1. Did not have all the information I needed
2. Website was confusing
3. Technical difficulties with computer/Internet service
4. Put on hold/long wait on telephone
5. Technical difficulties with automated phone system
97. Other **[OPEN END]**

P7. **[IF P3-4 ≤ 3]** What difficulties did you have scheduling the pick-up of your appliance(s)? Select all that apply. **[RANDOMIZE 1-5, MULTIPLE RESPONSE]**

1. No convenient time available
2. I needed to reschedule pick-up
3. Program rescheduled pick-up
4. They did not show up at all
5. They did not show up at the right time

97. Other **[OPEN END]**

P8. Using a scale from 1 to 5 where, 1 is “extremely dissatisfied” and 5 is “extremely satisfied” how would you rate your satisfaction with the program overall?

a. 1 = extremely dissatisfied
b. 2
c. 3
d. 4
e. 5 = extremely satisfied

98. Don’t know
99. I’d rather not answer

P9. Why did you give a rating of **[INSERT RATING FROM P8]**? Select all that apply. **[Reasons for satisfaction IF P8 > 3, RANDOMIZE 1-5, MULTIPLE RESPONSE]**

1. The pickup was convenient
2. The process went smoothly
3. The hauler/contactor was professional
4. The program is good for the environment
5. Satisfied with the amount of the incentive

97. Other **[OPEN END]**

[Reasons for dissatisfaction IF P8 ≤ 3, RANDOMIZE 1-5; MULTIPLE RESPONSE]

1. The hauler/contractor was unprofessional
2. The hauler/contractor did not show up on time
3. It took a long time to receive the incentive
4. Not satisfied with the amount of the incentive
5. The program was not clearly communicated

97. Other **[OPEN END]**
98. Don’t know

[IF APPTYPE1 = REFRIGERATOR, GO TO RF SERIES; IF APPTYPE1 = FREEZER GO TO FZ SERIES]

Refrigerators (RF SERIES)

[IF V2 = 1 AND NUM.RF = 1 OR IFV3.1 = 1] This next set of questions will ask about the old refrigerator that you had removed through the program.

[IF V2 = 1 AND NUM.RF > 1 OR IFV3.1>1] We are aware that you had more than one refrigerator removed through the program.

[IF V2 = 1 READ] For purposes of this survey, please think about the [IF UNIT.BRAND1<>" " **[Unit.Brand1]]** refrigerator with **[Configuration1]** configuration**.**

[IF V3.1 >1] Please keep only one refrigerator clearly in your mind as you answer the next few questions.

RF1. Which of the following best describes the refrigerator that was removed through the program? **[ALLOW ONLY ONE RESPONSE]**

1. It was the primary refrigerator that I used for my daily needs
2. It was a secondary or extra refrigerator
98. Don't know

RF2. Thinking about the 12 months before you recycled it, was the refrigerator plugged in… **[ALLOW ONLY ONE RESPONSE]**

1. All of the time **[GO TO RF4]**
2. Some of the time
3. Never **[GO TO RF4]**
98. Don't know **[GO TO RF4]**

RF3. **[ASK IF RF2 = 2]** How many months was the refrigerator plugged in the year before you recycled it? **[ALLOW WHOLE NUMBER BETWEEN 0 AND 12]**

RF4. Where in the house was the refrigerator located? **[RANDOMIZE 1-6; ALLOW ONLY ONE RESPONSE]**

1. Kitchen
2. Basement
3. Garage
4. Porch/Patio
5. Laundry room
6. Yard
97. Some other place **[OPEN END]**
98. Don't know

RF5. **[IF RF4≠1]** Is the space where the refrigerator was located heated by your heating system in the winter?

1. Yes
2. No
98. Don't know

RF6. Is the space where the refrigerator was located cooled with air conditioning in the summer?

1. Yes
2. No
98. Don't know

Refrigerator Free-ridership (RFR Series)

[DISPLAY IF NUM.RF > 1] Please continue thinking about just that one refrigerator for the next set of questions.

RFR1. Before you heard about the Mass Save Appliance Recycling Program, had you considered getting rid of the refrigerator? Meaning, did you already have plans to get the appliance out of your home by selling it, giving it away, having someone pick it up, or taking it to the dump or a recycling center yourself? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
98. Don't know

RFR2. If the Mass Save Appliance Recycling Program had not been available to you, what would you most likely have done with your refrigerator? **[ALLOW ONLY ONE RESPONSE]**

1. Gotten rid of it
2. Kept it **[SKIP TO RFR5]**
98. Don't know **[SKIP TO RFR5]**

RFR3. **[ASK IF RFR2=1]** Why did you want to get rid of the refrigerator? Select all that apply. **[RANDOMIZE 1 -5, MULTIPLE RESPONSE]**

1. I didn't need or use it anymore
2. I bought a new refrigerator
3. The old refrigerator was not working well
4. Reduce electricity costs
5. Recycling it is better for the environment
97. Other **[OPEN END]**
98. Don't know

RFR4. **[ASK IF RFR2=1]** If the Mass Save Appliance Recycling Program had not been available, how soon do you think you would have gotten rid of your refrigerator? **[ALLOW ONLY ONE RESPONSE]**

1. Within a year of when the program took it
2. More than a year later

98. Don't know

RFR5. **[ASK ALL]** Why did you recycle the refrigerator through the Mass Save Appliance Recycling Program? Select all that apply. **[RANDOMIZE 1-8, MULTIPLE RESPONSE]**

1. To receive the rebate/incentive
2. I didn't need or use it anymore
3. I bought a new refrigerator
4. The old refrigerator was not working well
5. It was easy to recycle it through Mass Save
6. Reduce electricity costs
7. Recycling it is better for the environment
8. I didn't want to pay to have it removed

97. Other **[OPEN END]**
98. Don't know

RFR6. Would you have participated in the Mass Save Appliance Recycling Program even if it did not pay a rebate? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
3. Maybe

98. Don't know

[IF RFR2 = 2 SKIP TO RFR14]

RFR7. **[ASK IF RFR2 ≠ 2]** If the Mass Save Appliance Recycling Program had not been available to you, what would you most likely have done to get rid of the refrigerator? **[RANDOMIZE 1-6, ALLOW ONLY ONE RESPONSE]**

1. Sold it **[GO TO RFR8]**
2. Given it away for free **[GO TO RFR9]**
3. Recycled it **[GO TO RFR10]**
4. Taken it to a garbage dump or put it out as trash **[GO TO RFR11]**
5. Hired a hauler to take it away **[GO TO RFR11]**
6. Had a retail store come and pick it up **[GO TO RFR11]**

97. Something else, please specify **[OPEN END] [GO TO RFR11]**
98. Don't know [**GO TO RFR11]**

RFR8. **[ASK IF RFR7=1]** Would you have sold the refrigerator to a private party, to a used appliance dealer, or someone else? **[RANDOMIZE 1-3, ALLOW ONLY ONE RESPONSE]**

1. Private party, such as a friend or family member
2. Used appliance dealer
3. Sold it online
97. Someone else, please specify **[OPEN END]**
98. Don't know

RFR9. **[ASK IF RFR7=2]** If you had given the refrigerator away for free, who would you have given it to? **[RANDOMIZE 1 TO 5, ALLOW ONLY ONE RESPONSE]**

1. To a private party, such as a friend or family member
2. To a charity, such as Goodwill Industries or a church
3. Put it on the curb
4. Posted it online
5. To a retail store
97. Given it away some other way **[OPEN END]**
98. Don't know

RFR10. **[ASK IF RFR7=3]** How would you have recycled the refrigerator? **[RANDOMIZE 1 TO 3, ALLOW ONLY ONE RESPONSE]**

1. Taken it to a recycling center
2. Put it out for pick-up
3. Hired someone to take it
97. Done something else **[OPEN END]**
98. Don't know

[ASK RFR11 TO RFR13 IF RFR2 ≠ 2]

RFR11. Prior to signing up for the Mass Save Appliance Recycling Program, had you tried to do any of the following to get rid of the refrigerator? Select all that apply. **[RANDOMIZE 1-7, MULTIPLE RESPONSE]**

1. Sell it
2. Give it away for free
3. Recycle it
4. Take it to a garbage dump or put it out as trash
5. Hire a hauler to take it away
6. Have a retail store come and pick it up
7. I had not tried to get rid of it
97. Something else, please specify **[OPEN END]**
98. Don't know

RFR12. If the Mass Save Appliance Recycling Program had ***not*** been available, would the need to physically move the refrigerator out of your house and transport it have prevented you from getting rid of it? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
3. Maybe
98. Don't know

RFR13. If the Mass Save Appliance Recycling Program had ***not*** been available, how much, if anything, would you have been willing to pay to have someone else remove or recycle your refrigerator? **[ALLOW ONLY ONE RESPONSE]**

1. $0–Would not pay any amount
2. $1-25
3. $26-50
4. $51-75
5. $76-100
6. More than $100
98. Don't know

RFR14. **[ASK IF RFR2=2]** If the Mass Save Appliance Recycling Program had ***not*** been available to you, what would you have done with the refrigerator? **[RANDOMIZE 1-2, ALLOW ONLY ONE RESPONSE]**

1. Continued to use it
2. Stored it unplugged
97. Something else, please specify **[OPEN END]**
98. Don't know

[IF APPTYPE1 = REFRIGERATOR, GO TO D1]

Freezers (FZ SERIES)

[ASK IF APPTYPE 1 = FREEZER]

[IF V2 = 1 AND NUM.FREEZERS = 1 OR V3.2 =1] This next set of questions will ask about the old **stand-alone freezer** you had removed through the program.

[IF V2 = 1 AND NUM.FREEZERS > 1 OR V3.2 >1] We are aware you had more than one stand-alone freezer removed through the program.

[IF V2 = 1 READ] For purposes of this survey, please think about the [IF UNIT.BRAND1 <>" " **[Unit.Brand1]]** freezer with **[CONFIGURATION]** configuration**.**

[IF V3.2 >1] Please keep only one freezer clearly in your mind as you answer the next few questions.

FZ1. Thinking about the 12 months before you recycled it, was the freezer plugged in… **[ALLOW ONLY ONE RESPONSE]**

1. All of the time **[GO TO FZ3]**
2. Some of the time
3. Never **[GO TO FZ3]**

98. Don't know **[GO TO FZ3]**

FZ2. **[ASK IF FZ1 = 2]** How many months was the freezer plugged in the year before you recycled it? **[ALLOW WHOLE NUMBER BETWEEN 0 AND 12]**

FZ3. Where in your house was the freezer located? **[RANDOMIZE 1-6; ALLOW ONLY ONE RESPONSE]**

1. Kitchen
2. Basement
3. Garage
4. Porch/Patio
5. Laundry room
6. Yard

97. Some other place **[OPEN END]**
98. Don't know

FZ4. **[IF FZ3≠1]** Is the space where the freezer was located heated by your heating system in the winter? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No

98. Don't know

FZ5. Is the space where the freezer was located cooled with air conditioning in the summer? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No

98. Don't know

Freezer Free-ridership (FFR Series)

[DISPLAY IF NUM.FREEZERS > 1] Please continue thinking about just that one freezer for the next set of questions.

FFR1. Before you heard about the Mass Save Appliance Recycling Program, had you considered getting rid of the freezer? Meaning, did you already have plans to get the appliance out of your home by selling it, giving it away, having someone pick it up, or taking it to the dump or a recycling center yourself? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
98. Don't know

FFR2. If the Mass Save Appliance Recycling Program had not been available to you, what would you most likely have done with your freezer? **[ALLOW ONLY ONE RESPONSE]**

1. Gotten rid of it
2. Kept it **[SKIP TO FFR5]**
98. Don't know **[SKIP TO FFR5]**

FFR3. **[ASK IF FFR2=1]** Why did you want to get rid of the freezer? Select all that apply. **[RANDOMIZE 1 -5, MULTIPLE RESPONSE]**

1. I didn't need or use it anymore
2. I bought a new freezer
3. The old freezer was not working well
4. Reduce electricity costs
5. Recycling it is better for the environment
97. Other **[OPEN END]**
98. Don't know

FFR4. **[ASK IF FFR2=1]** If the Mass Save Appliance Recycling Program had not been available, how soon do you think you would have gotten rid of your freezer? **[ALLOW ONLY ONE RESPONSE]**

1. Within a year of when the program took it
2. More than a year later
98. Don't know

FFR5. **[ASK ALL]** Why did you recycle the freezer through the Mass Save Appliance Recycling Program? Select all that apply. **[RANDOMIZE 1-8, MULTIPLE RESPONSE]**

1. To receive the rebate/incentive
2. I didn't need or use it anymore
3. I bought a new freezer
4. The old freezer was not working well
5. It was easy to recycle it through Mass Save
6. Reduce electricity costs
7. Recycling it is better for the environment
8. I didn't want to pay to have it removed

97. Other **[OPEN END]**
98. Don't know

FFR6. Would you have participated in the Mass Save Appliance Recycling Program even if it did not pay a rebate? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
3. Maybe

98. Don't know

[IF FFR2= 2 SKIP TO FFR14]

FFR7. **[ASK IF FFR2 ≠ 2]** If the Mass Save Appliance Recycling Program had not been available to you, what would you most likely have done to get rid of the freezer? **[RANDOMIZE 1-6, ALLOW ONLY ONE RESPONSE]**

1. Sold it **[GO TO FFR8]**
2. Given it away for free **[GO TO FFR9]**
3. Recycled it [**GO TO FFR10]**
4. Taken it to a garbage dump or put it out as trash **[GO TO FFR11]**
5. Hired a hauler to take it away **[GO TO FFR11]**
6. Had a retail store come and pick it up **[GO TO FFR11]**

97. Something else, please specify **[OPEN END] [GO TO FFR11]**
98. Don't know **[GO TO FFR11]**

FFR8. **[ASK IF FFR7=1]** Would you have sold the freezer to a private party, to a used appliance dealer, or someone else? **[RANDOMIZE 1-3, ALLOW ONLY ONE RESPONSE]**

1. Private party, such as a friend or family member
2. Used appliance dealer
3. Sold it online

97. Someone else, please specify **[OPEN END]**
98. Don't know

FFR9. **[ASK IF FFR7=2]** If you had given the freezer away for free. Who would you have given it to? **[RANDOMIZE 1-5, ALLOW ONLY ONE RESPONSE]**

1. To a private party, such as a friend or family member
2. To a charity, such as Goodwill Industries or a church
3. Put it on the curb
4. Posted it online
5. To a retail store

97. Given it away some other way **[OPEN END]**
98. Don't know

FFR10. **[ASK IF FFR7=3]** How would you have recycled the freezer? **[RANDOMIZE 1-3, ALLOW ONLY ONE RESPONSE]**

1. Take it to a recycling center
2. Put it out for pick-up
3. Hired someone to take it

97. Done something else [**[OPEN END]**
98. Don't know

[ASK FFR11 TO FFR13 IF FFR ≠ 2]

FFR11. Prior to signing up for the Mass Save Appliance Recycling Program, had you tried to do any of the following to get rid of the freezer? Select all that apply. **[RANDOMIZE 1-7, MULTIPLE RESPONSE]**

1. Sell it
2. Give it away for free
3. Recycle it
4. Take it to a garbage dump or put out as trash
5. Hire a hauler to take it away
6. Have a retail store come and pick it up
7. I had not tried to get rid of it

97. Something else, please specify **[OPEN END]**
98. Don't know

FFR12. If the Mass Save Appliance Recycling Program had ***not*** been available, would the need to physically move the freezer out of your house and transport it have prevented you from getting rid of it? **[ALLOW ONLY ONE RESPONSE]**

1. Yes
2. No
3. Maybe

98. Don't know

FFR13. If the Mass Save Appliance Recycling Program had ***not*** been available, how much, if anything, would you have been willing to pay your city, town, or someone else to remove or recycle your freezer? **[ALLOW ONLY ONE RESPONSE]**

1. $0–Would not pay any amount
2. $1-25
3. $26-50
4. $51-75
5. $76-100
6. More than $100

98. Don't know

FFR14. **[ASK IF FFR2 = 2]** If the Mass Save Appliance Recycling Program had ***not*** been available to you, what would you have done with the freezer? **[RANDOMIZE 1-2, ALLOW ONLY ONE RESPONSE]**

1. Continued to use it
2. Stored it unplugged

97. Something else, please specify **[OPEN END]**
98. Don't know

Demographics

We have a few final questions about your household.

D1. What type of home do you live in?

1. Single-family house
2. Single-family attached house (townhouse, row house, or duplex)
3. Apartment building or condo with two to four units
4. Apartment building or condo with five or more units
5. Mobile home or house trailer

97. Other **[OPEN END]**
99. I'd rather not answer

D2. Do you, or members of your household, own or rent your home?

1. Own
2. Rent
3. Occupied without payment of rent

97. Other **[OPEN END]**
99. I'd rather not answer

D3. Approximately how many square feet is your home?

1. Less than 1,400 square feet
2. 1,400 to 1,999
3. 2,000 to 2,499
4. 2,500 to 3,499
5. 3,500 to 3,999
6. 4,000 to 4,999
7. 5,000 or more
98. Don't know
99. I'd rather not answer

D4. What is the highest level of education that you have completed?

1. Less than ninth grade
2. Ninth to twelfth grade, no diploma
3. High school graduate (Includes GED)
4. Technical or trade school graduate
5. Some college, no degree
6. Associates degree
7. Bachelor's degree
8. Graduate or professional degree
99. I'd rather not answer

D5. Counting yourself, how many people live in your home?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 7
7. 8 or more
99. I'd rather not answer

D6_1 **[IF D5=1]** Which of these categories best describes your expected total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $34,380, OR **[GO TO D7]**
2. $34,380 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_2 **[IF D5=2]** Which of these categories best describes your expected total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $44,958, OR **[GO TO D7]**
2. $44,958 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_3 **[IF D5=3]** Which of these categories best describes your expected total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $55,536, OR **[GO TO D7]**
2. $55,536 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_4 **[IF D5=4]** Which of these categories best describes your total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $66,115, OR **[GO TO D7]**
2. $66,115 or more **[GO TO D7]**
99 I'd rather not answer **[GO TO D7]**

D6_5 **[IF D5=5]** Which of these categories best describes your total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $76,693, OR **[GO TO D7]**
2. $76,693 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_6 **[IF D5=6]** Which of these categories best describes your total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $87,271, OR **[GO TO D7]**
2. $87,271 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_7 **[IF D5=7]** Which of these categories best describes your total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $89,255, OR **[GO TO D7]**
2. $89,255 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D6_8. **[IF D5=8]** Which of these categories best describes your total household income in 2017 before taxes – counting everyone living in your house?

1. Less than $91,238, OR **[GO TO D7]**
2. $91,238 or more **[GO TO D7]**
99. I'd rather not answer **[GO TO D7]**

D7. What category best describes your total household income in 2017, before taxes?

1. Less than $20,000
2. $20,000 to $29,999
3. $30,000 to $39,999
4. $40,000 to $49,999
5. $50,000 to $59,999
6. $60,000 to $69,999
7. $70,000 to $79,999
8. $80,000 to $89,999
9. $90,000 to $99,999
10. $100,000 to 124,999
11. $125,000 to $149,999
12. $150,000 to $199,999
13. $200,000 or more
98. I'd rather not answer

D8. What is your age?

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
99. I'd rather not answer

[END] Thank you very much for taking the time to complete this important survey.