UMP, There It Is: A Collaborative Process Results in Standardized Appliance Recycling Evaluation Guidelines

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ABSTRACT

Few demand-side management programs generate more conversation—and confusion—than appliance recycling programs. Despite this simple concept—"we give you money, you give us your old refrigerator"—recycling-specific evaluation concepts such as part-use, induced replacement, and secondary market impacts routinely befuddle implementers, evaluators, utilities, and regulatory stakeholders alike. This can result in ineffective discussion and inconsistent program designs and evaluation findings.

For these reasons, refrigerator recycling is one of the first measures addressed by the U.S. Department of Energy through its Uniform Methods Project (UMP). In a collaborative process that included designating subject matter experts, convening a technical advisory group and steering committee, and conducting a public review, the UMP achieved a protocol that establishes best practices for consistent and accurate recycling evaluation and is a consensus of the evaluation community.

This paper concisely and clearly summarizes the UMP evaluation protocol and explains problematic evaluation concepts. The paper also discusses how the protocol's methodology aligns with or deviates from previous evaluation practices; addresses the often controversial issues of part-use, replacement, and secondary market impacts; and illustrates the UMP evaluation protocol in an evaluation-flow diagram.

As recycling programs are part of many utilities' residential portfolios, it is critical that stakeholders have a firm understanding of the UMP protocol's logic and rationale for appliance recycling. This paper aims to improve this understanding for evaluators interested in following best practices, implementers wanting to know how their programs will be evaluated, and other stakeholders wishing to be conversant in recycling-specific evaluation methodology.

Introduction

Most demand-side management (DSM) programs generate energy savings by offering incentives, directly or indirectly, that encourage customers to purchase a more efficient version of a particular end-use than they otherwise would have. Thus, most DSM evaluations follow a common blueprint: establish the energy consumption of both the inefficient and efficient end-use and compare their values. The fact that appliance recycling programs generate savings through the removal of an existing appliance—not just from a specific home, but from a utility's electrical grid—has forced evaluators to develop a different, yet analogous, model for assessing the gross and net energy impacts of these ubiquitous residential programs. This departure from the archetypal program evaluation model has also necessitated the establishment of recycling-specific evaluation concepts and terminology.

These concepts and terminology were established primarily through a series of evaluations in California, where Southern California Edison (SCE) has offered its customers a refrigerator and freezer recycling program since 1994. Pacific Gas & Electric and San Diego Gas & Electric have also offered programs for more than a decade. The considerable size and unmatched maturity of these programs has caused these California investor-owned utilities to sponsor the country's most robust appliance recycling evaluations to date in support of 2002-2003, 2004-2006, and 2006-2008 program cycles. These three evaluations, led by KEMA-XENERGY Inc. (2004), ADM Associates, Inc. (2008), and Cadmus (2010), respectively, were instrumental in establishing the key evaluation concepts and terminologies used by the majority of current evaluations across the country.

In 2012, the U.S. Department of Energy (DOE) sought to document these appliance recycling-specific concepts and terminology through its Uniform Methods Project (UMP). DOE created UMP "to establish easy-to-follow protocols based on commonly accepted engineering and statistical methods for determining gross savings for a core set of commonly deployed energy efficiency measures" (DOE/EERE 2012). In recognition of the recycling program's common role in residential DSM portfolios, as well as its unique evaluation model, the DOE identified refrigerator recycling as one of the first seven measures addressed through UMP.

Over a year-long collaborative process that included designating subject matter experts, convening a Technical Advisory Group and Steering Committee, and conducting a public review, UMP sought to establish a refrigerator recycling evaluation protocol that is a consensus of the evaluation community. It also aimed to document best practices for consistent and accurate recycling evaluations, thereby minimizing evaluator influence over savings estimates, ensuring that implementers know how evaluators will assess their programs, and allowing the comparison of program performance across regions. The final version of the protocol was completed in April 2013; Chapter 7 describes the refrigerator recycling evaluation protocol (Bruchs & Keeling 2013).

The following concisely and clearly summarizes the UMP refrigerator protocol and conveys frequently problematic evaluation concepts with supporting graphics. The paper also highlights where the UMP's protocol methodology aligns with or deviates from previous evaluation practices; addresses the often controversial issues of part-use, replacement, and secondary market impacts; and illustrates the UMP evaluation protocol in a flow diagram.

Protocol Application

The protocol begins by defining the measure and explaining when evaluators should apply it. While the protocol was written specifically to evaluate "refrigerator recycling," it is important to note that most of the evaluation concepts and methodologies described in the protocol also apply to recycling freezers. (Some concepts and methodologies also apply to other residential appliances—such as room air conditioners or dehumidifiers—that are sometimes picked up with a refrigerator or freezer through utility appliance recycling programs.)

The protocol focuses on the standard recycling program: free removal service, pick-up incentive, and dissemination of information about operating costs. These are appropriate to any program that recycles operable primary or secondary refrigerators regardless of other program-specific features such as age-eligibility restrictions or partnerships with appliance retailers.

Aspects of the protocol, such as estimating gross energy savings, are also applicable to low-income, direct install programs that offer refrigerator replacement. (Other elements, such as induced replacement, are not relevant for this particular program design.)

Key Evaluation Elements

The UMP protocol discusses best practices for estimating gross energy savings in significant detail, and these methods (determining annual energy consumption via the regression modeling of metered data) are widely practiced already. Instead, this paper focuses on three less understood aspects of appliance recycling evaluations:

- Part-use
- Induced replacement
- Secondary market impacts

Part-Use

"Part-use" is an appliance recycling-specific adjustment factor used to convert the annual unit energy consumption (UEC) determined through the gross savings analysis into an average per-unit gross savings value. The UEC itself is not equal to the gross savings value as not all recycled refrigerators would have operated year-round had they not been decommissioned through the program. While the partial use concept was posited in KEMA-XENERGY's 1996 evaluation of the SCE's 1994 program year, the term part-use was coined in KEMA-XENERGY's 2002-2003 evaluation.

Table 1 lists the three possible part-use categories and their part-use factors. Two part-use factors are consistent across evaluations: refrigerators that would have run full-time (1.0) and refrigerators that would not have run at all (0.0). One part-use factor varies by program: refrigerators that would have been used for a portion of the year (between 0.0 and 1.0). For example, a refrigerator estimated to operate a total of three months over the course of a year (most commonly to provide additional storage capacity during the holidays) would have a part-use factor of 0.25.

Table 1. Part-Use Factors by Category

Part-Use Category	Part-Use Factor
Likely to not operate at all in absence of the program	0.0
Likely to operate part-time in absence of the program	0.0 to 1.0
Likely to operate year-round in absence of the program	1.0

The protocol recommends that evaluators use participant surveys to determine the number of recycled units in each part-use category and the portion of the year the refrigerators *would have been used part-time*. The protocol recommends handling this assessment by following this multi-step process:

1. ***Ask participants where the refrigerator was located for most of the year prior to being recycled.***[1] By asking about the refrigerator's long-term location, evaluators can obtain more reliable information about the unit's usage type and can avoid using terms that often confuse participants (such as primary and secondary), especially if the refrigerator has been replaced. It is recommended that evaluators designate all refrigerators previously located in a kitchen as primary units and all other locations as secondary.
2. ***Ask those participants who indicated recycling a secondary refrigerator if that refrigerator was unplugged, operated year-round, or operated for a portion of the preceding year.*** (Evaluators can assume all primary units are operated year-round.)
3. ***Ask those participants who indicated that their secondary refrigerator was operated for only a portion of the preceding year to estimate the total number of months the refrigerator was plugged in.*** The average number of months specified by this subset of participants is then divided by 12 to calculate the part-use factor for all refrigerators operated for only a portion of the year.

These three steps enable evaluators to obtain important and specific information about how a refrigerator was used before it was recycled. The calculations for an example program are provided in Table 2, which shows:

- The participant survey determined that 93% of recycled refrigerators were operated year-round, either as primary or secondary units. (Again, the part-use factor for these refrigerators is 1.0.)

[1] Note that it is important <u>not</u> to ask about the refrigerator's location when it was collected by the program implementer, as many units are relocated to accommodate the arrival of a replacement appliance or to facilitate program pickup.

- Four percent of refrigerators were not used at all in the year before being recycled. The part-use factor for this portion is 0.0, and no energy savings are generated by the refrigerator's removal and eventual decommissioning.
- The remaining refrigerators (3%) were operational for a portion of the year. The survey specifically determined that part-time refrigerators were operated for an average of three months a year (indicating a part-use factor of 0.25).

Using this information, the protocol recommends that evaluators calculate the overall part-use factors for both secondary units only and for all recycled units. These factors are derived by first multiplying each part-use factor by the evaluation's estimated annual energy consumption. In this example, we assume annual energy consumption of a refrigerator plugged in year round is 1,240 kWh. This results in part-use adjusted energy savings of 0, 310, and 1,240 kWh/year for refrigerators in the Not in Use, Used Part-Time, and Used Full-Time categories, respectively. Evaluators can estimate the secondary-only part-use factor and the overall part-use factor by calculating the weighted average of the adjusted part-use per-unit energy savings for each. In this example (Table 2), the program's secondary-only part-use factor is 0.88, while the overall part-use factor is 0.93.

Table 2. Example Calculation of Historical Part-Use Factors

Usage Type and Part-Use Category	Percent of Recycled Units	Part-Use Factor	Per-Unit Energy Savings (kWh/Yr)
Secondary Units Only			
Not in Use	6%	0.00	-
Used Part-Time	8%	0.25	310
Used Full-Time	86%	1.00	1,240
Weighted Average	**100.0%**	**0.88**	**1,091**
All Units (Primary and Secondary)			
Not in Use	4%	0.00	-
Used Part-Time	3%	0.25	310
Used Full-Time	93%	1.00	1,240
Weighted Average	**100.0%**	**0.93**	**1,163**

Next, evaluators should combine these historically observed part-use factors with participants' self-reported action had the program *not* been available. (That is, the participants are reporting if they would have kept or discarded their refrigerator.)[2] The example in

Table 3 demonstrates how a program's part-use factor is determined using a weighted average of historically observed part-use factors and the participants' likely action in the absence of the program.[3] Here, the result is a part-use value of 0.91, based on the expected future use of the refrigerators had they not been recycled.

[2] Since the future usage type of discarded refrigerators is unknown, evaluators should apply the weighted part-use average of all units (0.93, in this example) for all refrigerators that would have been discarded independent of the program. This approach acknowledges that discarded appliances might be used as primary or secondary units in another recipient's home.

[3] Evaluators should not calculate part-use using participant's estimates of future use had the program not been available. Historical estimates based on actual usage rates are more accurate, especially because it is possible participants will underestimate future usage (believing they will only operate it part of the year, despite the fact that the majority of refrigerators operate continuously once plugged in).

Table 3. Example Calculation of Prospective Program Part-Use

Use Prior to Recycling	Likely Use Independent of Recycling	Part-Use Factor	Percent of Participants
Primary	Kept (as primary unit)	1.0	15%
	Kept (as secondary unit)	0.88	25%
	Discarded	0.93	15%
Secondary	Kept	0.88	30%
	Discarded	0.93	15%
Overall	**All**	**0.91**	**100%**

Recent evaluations of appliance recycling programs have determined that part-use factors typically range from 0.85 to 0.95 (Navigant 2010). Newer appliance recycling programs have exhibited a part-use factor at the lower end of this range. This is attributed to the fact that many unused or partially used appliances sat idle before the program launch simply because participants lacked the means to discard them. (The recycling program then provided the means.)

In addition, the newer programs tend to focus on collecting secondary units (which are subject to part-use), while mature programs tend to focus on avoided retention (replacing primary appliances). As a result, part-use factors tend to increase over time.

The protocol also recommends that part-use factors should be reassessed annually for newer programs, because these factors may change more rapidly during the early stages of a program's life cycle. After a program has been in operation for at least three years, it is sufficient to conduct a part-use assessment every other year.

Induced Replacement

Concept of Replacement. Before discussing induced replacement, it is important to first explore the concept of replacement more broadly. In most cases, *the per-unit gross energy savings attributable to a program is equal to the energy consumption of the recycled appliance* (rather than being equal to the difference between the consumption of the recycled appliance and its replacement, when applicable).

This is because the energy savings generated by the program are not limited to the change within the participant's home, but rather to the total change in energy consumption at the grid level. This is a key difference between appliance recycling programs and many other DSM programs and is the source of great confusion in the evaluation community.

This concept is best explained with an example. Suppose a customer decides to purchase a new refrigerator to replace an existing one. When the customer mentions this to a neighbor, the neighbor asks for that existing refrigerator to use as a secondary unit. The customer agrees to give the old appliance to the neighbor; however, before this transfer is made, the customer learns about a utility-sponsored appliance recycling program. The customer decides to participate in the program because the incentive helps offset the cost of the new refrigerator. As a result of program intervention, the customer's appliance is permanently removed from operation in the utility's service territory.

From the utility's perspective, the difference in grid-level energy consumption—and the corresponding increase in program savings—are equal to the consumption of the recycled appliance and *not* to the difference between the energy consumption of the participating appliance and its replacement. In this example, it is important to note that the participant had already planned to replace the appliance.

With the exception of induced replacement—which is discussed below—the purchase of new refrigerators is part of the naturally occurring appliance life cycle, typically independent of the program and tantamount to refrigerator load growth. It is not the purpose of the recycling program to prevent these inevitable purchases; rather, it is to minimize the grid-level refrigerator load growth by limiting the number of existing appliances that continue to operate once they are replaced.

Induced Replacement. Evaluators must account for replacement units *only* when a recycling program induces replacement (that is, when the participant would *not* have purchased the replacement refrigerator in the absence of the recycling program). As previously noted, the purchase of a refrigerator in conjunction with program participation does not necessarily indicate induced replacement. (The refrigerator market is continuously replacing older refrigerators with new units, independent of any programmatic effects.)

However, if a customer would have not purchased the replacement unit (that is, would not have put another appliance on the grid) in the absence of the program, the net program savings should reflect this fact. This is, in effect, akin to negative spillover and should be used to adjust net program savings downward.

Estimating the proportion of households induced to replace an appliance is subtle and must be handled via participant surveys with great care. As an example of a question at the start of a survey, participants could be asked, "Would you have purchased your replacement refrigerator if the recycling program had not been offered?" However, this simplistic approach alone is insufficient.

Because an incentive ranging from $35 to $50 is unlikely to be enough motivation to purchase an otherwise-unplanned replacement unit (which can cost $500 to $2,000), it is critical that evaluators ask follow-up questions. These questions should confirm the participants' assertions that the program alone caused them to replace their refrigerator.

For example, participants could be asked, "Let me be sure I understand correctly. Are you saying that you chose to purchase a new appliance because of the appliance recycling program, or are you saying that you would have purchased the new refrigerator regardless of the program?"

When calculating induced replacement, evaluators should also consider the usage type of the appliance recycled through the program. For example, when customers indicate they would have discarded their primary refrigerator independent of the program, it is not possible that the replacement was induced (because it is extremely unlikely the participant would live without a primary refrigerator). But induced replacement *is* a viable response for all other usage types and stated intention combinations.

As one might expect, previous evaluations have shown that the number of induced replacements is considerably smaller than the number of naturally occurring replacements unrelated to the program (Cadmus 2012). Once the number of induced replacements is determined, this information is combined with the energy consumption replacement appliance, as shown in Figure 1, to determine the total energy consumption induced by the program (on a per-unit basis).[4,5] As the figure shows, this analysis results in an increase of 17 kWh in savings per unit that is derived from induced replacement.

[4] Unlike the secondary market effects analysis, it is possible to ask survey participants who say their replacement was induced by the program if the replaced unit was a comparable used appliance, a new standard-efficiency unit, or a new ENERGY STAR unit. For simplicity, the analysis assumes all induced replacements were new, standard-efficiency units because (1) it seems likely customers would upgrade their appliance (that is, they would be less likely to replace with another used unit); and (2) similar to the secondary market effects analysis, excluding ENERGY STAR units avoids potential double counting between programs when utilities offer concurrent retail rebates. Evaluators should use this more detailed information when it is available and when double counting is either not applicable or can be addressed through the survey.

[5] Evaluators should determine the energy consumption of a new, standard-efficiency appliance using unit specifications obtained on the ENERGY STAR Website at http://www.energystar.gov/. Specifically, evaluators should average the reported energy consumption of new, standard-efficiency appliances with units that are comparably sized and have configurations similar to the program units.

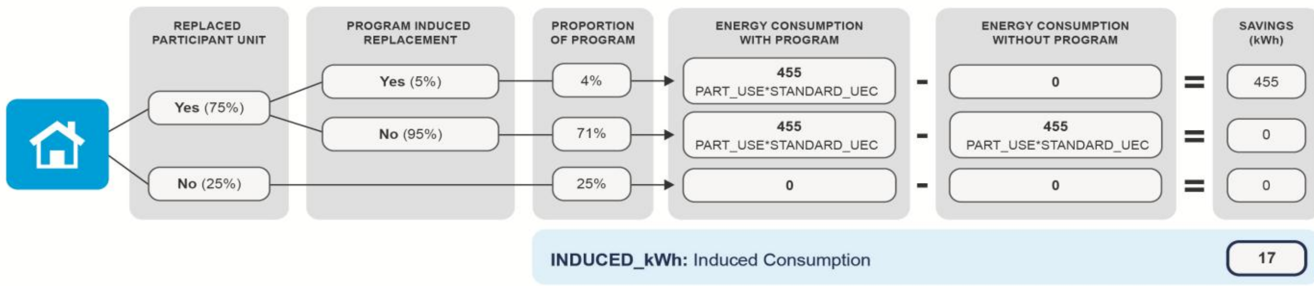


Figure 1. Induced Replacement

Secondary Market Impacts

In general, independent of program intervention, participating refrigerators would have been subject to one of the following scenarios:

- The refrigerator would have been kept by the household.
- The refrigerator would have been discarded by a method that transfers it to another customer for continued use.
- The refrigerator would have been discarded by a method leading to its removal from service.

These three scenarios encompass what is usually referred to as freeridership (the portion of units would have been taken off the grid absent the program). As with estimating per-unit annual energy consumption, the evaluation community is already consistent in how it assesses freeridership. The methodology, which involves surveys with both participants and nonparticipants, and often market actors, is detailed in Section 5.1.1 of Chapter 7 of the protocol (Bruchs & Keeling 2013), but is not discussed in this paper.

A related, but less widely applied, net-to-gross issue detailed in the protocol is the impact recycling programs have on the regional appliance market. The UMP protocol recommends that this secondary market impact be accounted for but, to date, most evaluations have not. The issue concerns units that would have been transferred independent of program intervention (i.e., avoided transfers). Specifically, as in the second scenario above when the unit would have been transferred to another household, the question then becomes what purchasing decision is made by the would-be acquirer of that now-unavailable unit. These would-be acquirers could:

- Not purchase/acquire another unit.
- Purchase/acquire another used unit.

Adjustments to savings based on these two factors are the program's secondary market impacts. Quantification of these impacts, as prescribed in the UMP protocol, is described below

If it is determined that, without the program, the participant would have directly or indirectly (through a market actor, such as a used appliance dealer or charity) transferred the unit to another customer on the grid, the next question addresses what that potential acquirer did because that unit was unavailable. There are three possibilities:

- ***Possibility A: None of the would-be acquirers would find another unit.*** That is, program participation would result in a one-for-one reduction in the total number of refrigerators operating on the grid, and the total energy consumption of avoided transfers (participating appliances that otherwise would have been used by another customer) should be credited as savings to the program. This assumes that participating appliances are essentially convenience goods for would-be acquirers: the potential acquirer would have accepted the refrigerator had it been readily available but, because the refrigerator was not a necessity, the potential acquirer would not seek out an alternate unit.

- ***Possibility B: All of the would-be acquirers would find another unit.*** Thus, program participation has no effect on the total number of refrigerators operating on the grid. This assumes that participating appliances are necessities and that customers will always seek alternative units when participating appliances are unavailable.
- ***Possibility C: Some of the would-be acquirers would find another unit, while others would not.*** This assumes that some acquirers were in the market for a refrigerator and would acquire another unit, while others were not (and would only have taken the unit opportunistically).

It is difficult to determine the secondary market impacts with certainty, absent utility-specific information regarding the total number of refrigerators (both overall and used) that were active before and after program implementation. In some cases, evaluators have conducted in-depth market research to estimate both the program's impact on the secondary market *and* the appropriate attribution of savings for this scenario.

Although imperfect, this research can support estimates of the program's net energy impact. The protocol recommends, when feasible, that evaluators and utilities design and implement this top-down market-based approach. Unfortunately, this type of research tends to be cost-prohibitive, or the necessary data may simply be unavailable.

When the data is unavailable, evaluators have employed a bottom-up approach to identify and survey recent acquirers of non-program used appliances. These acquirers are asked what they would have done had the specific used appliance they acquired not been available. While this approach results in quantitative data to support evaluation efforts, it is uncertain if:

- The newly acquired used appliances are comparable in age and condition to those recycled through the program.
- These acquirers can reliably respond to the hypothetical question.

Further, any sample composed entirely of customers who recently acquired a used appliance seems inherently likely to produce a result that aligns with possibility B—*all of the would-be acquirers would find another unit*.

As a result of these difficulties and budget limitations, the UMP protocol recommends assuming possibility C—*some of the would-be acquirers would find another unit, while others would not*—when primary research cannot be undertaken. Specifically, it states that evaluators should assume that half (0.5, the midpoint of possibilities A and B) of the would-be acquirers of avoided transfers found an alternate unit.

Once the proportion of would-be acquirers who are assumed to find an alternate unit is determined, the next question is the likelihood of the alternate unit to be: (1) another used appliance (similar to those recycled through the program) or, with fewer used appliances presumably available in the market due to program activity, (2) a new standard-efficiency unit.[6]

For the reasons previously discussed, it is difficult to estimate this distribution definitively. Thus, the protocol again recommends a midpoint approach when primary research is unavailable: evaluators

[6] It is also possible the would-be acquirer of a program unit would instead select a new ENERGY STAR unit. However, we recommend evaluators assume that any such upgrades (because the used appliance supply is restricted) be limited to new, standard-efficiency units because (1) it seems most likely a customer in the market for a used appliance would upgrade to the new lowest price point and (2) excluding ENERGY STAR units avoids potential double counting between programs when utilities offer concurrent retail rebates.

should assume half (0.5) of the would-be acquirers of program units would find a similar, used appliance and half (0.5) would acquire a new, standard-efficiency unit.[7]

Figure 2 shows the methodology for assessing the program's impact on the secondary market and the application of the recommended midpoint assumptions when primary data are unavailable. The methodology accounts for market effects in three savings scenarios:

- Full savings (per-unit gross savings)
- No savings
- Partial savings (the difference between the energy consumption of the program unit and the new, standard-efficiency appliance acquired instead).[8]

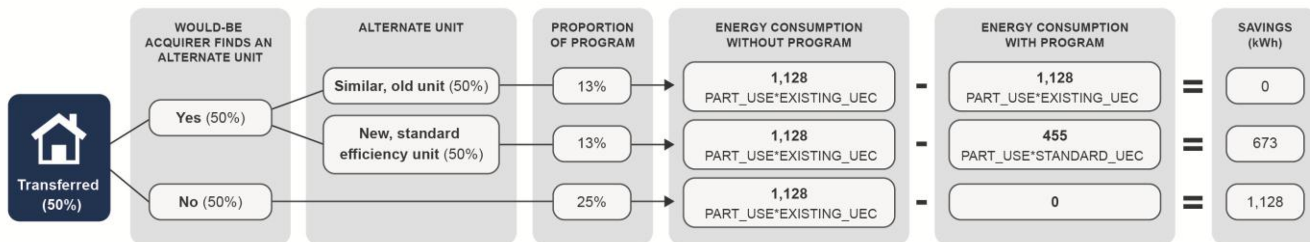


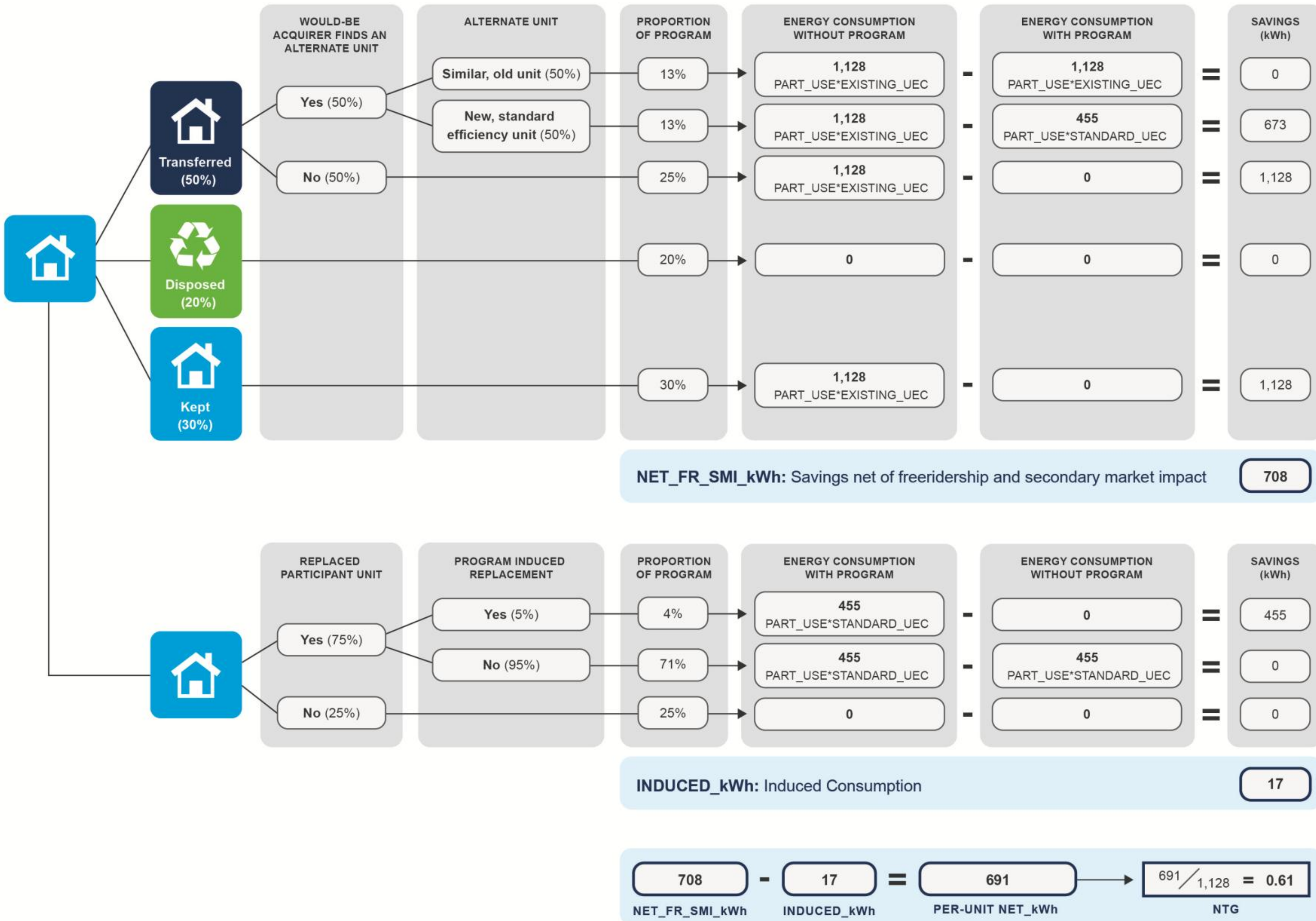
Figure 2. Secondary Market Impacts

Evaluation Summary Diagram

To illustrate the quantification of net savings (which includes induced replacement, freeridership, and secondary market impacts), the UMP protocol developed the evaluation summary diagram (Figure 3, shown below). The diagram, using a decision tree format, presents all possible savings scenarios. A weighted average of these scenarios is then taken to calculate the savings that can be credited to the program after accounting for either freeridership or the program's interaction with the secondary market. This decision tree is populated by (1) what the participating household would have done outside the program *and*, if the unit would have been transferred to another household, (2) would the would-be acquirer of that refrigerator have found an alternate unit.

[7] Evaluators should determine the energy consumption of a new, standard-efficiency appliance using the ENERGY STAR Website. Specifically, evaluators should average the reported energy consumption of new, standard-efficiency appliances of comparable size and similar configuration to the program units.
[8] More detail on how this information is used to determine net savings can be found in Section 6, *Summary Diagram*, of Chapter 7 (Bruchs & Keeling 2013).

Figure 3. UMP Refrigerator Recycling Net Savings Evaluation Protocol: Summary Diagram



Conclusion

The idea is simple: "we give you money, you give us your old refrigerator." Residential appliance recycling programs have, however, generated much conversation—and confusion—among implementers, evaluators, utilities, and regulatory stakeholders, especially about recycling-specific evaluation concepts such as part-use, induced replacement, and secondary market impacts.

In order to promote effective discussion and standardize program designs and evaluation findings, the DOE identified refrigerator recycling as one of the first measures addressed through its UMP. This paper has described the evaluation protocol codified by UMP and explains part-use and three of its possible categories; the concept of appliance replacement in general and how recycling programs induce replacement; and the impacts of the secondary market. This should help evaluators interested in following best practices, implementers who want to know how their programs will be evaluated, and other stakeholders interested in being conversant in recycling-specific evaluation methodology.

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