The 2010-2012 Appliance Recycling Program (ARP) evaluation study (WO35)[[1]](#footnote-1) expanded on previous evaluations of the program as well as previous DEER analysis. The 2010-2012 evaluation[[2]](#footnote-2) included an investigation of the numerous and varied retention and transfer mechanisms by which refrigerators and freezers removed from service in their current location may, via “transfer paths”, be ultimately relocated to an alternate service home and thus stay connected to the electricity grid as a load. itemizes, for PG&E, the various transfer paths identified by the study and develops a gross savings contribution for each transfer path that can be followed by a collected appliance. The values listed in columns B and E represent the typical unit energy consumption (UEC) values of the collected (baseline) and alternate (measure – installed rather than baseline) units for each path. In the WO35 study, these values represent in situ UEC values that are specific to the accomplishments for the evaluated program period. The WO35 report includes similar tables for SCE and SDG&E.

For the in situ gross savings analysis, the WO35 evaluation utilizes several discreet appliance UECs. One value represents the UEC of the collected appliance. Each alternate UEC represents a particular scenario based on actions of an appliance acquirer due to the program removing the collected appliance from the available choices.

* Acquired nothing (UEC = 0)
* Acquired a similar “Free” used unit
* Purchased a similar used unit
* Unit destroyed, requiring purchase or acquisition of substantially more efficient unit
* Did nothing, kept existing unit that otherwise would have been replaced
* Purchased a new refrigerator

itemizes, for PG&E, for each transfer path identified by the study a savings estimate, along with a designation as to the treatment of the savings in that path as either representing a free-rider or non-free-rider. In this manner the study develops both gross savings and a net-to-gross ratio (NTGR) value. The WO35 report includes similar tables for SCE and SDG&E. It should be noted that only the two “discard anyway” scenarios are considered free riders in Figure 2.

Figure - Example of Gross Savings Calculation from ARP Evaluation (WO35)[[3]](#footnote-3)



Figure - Example of Net Savings Calculation from ARP Evaluation (WO35)[[4]](#footnote-4)



The DEER team review of the WO35 data and analysis methodology identified issues as well as limitations with the approach and therefore performed further development in order to apply the results in a forward looking manner to future program activities. For this reason the DEER team utilized the same data and an expanded version of the methodology to develop more appropriate gross and net savings for application to future refrigerator and freezer ARP activities. The DEER expanded approach, following CPUC policy, develops a “standard practice” baseline for refrigerator and freezer recycling using the research data developed under the WO35 study[[5]](#footnote-5). Additionally, the DEER approach treats discreet age ranges of used units as having distinctly different levels of viability in the used appliance market; in other words, used appliances of different ages have different probabilities of being able to be transferred to new service locations when retired from service at their current location. The DEER expanded approach was developed by analyzing the data and results from the WO35 research including the below items.

* Characteristics of units in the claims data set for the 2010-2012 program years including:
  + Unit type (refrigerator or freezer)
  + Configuration such as side-by-side, top or bottom freezer, chest or upright freezer
  + Age
  + Size
* Surveys of participant and non-participant acquirers and discarders used by WO35 to identify alternative decisions that could have occurred in place of the decision to utilize the ARP service. The DEER team utilized these survey data to establish a standard practice baseline for the program within each IOU service territory.
* The nameplate UEC of each collected appliance was used to develop baseline and alternative case UEC values. A portion of the claims records did not include enough unit information for the WO35 team to determine the nameplate UEC. For these units, the WO35 team developed and implemented an approach to impute the UEC.
* WO35 expanded the existing data set, developed under previous ARP evaluation studies, of laboratory tested appliances. The DEER team utilized these lab test results to develop degradation adjustment factors to apply to the nameplate UEC of refrigerators and freezers to account for the increased energy use over the nameplate values as observed in used appliances.

**Gross Unit Energy Savings**

The WO35 results as well as previous versions of DEER have assumed that the baseline is average nameplate UEC, adjusted based on either short-term in-situ metering or building modeling, of collected appliances from the most recent program evaluation. The DEER team has three concerns with this approach. First, this baseline assumption is utilizing a pre-existing equipment baseline assumption for all equipment when this baseline assumption is only allowed in the case of program induced early retirement[[6]](#footnote-6). Second, the previous approach to establishing baseline assumes that all collected appliances have equal full viability in the secondary market and are able to be successfully transferred for continued use. Third, the use of nameplate UEC does not consider the likelihood that the efficiency of appliances degrades with time. Each of these concerns is further described below.

**Viability in Secondary Market and the Standard Practice Baseline**

The DEER team agrees with using the pre-existing equipment (collected unit) baseline for the fraction of the units the participant discarder identified they would have kept in service at their home had the program not induced them to remove the unit. This is the first disposition pathway line in Figure 1 and Figure 2 above. However, the other lines in these tables require further examination of their baseline assumptions.

The WO35 research included surveys of acquirers and non-participant discarders of used appliances. Acquirers were asked to provide the approximate age of the refrigerator or freezer they acquired. These results provide an indication of the market preferences for used refrigerators and freezers in terms of age. Non-participant discarders were asked how they discarded their appliances. A portion of discarders disposed of units in a way that would have resulted in the unit being destroyed, such as taking it to a landfill or an appliance recycler. However, others reported that they successfully sold or gave (for free) the unit to another person. These results provide an indication of the likelihood that appliances have any viability, in terms of age, in the used appliance market. In other words, the survey results indicate the likelihood that an appliance within a particular age range could be successfully transferred to a new owner and keep in service. Table 1 includes the results of these two survey questions as well as the distribution of collected units by age from the 2010-2012 program cycle. Table 2 contains some details of the acquirer sample. and show the same information graphically. It can be seen that used units older than 9 years in age have a rapidly decreasing attractiveness in the used market place. A similar trend can be observed in similar survey data from the 2006-2008 ARP evaluation[[7]](#footnote-7) thus cannot be attributed to the recent ARP activities, but rather is a reality of the used appliance market place. Thus, despite a discarder’s likely intention to sell or give away the unit, the probability of a successful transfer will be greatly decreased with increasing unit age.

It should also be noted that if collected units are placed into the used market rather than being recycled there is no indication that the used market would grow in size substantially due to a unmet demand of used units. However, it can be reasonably assumed that if added units are placed into the market that are attractive to purchasers, they will displace older less attractive units in the market such that those other units will have a lower probability of being acquired. So, introducing a substantial number of units into the used market that are 10-14 years old will likely reduce the ability of currently available units older than that in the market place from being successfully sold or otherwise transferred. For this reason, combined with acquirer preference data, the DEER process applies rapidly decreasing probability, as the age of collected unit increases, if they were allowed to be re-introduced into the used appliance market.

The data discussed above provide strong evidence that the older age ranges of used appliances collected, notwithstanding an owner’s stated desire to transfer the unit, would have rapidly decreasing value in the secondary market with age and therefore would have a greatly reduced ability to be successfully transferred. Instead, these units would be destroyed or taken out of service permanently with or without the ARP program.

Table - Age Distribution of Collected, Transferred and Acquired Appliances



Table - Sample Statistics for Age Distribution Acquired Refrigerators



Figure - Age Distribution of Collected, Transferred and Acquired Refrigerators



Figure - Age Distribution of Collected, Transferred and Acquired Freezers



To account for this, the DEER team calculated two baselines, one representing the non-viable units and one representing viable units. The DEER team accomplished this by applying adjustment factors based on age to the entire set of claimed appliances from the 2010-2012 program cycle. This enabled the calculation of viable versus non-viable UEC by IOU service territory. Then the percentages of each alternative disposition path as shown in above were adjusted to reflect the fraction of non-viable units within each IOU service territory. Table 3 lists the market viability factors developed by the DEER team. The table includes the values originally proposed in June, 2015, to be used for the DEER 2016 update. As noted above, the viability factor in the for the initial DEER 2016 proposal deceases rapidly with increasing age since introducing younger units into the market causes both existing market older units and newly introduced older units to be less viable. Table 3 also includes the values for viability factors to be included in the final adopted DEER 2016 revision as directed by the Commission in response to the DEER team proposal. The UEC of viable units is determined by multiplying the UEC of each claimed appliance by the factor, then weight averaging all units together. The UEC of the non-viable units is determined by multiplying the UEC of each claimed appliance by one minus the factor, then weight averaging all units together. Table 4 shows the results of applying the market viability factors along with the percentage of collected appliances within each IOU service territory that have negligible market viability.

Table - Estimated Market Viability of Collected Appliances



Table - Recalculated Non-Viable and Viable UECs



For the proposed DEER revisions published in June, 2015, the DEER team adjusted the dispositions paths for each IOU to reflect the fraction of non-viable units as determined from the units collected during 2010-2012 program years. For the final adopted DEER values, CPUC staff was directed to further examine the WO35 analysis for determining disposition paths to ensure that the adjustments were reasonable and did not double count paths with zero savings. As a result of this review the DEER team identified the following needed corrections:

1. The portions of primary and secondary refrigerators within the peer-to-peer channel did not sum to 100%. The DEER team renormalized these values so that they summed to 100%.
2. The fraction of units destroyed by retail market actors appears to have had some portion reallocated back in to peer-to-peer transfers. This appears to be an attempt, out of an abundance of caution, to account for the possibility that, while peer-to-peer market actors may state that they would have transferred the unit to a new owner, there are likely some refrigerators that would not be successfully transferred, regardless of the discarders’ intentions. The DEER team has used the viability factors to account for these attempted, but unsuccessful, transfers, assuming those should be counted in the standard practice baseline. Therefore, the DEER team removed this adjustment made in the WO35 development of disposition paths, and left the fraction destroyed by retail market actors only in the retail transfer group. The result is a slight increase in the percentages of paths that result in part and full savings with corresponding small increases in gross savings.
3. Two disposition paths for freezers were incorrectly identified. The DEER team identified two freezer disposition paths as “Keep Existing” when they should have been “Not Replaced”. “Keep Existing” results in a savings of zero while “Not Replaced” results in full savings. The correction to these disposition paths resulted in a gross savings increase for freezers of 60%-100% depending on the IOU.

The adjusted proportions for each disposition path are shown in Table 5 and Table 6 for refrigerators and freezers, respectively.

Table - DEER vs. WO35 Alternative Disposition Paths for Refrigerators



Table - DEER vs. WO35 Alternative Disposition Paths for Freezers



One of the principle differences between the recommended DEER approach and the WO35 approach is that the DEER team has assumed that non-viable units, as well as those units destroyed by secondary market actors represent the policy directed standard practice baseline and therefore have no gross savings. The effect of these assumptions is that gross savings decrease by a substantial amount compared to DEER2014 and WO35 results.

**Age Degradation and Appliance UEC**

A review of the laboratory testing results performed as part of the WO35 research as well as previous evaluation studies indicates that even relatively new refrigerators and freezers experience significant deviation in efficiency as compared to the DOE rating value when placed into service in a home. and provide a compilation of the lab-tested UEC compared to nameplate UEC by age for refrigerators and freezers. Lab results appear to show that tested appliance efficiency is higher for all ages of appliances, even relatively new units. There is a general trend toward greater deviation with age. It is not known if this deviation represents a degradation of performance that occurs after a unit has been in service for a relatively short period or if this represents a typical difference between the rating method result compared with the performance of units delivered into service. To develop a typical UEC for the various baseline and alternative path dispositions, the DEER team has adjusted the nameplate UEC values by age factors from the Table 7 and Table 8.

Table - Comparison of Laboratory and Nameplate UECs for Refrigerators



Table - Comparison of Laboratory and Nameplate UECs for Freezers



**UEC of a Newly Purchased Appliance**

Several transfer pathways result in a new unit being placed in service as the alternative to the recycled unit being placed into service post transfer. For this case the WO35 approach developed the UEC of the new appliance based on the total sales volume of refrigerators published by the Association of Home Appliance Manufacturers (AHAM). The AHAM data is reasonable for all newly purchased refrigerators and freezers. However, respondents to the survey were asked if they would acquire a similar unit to the one they discarded. The overall AHAM reported value is not representative of the units for the transfer pathways of the ARP activity based on what the survey respondents indicate would happen. Therefore, the DEER team recalculated the UEC for each collected appliance from 2010-2012 claims using the currently applicable code requirements. These values were then averaged to determine equivalent UECs by IOU for new refrigerators and freezers.

**Determination of Gross Savings**

All issues and expanded methods discussed above have been used to develop the gross savings recommended by the DEER team are incorporated into the workbook available on the DEER website (DEER2015\_ARPUpdate\_2015-06-02.xlsx). Table 11 provides the gross savings components for refrigerators along with their baseline and alternative path UEC bases, similar to above from the WO35 report. The differences between the DEER analysis and the WO35 analysis are:

1. The DEER approach includes a disposition pathway for non-viable units. This portion of collected the units are determined to have no transfer potential into the secondary market and will be destroyed in the standard practice baseline case, and thus are assigned a gross savings of zero.
2. WO35 assigned gross savings but no net savings for the “destroyed by discarder” pathway. The DEER team expects that a portion of the units following this pathway should also be included into the standard practice baseline, however has not determined the fraction of units following this path which should be included into the standard practice baseline. If the destroyed units have market value, then there may be gross savings associated with the program removing them, even if the discarders would have destroyed them without the program. In either case, the net savings would be unchanged and only a difference in the gross savings would result. At this time, pending additional research, the final DEER values retain the WO35 proposed disposition on this pathway. Retaining the WO35 and assigning a non-zero value for gross savings causes the net-to-gross ratio to be less than one.
3. WO35 assigned gross savings but no net savings for the “destroyed by secondary market actors” path. The DEER team has assigned this path to the standard practice baseline and thus a zero gross savings since they are likely non-viable units. Secondary market actors would have removed and destroyed these units from inventory since they would have no value in used retail channel.

For refrigerators these changes result in some differences in the disposition pathway percentages and also the resultant standard error and 90% confidence intervals on those percentages. A summary of the percentages, standard errors and 90% confidence intervals provided by for the WO0-35 results and DEER team alterations is found in Table 9. A similar summary for freezers is found in Table 10.

Table - WO035 and DEER2016 Refrigerator Recycling Disposition Paths



Table - WO035 and DEER2016 Freezer Recycling Disposition Paths



Table - 2015 DEER Refrigerator Recycling Disposition Paths

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The final step in determining the gross savings is to adjust the gross nameplate UES values based on the space type, conditioned or unconditioned, where the appliances will likely be operated. These adjustments vary by space type (conditioned or unconditioned), building type (single family, multi-family or manufactured home), climate zone and building vintage and were most recently revised as part of the 2014 DEER update process. In general, whole building UEC values of appliances (and therefore energy savings of more efficient appliances) are lower than the nameplate ratings. This is due to ambient temperatures seen by appliances in homes are lower than the ambient temperatures the appliances are exposed to in testing procedures used to determine the rated UEC values. The typical refrigerator and freezer use, including alternative internal temperature settings and door openings, do not impose large enough added loads on the unit in most climates to out-weigh the environmental temperature differences between the rating test and in-situ use. The weighting values for building type, climate zone and vintage have not changed since DEER 2014. Fractions of conditioned and unconditioned space have been revised based on survey results from WO35 using the criteria described below. lists the fractions of appliances installed in conditioned versus unconditioned space.

Refrigerators: Acquirers of refrigerators were asked if the acquired appliance was to be the primary or spare unit. The DEER approach assumes that primary refrigerators are located in conditioned space while secondary refrigerators are located in unconditioned space or outdoors.

Freezers: Participant discarders were asked whether the discarded appliance was operated in conditioned or unconditioned space. The DEER approach assumes that placement of freezers is similar for discarders and acquirers.

Table - Fraction of Appliances Installed in Conditioned and Unconditioned Space

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Table 13shows the proposed savings values compared to the WO35 results and DEER 2014.

Table - Comparison of ARP Savings Values

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**Net-to-Gross Ratio**

WO35 assigned “free rider” status to the alternative disposition paths of “destroyed by discarder” and “destroyed by secondary market actors.” As discussed above, the DEER team has assigned units destroyed by secondary market actors to the standard practice baseline and thus a gross savings of zero, therefore eliminating that path from the NTG calculation. At this time, the final NTG values assume that the disposition path “Destroyed by Discarder” receives full credit in the gross savings calculation and no credit in the net savings calculation. The DEER team considers this disposition path to represent standard practice and thus should have a gross savings of zero. However developing an accurate conclusion in this regard from available data is not possible, so this pathway was left in as a component of gross savings. This disposition path should be a specific research area in future evaluation efforts to establish whether or not this is a standard practice as the DEER team believes may be true.

The final statewide NTG values[[8]](#footnote-8), [[9]](#footnote-9) are a weighted average of the calculated values shown in Table 13 and the relative quantities of collected appliances from each IOU during the 2010-2012 program years. The final DEER 2016 NTG values are included in Table 14.

Table 14 - Final DEER 2016 Net-To-Gross Values



**Measure Cost Consideration**

As shown in and several of the alternative path dispositions include the purchase of a new appliance rather than a used appliance. The percentages range from about 1 percent for PG&E freezers to about 8 percent for SDG&E refrigerators. The incremental cost associated with the purchase of a new appliance versus acquiring a used appliance has never been considered in the participant cost portion for the measure cost calculations used in determining the TRC. In future workpapers, IOUs must add this cost, based on the typical cost of new units with similar features as collected appliances, as a participant cost so that the TRC costs include this participant cost in addition to the program contractor, customer incentive and program administrator costs.

1. Appliance Recycling Program Impact Evaluation Volume 1&2: Report and Appendices Work Order 35, California Public Utility Commission, Energy Division, Prepared by KEMA, Inc., October 24, 2014. [↑](#footnote-ref-1)
2. Ibid [↑](#footnote-ref-2)
3. Ibid [↑](#footnote-ref-3)
4. Ibid [↑](#footnote-ref-4)
5. D.12-05-015, at 351: In the cases when there is no regulation, code, or standard that applies, which would normally set the baseline equipment requirements, the baseline must be established using a “standard practice” choice. For purposes of establishing a baseline for energy savings, we interpret the standard practice case as a choice that represents the typical equipment or commonly-used practice, not necessarily predominantly used practice. [↑](#footnote-ref-5)
6. D.12-05-015, at 346: Specifically, D.11-07-030 notes that it is necessary to establish, by a preponderance of evidence, that the program has induced the replacement rather than merely caused an increase in efficiency in a replacement that would have occurred without the program. [↑](#footnote-ref-6)
7. Residential Retrofit High Impact Measure Evaluation Report and Appendices, prepared for the California Public Utilities Commission Energy Division, The Cadmus Group, Inc., February 8, 2010. [↑](#footnote-ref-7)
8. D.12-05-015 at 54: We agree that similar measures delivered by similar activities should have single statewide values unless recent evaluations show a significant variation between utilities and that difference is supported by a historical trend of evaluation results. While it would be inappropriate to adopt planning values based on anomalous results we do not believe the 2006-2008 evaluation Net-to-Gross results overall are anomalous. We therefore accept Staff’s recommendation to use those results. We direct Commission Staff to strive for uniform statewide Net-to-Gross planning values that represent typical expected results in the DEER update for the next planning cycle for measures in which the variation between utilities is not significant. [↑](#footnote-ref-8)
9. D.12-05-015 OP 6: Commission Staff shall strive for uniform statewide Net-To-Gross planning values that represent typical expected results in the Database of Energy Efficient Resources update for the next planning cycle for measures in which the variation between utilities is not significant. [↑](#footnote-ref-9)