

Measure Retention Study: Revised Lifetimes for a Residential Weatherization Program

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ABSTRACT

As part of a large-scale process and impact evaluation study of a weatherization and education program in New England, the authors conducted a measure retention study. The assessment involved a combination of on-site and telephone surveys to gather data for the retention analysis. This analysis was designed to determine whether *ex ante* measure lifetimes are viable estimates of real measure lifetimes as components of calculating program savings or impacts, and cost-effectiveness.

The participant survey (849 households) was conducted in March and April 2001, and asked for information about installation and removal dates for a number of program measures including: compact fluorescent lights; torchiere lights; refrigerators; faucet aerators; showerheads; basement window coverings; water heater wraps or blankets; thermostats; and furnaces. Although other measures were installed under the program, they were not included in the retention analysis because they represented a small portion of the program savings, they were installed less frequently, or they posed difficulty in identifying their remaining functionality (e.g. caulking).

We found that there were significant removals of several important measures under the program. We fitted hazard functions and estimated effective useful lifetimes (EULs) based on field data. The analysis showed significant differences between *ex ante* and *ex post* EULs for two measures, leading to suggested revisions to EUL estimates for the measures.

Introduction

This study¹ examined the retention of electric energy (kWh) measures from the 1999 cohort of Northeast Utility's Weatherization Residential Assistance Partnership (WRAP) and Energy Smart Program (ESP). The programs were designed to help meet the energy efficiency needs of income-eligible customers. The programs were implemented by Northeast Utilities (NU) in two of its service areas—Connecticut Light & Power (CL&P) and Western Massachusetts Electric Company (WMECO). The WRAP program offers a full range of energy conservation measures to address lighting, water heating, inefficient heating equipment, refrigeration, and insufficient insulation.

Study Objective and Overview of Approach

The objective of this study was to estimate the effective useful life (EUL)² of measures for the program and to compare them to the *ex ante* EULs used in the initial

¹ Thanks and acknowledgment to NU's project manager, John Walsh, and prime consultant RER.

² That is, the elapsed amount of time by which 50% of the measures would have failed or been removed.

computations of savings for the program. Estimates of measure retention were based upon data collected from telephone surveys conducted with program participants.

The project involved several major steps, which are summarized below:

- *Participant Survey.* Telephone surveys were conducted with 849 participants. The surveys collected information to support the measure retention study as well as the impact evaluation, process evaluation, and non-energy benefits analysis.
- *Analysis of Measure Removal.* The survey results were analyzed to determine the number of program-installed measures of each type that were removed from the surveyed participant dwellings. Using installation dates provided by NU, the number of months between installation and removal was computed.
- *EUL Analysis.* For measures with sufficient failures to support an analysis, a classic survival analysis was conducted, fitting parametric models to the failure time data. Using the fitted model, the number of months at which 50% of the measures would still be in place was identified and used as the revised (or *ex post*) estimate of the EUL for the measure. These *ex post* EULs were compared with the planning (or *ex ante*) EULs initially used to compute program savings. Where there were significant differences at the 90% confidence level, these differences were noted.

Program Description and Data Collection

In 1999, Northeast Utilities operated two DSM programs targeting lower-income customers. The Weatherization Residential Assistance Partnership (WRAP) program, initiated in 1988, provided services to income-eligible CL&P and UI customers in Connecticut. The Energy Smart Program (ESP) provided services to income-eligible WMECO customers in Massachusetts. Both programs were coordinated through the WRAP unit operating in Glastonbury, Connecticut. Each program delivered weatherization services through local Community Action Agencies (CAAs).

The WRAP and ESP Programs were designed to provide comprehensive energy efficiency services to lower income customers in Connecticut and Massachusetts. In Massachusetts, customers needed to have incomes not greater than 175% of federal poverty level guidelines to qualify for the Program. In Connecticut, customers with incomes less than 150% of federal poverty guidelines were eligible for some service levels, and customers with incomes less than 200% of federal poverty guidelines were eligible for other program measures. For multifamily units, in which it is desirable to treat as many units as possible at a single visit, 75% of the units were required to meet the income eligibility requirements in order for the whole building to receive services. The elements of the program included:

- An on-site visit,
- Monitoring of refrigerator energy use ,
- Weatherstripping, caulking, and other weatherization services,
- Delivery of a set of measures, potentially including CFLs, low flow showerheads, faucet aerators, fixtures, refrigerators, furnaces, thermostats, and other measures,
- Replacement of halogen torchieres with safer torchieres, and
- On-site energy discussion and education.

Survey Sampling and Data Collection

Given that the project involved impact and process evaluations and an analysis of non-energy benefits, the project included surveys of both participants and non-participants; however, only the participant sample was used for the retention analysis.

The NU participant population was provided by NU from the tracking database. It contained information on 1999 WRAP participants, including: description and quantity of installed measures, installation date, estimated measure savings, electric utility account number, customer contact information, utility identifiers, and primary heating fuel type. The participant frame consisted of 4,631 households for CL&P, and 2,252 for WMECO. The participant database was stratified by utility (CL&P and WMECO); primary heating fuel (oil, gas, electric, other, and non-specified), and fuel type mix related to expected savings from installed measures (electric, gas, and oil), and quotas were assigned for the various cells. The phone survey was conducted in Spring of 2001. The survey sample was designed to achieve a relative error of $\pm 10\%$ with 90% confidence at the fuel type and state level.³

Analysis

One of the factors affecting the computations of measure savings in the benefit cost analysis is the lifetime of the measures. Up-front program estimates relied on “assumed”, or *ex ante*, measure lifetimes. Retention studies use data on actual measure removals to develop revised measure lifetime estimates. Two sources of information provided the basis for the measure retention analysis – program records and a participant survey. Program records provided information on the number and type of measures installed and the date installed. Participant surveys confirmed whether the measures were installed and provided the data on removal of relevant measures and the dates of removal. Statistical equations were then fitted to the data on the number of measures removed and in place. The fitted equations provided estimates of EUL, or the elapsed time by which 50% of the measures would have failed, been removed, or been unusable.⁴ If the planning (or *ex ante*) lifetime fell within the confidence interval surrounding the *ex post* estimated lifetime from the 2-year retention study, we did not suggest reconsideration of the EUL at this point. If, however, the *ex ante* lifetime fell outside the confidence interval, we noted that the *ex post* EUL may be more appropriate for use in savings and other calculations.

WRAP Retention Analysis Objectives

For the WRAP 1999 program year retention study, the analysis was designed to determine whether the revised estimates of the EULs for each of the measures were significantly different from the assumed planning (*ex ante*) estimates for the EULs. Using

³ Certain complexities were introduced because there was partial overlap between the gas, oil, and electric customers. Regional Economic Research (RER), the firm that conducted the impact evaluation, and the prime consultant on the project, assigned 150 extra sites to cover the non-overlap sites, spread proportionally between the two states by the number of program participants.

⁴ There is some controversy regarding the issue of replaced measures. Standard practice in California is to ignore replacements, which was the approach used in this study.

statistical tests, we determined whether the planning (*ex ante*) vs. *ex post* EULs for any of the measures were significantly different at the 90% confidence level. The study:

- Estimated the portion of measures that were installed through the program during the 1999 program year that remained operable,
- Provided NU and CL&P with statistically-based EUL estimates for each of the key measures included in the study, and
- Examined the appropriateness of the *ex ante* EULs for assessing savings for the program.

The end uses and their planning (*ex ante*) lifetimes are listed in Table 1 below.

Table 1. *Ex Ante* Measure Lifetimes for WRAP/ESP Program

Measures	<i>Ex ante</i> EUL point estimate provided by NU
Compact fluorescent light bulbs	7 years
Torchieres	20 years
Refrigerators	20 years
Faucet Aerators	10 years
Low Flow Showerheads	14 years
Basement Window Coverings	3 years
Water Heater Wrap	12 years
Furnace Measures	Various

Estimation Approach

The EUL (the number of years after installation at which 50% of the installed measures are still in place and operable) can be estimated by identifying the measure's survival function. A survival function is a parametric equation that describes the percentage of measures installed that are still in place at a given time. The EUL can be found along the survival function by examining the elapsed period since installation that is associated with the point at which 50% of the measures are still in place. The hazard rate for the survival function is defined as the rate at which measures fail or are removed.

For measures with long *ex ante* EUL, it is possible that well more than half of the installed measures will exist and be operable at the time of the survey, and we cannot compute an observed EUL. In this case, parametric specifications of the survivor function are required in order to extend beyond the censored lifetimes. The hazard function can be represented as: *Probability(failure=1)=h(age, in months)*, where *h* is the chosen probability function.⁵ The survival function is 1-cumulative hazard function. The survivor function, call it *S(t)*, gives the probability that the survival of a measure exceeds length *t*; so *1-S(t)* is the cumulative distribution function of the random variable *t*.

Under this approach, the observed data were fit to alternative parametric specifications of the survivor function: log-logistic, log-normal, Weibull, exponential, and gamma. These functions have been widely used in the medical and unemployment duration

⁵ In the models used in this project, age is the only covariate included. To provide an example of a fitted equation, the coefficients for the lognormal CFL model is an intercept of 3.782 and a scale coefficient of 1.019. The results are shown in Tables 4 and 5.

literature (Kalbfleisch and Prentice 1980). Because each function differs in the amount of weight that is placed in the upper tail of the estimated function, the associated EUL estimate differs. For estimates falling within the 90% confidence interval from the midpoint estimate, the midpoint estimate for the EUL was chosen; only if the *ex ante* EUL estimate falls outside the confidence interval for the *ex post* EUL estimate is the EUL estimate replaced.

The data needed to support the estimation of survival functions included: 1) the measures installed in the house, and the dates they were installed (from program records), and 2) date of failure or removal of any measures. The participant telephone surveys provided raw data on the fraction of measures installed under the WRAP program that had not been removed; that is, the fraction that were still in place and operating. The reported removal dates from the survey responses were used to estimate a survival function⁶ for each of the measures with sufficient failures.

The statistical procedures for estimating survival functions need to take into account the fact that all measures have not yet been removed and thus we do not yet know their ultimate failure dates. In survival analysis terms, a significant share of the observations is “right censored.” That is, for those measures that have not been removed, we can only say that a particular measure survives *at least* as long as it has been in place to date. We used the LIFEREG statistical procedure in SAS[®] to estimate likelihood functions and resulting EULs.⁷

Analysis Challenges

This analysis provided the first opportunity to estimate the EULs for the 1999 program year measures. However, several data issues can affect the specification of the survival function and the quality of ultimate EUL estimates.

- *Lack of removals.* The power of survival analysis comes from observed failures or removals, as they form the observations used to estimate the survival function. Relatively few failures complicate fitting a curve through the data points. A situation in which few measures have been removed can make it difficult for the statistical model to select between similar distribution functions, each of which may result in a different estimate for the EUL.
- *Long Planning (or ex ante) Lifetimes.* The elapsed time between 1999 program year installation and the 2001 retention study means that most of the measures have been in place for less than 2 years. If there are relatively long expected lifetimes of the measures installed (e.g. the longer of the 7-20 years found in the NU measures studied), few failures based solely on technical failures might be expected after such a short time. An additional source of failures might be removals by homeowners from

⁶ Estimated survival functions can take on a number of functional forms; discussions with another consultant team indicate that the authors of the Protocols in California suggested that *ex ante* EULs may be based on a log-logistic survival function.

⁷ “LIFEREG” is a statistical procedure in SAS[®] that is appropriate for use with this type of “censored” data. The statistical procedure generates a maximum likelihood estimate of the survival distribution given the observed test data, and lets the analyst specify the class of distribution functions to be assigned. A confidence interval can be constructed around this curve, and estimates of the median expected survival of measures can be calculated from the estimated curve.

dissatisfaction with the measures or a variety of other possible reasons. Either reason for removal affects the EUL of the measure.

There are several ways to help address these problems: 1) increase the number of surveys conducted in order to increase the chance of finding more failures;⁸ or 2) wait longer to conduct the surveys and analysis so additional failures can occur. Both options increase observations of failures in the sample and make it possible to improve the “fit” of the estimated survival curves and the EUL.⁹

Survey sample size issue. For the NU study, we used a large sample phone survey (860 interviews). There has been some debate about preferred data collection methods for retention studies. While a phone survey provides a way to gather data from many households affordably (or more affordably than on-site visits), some program-installed measures may be hard for residents to identify, potentially compromising the data quality. For example, recalling which CFL bulbs were installed by the program and what happened to them is likely to be more difficult than recalling the removal of a furnace or refrigerator.¹⁰ Measures removed as part of major construction events (remodeling, etc.) are also usually more easily recalled. The fact that we interviewed participants less than three years after measures were installed increased the chances that residents would be the same ones that had the measures installed, and that they would remember both measure removals and their approximate dates.¹¹

Study timing issue. The timing of the study did not allow us to wait longer for more measures to fail. The study was commissioned for 2001, evaluating the 1999 program year. We could conceivably have restricted our surveys to only those measures that had relatively short planning horizons. However, there were several reasons to include all key measures in the study, and to conduct the study after only a couple years. First, the extra cost to ask about all measures was relatively small once we had the respondent on the telephone. Second, even a household that did not yet have a failure provides more information for the next retention study than the analyst would have if the measure had not been included in this

⁸ One anonymous reviewer notes that, as mentioned elsewhere, the first two years may show only technical failure rates (which are not guaranteed to continue following any particular functional form) but are unlikely to show replacements based on aesthetics, taste, new technology, or other factors. All of these removals would work to shorten a 20 year technical life to a 10 year installed life.

⁹ One anonymous reviewer suggests that another strategy for helping solve this issue is to study similar older measures, and find out how long respondents kept their previous refrigerators before replacing them with the one installed under the program. They suggested that examining how long non-participants are keeping their refrigerators would also help.

¹⁰ However, it is important to point out that CFL-type measures are not necessarily better-remembered or identified during on-site interviews. The chances of high-quality data are improved if the measures (especially items like CFLs) are labeled with stickers, identifying that they were supplied as part of the program, and potentially the installation date and a number to call to report removals.

¹¹ Richardson and Skumatz (2000) described a residential retention study that also validated data collected via phone vs. on-site audit. The study concluded that telephone surveys provided the same results for the measures included in the program – a program that did not include CFLs, but did include space conditioning, stove, and other measures. This study recommended collecting retention data through a hybrid approach, using a periodic panel telephone survey (every 2-3 years), coupled with less frequent on-site inspections.

survey. If the household survey for the next retention study found that the respondent knew the measure had been removed, but did not know the date, the survey conducted in 2001 would make it clear the removal occurred after spring of 2001. Third, including all measures provided the opportunity to find out if there were long-term measures that had significant early removal problems. Finally, the failure date is an important data element in retention analysis. The better a resident's memory is regarding the failure date, the more usable the observation. In this case, we interviewed residents less than three years after installation of the measures. This increased the probability that they would remember the removal date, resulting in a higher quality observation for use in the study.

Measures Installed and Removed

- The telephone survey data was analyzed to identify the estimated number of measures installed, removed, and remaining by measure type.¹² Table 2 shows the percent of installed measures remaining for periods up to 27 months after installation. Measures with the greatest removals or failures were compact fluorescent light bulbs and torchieres. The majority of those removing CFLs also reported removing more than one bulb or fixture.¹³

The table shows that virtually no refrigerators or furnaces have yet been removed. These results are shown in Table 2 and highlighted below.

- A high percentage of households received CFLs, faucet aerators and low flow showerheads (about 50% or more of the participating households). Removals of program-installed lighting- and water-related measures were high within the first 2 years after installation.
- We found there were very few removals of some items, particularly refrigerators, basement window coverings, and furnaces.

The reasons for measure removal varied by measure. Reasons reported by those that removed measures are summarized in Table 3.

¹² The telephone approach supported a large sample; in-person visits to the household would be more expensive and given a fixed budget, the sample would be smaller. The survey protocol asked about each measure that program records indicated was installed, but also dictated that participants that did not recall having measures installed were not asked about whether the measures had been removed. One reviewer suggested that in-person interviews may have perhaps exposed the presence of forgotten measures. That may be possible, particularly for smaller measures. However, the in-person validation work in Richardson and Skumatz (2000) demonstrated that for measures of this type, phone approaches for retention work showed no discrepancies from on-site data collection.

¹³ The large number of multiple removals might be thought to represent the large number of whole multifamily buildings that participated; however, the respondents to this survey were individual units or participants. For most of the measures, only one was installed per household. The measure that most commonly had more than one installed per household was CFLs; in fact, some reported more than four bulbs removed. A reviewer notes that households that remove multiple bulbs suggest that removals are not uncorrelated, and that this may result in bias in the estimates. Another estimation method, for example maximum likelihood estimation (MLE) or non-linear generalized least squares (GLS) may address this issue. These techniques were not applied to this 2-year study, but should be considered for future studies.

Table 2. Measures Installed and Removed, 1999 Participants¹⁴

Measure	# Installed	% of Participants Receiving the measure	# Removed	# Remaining	% Removed of the Measures installed
HH's with CFLs	4,556	70.3%	796	3,760	17.5%
No. of CFL bulbs	22,907	-	5,648	17,259	24.7%
HH's with torchieres	1,029	15.5%	197	832	19.1%
No. of Torchieres	1,126	-	207	919	18.4%
Refrigerators	1,168	17.6%	4	1,164	0.3%
Faucet Aerators	3,659	55.0%	270	3,389	7.4%
Low flow showerheads	3,053	45.9%	280	2,773	9.2%
Basement Window Treatments	131	2.0%	7	124	5.3%
Water heater wrap	676	10.2%	50	626	7.4%
Furnace measures	32	0.5%	0	32	0.5%

Table 3. Reasons for Removal of Program Installed Measures

Measures	Reason for Removal
CFL ¹⁵	60% removed them because the bulb burned out 20% removed the measure because the bulb was broken 8% reported removing them because they didn't like the quality of light 2-3% reported it took too long to light 2-3% stated they did not like the looks of the bulb 10% reported they did not know or had some other reason
Refrigerator	The one refrigerator removed was reported removed because it was "broken" ¹⁶
Other measures	Reasons for removal not asked

Figure 1 shows the percent of installed measures remaining from 1 to 27 months after installation based on the information gathered from the telephone survey. For ease of reading, the measures were broken up onto five graphs, each with the same axes and scale. In order, the graphs show the percent of measures remaining for CFLs, torchieres, water measures, and on one graph, basement window treatments, thermostats, and water heater wraps. Virtually no refrigerators or furnace measures were removed and they are not graphed.

EUL Results and Findings

The statistical models were estimated using the data on measure removals and elapsed time since installation. Table 4 summarizes basic statistics for the fitted models. We examined the model performance and used a conservative approach in making recommendations about the EULs. In the case of CFLs and torchieres, the confidence intervals for all models estimated showed shorter lifetimes than the *ex ante* EUL. This was not the case for the other measures.

¹⁴ The table computations are based on respondents to 859 surveys, weighted to represent 6,600 participants.

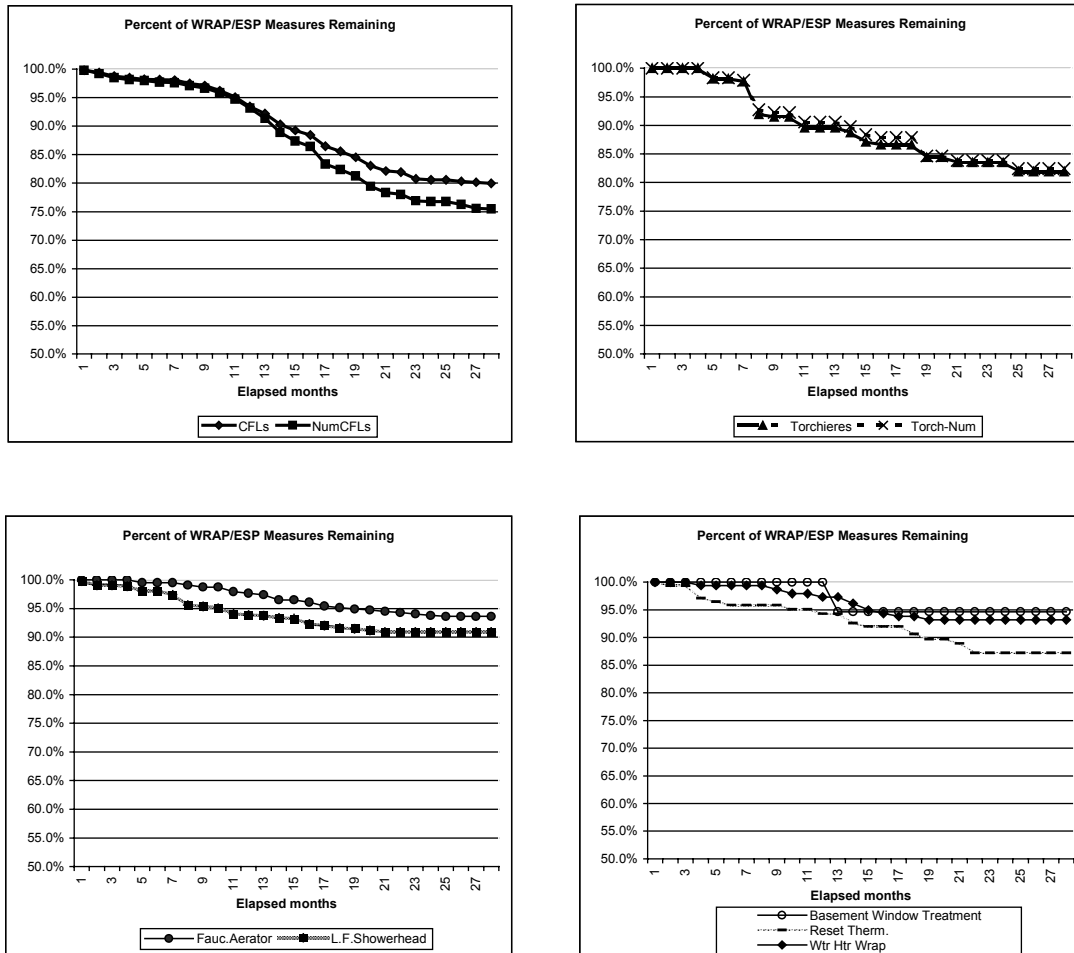
¹⁵ Note that 70% of the CFLs were reportedly replaced with incandescent bulbs, and 20% with CFLs. One percent reported replacing the bulbs with "both types", and the remainder of respondents reported they didn't know which kind was used to replace the removed bulb.

¹⁶ The table reflects four refrigerators due to weighting.

To provide one example (and in light of space considerations all models could not be included), Figures 2 and 3 provide the actual and fitted percent of measures removed for CFLs. Figure 2 shows the percent of measures removed, based on survey data, for the first 27 months; Figure 3 shows the fitted results using the lognormal model.

Table 5 summarizes the *ex post* EUL estimates (in months) based on the fitted statistical models, and compares the results with the *ex ante* estimates for the measure. Two (of the five) measures show that the *ex post* estimate differs significantly¹⁷ from the *ex ante* planning figure used – CFLs and torchieres.

Figure 1. Percent of Measures Remaining by Months after Installation

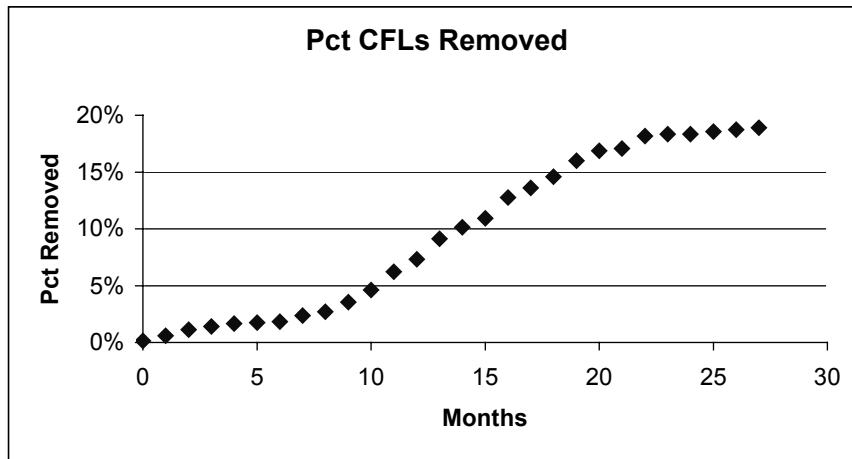


¹⁷ Using the 90% confidence interval.

Table 4. Information on Estimated Models for EULs

	Weibull	Lognormal	Exponential	Loglogistic
CFLs (<i>ex ante</i> =84 mo) EUL Estimate & Conf Int. Log Likelihood	N/a	43.9 (42.9-45.0) -14162	55.5 (54.2-56.7) -14881	35.5 (34.9-36.1) -13760
Torchiere (<i>ex ante</i> =240) EUL Estimate & Conf Int. Log Likelihood	36.4 (32.5-40.6) -480	50.2 (42.9-58.6) -481	76.8 (67.3-87.7) -513	40.8 (35.9-46.3) -481
Aerator (<i>ex ante</i> =120 mo) EUL Estimate & Conf Int Log Likelihood	76.0 (64.3-89.8) -736	147.6 (116.5-186.9) -734	277.1(244.5-314.0) -771	88.2 (73.4-106.1) -736
Showerhead (<i>ex ante</i> =168) EUL Estimate &Conf Int Log Likelihood	141.3 (113.6-175.8) -1118	335.4 (249.9-450.1) -1112	156.7 (141.4-173.6) -1119	180.0 (141.4-229.3) -1117
WRAP (<i>ex ante</i> =144 mo) EUL Estimate &Conf Int Log Likelihood	87.3 (60.5-125.9) -193	161.5 (98.6-264.3) -191	198.4 (155.9-252.6) -197	103.0 (68.8-154.1) -192

Figure 2. Percent Failed for CFLs – Actual to 27 months



Findings

The findings indicate that modifications may be appropriate for the EULs for the lighting-related measures – from 7 years to about 4 years for CFLs and from 20 years to about 7 years for torchieres. The short lifetimes and high failure rates (25% reported by program respondents) are consistent with the verbal reports of high failures from the multifamily building owner participant interviews that we conducted as part of the process evaluation. These interviewees noted that some of the lights and lighting fixtures installed had hums, flickers, and poor connections and needed to be replaced. Several interviewees recommended doing a better job of checking the equipment quality and/or dealing with different suppliers or manufacturers. NU is aware of the brands installed and has implemented this recommendation for the program.

Figure 3. Percent Failed for CFL Lognormal Model—Fitted

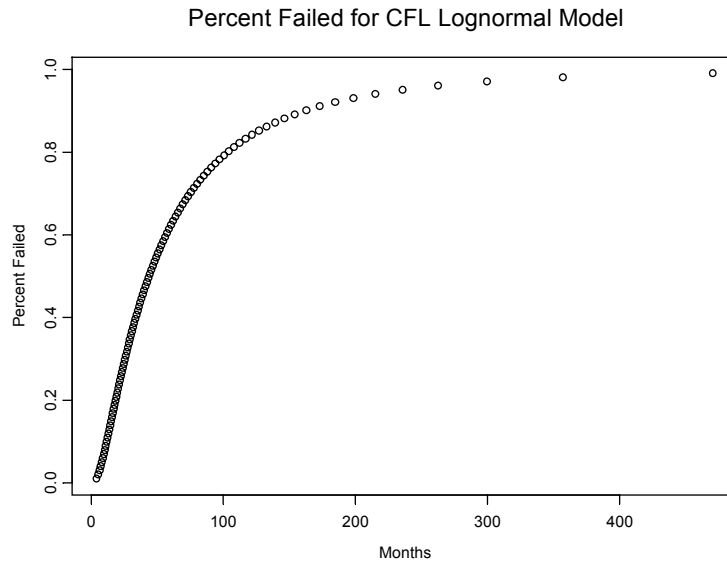


Table 5. Estimated EULs and Recommendations

Measures *	<i>Ex ante</i> planning EUL/lifetime	Estimated <i>ex post</i> EUL from retention study ¹⁸	Confidence interval (90%) and findings	Recommendations
Compact fluorescent light bulbs	84 months	43.9 months	42.9-45 months; <i>ex ante</i> point estimate falls above this range (and above range for all estimated models). These measures seem to be removed prematurely in the field.	Replace / reject <i>ex ante</i> EUL estimate.
Torchieres	240 months	76.9 months	67.3 – 87.7 months; <i>ex ante</i> point estimate falls above this range (and above range for all estimated models). These measures seem to be removed prematurely in the field.	Replace / reject <i>ex ante</i> EUL estimate.
Faucet aerators	120 months	147.6 months	116.6-186.9 months; <i>ex ante</i> point estimate falls in this range.**	Retain <i>ex ante</i> planning EUL.
Low Flow Showerheads	168 months	156.6 months	141.4-173.6 months; <i>ex ante</i> point estimate falls in this range.**	Retain <i>ex ante</i> planning EUL.
Water heater wrap	144 months	161.5 months	98.7-264.3; <i>ex ante</i> point estimate falls in this range.**	Retain <i>ex ante</i> planning EUL.
(*) There were insufficient measure removals to develop estimated EULs for furnace measures, basement window coverings, and refrigerators				
(**) Estimated models show results higher and lower than the <i>ex ante</i> EULs for these measures.				

¹⁸ The models selected for CFLs, aerators, and water heater wraps were lognormal, and exponential distributions were selected for the torchieres and low flow showerheads. Ultimately, however, the CFL and torchieres were the only ones with recommended EUL changes. We reviewed the performance of models in terms of standard error, log likelihood, probability, compatibility of the implied hazard function with the data, and Lagrange multiplier tests. However, to be conservative, we only recommended revised EULs if none of the models incorporated the *ex ante* EUL within the confidence interval.

Based on the analysis, the estimated EULs for torchieres and CFLs were shorter than those used in the program-related computations for benefit-cost analysis, cost-effectiveness, and regulatory tests. Revised computations may be in order because the retention analysis indicates the lifetime program energy savings may have been overestimated for these measures.

Suggestions for Revised Data Collection Procedures for Future Retention Studies

As time passes, more failures will occur, supporting improved EUL estimates for additional measure categories – or possibly confirming planning (*ex ante*) EUL values. The study recommended that the utility consider conducting another retention-related telephone survey in 2 or 3 years.¹⁹ Waiting too long hampers the recollections of failure dates by residents; conducting the survey too soon will not add enough additional failures to augment the estimations.

Implementing a panel survey – potentially using as its basis the survey respondents from this study – is a very appropriate design for a retention study. This approach streamlines sample selection and phone look-ups, but more importantly, if a measure is removed but the respondent cannot remember when, this current survey provides a benchmark. We are more certain that it was not removed before April 2001 than we would be if we took some other participant that was not previously surveyed.

WRAP/ ESP might also consider alternating telephone surveys with on-site audits for a subset of the sample. Some of the measures are difficult to identify (torchieres and CFLs for instance), and residents may not be qualified to determine if the water heater wrap is still functional. Certainly, if all the program measures were items like furnaces or very obvious measures, repeated or panel phone surveys could be an especially viable and cost-effective approach.²⁰

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¹⁹ These repeated panels should include survey questions on all measures, even those with long planning EULs because the additional cost and time is not very long, and because even the lack of failures can be valuable if residents cannot remember the removal date during the next survey.

²⁰ Of course, if the CFLs or light fixtures or torchieres are not very identifiable for the program, an on-site survey might not be much better than phone surveys.