Assessing Persistence: Experiences Documenting Savings Persistence Under the California Protocols

Mary O'Drain, Pacific Gas & Electric Company
Timothy O. Caulfield, Equipoise Consulting Incorporated

ABSTRACT

As California enters the final stages of DSM evaluation and verification under regulation, documentation of energy savings persistence (persistence) takes center stage with respect to earnings claims. The California Protocols both simplify and complicate the process of measuring persistence. This paper discusses the California Protocols and the interaction between individual utility studies and cooperative statewide studies in fulfilling the requirements of the Protocols. It addresses measure effective useful life and measure technical degradation. The paper describes how California utilities are grappling with the practical issues of projecting effective useful life based on limited attrition data and speculative survival functions. Specifically, the paper discusses the difficulty of establishing meaningful survival functions for the breadth of measures represented in California DSM programs. Similarly, California utilities as a whole are attempting to establish exactly what measure technical degradation means, and whether it actually exists. The paper recounts the process, documents the approaches taken, and documents publicly available information on both retention based effective useful life and study based measure technical degradation. Finally, the authors propose improvements in the approach to persistence assessment.

Introduction

As California moves into the final stages of DSM evaluation and verification under regulation, documentation of energy savings persistence (persistence) takes center stage with respect to earnings claims. The existence of the California Protocols both simplify and complicate the process of measuring persistence. The authors discuss the California Protocols, the interaction between individual utility studies and cooperative statewide studies in fulfilling the requirements of the Protocols, and attempt to define the order of magnitude of the task of documenting persistence. The paper addresses the issues that have arisen in measuring two primary components of the California persistence equation, measure effective useful life and measure technical degradation. Measure effective useful life has been discussed in conceptual terms for many years. Now, for the first time, California utilities are grappling with the practical issues of projecting effective useful life based on limited attrition data and speculative survival functions. Specifically the paper discusses the difficulty of establishing meaningful survival functions for the breadth of measures represented in California DSM programs. Similarly, the technical degradation of measures as they age has been widely discussed, but now California utilities are attempting, on a statewide basis, to establish exactly what this means, and whether it actually exists. The paper recounts the process, documents the approaches taken, and provides publicly available information on both retention-based effective useful life and study-based measure technical degradation. Finally, the authors propose improvements in the approach to persistence assessment.

California Protocols

Starting in 1992, the California utilities, in collaboration with the California Energy Commission, the Department of Ratepayer Advocates (now the Office of Ratepayer Advocates), and the National Resources Defense Council, began development of a set of standards for verifying the costs and benefits of California based demand side management programs. The result of these efforts was the Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs (Protocols 1996). These Protocols have been applied to all California investor owned utility DSM programs. As the Protocols have been used, improvements and clarifications have been discussed, approved, and incorporated through the intra-industry working group known as the California DSM Measurement Advisory Committee (CADMAC). The sections of the Protocols that define the measurement of retention and the incorporation of those measurements into utility earnings claims are Protocol Tables 8, 9, and 10. The equation that defines the measurement requirements appears in Protocol Table 10 and defines the basis for utility earnings recovery. The utilities recover the final 50% of the claims based on the following estimation of savings:

$$\text{Resource Benefits, net} = \sum_{i=1}^{k} \left(\text{Net Load Impacts}_i \times \text{Technical Degradation Factor}_i \right) \qquad (1)$$

Where:

Net Load Impacts are the final agreed claims for net impact from the first year impact evaluation. Once the impact study results have been agreed between the utilities and the regulators, the first year impacts are a fixed quantity.

k is the Effective Useful Life (EUL), for the purposes of this equation, is either the ex ante estimate or an adjusted estimate derived from the retention studies. The criteria for determining which EUL is applied is one of the main points of discussion in this paper. This is the factor with the largest uncertainty in the equation.

Technical Degradation Factor (TDF) is intended to account for any relative degradation in the performance of the energy efficient measure. The Protocols state that TDFs are to be estimated through performance studies for certain specified measures.

The EUL and TDF are discussed further in the following sections. The remainder of this paper discusses both the Protocols as they existed when persistence studies began, and the improvements that have been made as the Protocols have been applied. The evolution process is included to identify issues that might otherwise be lost.

Effective Useful Life/Retention

As originally stated, the Protocols defined EUL as *"An estimate of the number of years that a piece of equipment will operate if properly maintained, adjusted for early removal that would have occurred in the absence of the program."* However, this was not a definition that could be easily measured or applied to equation (1) above. An alternative definition of EUL that fits into the construct created by equation (1) was devised and approved by CADMAC. This definition is *"An estimate of the median number of years that the measures installed under the program are still in place and operable"*. The use of the median, rather than the mean, facilitates field measurements since it is only necessary to estimate the measure life for the measures removed, not those that remain. The term "in place and operable" is consistent with other retention phrasing in the Protocols[1] while clearly defining the criteria for deciding whether equipment is still there. It is important to note that "in place and operable" criteria does not require the field inspector to determine whether or how much the equipment is being used. This would only be necessary if impacts were being recalculated. Equation (1) does not require recalculation of the measure impacts.

It should be recognized that the EUL, as defined, has two contributing components; the failure rate of the equipment and the non-failure related equipment removal rate.

As originally defined by the Protocols *"The revised estimate of the effective useful life should be compared to the ex ante (i.e., forecast) useful life estimates. The forecast estimate should be considered the null hypothesis. If the difference between the revised estimate and the forecast estimate is statistically significant at the 70% confidence level, the revised estimate should be used to recalculate the lifecycle resource impacts for the end use element and linked to the recovery of the remaining 50% of earnings. If the difference is not statistically significant, then the forecast estimate should be used to calculate lifecycle resource impacts for the program year. In either case, the revised estimate of the useful life will be used for future year program and/or measure lifecycle calculations."* Thus it is important to clearly understand the measurement that is being made to determining the EUL and the confidence interval around the estimated EUL.

The EUL, as defined by the Protocols, is to be determined empirically through measure retention studies. The various approaches to conducting these studies are discussed later in this paper. Figure 1 illustrates graphically the extrapolation of retention level data to estimate EUL values and confidence intervals. The point illustrated here is that the EUL estimate is actually in a different dimension than the retention measurement, and that estimation of the confidence intervals is not an obvious result of the retention studies.

Figure 1
Retention vs. Effective Useful Life

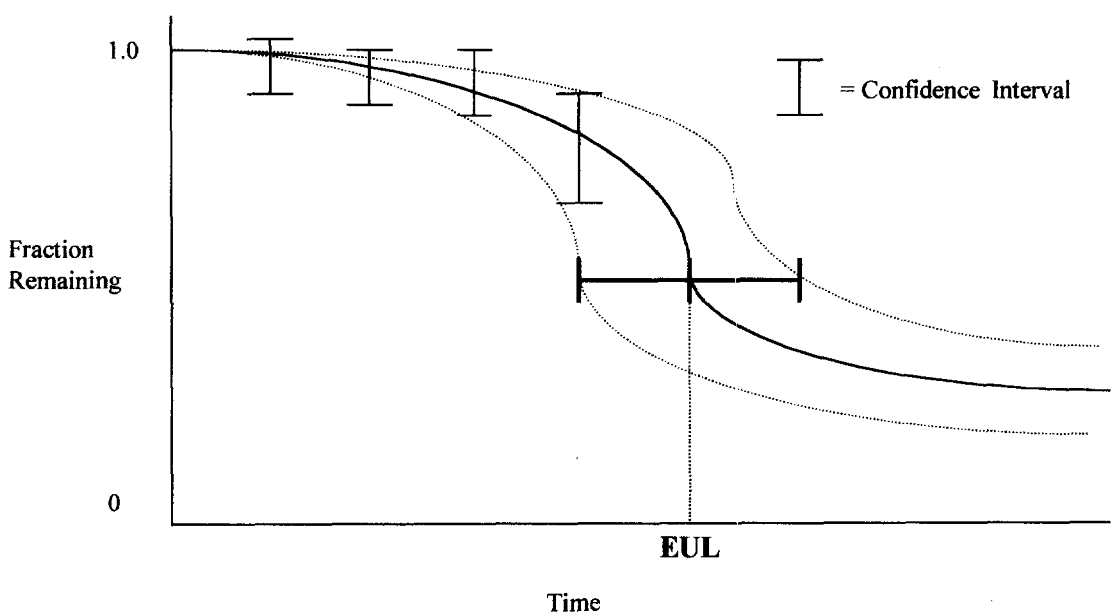

Figure 1 also illustrates that frequency of data collection is integrally tied to the approach used to perform the studies, as will be discussed later in this paper. However, the Protocols define the timing

[1] (Table9A, Note 3, sixth line and Table 9B, Note 2A, point B)

by program type and require that the studies "*be carried out and reported beginning in 1999 and every two years afterward; performance studies will be performed in parallel with retention studies*". This wording has recently been clarified by CADMAC and has resulted in a complex array of study and reporting cycles that will be incorporated in the next revisions to the Protocols. The official schedule aside, Figure 1 suggests that the more frequently the studies are performed, and the larger the datasets, the better the estimate of EUL. This further raises the issue of cost versus return for retention studies. These issues will be discussed later when study approaches are addressed.

Measures to be Included

The Protocols define either the specific measures to be included[2] or state that "*The utility should select the top ten measures ... ranked by net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less.*" While the "resource value" is not defined in the Protocols, for the purposes of this paper it is defined as "the amount of money the utility saves by not generating, transporting, and distributing the energy and demand saved as a result of it's conservation program. It is determined by multiplying the energy and demand saved by the marginal cost of generating, transporting and distributing a unit of energy." These statements leave little doubt concerning the measures to be covered in retention and performance studies. The statements also clearly point out that the intention is that the retention studies are to be conducted at the measure level, not the end use or program level.

Technical Degradation

As discussed earlier, the TDF is a key component to the earning mechanism. The approach for estimating the TDFs for each measure are fairly clearly defined in the Protocols[3] as follows: "*The performance studies should be performed by statewide studies or by selecting a sample of program participants with high performance equipment/shell measures in the first year and optionally, a comparison sample of standard efficiency equipment. The performance/efficiency of the equipment should be measured on site and then again four or five years later using similar measuring or monitoring techniques. For statewide studies, degradation factors may be estimated using multiple data sources, including site measurements, laboratory studies, and manufacturers tests.*" This approach obviously encourages statewide studies as an option to utility specific studies, and allows a greater degree of freedom in the selection of the data sources for the statewide studies.

As a result, the California utilities are currently conducting a series of statewide studies to assess the potential technical degradation of a combined set of measures that cover approximately 80% of the resource value for DSM programs fielded by the four California investor owned utilities. The first two studies are assessing the potential technical degradation of the high efficiency measure, in comparison to a similar standard efficiency measure, based on an engineering assessment of the operation of the equipment. These studies are expected to result in a small number of measures that will require actual measurement studies.

The first study, completed in April of 1996, covered 13 major measures and resulted in conclusive findings for 11 of the 13 measures. Table 1 lists these measures and presents the study-determined relative TDF for each measure.

---

[2] Table 9A and 9B.

[3] Table 9A and 9B, Note 4.

Table 1
Relative Technical Degradation Factors

Measure	Relative Technical Degradation Factor
Residential Central AC – High Efficiency	1.0 (+)
Refrigerator 10-30% Better than Standard	1.0 (+)
Electronic Ballasts	1.0
T8 with Electronic Ballasts	1.0
Optical Reflectors	1.0
HID Interior Metal Halide 250-400W	0.95
Occupancy Sensors	1.0
Motors – High Efficiency	1.0
Adjustable Speed Drives for HVAC Fan	1.0
Infra-red Gas Fryer	1.0
Residential Ceiling Insulation	1.0
Commercial Packaged AC	Requires Empirical Study
Evaporatively-Cooled Condensers	Requires Empirical Study

The 1.0 (+) used in Table 1 indicates that these measures can actually be expected to degrade less than the similar standard efficiency measure. The amount of "negative degradation" was not quantified because the utilities currently do not intend to claim the benefits of negative performance degradation.

As Table 1 illustrates, the vast majority of the measures are predicted to have time and use related performance changes similar to the comparable standard efficiency measure. Table 2 presents the measures studied during the second study. This study was completed during the April of 1998.

Table 2
Measures in Second TDF Study

Measure	Relative Technical Degradation Factor
LED Exit Lights	1.0
Process ASD on Water Pumps	1.0+
ASD on Injection Molding Machines	Requires Empirical Study
Wall and Floor Insulation	1.0
Daylighting Controls	Requires Empirical Study
Pump Replacement or Retrofit	1.0+
HVAC, VAV Conversion	Requires Empirical Study
HVAC, EMS System	Requires Empirical Study
Air Compressor	Requires Empirical Study
Air Distribution System Improvements	Requires Empirical Study
Compact Fluorescent Lighting	1.0

The second study identified five measures with definable TDFs. All five measures had TDFs of 1.0 of greater, indicating no relative degradation compared to standard efficiency equipment. Results actually indicated that the performance of three of these measures would degrade less than standard efficiency equipment. This left six measures from the second study (Table 2) and two measures from the first study (Table 1) requiring empirical assessment.

By agreement of the Persistence Subcommittee, the third study will collect data on the actual performance change of commercial package air conditioners, energy management systems, compressors and compressed air distribution systems for which the first two studies determined that empirical data is necessary.

The results of all of these studies need to be completed by February 1999 for the first retention based earnings claim filing.

Forgotten Specifications

While the drafters of the Protocols made a concerted effort to present a comprehensive persistence study approach, some elements were overlooked. As the utilities attempted to apply the Protocols for the first time, these issues arose and were addressed through CADMAC and it's Persistence Subcommittee. The primary issues that were not easily resolved are (1) sample sizes/precision/study approach and (2) default EUL values for measures not studied under the retention studies.

Sample Sizes/Precision/Study Approach. The Protocols do not define how the studies are to be conducted, how large the samples need to be, or what precision was to be sought. Each utility prepared for the studies in different ways, as will be discussed later, often locking in sample sizes, analysis approaches, and precision in the process. This meant that by the time study approach issues were discussed at the industry-wide level, most utilities were irreversibly committed to the retention approaches they were using.

Default EUL for Measures Not Studied. The Protocols defined the method of determining whether the measured EUL or the forecast (i.e., ex ante) EUL would be used for those measures in the top 10 measures or top 50% of the resource value that were studied. However, the Protocols did not define the EUL values to be used for the measures that represented the remaining resource value. This led to the development of two opposing approaches. Should the ex ante values be used for the non-studied measures? The ex ante EULs are the default for the measures in the top 50% of the resource value if the measures cannot be shown to be different at the 70% confidence level, so why not for the bottom 50% of the resource value. Alternatively, should the values empirically determined for the top 50% be somehow extrapolated to the measures that were not studied?

Both of these issues required discussion and negotiation within CADMAC to arrive at acceptable solutions.

Negotiated Resolution

The two "Forgotten Specifications" mentioned above were resolved through he collaborative process in a combined approach. The issues were presented to the CADMAC coordinating committee for discussion. Each utility agreed to submit a summary of the study approach to be used. The summary included a list of the measures fitting into the "resource value defined by the top ten measures or the top 50% of the resource value, whichever is less", and a list of measures not studied that are similar enough to allow transfer of the realization rates. The summaries permitted identification of the total percent of the resource value covered by studied and "like" measures. These summaries were submitted to one CADMAC member for review and recommendation. The issues were addressed at the CADMAC Persistence Subcommittee level and a consensus recommendation was submitted to CADMAC for approval. That consensus proposal contained the following elements:

- Accept the diverse study approaches,
- Accept the list of "like" measures and transfer the realization rates from the studied measures to the non studied "like" measures if the studied measure EUL values were significantly different than the ex ante values, as defined in the Protocols,
- "Other measures" that are different from the measures included in the retention studies, but within a studied end use, the ex ante measure effective useful life will be adjusted by the average percentage adjustment of all the studied measures within that end use.
- Use the ex ante estimate of EUL for the remaining non-studied measures as the best estimate of EUL for these measures.

This negotiated recommendation will (1) result in a range of different study approaches contributing to the knowledge base on how to conduct this type of study, (2) intelligently use the information derived from the study to maximize the measures covered by the study and (3) use the best existing estimate of EUL for the measures that are not studied.

Table 3 summarizes the resource values covered by the program under the consensus agreement. The ranges in Table 3 result from variation between utilities and among program years covered.

Table 3
Percent of Measures Covered

Program Description	Percent Covered
Commercial Energy Efficiency Incentives	57 - 66
Industrial Energy Efficiency Incentives	57 - 62
Agricultural Energy Efficiency Incentives	57 - 70
Nonresidential New Construction	58 - 100
Residential New Construction	99
Residential AEI – Space Conditioning	61
Residential AEI – Lighting	89 - 100
Residential AEI – Refrigeration	98 - 100
Residential WRI – Space Conditioning	77

By transferring significant EUL values to "like" measures, the resource value covered by the studies increased from about 50% to approximately 70% overall. Additional coverage will be accomplished by transferring the average adjustment to measures that are not studied, but are within studied end uses. This was a compromise accepted by all parties involved because it (1) traded on the known technical associations between the measures and the measure operating conditions in certain applications, (2) transferred an averaged adjustment to other measures in studied end uses, and (3) did not extrapolate adjustments to measures in non studied end uses.

Two additional changes were made to the Protocols to better quantify the measurement of EUL. The definition of EUL was restated to be "*An estimate of the median number of years that the measures installed under the program are still in place and operable.*" This clarified (1) what data needed to be collected in the field, and (2) that the collected retention data was not designed to recalculate the program impact. The second change was a clarification of the statistical language for assessing the difference between the ex ante and ex post EULs. This language was restated as "*If the estimated ex post measure effective useful life is significantly different than the ex ante measure effective useful life, the estimated ex post measure effective useful life will be used to recalculate the Resource Benefits, net. Otherwise, the Resource Benefits, net estimate will continue to use the ex ante measure effective useful life. Hypothesis testing will be conducted at the 20% significance level.*" The adjustment in significance level was intended to strike a better balance between rejection of/default to the ex ante estimate.

The next section discusses the approaches that are being used to measure EUL.

Estimation Approaches and Issues

This section of the paper discusses the general approaches that are being used to estimate the EUL values. There are two main approaches to estimating EUL, with several minor variations on each approach. These approaches can be classified as prospective and retrospective.

Prospective Approach. In the prospective approach the sample size is determined in advance based upon the anticipated failure rate and the study period (i.e., the period in which the desired number of failures must occur). The sample is then visited to establish that the equipment is present. While at the site the equipment is tagged. The sites and equipment are then revisited periodically to establish failure rates and reasons for failure or removal. Once the required number of failures has occurred the EUL can be calculated with a predetermined precision.

This approach has several advantages and disadvantages. It is probably the most statistically rigorous approach in that the sample, failure rates, and precision are defined at the time the study methodology is established. The disadvantages are cost, time, and potential customer alienation. The cost is high because (1) measures with long lives (low failure rate) require large sample sizes to achieve the desired number of failures within the study period, and (2) it is necessary to revisit sites four or five times, with the cost increasing proportional to the number of visits. In addition, the customers, besides potentially being annoyed with the frequent intrusions, may begin refusing to allow visits, leading to significant sample attrition.

Retrospective Approach. The second fundamental approach to estimating EUL is the retrospective approach. In the retrospective approach the site is not visited at regular intervals, but rather is visited at a point in time near when the estimate of EUL is desired (e.g., in year four when the estimate is needed for 5^{th} year retention). This method has the advantage of lower cost because the repeat visits are eliminated. There are two versions of the retrospective study.

The first depends on the participant to remember when and why the equipment was removed from service. This method is much more likely to work with large pieces of equipment or when the customer is intimately connected to the equipment (such as agricultural customers). It is less likely to work in situations such as mass installations of lighting equipment where the customer cannot possibly keep track of individual fixture failure. This approach must attempt to account for the potential tendency of the customers to not remember, remember incorrectly, or adjust their memories of when measures were removed in an attempt to meet their expectations of what the site auditor wants to hear.

The second method does not rely on the customer remembering the time of failure. Instead it assumes a failure function (or survival function) and simply observes the number of failures at the time of the visit, then fits the function to the single data point as determined at the time of the visit, adjusting the function to get the most logical fit. This method obviously depends heavily on choosing the correct survival function. In favor of this method is that in some instances it may be the only practical option (e.g., long life, low failure rate measures).

Measure Life Dependency. An added challenge arises for any method when the participation levels are low for a given measure, especially if the measure life is long. An example is chiller installations. Most programs have a small number of customers who install chillers simply because chiller costs are high and the installation rate of new or replacement chillers in the general population is low. Combine this with the very low failure/removal rates for this measure and none of the methods described here would be expected to work. The failure rate is simply too low and the sample size too small to obtain the number of failures necessary to project an EUL.

Development of Survival Functions

Independent of the approach used to collect the data, translating that data into a projection of the EUL for each measure is a difficult task. As discussed previously, there are two main approaches to this challenge. The first is to assume a functional shape, either based on other information or based on the most appropriate mathematical form, given the data. The second approach employs the trendline capabilities available in several different software packages. Each of these options is discussed below.

Assumed Function Approach. Assuming a mathematical form for the failure function (or survival function, depending on your point of view) is most appropriate when the data gathered supplies insufficient information on the shape of the function. This can occur for several reasons: (1) the data were not collected over time and the only data available are the retention data at one point in time, (2) the data are collected over time but the data are of insufficient precision to allow the development of the survival function using modeling, or (3) the modeled function contradicts classic or intuitive information on the appropriate shape for the model. In any of these cases, it can be appropriate to assume a functional shape for the survival function, then fit the function through the two known data points (year zero/100% and year x/y%) to project the point at which 50% of the measures remain. One potent argument for the choice of the survival function in such cases is that one should begin with the simplest mathematical form, for example an exponential function or a log-likelihood function. The argument is that in the absence of additional information, these functions represent the most likely functional form.

Trendline Software. Several commercial software packages (e.g., Excel, Forecast Pro, SAS) include the capability to estimate functional shapes from time-series datasets. These software packages usually supply the option to assume various mathematical forms (e.g., linear, logarithmic, exponential, polynomial, power, moving average) and also supply basic statistics (depending on the package) such as standard deviation, confidence intervals, and R^2. Each of these forms can be tried with the data set to see which form supplies the best fit to the data, and as a consequence, which form best predicts the EUL for the measure.

The polynomial trendline function was applied to the retrospectively collected data for one agricultural measure (pump retrofit) and resulted in an estimate EUL of 9.6 years compared to the ex ante measure life of 9.0 years. The R^2 for the estimate was 0.84. This shows that the trendline function can supply useful estimates for well-behaved datasets.

Practical Application Issues

Several practical issues arose when trying to follow the Protocols. One of the most significant issues resulted from the initial lack of clarity in the retention portions of the Protocols. Each utility, in a good faith effort to meet the requirements of the Protocols, interpreted the requirements differently. This resulted in several different approaches being taken to the study approach, the collection of baseline data, the collection of retention data, and the computation of the final EUL estimates.

Since the Protocols specified either third or fourth year retention studies (depending on the program sector) many of the issues around when the data should be collected, how it should be collected, and how it should be analyzed, were not addressed until the third or fourth year after the measures were installed. This meant that each utility was fully committed to their methodology and data collection approach by the time Protocol clarity issues came to the surface. The result was at least three distinct approaches to collecting and analyzing data to determine ex post EULs.

Approaches Taken

The following descriptions summarize three utility approaches.

Utility 1. Utility 1 chose to develop a prospective assessment addressing measures representing 80% of the resource value for Energy Efficiency Incentive type measures and covering two program years. This study designed the sample based on assumed measure lives and the anticipated number of failures required to estimate the EUL for each measure. The data collection was designed to span four years. All sites were visited in the first year. During these first visits the equipment was documented and tagged so that the same equipment could be identified later. During subsequent years half of the sites received a site visit and half received a telephone interview, the data collection technique being switched on alternate years. The study includes approximately 850 sites and 1,600 pieces of equipment. At the end of the study the data will be analyzed to estimate EULs for each measure covered. The study acknowledges potential problems estimating EULs for long life/low participation measures. Since the study is very large, the utility anticipates extrapolating the results to other program years.

Utility 2. Utility 2 chose to establish retention panels in year one that consisted of sets of sites where type, number, and location of equipment were documented. This equipment would then be revisited in 1998 covering the 1994 program year for four years after installation and the 1995 program year for three years after installation. The retention data collection includes questions on when equipment was removed. This data collection approach results in two potential outcomes. The first is that the retrospective questions result in data adequate to estimate the EUL, resulting in sound ex post estimates. If the retrospective data does not result in data adequate to estimate EULs, then at least three firm retention data points exist from the inspections in years 1, 3, and 4. With either set of data the first approach to estimating the EULs will be to attempt the use of trendline functions. If these result in nonsensical functional forms, then an assumed functional form will be fitted through the data to estimate EUL values. In either case statistical confidence intervals will be estimated around the EUL estimates.

Utility 3. Utility 3 chose to select sites for retention studies in 1998 using the data collection schedule similar to Utility 2 above. These data will be combined with a standard likelihood function to estimate the EULs and the confidence intervals.
For each of the three utility approaches described above, the general approach described applies to the majority of the programs being evaluated. Each utility has variations and even completely different methods for some programs.

All of these approaches have been reviewed by CADMAC in an attempt, even if retroactively, to develop an overall consensus to the approaches used for estimating the ex post EULs.

The application of three different approaches has advantages and disadvantages. The advantage is that it will potentially be possible to compare the outcomes and shift any future efforts toward the more successful approach. This advantage will probably not come to fruition because of the differences between utility programs, evaluation approach costs, and pre-commitment to current approaches. The disadvantage is that, if the results come out different from utility to utility, it will be difficult to separate whether the differences are real (i.e., related to utility services area/program differences) or are an artifact of the evaluation method.

Conclusions

This paper documented the process that has evolved in California for estimating the EUL and TDF for DSM measures installed under the regulated DSM programs. The Protocols supplied the framework for conducting the assessment, and supplied good definition of criteria for measuring the differences between the studied measures and their ex ante estimates. However the Protocols fell short in terms of the specific detail needed in the early stages of retention assessment design and on whether or how to adjust the non studied measures. The following suggestions may help future retention assessment efforts.

Improvements in Retention Approach Specification

The California Protocols are generally very specific in terms of evaluation definitions. The evolutions of the retention portion of the Protocols - which anecdotally include both the addition of the retention portion late in the process and the exhaustion of the Protocol drafters after completing the impact portions of the Protocols - led to incomplete specification of some portions of the retention studies. Future Protocols should include specifics on:

1. the sample size and precision requirements,
2. the default values for the measures not covered by the studies,
3. the criteria for selection of the approach for estimating ex post EUL.

The final conclusion is that the California collaborative process worked for retention studies. The mechanisms developed over the past five years by the Persistence Subcommittee and the CADMAC steering committee supplied the mechanism to satisfactorily resolve the issues created by the missing specifications. While compromises were made, technical integrity was maintained and a workable solution was found.

Acknowledgements

The authors would like to acknowledge that the work presented here could only have been presented because of the combined efforts of the DSM staff of the California utilities, the members of the CADMAC steering committee, and the CADMAC Persistence Subcommittee. The statements and interpretation of that information are solely those of the authors.

References

1. Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs (Protocols 1996); As adopted by California Public Utilities Commission Decision 93-05-063, Revised January 1997 Pursuant to Decision 94-05-063,94-10-059, 94-12-021, 95-12-054, and 96-12-079.