Customer Energy Efficiency Program
Measurement and Evaluation Program

PACIFIC GAS & ELECTRIC COMPANY
PY94 NONRESIDENTIAL NEW CONSTRUCTION
RETENTION STUDY

PG&E Study ID number: 323 R1

March 1, 1999

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Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission Decision 93-05-063, revised January, 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079.

This study evaluated the retention of electric energy (kWh) and demand (kW) savings from the 1994 and 1996 Nonresidential New Construction (PY94/96 NRNC) programs. In particular, it developed estimates of effective useful life (EUL) and technical degradation factors (TDFs) for savings from the combined PY94/96 NRNC programs.

Methodology

Effective Useful Life Analysis: For each sampled site, data products from the first-year impact evaluation were reviewed to provide a basis for administering a brief telephone survey to identify changes in energy-saving measures at a site. For sites with changes, surveyors carefully reviewed first-year DOE-2 models and arranged an on-site survey. Data collected during this survey supported modification of the as-built DOE-2 models to calculate changes in the first-year estimates of gross kW and kWh savings for each site. For several sites with no reported changes, on-site surveys were performed to confirm the validity of the telephone self-report method.

Once all sites with changes were identified and analyzed, the number and magnitude of the changes to savings were assessed. Since no kWh failures occurred at sites where on-site surveys were conducted, the data were insufficient to support a classic survival analysis. Data also would not support alternative approaches to estimating a program EUL, such as an ordinary least squares regression, adoption of a functional form, or a time-series analysis. Consequently, the ex ante EUL estimate of 16 years was judged to provide the best available figure.

Technical Degradation Factor Analyses: Of the 24 technologies evaluated by the statewide measure performance study, three technologies—metal halide lighting fixtures, energy management systems (EMS), and oversized evaporative condensers for groceries—affected sites in the sample. The first-year evaluation database and DOE-2 models were examined to identify sites with TDF-affected measures. Since the TDFs applied to individual measures, savings for TDF-affected measures were separated from the reported first-year evaluation site-level savings estimates. This was accomplished by modifying the as-built DOE-2 models to reflect the building with the TDF-affected measure removed. Once the savings associated with each measure were calculated, the whole-building TDF was calculated as the ratio of first-year evaluation savings minus TDF effects to first-year savings.

Program-level TDFs were computed as the sample-weighted mean of the whole-building-level TDFs. Combined case weights were applied to the sample, where the weights accounted for both the first-year sample of the program population and our sample of the first-year evaluation participants. Doing so permitted results to be extrapolated from the retention sample of 150 sites to the program population of 861 sites.

Study Results

The absence of any kWh failures among surveyed sites made the estimation of any statistical models impossible. As a result, the ex ante EUL estimate of 16 years was retained as the ex post estimate, as shown in the table below:

PG&E's PY94 Nonresidential New Construction Retention Study
Summary of Ex Post Effective Useful Life Estimates

End Use: Whole building

		EUL		**Upper 80% CL**	**Lower 80% CL**	**EUL for Claim**
Measure Description	**Code**	**Ex Ante**	**Ex Post**	**Ex Post**	**Ex Post**	**-**
Whole building	NA	16 years	16 years	NA	NA	16 years

Program-level TDFs calculated in this study are as follows:

	Program-Level TDF
Demand (kW)	0.986
Energy (kWh)	0.990

Regulatory Waivers and Filing Variances

The evaluation incorporated the adjustments to nonresidential new construction retention study requirements laid out in the waiver titled "Southern California Edison and Pacific Gas & Electric Retroactive Waiver Nonresidential New Construction Program Persistence Studies" (Study ID Numbers 548/554 and 323-R1, approved March 18, 1998).

There are no E-Table variances.

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

This study evaluated the retention of electric energy (kWh) and demand (kW) savings from the 1994 and 1996 Nonresidential New Construction (PY94/96 NRNC) programs. Estimates of retention effects were based upon data collected from program participants via telephone and on-site surveys. This evaluation had five major objectives:

1. Estimate effect of changes to energy-efficiency measures on first-year whole-building savings.
2. Estimate the effective useful life (EUL)[1] of savings for the combined PY94/96 NRNC programs.
3. Calculate whole-building technical degradation factors (TDFs)[2].
4. Calculate program-level TDFs for the combined PY94/96 NRNC programs.
5. Create databases containing the results of this study.

Completing these objectives allows Pacific Gas and Electric (PG&E) to calculate net resource benefits to support their third earnings claim, as specified by the California Public Utilities Commission Protocols.

Background

PG&E has offered programs to its nonresidential customers that provide financial incentives for adopting efficiency measures and design features that reduce electric consumption and demand in new construction projects. PG&E paid out incentives for a total of 861 sites under the Prescriptive and Performance Programs NRNC programs during 1994 and 1996. PG&E subsequently hired consultants to perform first-year impact evaluations of these programs. These estimated ex post savings at the "whole building" level, where the term "whole building" refers to a building or collection of buildings at a site. These whole-building-level results were then extrapolated to the program, yielding program-level estimates of first-year gross and net savings. These estimates, and the information collected to develop them, formed the basis for this evaluation.

Results

The disposition of the analysis sample frame, along with the results of the analyses, is summarized below. The methods described in the next section were used to estimate effective useful life and the effect of technical degradation factors for the PY94/96 NRNC programs.

Sample Disposition

The first-year impact evaluations of the PY94/96 NRNC programs estimated ex post savings for a total of 228 participant sites. Out of the population of 861 program participant sites, these 228 that received detailed analysis comprised the sample frame for this retention study. Since no other studies similar to

[1] EUL is defined as the amount of time that elapses until half of the whole-building level savings achieved by the NRNC program have failed.

[2] TDFs are numbers that account for time- and use-related changes in the energy savings of a high efficiency measure or practice, relative to a standard efficiency measure or practice.

this had been completed, and the CPUC Protocols did not specify a required sample size, a sample size of 150 was selected. These 150 accounted for over 85% of the gross savings from the first-year impact study.

We were able to administer a telephone survey successfully for 150 of the 151 sites we contacted, a success rate of 99.3%. The one site that refused to participate accounted for only about 0.1% of the unweighted first-year gross savings. The 150 telephone surveys that were successfully completed led to a total of nine sites for which we attempted to set up on-site surveys. We were able to complete on-site surveys for all nine of these sites.

Effective Useful Life

The 150 telephone surveys revealed possible changes to whole-building savings at five sites. At two of these sites, on-site surveys and subsequent analysis resulted in no changes to savings. At the other three sites, the customer upgraded to higher-efficiency lighting, increasing whole-building savings. Overall, the changes at these sites resulted in increases of 0.01% and 0.02% of the unweighted program kW and kWh ex post gross savings, respectively. We did not learn of any failures—at the kWh, measure, or whole building levels--among the 150 surveyed sites.

Originally, we intended to use the calculated changes at sites with kWh failures to develop a statistical model to estimate EUL. The EUL for the program is defined as the amount of time that elapses until half of the program savings have failed. The absence of any kWh failures made the estimation of any statistical models impossible. Ex ante and ex post EULs are shown in Table 1.

Technical Degradation

In the sample of 150 sites, we applied measure-specific TDFs to a total of 78 sites. TDFs account for degradation in high efficiency measure performance resulting in a reduction (or in some cases, improvement) in energy savings, relative to a standard efficiency measure. This degradation was quantified for each measure in the statewide measure performance studies (References 9, 10, & 11). These studies addressed three technologies applicable to our sample with TDFs not equal to 1. The technologies and number of sites affected are as follows: 55 sites with energy savings from metal halide lighting fixtures, 20 sites with energy management systems (EMS), and 18 sites with oversized evaporative condensers. For sites with metal halides, EMS, and oversized condensers, first-year gross savings decreased because of technical degradation by about 0.9%, 2.9%, and 0.6%, respectively.

Figure 1 summarizes the results of the whole-building-level TDF analysis. About 48% of sites had 1998 TDFs of 1.00, indicating that no technical degradation occurred. Among the remaining sites, TDF-affected measures had only small effects on whole-building TDFs. Only about 7% of the latter fell outside of the range 0.95 – 1.00. In several cases, the whole-building TDFs exceeded 1.00. This occurred because the first-year evaluation estimated negative savings, and the measure-level TDFs caused the savings to become even more negative.

A program-level TDF was computed for both demand and energy by applying the combined case weights to the whole-building-level TDFs. These TDFs represent the fraction of the first-year savings estimates that remained in 1998. The computed values are presented in Table 2.

Figure 1: Frequency Distribution for Whole-Building Technical Degradation Factors

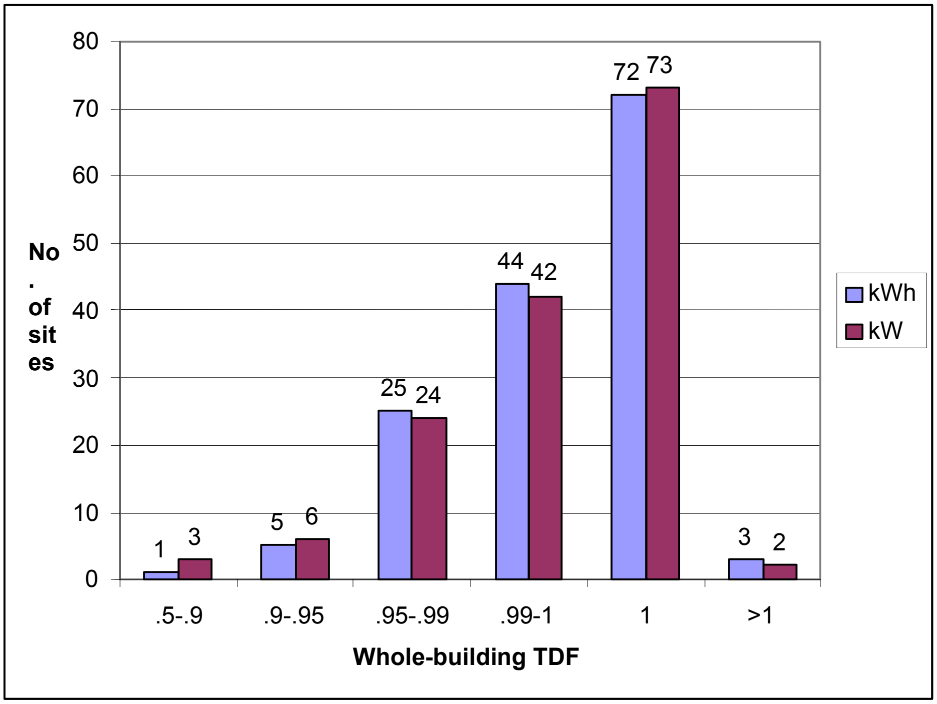


Table 1: Ex Post Effective Useful Life Estimates

End Use: Whole building

		EUL		Upper 80% CL	Lower 80% CL	EUL for Claim
Measure Description	**Code**	**Ex Ante**	**Ex Post**	**Ex Post**	**Ex Post**	**-**
Whole building	NA	16 years	16 years	NA	NA	16 years

Table 2: Program-Level Technical Degradation Factors

	Program-Level TDF
Demand (kW)	0.986
Energy (kWh)	0.990

Methodology

EUL Analysis

For each sampled site, we reviewed data products from the first-year impact evaluation. This information provided a basis for administering a brief telephone survey to identify changes in energy-saving measures at a site. For sites with changes, surveyors carefully reviewed first-year DOE-2 models and arranged an on-site survey. Data collected during this survey allowed us to modify the as-built DOE-2 models to calculate changes in the first-year estimates of gross kW and kWh savings for each site. For several sites with no reported changes, on-site surveys were performed to confirm the validity of the telephone self-report method.

Once we identified and analyzed all sites with changes, we examined the data in the site evaluation database and assessed the number and magnitude of the changes to savings. Since we found no kWh failures at sites where we conducted an on-site survey, the data were insufficient to support a classic survival analysis. The latter uses data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end point. Data also would not support alternative approaches to estimating a program EUL, such as an ordinary least squares regression, adoption of a functional form, or a time-series analysis.

TDF Analyses

Of the 24 technologies for which measure-level TDFs were developed by the statewide measure performance study, three technologies--metal halide lighting fixtures, energy management systems (EMS), and oversized evaporative condensers for groceries—affected sites in our sample. We examined the first-year evaluation database and DOE-2 models to identify sites with TDF-affected measures. Since the TDFs applied to individual measures, we separated savings for TDF-affected measures from the reported first-year evaluation site-level savings estimates. To accomplish this, we modified the as-built DOE-2 models to reflect the building with the TDF-affected measure removed. Once the savings associated with each measure were calculated, the whole-building TDF was calculated as the ratio of first-year evaluation savings minus TDF effects to first-year savings.

Program-level TDFs were computed as the sample-weighted mean of the whole-building-level TDFs. We applied new combined case weights to our sample, where these weights accounted for both the first-year sample of the program population and our sample of the first-year evaluation participants. Doing so permitted us to extrapolate results from our retention sample of 150 sites to the program population of 861 sites.

Implications

The lack of kWh failures detected in the study sample leads us to conclude that:

- The ex ante whole-building EUL of 16 years provides the best available estimate.
- Program kWh failures, rather than occurring steadily and gradually from the outset in so-called exponential decay, may in fact approach zero for a number of years, then increase dramatically for a short period. The latter is commonly referred to as a logistic survival curve.
- Evaluating retention in the fourth year is premature for NRNC programs.

In addition, the very high program-level TDFs indicate that:

- Technical degradation of energy efficiency measures has a minimal impact on program savings.

1. Introduction

1.1 Background

Pacific Gas and Electric (PG&E) has offered programs to its nonresidential customers that provide financial incentives, in the form of rebates, for adopting efficiency measures and design features that reduce electric consumption and demand in new construction projects. PG&E paid out incentives for a total of 861 sites under the 1994 and 1996 Nonresidential New Construction programs (referred to hereinafter as the "PY94/96 NRNC" programs). Although incentives were paid during those two years, rebates were authorized for these sites during the program years 1993 through 1996. Key end uses affected by the programs include motors, lighting, HVAC (heating, ventilation, and air conditioning), refrigeration (in groceries and warehouses), and the building shell (including glazing and insulation).

The Nonresidential New Construction Program was available to all owners, developers, and contractors of buildings, refrigerated warehouses, or industrial processes who used PG&E power for the completed facility. The Program applied to new facilities of any size. Major rehabilitation and renovation projects were also included, where entire lighting or mechanical systems were replaced and building permits were required. Buildings were required to exceed either the 1992 or 1995 California Title 24 Energy Efficiency Standards (Title 24), depending on which applied. PG&E offered participants two program options for demonstrating compliance. Each is described below:

> *Prescriptive Program*: This program applied to new construction projects using the prescriptive method of compliance with Title 24. Incentives were offered for a wide range of technologies, including lighting and HVAC. The target market for the Prescriptive Program was primarily Title 24 occupancies, such as large and small offices and non-food retail stores. Grocery stores, schools, warehouses and industrial customers installing new process systems also participated. For measures and industrial processes that are not regulated by Title 24, the program required that the measure exceed required industry standards.
>
> *Performance Program*: This program targeted projects using the performance method of compliance. These projects were generally larger and more complex than those using the prescriptive method for Title 24 compliance. The target market was commercial buildings of any size, but primarily Title 24 occupancies. Certain specialized building types were also included, such as: controlled-atmosphere warehouses, food and beverage distribution centers, industrial refrigeration plants, food processing plants, refrigerated packing sheds, winery process refrigeration, and refrigeration plant expansions where new refrigeration load was added. Specialized manufacturing plants and industrial processes were also included, such as biotech, pharmaceutical, semiconductor, and automobile plants, as well as water- and wastewater treatment and food processing plants.

PG&E subsequently hired consultants to perform first-year impact evaluations of the PY94/96 NRNC programs (References 12 & 13). These estimated ex post savings at the "whole building" level, where the term "whole building" refers to a building or collection of buildings at a site. These whole-building-level savings estimates consisted of the combined impacts of one or more energy efficiency measures at the site, both rebated and unrebated. Whole-building-level results were then extrapolated to the program, yielding program-level estimates of gross and net savings. The latter provided a basis for calculating the net resource benefits of the PY94/96 NRNC programs.

1.2 Evaluation Research Objectives

This report presents the methodology and results from our evaluation to determine the long-term retention of electric energy (kWh) and demand (kW) savings from the PY94/96 NRNC programs. This evaluation estimated the impact of kWh failures[3] on whole-building savings since the first-year impact evaluations were conducted. It also determined the effect of statewide technical degradation factors (TDFs) on first-year ex post savings estimates.

For this study, *effective useful life* (EUL) is defined as the amount of time that elapses until half of the whole-building-level savings achieved by the PY94/96 NRNC programs have failed. A *technical degradation factor* (TDF) is defined as a scalar to account for time- and use-related change in the energy savings of a high efficiency measure relative to a standard efficiency measure. Both of these concepts are discussed in more detail in Section 6 (Analysis Methods).The objectives of this study are summarized as follows:

1. Estimate Changes in Whole-Building Savings: Estimate the change in whole-building kWh and kW savings at each point in time when energy efficiency measures suffer kWh failure for any of the buildings included in the first-year impact studies of the PY94/96 NRNC programs.
2. Determine Program EUL: Estimate the EUL of savings applicable to the PY94/96 NRNC programs based on savings reductions caused by kWh failures.
3. Calculate Whole-building TDFs: Estimate the change in whole-building kWh and kW savings associated with the statewide TDFs for energy efficiency measures installed in the buildings included in the first-year impact studies of the PY94/96 NRNC programs.
4. Calculate Program TDFs: Estimate TDFs applicable to the PY94/96 NRNC programs.
5. Create Evaluation Databases: Provide fully-documented databases containing the results of this study.

1.3 M&E Protocol Compliance

Accomplishing the objectives listed above allows PG&E to calculate net resource benefits for the PY94/96 NRNC program, according to the following formula:

Net resource benefit = (First-year net impact) × (Program-level EUL) × (Program-level TDF)

This retention study complies with the CPUC-adopted statewide measurement and evaluation Protocols[4] for ex post measurement of program savings. It also adheres to the conditions of the joint waiver filed by

[3] A kWh failure occurs when a change to one or more measures at a site reduces associated whole-building energy savings. kWh failure can occur in both removal and replacement situations, e.g., when lighting fixtures are removed, or where efficient compressors are replaced with less-efficient models. In both cases, the whole building energy savings would be reduced. In the extreme cases where all equipment related to a particular measure is removed, or all measures at a site are removed, then the kWh failure also constitutes measure failure and whole-building failure, respectively.

[4] Protocols is used throughout this report as a shortened designation for the "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission in May 1993 and most recently revised in January 1997 (Reference 1).

PG&E and Southern California Edison concerning NRNC program savings retention studies. Both the relevant Protocols and the joint waiver are referenced in greater detail in Section 6.2. Appendix G (M&E Protocol Information) contains the entire text of the joint waiver.

1.4 Summary of Contents

This report consists of nine sections, including this introductory section and executive summary preceding it. The contents of each of these nine sections is briefly summarized below:

Executive Summary: Summarizes key findings of the evaluation, as well as the evaluation methodology.

Section 1 – Introduction: Includes a brief discussion of PG&E programs, evaluation research objectives, and M&E protocol compliance.

Section 2 – Overview of Research Design: Provides a summary of key elements of our research approach, including the methodology for both the EUL and TDF analyses, sources of data and methods for collecting them, and sampling strategy.

Section 3 – Evaluation Results: Contains detailed write-ups of the findings of both the EUL and TDF analyses.

Section 4 – Sample Design: Discusses how we developed the sample frame and selected the evaluation sample. It also presents our strategy for selecting replacement sites.

Section 5 –Data Collection: Describes our approaches for collecting telephone and on-site survey data collected as part of this evaluation.

Section 6 – Analysis Methods: Explains in detail all aspects of the evaluation methodology, beginning with clear definitions of units of analysis and our compliance with CPUC Protocols. The section then lays out each aspect of the EUL and TDF analyses.

Section 7 – Conclusions and Recommendations: Provides suggestions for improving future retention studies.

Section 8 – References: Lists key sources of information, techniques, and guidelines used in this evaluation.

The report also contains seven appendices. These include, among other things, survey instruments, lists of evaluated sites, database documentation, and Protocol compliance information.

2. Overview of Study Approach

This section of the report summarizes our approach and findings, and refers the reader to subsequent sections for additional details and explanation. This overview also summarizes the results, sampling strategy, data collection, analysis methods, and conclusions/recommendations for the evaluation.

The overall approach to meeting the study objectives is shown in Figure 2-1. More detailed discussion of each step is provided in Section 5 (Data Collection) and Section 6 (Analysis Methods). The first step was to review existing data, Next, we performed parallel analyses to estimate TDFs and changes in whole-building-level savings. In both cases, we modified the DOE-2 models developed during the first-year impact evaluations to reestimate whole-building energy savings. Finally, we used the analysis results to estimate program-level EUL and TDFs. This methodology, along with the corresponding data sources and sampling plan, is summarized in more detail below.

2.1 Evaluation Methodology

2.1.1 Review Existing Data

The four major sources of existing data to support this evaluation were:

1. First-Year Evaluation Databases
2. First-Year Evaluation Paper Files
3. First-Year Evaluation DOE-2 Models
4. Statewide TDF Studies

The first three sources contain data collected during the first-year evaluations. This included information on site and company contacts, building systems and layouts, and savings estimates. These data were important for administering telephone and on-site surveys, and subsequently for modifying the DOE-2 models to support the EUL and TDF analyses. The fourth data source, the Statewide TDF Studies (References 9, 10, & 11), provided the measure-level TDFs necessary to calculate whole-building TDFs.

2.1.2 EUL Analysis

It was important for the EUL analysis to develop precise definitions of the terms as they related to whole-building savings. The final agreed-upon definitions are as follows:

> Change: A whole-building *change* occurs when original energy-saving equipment is modified or replaced. This change may affect: (1) the entire building, e.g., a demolition, (2) a specific portion of the building, e.g., conversion of a warehouse area into office spaces, (3) a building system, e.g., a complete lighting system change out, or (4) a portion of a system, e.g., replacing an efficient motor with another unit. These modifications, replacements, or removals can cause energy savings to increase, decrease, or stay the same.
>
> Change in Savings: When a *change* occurs to one or more measures at a site, then the whole-building savings associated with the site may or may not be affected. If, for instance, a *change* occurs to a motor measure so that it is replaced with a lower-efficiency model, then the *change in savings* would be negative. It is also possible, however, for a *change* to yield no *change in*

savings, as when, for example, lighting ballasts are replaced with ones with the same make, model, and performance. *Changes in savings* can also be positive, for example, if a rebated refrigeration compressor is replaced with a higher-efficiency unit.

Failure: *Failure* occurs when a *change*, as defined above, results in decreased savings, or a negative *change in savings*. For this evaluation, failure can occur at three levels, as follows:

kWh failure: Occurs when a *change* to one or more measures at a site reduces associated whole-building energy savings. kWh failure can occur in both removal and replacement situations, e.g., when lighting fixtures are removed, or where efficient compressors are replaced with less-efficient models. In both cases, the whole building energy savings would be reduced. In the extreme cases where all equipment related to a particular measure is removed, or all measures at a site are removed, then the *kWh failure* also constitutes *measure failure* and *whole-building failure*, respectively. All of the techniques for statistical analysis of effective useful life proposed for this study concern themselves only with *kWh failure*.

Measure failure: Occurs when a *change* to a particular measure at a site eliminates all associated energy savings. For example, if all rebated efficient motors at a site were removed and not replaced, *measure failure* would have occurred for the efficient motor measure.

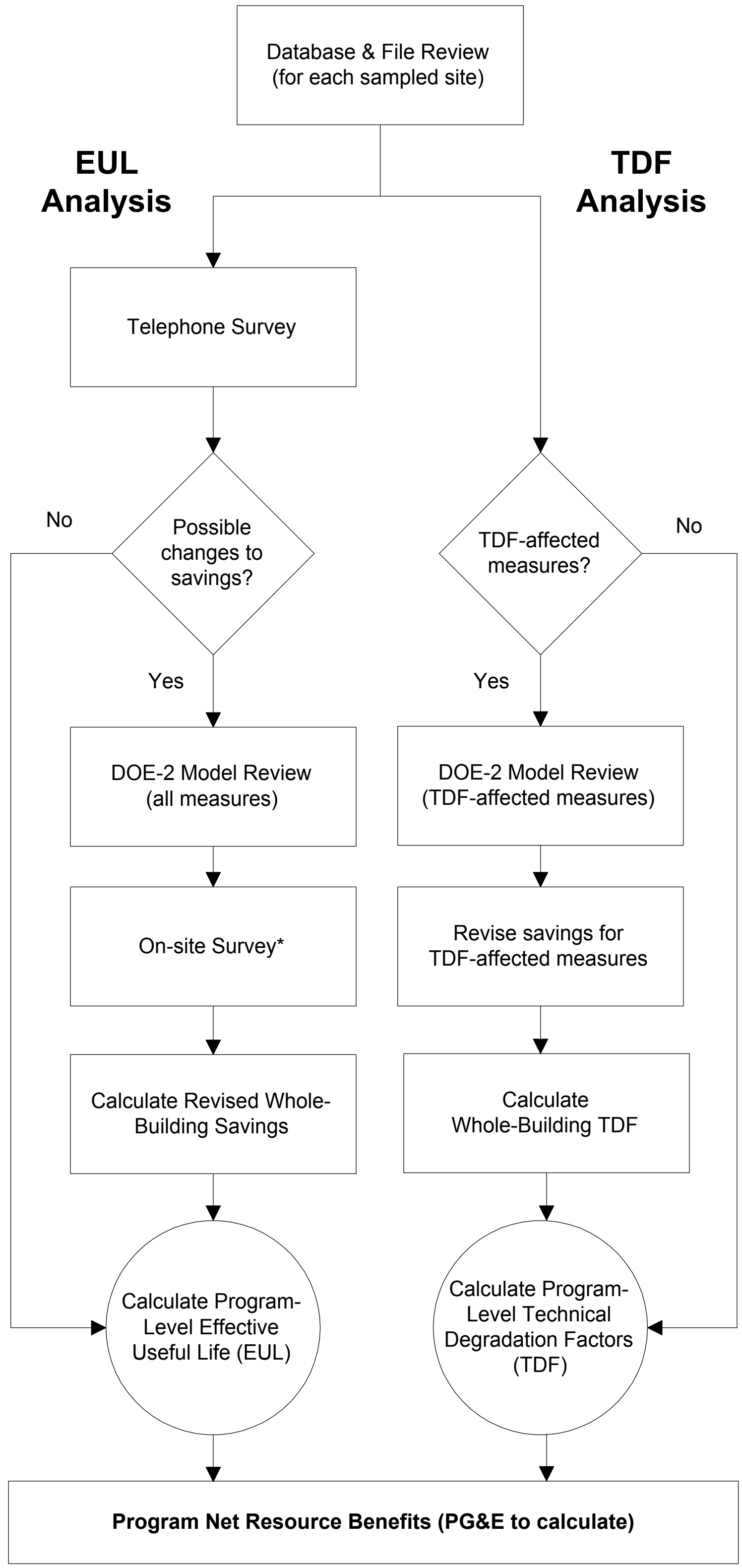
Whole-building failure: Occurs when there is measure failure for all measures at a site. For example, if an industrial facility is demolished, then all measures at the site have failed, and the whole building has failed from an energy savings perspective.

The major tasks associated with the EUL analysis are as follows:

Conduct Telephone Surveys/DOE-2 Model Review

The purpose of the telephone survey was to first recruit evaluation participants, then collect the information from them needed to determine whether changes occurred in energy efficiency measures installed by program participants. For each sampled site, we reviewed first-year evaluation database entries and paper files to become familiar with general aspects of the facility, including first-year savings for each end use. This information provided a basis for surveyors to administer a brief telephone survey to identify changes in measures at a site. For sites with changes, surveyors carefully reviewed first-year DOE-2 models and if necessary, determined whether the change was "significant" (where "significant" meant greater than 10% of the installed measure capacity had failed). Because the telephone survey revealed no significant changes, we ultimately arranged for an on-site survey at all sites with changes.

Figure 2-1: Summary of Evaluation Work Flow



*Also performed at four sites with no changes to verify telephone survey self-reports

On-Site Survey

For all sites with changes, we administered an on-site survey. The purpose of this survey was to collect specific observations of the changes to key measure parameters, such as the number of units or rated efficiencies. These observations permitted us to modify the first-year DOE-2 models to reflect changes to equipment, and subsequently calculate changes in whole-building savings. For four sites with no changes reported in the telephone survey, we performed on-site surveys to confirm the validity of the telephone self-report method.

Calculate Revised Whole-Building Savings

Data collected during the on-site survey allowed us to modify the as-built DOE-2 models to reestimate ex post gross savings to account for the changes to measures. We then calculated changes from the first-year estimates of gross kW and kWh savings for each site. Section 3.1.1 documents the results of this task.

Calculate Program-Level EUL

Once we identified and analyzed all changed measures at the sampled sites, we examined the data in the site evaluation database and assessed the number and magnitude of the changes to savings. Since we found no kWh failures at sites where we conducted an on-site survey, the data were insufficient to support a classic survival analysis. The latter uses data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end point. Data also would not support alternative approaches to estimating a program EUL, such as an ordinary least squares regression, adoption of a functional form, or a time-series analysis. Consequently, we concluded that the ex ante EUL estimate of 16 years provides the best available figure. Section 3.1.2 documents the results of this task.

2.1.3 TDF Analyses

TDF-Affected Measures

Of the 24 technologies evaluated by the statewide measure performance studies (References 9, 10, & 11), three technologies--metal halide lighting fixtures, energy management systems (EMS), and oversized evaporative condensers for groceries—affected sites in our sample. These studies provided a 20-year stream of TDFs for each measure. We used the Year 2 and Year 4 TDFs for our analyses under this study.

DOE-2 Model Review/TDF Measures

We examined the first-year evaluation database and DOE-2 models to identify sites with TDF-affected measures. Since the TDFs applied to individual measures, we separated savings for TDF-affected measures from the reported first-year evaluation site-level savings estimates. To accomplish this, we modified the as-built DOE-2 models to reflect the building with the TDF-affected measure removed.

Revise Savings for TDF Measures/Calculate Whole-Building TDF

The annual energy consumption and non-coincident peak demand differences between the first-year evaluation as-built DOE-2 model output and the modified as-built model output (with the TDF measure removed) provided the savings associated with the specific TDF measure at the site. Once the savings associated with each measure were calculated, the whole-building TDF for each site was calculated as the ratio of first-year evaluation savings minus TDF effects to first-year savings. Sections 3.2.1 and 3.2.2 document results for this task.

Calculate Program-Level TDF

Program-level TDFs were computed as the sample-weighted mean of the whole-building-level TDFs. We applied new combined case weights to our sample. These weights accounted for both the first-year sample of the program population and our sample of the first-year evaluation participants. Doing so permitted us to extrapolate results from our retention sample of 150 sites to the program population of 861 sites. *Section 3.2.3 documents results for this task.*

2.2 Final Database

The final database consists of critical identifying variables for linking back to the first-year impact evaluation, information collected during the telephone and on-site surveys, measure-level and whole-building-level analysis results, and weights used to extrapolate retention sample results to the program population. We also provide hard copy site files containing telephone surveys, contact logs, and field notes, as well as electronic site files containing key analysis components, such as modified DOE-2 models and TDF calculation spreadsheets.

The data described above contains all information necessary to conduct future retention studies, plus all information necessary to reproduce the results of this evaluation.

Table 2-1: Participant Sample Design

	Number of Sites			**Sample Weights***	**% of Ex Post Savings****	
Retention Study Stratum	Program Population (estimate)	First-Year Impact Evaluation Sample	Retention Sample	Retention to First-year	kWh	kW
1	536	102	49	2.082	2.4	3.3
2	158	45	32	1.406	8.4	9.9
3	73	32	20	1.600	10.7	9.2
9	94	49	49	1.000	66.6	63.0
All	**861**	**228**	**150**	**--**	**88.1**	**85.4**

* For simplicity's sake, only the four sample weights to extrapolate retention sample results to the first-year evaluation sample are shown. The 10 weights used to extrapolate first-year evaluation sample results to the program population span the retention evaluation strata. Multiplying these 10 weights by the 4 other weights on a site-by-site basis yields a total of 32 combined case weights that extrapolate the retention sample to the program population.
** Based on unweighted totals for 1994 & 1996 combined.

2.3 Sampling Plan

The first-year impact evaluations of the PY94/96 NRNC programs estimated ex post savings for a total of 228 participant sites. Out of the population of 861 program participant sites, only these 228 received the detailed analysis necessary to create site-specific DOE-2 models. These DOE-2 models and accompanying data were essential for quantifying changes to savings resulting from equipment modifications and technical degradation for our retention study. Consequently, they comprised the sample frame for this evaluation.

For the effective useful life analysis, the required sample size depended on the number of kWh failures observed. At the time we were developing our sample, no other studies similar to this had been completed, and the Protocols did not specify a required sample size. Given these uncertainties, a sample size of 150 was selected. This sample was a large fraction (66%) of all the 228 sites evaluated in the first-year impact study.

We selected our sample of 150 sites using commonly-used statistical methods first to define four strata from which to select, then to specify the percentage of sites within each stratum to be randomly chosen. These methods minimize the relative error of the ex post estimates of kWh savings, thus maximizing how representative our sample is of the sample frame.

We ultimately defined four strata, including a certainty stratum consisting of the 49 sites with the highest savings. The 150 sampled sites account for over 85% of both ex post kW and kWh savings. Using case weights that combine the weights developed for this study, as well as those from the first-year impact evaluation, we extrapolated the results from these 150 sites to the program population.

Table 2-1 shows the sample design. We replaced sites that refused to participate with randomly-selected replacement sites within the corresponding sample stratum, until we completed the required number of surveys within each stratum. See Section 4 for more details on the sampling plan and sample disposition.

3. Evaluation Results

This section of the report describes the results of our evaluation of both effective useful life and the effects of technical degradation factors.

Section 3.1 (Effective Useful Life Analysis) first details the impact of whole-building changes on gross savings estimates. It then discusses the implications of our finding that savings have not diminished since energy-saving equipment was installed, in particular specifying the appropriate EUL to use, based on the data.

Section 3.2 (Technical Degradation Factor Analysis) presents detailed results of the TDF analysis. It first provides the whole-building-level savings impacts for each of the three TDF-affected measures. It then discusses overall results for the 150 sampled sites, and concludes with an explanation of program-level TDFs.

3.1 Effective Useful Life Analysis

3.1.1 Savings Impacts of Changes

This section discusses the results of our analysis of data gathered from the 150 telephone surveys and nine on-site surveys that were successfully completed. This analysis quantified the effect that changes to measures had on gross savings. Table 3-1 summarizes analysis results for the nine sites where on-site surveys were performed. These sites include five where the telephone survey indicated possible measure changes, and four more sites chosen to confirm that no changes occurred. Overall, these nine sites accounted for 5.8% and 5.9% of the unweighted first-year database ex post gross savings.

The nine sites that received on-site surveys can be divided into three groups:

1. Changes that affect savings. The first three lines in Table 3-1 correspond to the three sites where the telephone survey first revealed possible changes, and the on-site survey confirmed the changes. The changes at these sites were all similar: fluorescent lighting fixtures where lamps and/or ballasts had been replaced with more efficient T-8 lamps and/or electronic ballasts. These upgrades to higher-efficiency lighting resulted in positive changes to savings for all three sites, that is, current lighting at each site uses less energy than that in place during the first-year savings evaluation. These changes, therefore, did not result in kWh failure.

   For all three sites, lighting savings comprised a significant portion of the first-year site-level savings. Lighting kW savings for the three sites combined accounted for 56% of total kW savings for the three sites, and lighting kWh savings made up 77% of total kWh savings for the three sites.

   These three sites account for 2.7% and 2.6% of the total first-year database ex post kW and kWh gross savings, respectively. The increases in site-level (whole building) savings range from 0.3% to 0.6% of the original site-level ex post kW savings, and 0.4% to 0.9% of the kWh savings. Across all nine sites that received on-site surveys, kW and kWh savings estimates increased by 0.3% and 0.5%, respectively, because of these changes.

Table 3-1: Summary of On-Site Survey Results

Change?	Change in savings?	kWh Failure?	Measure failure?	Whole building failure?	Site ID	Description of Changes Found by Telephone Survey	Description of Changes Found by On-site Survey	% first-year database ex post savings kW	% first-year database ex post savings kWh	% change in savings estimate kW	% change in savings estimate kWh
x	x				7179	80 lighting fixtures relamped with T-8s.	Confirmed telephone survey findings.	2.0%	2.0%	0.4%	0.7%
x	x				7323	Lighting fixtures for ~5,000 sq. feet (about 5% of floor area) relamped with T-8s.	Confirmed telephone survey findings.	0.6%	0.5%	0.3%	0.4%
x	x				43	10 lighting fixtures relamped with T-8s and electronic ballasts.	Confirmed telephone survey findings.	0.1%	0.1%	0.6%	0.9%
x					343	32 fluorescent ballasts replaced (type and make unknown)	Ballasts replaced with identical types and makes.	0.6%	0.5%	-	-
x					400	125-hp refrigeration compressor replaced (make and efficiency unknown)	Efficiency of new compressor same as old one.	0.4%	0.2%	-	-
					197	None	None	0.6%	0.9%	-	-
					340	None	None	0.6%	0.8%	-	-
					397	None	None	0.6%	0.5%	-	-
					352	None	None	0.4%	0.3%	-	-
TOTALS FOR ALL ON-SITE SURVEYS:								**5.8%**	**5.9%**	**0.3%**	**0.5%**

2. <u>Changes that did not affect savings</u>. The fourth and fifth rows in Table 3-1 show results for the two sites where the telephone survey indicated potential changes, but the on-site survey determined that the changes had no effect on savings. In the first case, fluorescent ballasts had failed and were replaced with identical units. In the second case, a refrigeration compressor was replaced with one of a different make, but with the same capacity and efficiency. These two sites account for 1.0% and 0.7% of the total first-year database ex post kW and kWh gross savings, respectively.

3. <u>No changes</u>. The last four rows in Table 3-1 list the four larger sites where the on-site survey confirmed the telephone survey findings that no changes occurred. These sites were chosen to test whether the self-report method of determining changes was producing reasonably accurate results. These four sites accounted for 2.2% and 2.5% of total first-year database ex post kW and kWh gross savings, respectively.

Note that in all nine cases, the on-site surveys did not uncover any additional changes not first discovered during the telephone surveys. We also did not learn of any failures—at the kWh, measure, or whole building levels--among the 150 surveyed sites. Overall, the changes at these nine sites resulted in increases of 0.01% and 0.02% of the unweighted program kW and kWh ex post gross savings, respectively

3.1.2 Implications of Survey Results

The fact that the analysis of the savings impact of changes estimated no kWh failures affects three key elements of the retention study: 1) the *ex ante* EUL, 2) the functional form of the survival curve, and 3) the timing of the retention study. Each will be discussed below.

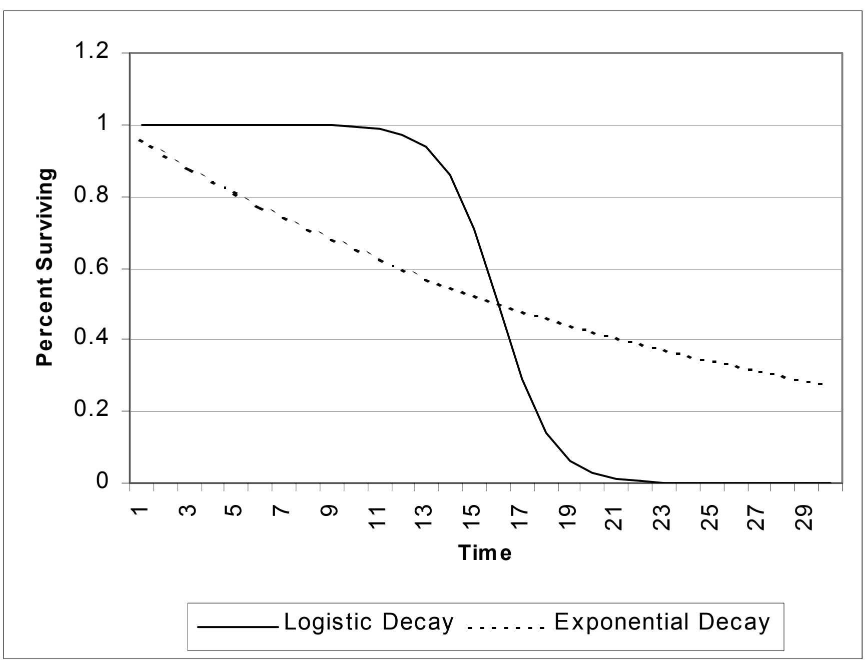
1) Acceptance of Ex Ante EUL

Given that there were no failures in the sample, the *ex ante* whole-building EUL of 16 years cannot be rejected. We therefore recommend that the ex ante EUL be adopted as the ex post EUL for calculating net resource benefits for PG&E's third earnings claim.

2) Functional Form of Survival Curve

The fact that the observed data contained no kWh failures is not consistent with the exponential survival function. These data appear to be more consistent with the logistic survival curve. Assuming that the ex ante EUL of 16 years was correct and that the functional form of the decay was exponential, we would had to have found approximately 16% of the sample kWh to have failed. Instead, zero kWh failures were found. This is graphically illustrated in Figure 3-1, which compares the exponential and logistic functional forms..

Figure 3-1: Effective Useful Life Functional Forms



3) The Timing of the Retention Study

It seems clear that for new construction programs, the fourth-year retention studies were premature. Requiring eighth-year and twelfth-year retention studies instead of fourth-year and ninth-year retention studies would very likely have provided more useful information for hypothesis testing in the new construction arena.

3.2 Technical Degradation Factor Analysis

The TDF analysis methodology described in Section 6.4 of this report was successfully applied to all sampled sites. We applied TDFs to:

- 55 sites with energy savings from metal halide lighting fixtures.
- 20 sites with energy savings from energy management systems (EMS).
- 18 sites with energy savings from oversized evaporative condensers.

Of the 78 sites with TDF-affected measures, 15 contained multiple TDF-affected measures. The 72 remaining sampled sites without TDF-affected measures were assigned a TDF of 1, indicating no degradation.

For kW savings, we used non-coincident annual peak demand savings for both program years. This provides a consistent basis for use in the PG&E E-tables.

3.2.1 Measure-Level Analysis

The specific results obtained for each of the three TDF-affected measures are described below.

Metal Halide Lighting Fixtures

Tables 3-2A and 3-2B present the TDF impacts of the metal halide lighting fixture measure. The tables are sorted in descending order by kWh TDF for each program year. A total of 55 sites—20 in 1994, and 35 in 1996—had metal halide fixtures installed. TDFs for this measure reduced 1994 first-year kWh and kW gross savings by 1.3%, and 1996 kW and kWh savings by 0.7% and 0.6%, respectively. Overall, program kWh and kW gross savings decreased by 0.8% and 0.9%, respectively, because of metal halide technical degradation.

Although the TDFs adjusted measure savings by a constant ±4%, the estimated whole-building savings that metal halides accounted for varied substantially from site to site. In some cases very few metal halides were installed relative to the entire lighting inventory, such that only a small quantity of savings were attributed to the metal halides. Other sites were predominantly lit by metal halides. However, the quantity of metal halide fixtures installed was not necessarily proportional to the magnitude of TDF-affected savings. Some sites were lit predominantly by metal halides, but the as-built lighting power density of the individual spaces was not substantially lower than the Title-24 requirements, so the savings estimates were low. In twelve instances, the metal halide fixtures were installed in spaces that exceeded the allowable Title-24 requirements, resulting in negative savings due to the measure. Sites with negative savings are flagged in the third column of Tables 3-2A and 3-2B.

The percent savings reduction attributable to metal halide technical degradation varied significantly from site to site as well. Across the program, the percent reduction in kWh savings ranged from 4.4% to –10.0% (the latter represents an increase in savings of 10%). The corresponding percent reduction in kW savings ranged from 4.0% to –10.2%.

Table 3-2A: TDF Impacts of the Metal Halide Fixture Measure

		MH measure resulted in negative savings (kW or kWh)	First Year Evaluation Whole Building Savings Estimates		% Savings Reduction*	
Year	Site ID		kWh	kW**	kWh	kW**
1994	7383		88,534	32.69	4.4	3.8
	7152		241,550	119.31	4.4	3.5
	7344		41,333	11.89	4.2	4.0
	7156		214,902	82.45	3.8	3.6
	7248		374,179	103.03	3.7	3.2
	7301		509,694	107.38	3.7	2.8
	7295		196,590	60.35	3.6	3.7
	7304		277,366	81.20	3.5	3.6
	7237		51,198	8.28	1.7	2.1
	7267	Yes	9,169	7.85	1.0	0.3
	7260		164,623	28.99	0.9	0.8
	7388	Yes	166,731	26.04	0.8	1.0
	7240	Yes	19,948	9.17	0.6	0.2
	7182		214,014	26.82	0.3	0.5
	7360		118,266	29.41	0.2	0.2
	7201		178,027	58.04	0.2	0.2
	7157		1,050,087	336.36	0.1	0.1
	7367	Yes	564,317	317.78	0.0	0.0
	7271		571,076	96.69	0.0	0.0
	7434		933,198	56.02	0.0	0.0
1994 Total			**5,984,802**	**1,599.74**	**1.3**	**1.3**

* TDFs of 0.96 (for positive savings) and 1.04 (for negative savings) were applied to metal halide savings for Year 4 for 1994 sites and Year 2 for 1996 sites.
** Based on non-coincident peak annual demand.

Table 3-2B: TDF Impacts of the Metal Halide Lighting Fixture Measure (continued)

		MH measure resulted in negative savings (kW or kWh)	First Year Evaluation Whole Building Savings Estimates		% Savings Reduction*	
Year	Site ID		kWh	kW**	kWh	kW**
1996	204		652,619	106.75	4.0	3.9
	97		14,917	6.88	3.9	3.9
	132		63,620	19.62	3.8	3.7
	343		363,553	103.93	3.5	3.3
	377		47,873	12.24	3.5	3.5
	331		198,089	44.37	3.2	2.7
	352		239,517	58.53	3.0	2.2
	359		337,214	50.35	3.0	3.1
	184		289,079	87.11	2.8	2.2
	277		1,044,806	127.87	2.0	1.8
	260		129,578	24.77	1.9	2.0
	178		158,928	43.43	0.5	0.2
	226		545,224	119.04	0.4	0.4
	336		269,448	68.51	0.3	0.3
	187	Yes	592,718	130.14	0.2	0.2
	281		652,087	192.08	0.2	0.2
	388		46,482	15.94	0.1	0.1
	212		633,982	59.95	0.1	0.2
	194	Yes	194,584	43.14	0.1	0.1
	340		583,083	99.18	0.1	0.1
	197		685,363	105.04	0.1	0.0
	120		421,633	43.06	0.1	0.1
	222		2,869,470	570.15	0.0	0.0
	386		36,077	10.33	0.0	0.0
	155		787,538	70.31	0.0	0.1
	317	Yes	188,486	79.43	0.0	0.0
	358	Yes	75,323	44.97	0.0	0.0
	294	Yes	618,185	136.45	0.0	0.0
	205		1,280,140	225.77	0.0	0.0
	389		210,398	74.52	0.0	0.0
	198		617,420	72.30	0.0	0.0
	390	Yes	1,966,476	291.74	0.0	0.0
	144		-7,019	-22.63	-0.4	0.0
	76	Yes	-2,869	-0.46	-7.1	-10.2
	171	Yes	-9,787	22.43	-10.0	0.8
1996 Total			**16,794,235**	**3,137**	**0.7**	**0.6**
Total for all affected sites			**22,779,037**	**4,737**	**0.8**	**0.9**

* TDFs of 0.96 (for positive savings) and 1.04 (for negative savings) were applied to metal halide savings for Year 4 for 1994 sites and Year 2 for 1996 sites.
** Based on non-coincident peak annual demand.

Energy Management System

Table 3-3 presents the TDF impacts of the energy management system (EMS) measure. The table is sorted in descending order by kWh TDF for each program year. A total of 20 sites—10 each in 1994 and 1996—claimed savings from this measure. TDFs for this measure reduced 1994 first-year kWh and kW gross savings by 5.1% and 5.8%, respectively. They reduced 1996 kWh and kW savings by 0.5% and 2.0%, respectively. Overall, program kWh and kW gross savings decreased by 2.4% and 3.4%, respectively, because of EMS technical degradation.

The estimated savings due to the EMS measures varied substantially from site to site. In 14 cases, the EMS resulted in negative savings estimates. In many of these cases, the modeled EMS feature was an optimal start control for the HVAC equipment. Optimal start controls allow HVAC equipment to turn on earlier in the day, if necessary, to reach the desired setpoint temperatures. While this feature creates a more comfortable environment for the occupants, it also can increase energy consumption, resulting in negative energy savings.

The TDF degradation percentages are much higher for the EMS measure than for any of the other measures discussed here. At Year 2 and Year 4, EMS savings degrade by 20% and 60%, respectively (refer to Table 6-1 for a complete listing of measure-level TDFs). For sites with negative EMS savings (indicated in the third column of Table 3-3), the savings increase by 20% or 60%. According to the Statewide Measure Performance Studies that form the basis for estimating TDFs, EMS measures often degrade dramatically in the first few years after installation, primarily because the systems are particularly vulnerable to human error, poor operations and maintenance practices, and sensor failure.

The percent savings reduction attributable to EMS technical degradation varied significantly from site to site as well. Across the program, the percent reduction in kWh savings ranged from zero to 34.8%. The corresponding percent reduction in kW savings ranged from zero to 42.4%.

Oversized Evaporative Condensers for Groceries

Table 3-4 presents the TDF impacts of the oversized evaporative condenser measure in grocery applications. The table is sorted in descending order by kWh TDF. All 18 sites with this measure participated in 1996 and yielded positive savings. The savings associated with the measure varied slightly from site to site. The Year 2 TDF of 0.98 for this measure reduced the combined first-year kWh and kW gross savings for the 18 sites by 0.6%. Across the program, the percent reduction in kWh savings per site ranged from 0.4% to 1.2%. The corresponding percent reduction in kW savings per site ranged from 0.3% to 1.3%.

Table 3-3: TDF Impacts of the Energy Management System Measure

		EMS measure resulted in negative savings (kW or kWh)	First Year Evaluation Whole Building Savings Estimates		% Savings Reduction*	
Year	Site ID		kWh	kW**	kWh	kW**
1994	7389		234,245	51.14	34.8	13.2
	7179		1,478,067	183.11	7.5	1.9
	7383	Yes	88,534	32.69	4.5	4.1
	7203	Yes	55,908	13.80	3.7	42.4
	7394	Yes	334,599	92.05	3.4	7.9
	7248	Yes	374,179	103.03	2.1	6.6
	7369	Yes	474,760	128.67	2.1	16.3
	7262		403,470	236.57	1.3	0.0
	7201	Yes	178,027	58.04	0.3	5.1
	7434	Yes	933,198	56.02	0.1	0.0
1994 Total			**4,554,987**	**955.12**	**5.1**	**5.8**
	235		157,860	211.65	8.9	0.0
	48	Yes	41,072	37.12	6.2	3.9
	221	Yes	350,065	53.70	0.6	0.1
	246		632,239	307.01	0.5	2.5
	226	Yes	545,224	119.04	0.4	1.9
	250		957,228	323.40	0.3	1.7
	390	Yes	1,966,476	291.74	0.3	0.0
	281	Yes	652,087	192.08	0.2	5.8
	263	Yes	813,202	99.28	0.1	0.0
	344	Yes	565,828	76.48	0.0	7.8
1996 Total			**6,681,280**	**1,711.50**	**0.5**	**2.0**
Total for all affected sites			**11,236,267**	**2,666.62**	**2.4**	**3.4**

* Year 4 TDFs of 0.40 (for positive savings) and 1.60 (for negative savings) were applied to the EMS savings for 1994 sites. Year 2 TDFs of 0.80 (for positive savings) and 1.20 (for negative savings) were used for 1996 sites.
** Based on non-coincident peak annual demand.

Table 3-4: TDF Impacts of the Oversized Evaporative Condensers Measure

		First Year Evaluation Whole Building Savings Estimates		% Savings Reduction*	
Year	Site ID	kWh	kW**	kWh	kW**
1994	(no 1994 sites had oversized evaporative condenser measures)				
1996	155	787,538	70.31	0.4	0.6
	197	685,363	105.04	0.5	0.4
	198	617,420	72.30	0.5	0.6
	212	633,982	59.95	0.4	0.4
	213	595,476	73.41	0.7	0.7
	221	350,065	53.70	0.6	0.5
	239	708,166	76.04	0.5	0.5
	243	704,777	86.09	0.6	0.5
	262	881,184	102.72	0.7	0.6
	263	813,202	99.28	0.5	0.6
	268	891,711	110.42	0.8	0.7
	273	278,584	41.58	1.2	1.3
	299	490,155	60.75	0.9	0.7
	312	420,067	48.83	0.5	0.4
	335	587,726	84.61	0.5	0.3
	339	287,738	25.48	0.4	0.3
	340	583,083	99.18	0.6	0.7
	344	565,828	76.48	0.6	0.7
Total for all affected sites		**10,882,062**	**1,346.15**	**0.6**	**0.6**

* A Year 2 TDF of 0.98 were applied to grocery oversized evaporative condenser savings for 1996 sites.

** Based on non-coincident peak annual demand.

3.2.2 Whole-Building-Level Analysis

Figure 3-2 summarizes the results of the whole-building-level TDF analysis for the 150 sampled sites in this evaluation. Almost half of the sites (48% for kW, 49% for kWh) had 1998 TDFs of one, indicating that no technical degradation occurred. Although 78 sites had TDF-affected measures, in nearly all of these cases, their effect on the whole-building TDF was minimal. Of the 150 sites, only 9 sites (6%) had kWh TDFs that fell outside of the range 0.95 – 1.00. A total of 11 sites (7.3%) had kW TDFs outside of the range.

Tables 3-5A and 3-5B provide a detailed listing of whole-building-level kW and kWh TDFs for each of the 78 sites in the sample that were impacted by either metal halides, EMS, or oversized evaporative condensers in groceries. The listing is sorted in descending order by kWh TDF for each program year. For the remaining 72 sites in the sample of 150 that were not impacted by any of these measures, the whole-building-level kW and kWh TDFs are 1.0.

In the majority of the sites with TDF-affected measures, the whole-building-level TDFs ranged between 0.95 and 1.0, indicating that the technical degradation factors had a very small impact on the total building savings estimates. Several outlier cases, however, deserve some explanation.

Figure 3-2: Frequency Distribution for Whole-Building Technical Degradation Factors

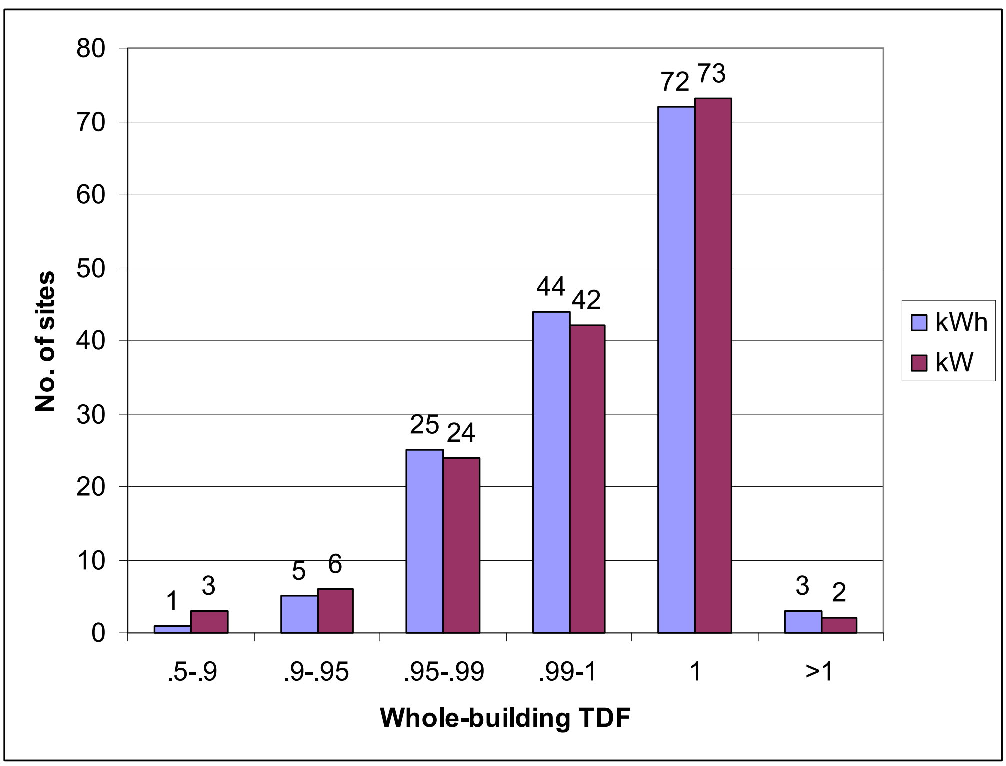


Table 3-5A: Whole-Building Technical Degradation Factors

		TDF Affected Measures *			Whole Building TDF **		
Year	Site ID	MH	EMS	OEC	kWh	kW***	Outlier
1994	7152	X			0.956	0.965	
	7156	X			0.962	0.964	
	7157	X			0.999	0.999	
	7179		X		0.925	0.981	
	7182	X			0.997	0.995	
	7201	X	X		0.995	0.947	
	7203		X		0.963	0.576	X
	7237	X			0.983	0.979	
	7240	X			0.994	0.998	
	7248	X	X		0.942	0.903	
	7260	X			0.991	0.992	
	7262		X		0.987	1.000	
	7267	X			0.990	0.997	
	7271	X			1.000	1.000	
	7295	X			0.964	0.963	
	7301	X			0.963	0.972	
	7304	X			0.965	0.964	
	7344	X			0.958	0.960	
	7360	X			0.998	0.998	
	7367	X			1.000	1.000	
	7369		X		0.979	0.837	X
	7383	X	X		0.911	0.921	
	7388	X			0.992	0.990	
	7389		X		0.652	0.868	X
	7394		X		0.966	0.921	
	7434	X	X		0.999	1.000	
1994 Savings Weighted Average:					0.965	0.967	

MH = metal halide lighting fixture; EMS = energy management system; OEC =
ersized evaporative condenser for groceries.
Reported TDFs occur in Year 4 for PY94 and Year 2 for PY96.
Based on non-coincident peak annual demand.

Table 3-5B: Whole-Building Technical Degradation Factors (continued)

		TDF Affected Measures *			Whole Building TDF **		
Year	Site ID	MH	EMS	OEC	kWh	kW***	Outlier
1996	48		X		0.938	0.961	
	76	X			1.071	1.102	X
	97	X			0.961	0.961	
	120	X			0.999	0.999	
	132	X			0.962	0.963	
	144	X			1.004	1.000	X
	155	X		X	0.995	0.994	
	171	X			1.100	0.992	X
	178	X			0.995	0.998	
	184	X			0.972	0.978	
	187	X			0.998	0.998	
	194	X			0.999	0.999	
	197	X		X	0.995	0.996	
	198	X		X	0.995	0.994	
	204	X			0.960	0.961	
	205	X			1.000	1.000	
	212	X		X	0.995	0.994	
	213			X	0.993	0.993	
	221		X	X	0.988	0.994	
	222	X			1.000	1.000	
	226	X	X		0.992	0.977	
	235		X		0.911	1.000	
	239			X	0.995	0.995	
	243			X	0.994	0.995	
	246		X		0.995	0.975	
	250		X		0.997	0.983	
	260	X			0.981	0.980	
	262			X	0.993	0.994	
	263		X	X	0.994	0.994	
	268			X	0.992	0.993	
	273			X	0.988	0.987	
	277	X			0.980	0.982	
	281	X	X		0.996	0.940	
	294	X			1.000	1.000	
	299			X	0.991	0.993	
	312			X	0.995	0.996	
	317	X			1.000	1.000	
	331	X			0.968	0.973	
	335			X	0.995	0.997	
	336	X			0.997	0.997	
	339			X	0.996	0.997	
	340	X		X	0.993	0.992	
	343	X			0.965	0.967	
	344		X	X	0.994	0.915	
	352	X			0.970	0.978	
	358	X			1.000	1.000	
	359	X			0.970	0.969	
	377	X			0.965	0.965	
	386	X			1.000	1.000	
	388	X			0.999	0.999	
	389	X			1.000	1.000	
	390	X	X		0.997	1.000	
1996 Savings Weighted Average:					0.992	0.987	
All Sites Savings Weighted Average					0.985	0.981	

MH = metal halide lighting fixture; EMS = energy management system; OEC = ersized evaporative condenser for groceries.
Reported TDFs occur in Year 4 for PY94 and Year 2 for PY96.
` Based on non-coincident peak annual demand.

Three of the 1994 sites had whole-building TDFs under 0.90 for kWh and/or kW. It is significant that for all three of these sites, the TDF measure was an EMS. As mentioned earlier, the EMS measures accounted for a wide range of savings from site to site. The various functions of an EMS can result in both positive and negative energy savings. Additionally, the TDFs degrade the savings associated with energy management systems by 60% in the fourth year. Detailed results for each of the three sites are provided below:

> Site 7203: The EMS features modeled for this site resulted in estimated demand savings of -9.75 kW. At the four-year point, with the TDF of 1.60 applied, the predicted savings drops to -15.60 kW. The total building first-year demand savings were estimated at 13.80 kW. The whole-building kW TDF at Year 4 was calculated to be 0.576.
>
> Site 7369: Similar to Site 7203, the EMS at this site yielded negative savings, although they were not as significant, compared to the positive savings of the other measures. The whole-building kW TDF was calculated to be 0.837.
>
> Site 7389: This site's characteristics differed from Site 7203, but also yielded a very low whole-building kWh TDF. The EMS measure resulted in positive first-year savings of 135,682 kWh, which is 58% of the whole-building first-year savings estimate of 234,245 kWh. At Year 4, 60% of the savings due to the EMS were lost. The whole-building kWh TDF was calculated to be 0.652.

Three of the 1996 sites (76, 144, and 171) resulted in whole-building TDFs that were greater than one. This does not mean, however, that savings estimates in Year 2 will be higher than those from the first-year evaluation. In all three cases, the first-year evaluation estimated negative total building savings. Applying the measure-level TDF caused the savings to become even more negative in Year 2.

The savings-weighted averages of the whole building TDF across all of the sampled sites affected by the TDF measures were 0.985 and 0.981 for kWh and kW, respectively. The 1.5% and 1.9% reductions in kWh and kW savings, respectively, demonstrate that the technical degradation of the measures does not significantly affect the first-year energy savings estimates.

3.2.3 Program-Level Analysis

A program-level TDF was computed for both demand (kW) and energy (kWh) as the sample-weighted mean of the corresponding whole-building-level TDFs. The combined case weights for this evaluation was used to extrapolate the results from the sample of 150 sites in this evaluation to the program population of 861 sites. The computed values are presented in the table below.

The values listed here are based on the whole building TDFs calculated for the year 1998, which corresponds to Year 4 for 1994 sites, and Year 2 for 1996 sites. From a program perspective, TDFs had little impact on first-year gross savings estimates. The kW TDF of 0.986 and kWh TDF of 0.990 indicate that the first-year evaluation estimates of program savings do not decrease significantly after measure-level technical degradation factors are applied. Note that these numbers are quite similar to the savings-weighted average for 150 evaluated sites (0.981 for kW, 0.985 for kWh). This shows that extrapolating sample results to the program population did not change the value of the TDF significantly.

Table 3-6: Program-Level Technical Degradation Factors

	Program-Level TDF
Demand (kW)	0.986
Energy (kWh)	0.990

4. Sample Design

4.1 Sample Frame

The 228 participant sites included in the first-year impact evaluations comprised the sample frame for this evaluation. Development of this sample frame began with a detailed examination of the databases and final reports for the PY94/96 NRNC first-year impact evaluations. Overall, PG&E paid out incentives to 469 sites in the 1994 program, and 392 in the 1996 program, for a total of 861 participant sites. The first-year evaluations involved performing on-site surveys and estimating ex post savings for 89 of these sites in 1994, and 139 sites in 1996, for a total of 228 evaluated sites. The results from these sites, extrapolated up to the program population, yielded ex post energy savings of 165,320 MWh and ex post demand savings of 39.6 MW.

4.2 Sample Selection and Stratification

Appendix F (Survival Analysis Methodology) discusses in detail our original approach for the effective useful life analysis. For this analysis, the sample size required for this study was a function of the number of observed measure failures. If similar studies had been completed at the time we developed the sample, we could have used their findings to estimate the number of failures to be expected and thus the size of the required sample. However, this is one of the first studies of its kind for new construction rebate programs. Furthermore, the Protocols do not specify a required sample size. Given these uncertainties, a sample size of 150 was selected. This sample was a large fraction of all the cases evaluated in the first-year impact study, and it could be achieved even with a significant number of building owners refusing to participate in the study.

We first examined the sample design for the 1994 and 1996 first-year impact evaluations. The strata boundaries and sample weights for each year were significantly different. To create the best possible sample of 150, we calculated new strata boundaries and sampling fractions using standard statistical techniques to optimize the sample. The objective of the optimization was to minimize the relative error of the ex post estimates of kWh savings. This process entailed the following steps:

1. <u>Order sites by savings</u>: We first ranked each of the 228 sites in the sample frame in descending order by ex post kWh savings.

2. <u>Define certainty stratum</u>: Next, we defined a certainty stratum (Stratum 9) consisting of the 49 sites with the highest savings. These sites had a probability of one, i.e., certainty, of being selected for the sample. Their inclusion reduces the relative error of the sample. Case weights for sites in this stratum were equal to one.

3. <u>Define other strata</u>: The remaining 179 sites were assigned to three non-certainty strata, using the Dalenius and Hodges method (from Cochran, Reference 2). This technique yields strata boundaries at equal intervals of the cumulative sum of the square root of the ex post kWh savings.

4. <u>Determine sampling fractions</u>: Finally, we needed to determine the sampling fraction in each stratum, i.e., the ratio of the number of sampled sites to the total number of sites in the stratum. We used a Neyman allocation (from Cochran, Reference 2) to determine an optimum sampling fraction for each stratum. We oversampled in each stratum to allow for replacements. Case weights for sites in these strata are simply equal to the reciprocal of the sampling fraction.

Table 4-1 shows our final sample design, broken down by retention study stratum. The 150 sites in the retention sample make up a large percentage of the 228 sites in the sample frame. In fact, they account for over 85% of both ex post kW and kWh savings.

Extrapolating results for the 150 sampled sites to the population of 861 sites required that we calculate a combined case weight, consisting of the original first-year impact evaluation case weight multiplied by the new case weight. The new weight allows one to expand the new retention sample of 150 up to the original sample of 228, and the original weight allows one to expand the original sample of 228 up to the original population of 861. The combined case weight, in turn, allows one to expand the new retention sample to the original population. For simplicity's sake, only the four new case weights, rather than the 32 combined case weights, are shown in Table 4-1.

Table 4-2 provides an analysis of final sample performance. It compares the population estimates of kWh and kW savings in the sample of 150 sites to the final program totals. The population estimates are the sums of the sampled savings, multiplied by their respective combined case weights. Because of the error inherent in sampling, the population estimates do not equal the program totals.

The relative error shown in the table provides another measure of sample performance. Relative error is calculated using standard statistical measures, such as variances and means, and provides an indicator of the level of confidence one can have that the sample closely approximates the population. The relative error for both kWh and kW savings is small, 1.3% and 2.7% for kWh and kW, respectively, at the 90% confidence level.

4.3 Replacements

For non-certainty strata (Strata 1-3), we replaced sites that refused to participate in the survey with other randomly-selected sites within the corresponding sample stratum, until we completed the required number of surveys within each stratum. In the certainty stratum (Stratum 9), we completed a census of all sites.

4.4 Sample Disposition

We were able to administer the telephone survey successfully in nearly all cases. A total of 150 of 151 sites we contacted agreed to complete the survey, a success rate of 99.3%. The one site that refused to participate (Site No. 7169) was in Stratum 1, the stratum that contained sites with the smallest ex post gross savings. The respondent for the refusing site explained that they had recently started at the organization and thus had no time for the survey, and in addition, felt that no one there had sufficient knowledge of past efficiency measures. Site No. 7169 accounted for 0.11% of the unweighted ex post kWh gross savings kWh and 0.15% of the kW savings.

Site No. 7169 was subsequently replaced with Site No. 7254. Doing so had an insignificant effect on the evaluated percentage of ex post savings and sample performance shown in the research plan for this evaluation (Reference 15). Tables 4-1 and 4-2 below show actual sample disposition. The only noticeable changes between the actual sample and the proposed sample shown in the research plan are (a) an increase of 0.1% in the Stratum 1 percentage of ex post kW savings in Table 6-1, and (b) changes of +0.05% and –0.3%, respectively, in the population estimates of ex post kWh and kW savings in Table 6-2. These changes occur solely because of savings differences between the one site that refused to participate and its replacement.

The 150 telephone surveys that we successfully completed led to a total of nine sites for which we attempted to set up on-site surveys. We were able to complete on-site surveys for all nine of these sites, for a success rate of 100%.

Table 4-1: Final Participant Sample

	Number of Sites			Sample Weights*	% of Ex Post Savings**	
Retention Study Stratum	Program Population (estimate)	First-Year Impact Evaluation Sample	Retention Sample	Retention to First-year	kWh	kW
1	536	102	49	2.082	2.4	3.3
2	158	45	32	1.406	8.4	9.9
3	73	32	20	1.600	10.7	9.2
9	94	49	49	1.000	66.6	63.0
All	**861**	**228**	**150**	**--**	**88.1**	**85.4**

* For simplicity's sake, only the four sample weights to extrapolate retention sample results to the first-year evaluation sample are shown. The 10 weights used to extrapolate first-year evaluation sample results to the program population span the retention evaluation strata. Multiplying these 10 weights by the 4 other weights on a site-by-site basis yields a total of 32 combined case weights that extrapolate the retention sample to the program population.
** Based on unweighted totals for 1994 & 1996 combined.

Table 4-2: Final Sample Performance

	Ex post savings	
	kWh	kW
1994/96 program total	165,318,863	39,551
Population estimate*	169,797,666	39,158
Relative error at 90% confidence interval	1.3%	2.7%

* Equal to the weighted sum of savings for sampled sites. Note that because of sampling error, this sum does not equal the program total.

5. Data Collection

This section describes the two sources of data collected specifically for this evaluation, the telephone and on-site surveys, and how each was used in the EUL and TDF analyses. The manner in which we administered these surveys is described in detail in this section. Existing data sources are discussed separately in Appendix C (Data Sources).

5.1 Telephone Survey Approach

The telephone survey served several purposes: (1) to recruit previously-evaluated customers to participate in this evaluation, (2) to collect the information needed to determine whether substantial changes occurred in energy efficiency measures installed by program participants, and (3) to obtain the names and phone numbers of other appropriate customer contacts.

Figure 5-1 displays a flowchart showing the work flow for the telephone survey. The steps depicted in the flowchart are described in detail in Sections 5.1.2 through 5.1.6 below. The survey instrument, along with detailed instructions for telephone surveyors, is provided in Appendix B (Telephone Survey Instrument).

5.1.1 Survey Instrument Development and Testing

The telephone survey instrument was developed as part of the research plan for this evaluation. It was pre-tested on five sites to ensure that the most appropriate respondent was being surveyed and that the proper information was being collected. Results from the pre-test were used to fine-tune the methodology for recruiting and surveying respondents. The pretest showed the telephone survey to be fairly easy to administer, and revealed two minor changes that were subsequently made to improve the survey methodology: (1) carefully checking site addresses in the paperwork and databases prior to contacting customers to determine the exact facility in question, and (2) asking the customer contact about additional authorizing and on-site contacts after, rather than before, asking about changes to program measures.

5.1.2 Site Assignment

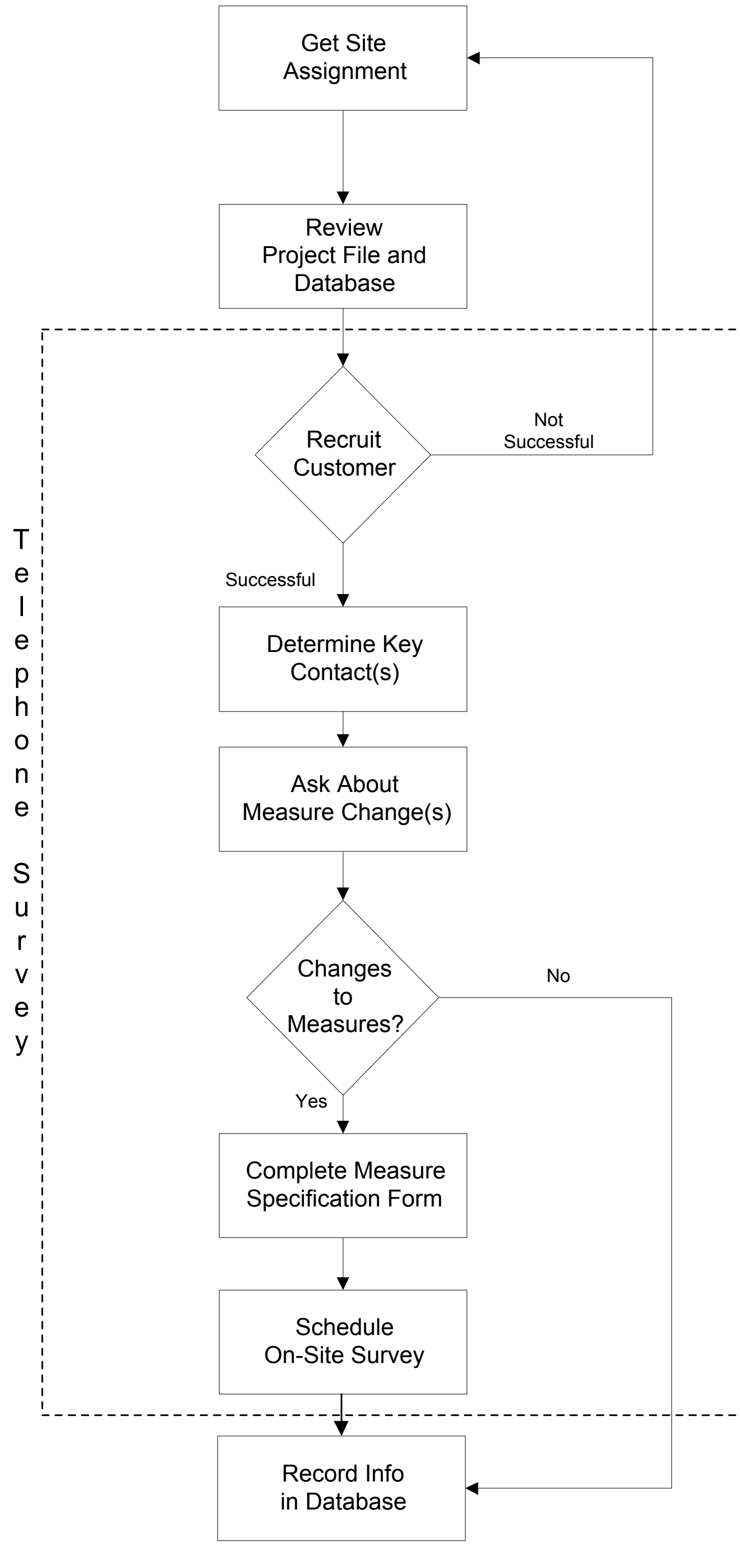
A site assignment coordinator on our team assigned each site to a telephone surveyor. The surveyor received a project file that contained the following items:

- **PG&E Project Documentation.** A copy of relevant site documentation from the first-year evaluation.

- **Contact Log.** A form for recording contact names and the results of significant communications with the customer or PG&E Representative. Contact log procedures are provided in Appendix D (Measurement Specification Form and Contact Log).

- **1994/96 Measure Specification Form**. A form that documented important information for the site. The top portion of the form was pre-filled with important savings, characteristics, and program information from the first-year savings evaluation database. The bottom of the form was reserved for information about both rebated and non-rebated measures. A copy of this form can be found in Appendix D (Measurement Specification Form and Contact Log).

Figure 5-1: Summary of Telephone Survey Work Flow



5.1.3 Recruitment

The first step in administering the telephone survey was recruiting the customer to participate. The telephone surveyor first called the site contact listed on the Measurement Specification Form, explained the purpose of the survey, and asked the contact to participate in the study. At least six attempts were made to contact each customer. If these attempts were unsuccessful, we sent a letter to the customer on PG&E letterhead explaining the purpose of the evaluation and emphasizing the importance of their participation. The surveyor made additional attempts to recruit the customer until it was clear that the customer was unwilling to participate. If the site did not participate, a randomly selected replacement site was assigned and recruitment continued. Surveyors followed the customer contact procedures found in the Customer Contact Plan (from the research plan for this evaluation) during recruitment and all other downstream activities that involved interacting with the customer. The site assignment coordinator was informed of customers that refused to participate.

A full description of recruitment results can be found in Section 4.4 (Sample Disposition).

5.1.4 Preparation for Telephone Survey

Before administering the telephone survey, we prepared a database summary for each site on the top portion of the 1994/96 Measure Specification Form to identify the building systems (HVAC, Lighting, Motors, Refrigeration, Building Shell) for which gross savings were estimated in the first-year evaluation. This summary provided estimates of first-year gross savings for each of the building systems at the site, as well as descriptions of affected energy systems and efficiency measures to discuss with the customer. The top portion of the Measure Specification Form was also pre-filled with important site information from the database summary.

The bottom portion of the form contained measure-specific information. For sites with HVAC or refrigeration measures, we prefilled the bottom of the form before the telephone survey. If HVAC or refrigeration gross savings were not equal to zero, then a senior engineer reviewed the first-year DOE-2 models prior to site assignment to identify HVAC (including EMS) and refrigeration measures included in the first-year impact evaluation. The engineer then summarized the nature of these measures at the bottom of this form. Because of the complexity of many industrial HVAC and refrigeration systems, having such information before the telephone survey allowed telephone surveyors to ask targeted, more effective questions of respondents, such as "Did you make any changes to the two refrigeration compressors serving Warehouse A?," rather than a general query, such as "Did you change your refrigeration systems?"

We did not prefill the bottom of the Measurement Specification Form for other end uses, since lighting, motor, and shell measures generally were much less complex. For measures in these end uses, the telephone surveyor documented the measure and any changes to it at the conclusion of the telephone survey. In all cases, the surveyor carefully reviewed all information on the form before administering the survey.

5.1.5 Administration of Telephone Survey

Surveyors administered the telephone survey by following the instructions on the survey instrument. The customer was asked for the names and phone numbers of the people who would best know of changes to particular building systems, as well as those able to authorize a site visit and schedule the on-site survey, if necessary. If the initial contact was familiar with one or more of the building systems, that person was asked to describe any changes to those systems. As necessary, other contacts were asked for information about changes to all applicable end uses. If the respondent reported a significant change, when it was immediately obvious that the change influenced savings by more than 10%, then the surveyor was allowed to schedule an on-site survey right away to collect additional information about changes.

5.1.6 Documentation of Telephone Survey

After administering the survey, we recorded the data collected during the survey in the survey database. The contact name, date surveyed, surveyor initials, and other pertinent information were recorded on the contact log.

5.2 On-site Survey Approach

On-site surveys were conducted for several reasons: (1) to confirm and collect additional information for detailed analysis on measure changes learned of during the telephone survey, (2) to determine if changes occurred to energy systems beyond energy efficiency measures and affected end uses identified in the first-year impact evaluation, and (3) to confirm that no changes occurred at sites where respondents had stated none took place.

We conducted on-site surveys at:

(a) Five sites where respondents reported changes to measures in the telephone survey. For the changed measures, the survey collected the data necessary to re-estimate gross savings and establish the statistical model for the EUL analysis.

(b) Four sites that reported no changes. These sites were selected from among those with larger first-year savings to test the validity of the self-report method of data collection used in the telephone survey.

The survey procedures for these two categories of on-site survey are described in detail below.

Survey of Sites with Change

Prior to visiting a site with a changed measure, the field surveyor first determined all measures included in the first-year evaluation. This was done by identifying all end uses at the site with non-zero first-year gross savings, then examining the corresponding first-year DOE-2 model parametric runs and performing file comparisons to identify differences in the models that accounted for the gross savings estimates. As much as possible, fields on the Measure Specification Form were filled for each measure included in the first-year evaluation. Our team also printed out relevant tables, forms, or database extracts to help find and assess measures in the field.

The field surveyor then made another call to the appropriate contact identified in the telephone survey and set an appointment for a site visit. In some cases, this contact was the same as the telephone survey respondent. Once on-site, the surveyor asked the site contact about all first-year measures, even if they had already asked the contact about them during the telephone survey. The surveyor inspected all measures, if possible, to uncover any additional changes. For any measure changes discovered , they also documented all information necessary to modify the DOE-2 model to reflect the change, such as revised efficiencies, capacities, square footages, or unit counts. Forms containing this information were placed in the project file for the site.

Survey of Sites with No Change

We identified changes to the program measures solely using self-report information provided by the respondent. The accuracy of the measure status information supplied by the respondent was verified only in cases where the survey detected a change. In these cases, the subsequent on-site survey covered all program measures, regardless of the degree of reported change. However, when no changes were reported at a site, we could not perform an on-site verification of data accuracy. These cases presented no way to account for measurement error associated with respondents' incomplete memory or an unwillingness to reveal questionable operation of a program measure. Although the surveyors always made sure that they discussed measure status with the most knowledgeable contact at each site, there was no means of assessing the accuracy of the information that they provided.

Initially, we assumed that the number of reported changes would be significant, requiring many site visits. If this occurred, there would be sufficient verification of unchanged measures to assess the adequacy of the self-report method. However, upon learning that the number of reported changes would be very small, and that no kWh failures were reported, the adequacy of the method became a concern. To address this issue, field surveyors collected additional on-site data at four sites that reported no change, using the same data collection methodology described in Section 5.2.1 above.

Additional on-site surveys would have been performed had these four on-site surveys revealed either unreported changes or discrepancies in telephone survey respondent's descriptions of changes.

6. Analysis Methods

This section of the report discusses our approach for satisfying the first four evaluation research objectives, that is, to:

1. Estimate changes to whole-building savings for each site.
2. Determine the program EUL.
3. Calculate whole-building TDFs for each site.
4. Calculate program TDFs.

We first define the units of analysis used in this evaluation, then discuss the portions of the M&E Protocols applicable to it. The final two parts of this section explain the EUL and TDF analysis methods in detail.

6.1 Units of Analysis

Whole Building: A whole building (also referred to in some contexts as a "site") is defined as one or more contiguous structures operated by the same corporation within a ZIP code area. The first-year evaluation consultant assigned each whole building a unique site identification number.

End Use: Categories of energy consumption that correspond to building energy systems. End uses of interest to this study include (1) building envelope, (2) HVAC, (3) lighting, (4) motors, and (5) refrigeration.

Measure: Equipment or design features installed in a customer's facilities that are different from the baseline equipment required by Title 24/20 or the baseline assumptions of the PY94/96 NRNC programs. Installing the equipment or adopting the design feature changed energy consumption relative to the baseline. In some cases, PG&E provided rebates to the customer for the installation of such a measure. Each whole building in the first-year evaluations had one or more measures. The combined savings for each measure at the whole building yielded the whole-building-level savings.

In many cases, the database for the first-year evaluation did not explicitly identify measures. By examining the differences between the DOE-2 building models used to estimate first-year savings, however, we could discern individual measures, such as lighting levels or air conditioner efficiencies that go beyond Title 24/20 requirements. Note that in some cases, the first-year analysis approach yielded measures that increased energy consumption, that is, where the as-built equipment was less efficient than the baseline.

Program: PG&E's combined 1994 and 1996 Nonresidential New Construction programs. A total of 861 PG&E customer sites received incentives during these two program years.

6.2 Compliance with M&E Protocols

This evaluation report is in strict compliance with the Protocols. Relevant tables from the Protocols include the following:

Table 6	Protocols for Reporting Results of Required Studies Used to Support an Earnings Claim (Section B)
Table 7	Documentation Protocols for Data Quality and Processing (Section B)
Table 8A	Impact and Persistence Studies Required for an Earnings Claim for PG&E, SDG&E, and SCE
Table 9A	Measurement Schedule and Protocols for Persistence Studies for PG&E, SDG&E, and SCE
Table 10	Earnings Distribution Schedule

The evaluation incorporated the adjustments to nonresidential new construction retention study requirements laid out in the waiver titled "Southern California Edison and Pacific Gas & Electric Retroactive Waiver Nonresidential New Construction Program Persistence Studies" (Study ID Numbers 548/554 and 323-R1, approved March 18, 1998). A copy of this waiver can be found at the end of Appendix G (M&E Protocol Information). Evaluation results are presented in conformance with the latest versions of Protocol Tables 6 (Section B) and 7 (Section B), as proposed by the CADMAC in the 1998 Annual Earnings Assessment Proceeding (AEAP).

6.3 Effective Useful Life Analysis

This section describes our methodology for estimating effective useful life (EUL). It first presents how we calculated energy impacts for changes uncovered during the telephone and on-site surveys. It then discusses the framework for the statistical analysis, and how the lack of kWh failures affected our ability to perform a meaningful analysis. Note that Appendix F (Survival Analysis Methodology) details the original approach for estimating EUL that we would have used had the data we gathered contained a sufficient number of kWh failures.

6.3.1 Calculation of Energy Impacts for Observed Changes

After the on-site survey was completed, the changes in kW and kWh savings for each affected measure were calculated using the procedures in the handbook prepared for this evaluation (Reference 17). The main steps in these procedures are summarized below.

- **Copy DOE-2 model:** For each changed measure at a site, an engineer created a separate DOE-2 model based on the final parametric run.
- **Modify inputs:** Using information gathered during the on-site survey, the engineer modified each measure-specific copy of the final parametric DOE-2 run, so that the model reflected changes pertaining to that measure.
- **Select weather:** The engineer searched the DOE-2 output file to determine the California climate zone weather file used in the first-year evaluation.
- **Determine reduction in savings:** After running the new model and the original final parametric run, the engineer documented the annual kWh consumption and maximum annual kW demand for both. The difference between the kWh and kW numbers for each model yielded the change in kW and kWh savings for the affected measure.

- **Review and record results:** Once the engineer calculated changes in kW and kWh savings, he compared their magnitude against the total gross savings for the end use. Using engineering judgement, he assessed whether or not the magnitude of the reduction was appropriate for the measure change. If the results appeared reasonable, he recorded the final results on the site evaluation database input form. Otherwise, he re-examined the analysis inputs, made appropriate adjustments, and recalculated savings.

- **Store files and enter results into database:** We stored the DOE-2 working files for each site in a corresponding zip file, and entered key results into the retention study database.

6.3.2 Statistical Analysis

The research plan for this evaluation called for a classic survival analysis, which needed a certain number of kWh failures to meet the power requirements of the statistical model. If the required number of failures was not found, we were prepared to use the approach employed by RLW Analytics in their 1998 evaluation, as well as standard regression techniques. RLW Analytics's approach, referred to here as the assumed functional form (AFF) approach, involves assuming a functional form such as the exponential, conducting a survey at a given point in time after the installation, and using the data in conjunction with the assumed functional form to estimate the EUL. However, finding no failures made it impossible to estimate any statistical models or use the RLW Analytics approach. If we had found even a few kWh failures that indicated the proportion of total savings across all buildings in the sample was 99 percent for the 1994 Program, then the RLW Analytics' approach would have yielded an implausibly large EUL estimate of approximately 275 years.

Note that this result of no failures reported for the 150 sites is consistent with the retention results reported by RLW Analytics, Inc., in their 1998 evaluation of Southern California Edison's 1994 and 1996 Nonresidential New Construction Programs. RLW found retention rates of 99 percent and 100 percent for the 1994 and 1996 programs, respectively. Also, the 90 percent confidence interval for the 1994 program included 100 percent, meaning that the difference between 99 percent and 100 percent is not statistically different.

6.4 Technical Degradation Factor Analysis

This section first defines technical degradation factors (TDF), then presents our methodology for estimating measure-level, whole-building-level, and program-level TDFs .

6.4.1 Identification of TDF-Affected Measures

A technical degradation factor (TDF) is defined in the Protocols and statewide measure performance studies (References 9, 10, & 11) as a scalar that accounts for time- and use-related change in the energy savings of a high efficiency measure or practice relative to a standard efficiency measure or practice. For positive savings, TDFs are expressed as decimal fractions between 0 and 1. A value of 1 indicates that no degradation of savings has occurred relative to standard efficiency. A value of 0 indicates that none of the savings remain relative to standard efficiency. For negative savings, TDFs are expressed as values ranging from 1 to 2. The amount of degradation increases as the TDF increases above 1. The statewide measure performance study reports provide a 20-year (after installation) stream of TDFs for 24 measures that were applicable to a range of residential, commercial, and industrial facilities. In this study, we applied TDFs from the statewide study to applicable PY94/96 NRNC measures and revised energy savings estimates from the first-year evaluation to reflect TDF effects.

The statewide measure performance study evaluated the technical degradation of 24 technologies. Only 16 of the 24 technologies were applicable to the facility classifications addressed by the PY94/96 NRNC first-year evaluations. Of these, only three technologies were determined to have a TDF less than 1 for any of the 20 years after installation, as well as being applicable to the measures in the sampled sites. These three technologies were:

1. Metal Halide Lighting Fixtures
2. Energy Management System (EMS)
3. Oversized Evaporative Condensers for Groceries

We determined instances of these measures in the sampled sites by examining documentation from the first-year evaluation. Querying lighting inventory fields in the first-year evaluation databases isolated sites that contained interior metal halide lighting fixtures. No savings due to exterior lighting fixtures were included in the first-year evaluation, so exterior metal halide fixtures were excluded from this analysis.

The EMS and oversized evaporative condenser measures were identified by examining the first-year evaluation DOE-2 models. The first-year evaluation used separate parametric DOE-2 runs to estimate the impact of each end-use. A file comparison between the end-use parametric runs for each end use revealed specific changes made to the DOE-2 model that resulted in savings estimates for each end-use. For each of the sampled sites with first-year HVAC savings estimates, a file comparison was completed to determine if any of the estimated HVAC savings were due to the inclusion of an EMS. Similarly, for each of the sampled sites with first-year refrigeration savings estimates, a file comparison was completed to determine if any of the estimated refrigeration savings were due to the inclusion of oversized evaporative condensers in a grocery application.

6.4.2 Measure-Level TDF Impacts

The 20-year stream of TDFs assigned to the three measures is shown in Table 6-1. This table provides decimal fractions between 0 and 1 for application to positive savings and factors greater than 1 for application to negative savings. The values used in our analysis are in a bold typeface. For 1994 and 1996 sites, we applied Year 4 and Year 2 TDFs, respectively. We applied these TDFs to the first-year impact evaluation kW and kWh savings estimates for each of the three measures as they occurred at a site.

Application of TDFs to the first-year evaluation savings was complicated by the fact that the first-year evaluation prepared savings estimates at the end use level, so the desired resolution of savings at the measure level was not available from the previous work. In cases where there were multiple measures within an end use and one of these measures was on the above list, it was necessary for this study to separate out the savings associated with the measure(s) of interest. This was done by making sensitivity runs with DOE-2 as necessary to disaggregate both kW and kWh savings for these measures. For kW savings, we used non-coincident annual peak demand savings for both program years. This provides a consistent basis for use in the PG&E E-tables.

For all three measures, the sensitivity analysis involved modifying the as-built DOE-2 run prepared in the previous work. Each DOE-2 model was run using the same Typical Meteorological Year (TMY) weather data used in the first-year evaluation.

Table 6-1: Technical Degradation Factors

Year	Energy management system (EMS)		Metal halide lighting fixtures		Oversized evaporative condensers in groceries	
	Positive Savings	Negative Savings	Positive Savings	Negative Savings	Positive Savings	Negative Savings
1	1.00	1.00	0.96	1.04	1.00	1.00
2	**0.80**	**1.20**	**0.96**	**1.04**	**0.98**	**1.02**
3	0.60	1.40	0.96	1.04	0.96	1.04
4	**0.40**	**1.60**	**0.96**	**1.04**	**0.93**	**1.07**
5	0.20	1.80	0.96	1.04	0.91	1.09
6	0.10	1.90	0.96	1.04	0.89	1.11
7	0.10	1.90	0.96	1.04	0.87	1.13
8	0.10	1.90	0.96	1.04	0.84	1.16
9	0.10	1.90	0.96	1.04	0.82	1.18
10	0.10	1.90	0.96	1.04	0.80	1.20
11	0.10	1.90	0.96	1.04	0.80	1.20
12	0.10	1.90	0.96	1.04	0.80	1.20
13	0.10	1.90	0.96	1.04	0.80	1.20
14	0.10	1.90	0.96	1.04	0.80	1.20
15	0.10	1.90	0.96	1.04	0.80	1.20
16	0.10	1.90	0.96	1.04	0.80	1.20
17	0.10	1.90	0.96	1.04	0.80	1.20
18	0.10	1.90	0.96	1.04	0.80	1.20
19	0.10	1.90	0.96	1.04	0.80	1.20
20	0.10	1.90	0.96	1.04	0.80	1.20

To determine the savings associated with each of the TDF-affected measures, a revised baseline DOE-2 model was created, so that the measure savings equaled the difference between the consumption for the first-year evaluation as-built model and the revised baseline model. The revised baseline model was equivalent to the first-year evaluation as-built model with the effects of the TDF-affected measure removed. Removal of the TDF measure was accomplished by reverting key model parameters back to the baseline condition. The procedures used for each of the three analyzed measures were as follows:

1. **Metal Halide Lighting Fixtures**

   To create the revised baseline model for the metal halide fixture measure, the as-built DOE-2 model was reviewed to determine the total installed lighting capacity (kW) and the installed metal halide capacity in each space. Additionally, the first-year evaluation baseline DOE-2 model was examined to determine the assumed Title-24 baseline in the space. The installed kW of the as-built model for the space was adjusted to reflect the removal of the metal halide fixtures. The following equation was used to calculate the revised kW:

$$\text{Revised kW} = \left[\frac{(\text{Baseline}_{kW} - \text{AB}_{kW}) \times (\text{MH}_{kW})}{\text{AB}_{kW}}\right] + \text{AB}_{kW}$$

where:

$Baseline_{kW}$ = kW assumed in the first-year evaluation baseline DOE-2 model for the space, based on Title 24 requirements.

AB_{kW} = kW assumed in the first-year evaluation as-built DOE-2 model for the space, based on the lighting inventory.

MH_{kW} = kW associated with the metal halide fixtures installed in the space.

This equation assumes that the savings associated with the metal halides are directly proportional to the ratio of metal halide fixture capacity to the total lighting inventory capacity in the space. Thus the revised kW is equal to the as-built kW plus the kW savings associated with the metal halide fixtures. This calculation was repeated for each space identified in the as-built model that had metal halide fixtures installed. Revised kW values were entered into a copy of the as-built model to create the revised baseline model.

2. Energy Management System (EMS)

To create the revised baseline model for the EMS measure, we performed a file comparison between the baseline and as-built HVAC parametric DOE-2 models to identify differences in the models that could be associated with an energy management system. Only EMS features that resulted in changes in energy usage were analyzed. The HVAC features associated with an EMS were removed from the as-built DOE-2 model and replaced with the baseline conditions for the EMS features from the first-year impact evaluation to create the revised baseline model. Examples of such features include supply air temperature reset control and HVAC optimal start. Although the program databases did identify cases where an EMS controlled non-HVAC equipment (such as lighting controls), these features were not identified as measures in the first-year evaluation, and thus did not result in any first-year energy savings. Thus, a TDF analysis was not appropriate for such features.

3. Oversized Evaporative Condensers for Groceries

To create the revised baseline model for the oversized evaporative condenser measure, we performed a file comparison between the baseline and as-built refrigeration parametric DOE-2 models. This allowed us to identify differences in the models that could be associated with an oversized evaporative condenser in a grocery application. The refrigeration features associated with an oversized evaporative condenser were removed from the as-built DOE-2 model and replaced with the baseline conditions for the refrigeration features from the first-year impact evaluation to create the revised baseline model.

In cases where multiple TDF-affected measures were evident at the site, measures were individually removed from the as-built model to account for interactive effects between measures. For example, in a hypothetical case where all three TDF-affected measures occurred at one site, the savings due to each measure would be calculated using the following four model runs.

1. As-built model.

2. As-built model with oversized evaporative condenser measure set to baseline conditions.

3. As-built model with oversized evaporative condenser and EMS measures set to baseline conditions.

4. As-built model with oversized evaporative condenser, EMS, and metal halide measures set to baseline conditions.

The difference between Runs 1 and 2 accounted for the savings due to the oversized evaporative condenser measure. The difference between Runs 2 and 3 accounted for the savings due to the EMS measure, as well as any potential interaction between the EMS and the oversized evaporative condenser. The difference between Runs 3 and 4 accounted for the savings due to the metal halide measure, as well any potential interaction between the metal halide lighting and the EMS and oversized evaporative condenser measures.

6.4.4 Whole-Building-Level TDF Impacts

After the first-year evaluation gross savings associated with each of the three measures of interest were determined, the savings values were entered into a TDF spreadsheet, developed as part of this study. The spreadsheet applied the appropriate Year 2 or Year 4 TDF factors from Table 6-1 to the savings and produced annual estimates of degraded savings for each measure. The spreadsheet summed the reduction in savings across all measures and subtracted this sum from the first-year total gross savings. This revised whole-building-level total was then divided by the first-year gross savings to compute a whole-building-level TDF. This process can be summarized by the following equation:

$$\text{Whole Building TDF} = \frac{\{(\text{1st Year Savings}) - \sum[(\text{1st Year TDF measure savings}) \times (1 - \text{TDF})]\}}{(\text{1st Year Savings})}$$

where:

1st Year Savings	= gross savings estimated by the first-year impact evaluation.
1st Year TDF measure savings	= gross savings estimate due to the TDF measure (i.e. metal halides, EMS, oversized evaporative condensers).
TDF	= technical degradation factor found in Table 7.

For all sites that did not contain TDF-affected measures, a whole-building-level TDF of 1 was assigned to indicate that no degradation occurred.

6.4.4 Program-Level TDF Impacts

Using the whole-building-level TDF impacts, we calculated the 1998 TDFs applicable to the combined 1994 and 1996 NRNC programs. Each of the program-level TDFs was computed as the sample-weighted mean of the corresponding whole-building-level TDFs. The combined case weights for this evaluation (developed during sample design, as described in Section 4.2) were used to extrapolate the results from the sample of 150 sites in this evaluation to the program population of 861 sites.

7. Conclusions and Recommendations

This section lists conclusions and recommendations from our retention study of the 1994/96 Nonresidential New Construction Programs.

7.1 Conclusions

Ex ante EUL is the best estimate: The ex ante EUL remains the best estimate of program effective useful life. The number of measure changes since the first-year evaluation was insignificant, primarily because so little time elapsed between the first-year evaluation and subsequent retention evaluation. The time elapsed between the two ranged from 10 to 15 months for 1996 sites, and 23 to 28 months for 1994 sites, hardly enough time for a significant number of measure changes to occur. As a result, it was impossible to perform a satisfactory statistical survival analysis to reestimate the EUL.

Impact of TDFs was minimal: The impact of technical degradation factors on program savings was minimal. For the combined 1994 and 1996 programs, we estimated that 1998 gross kW and kWh savings were 98.6% and 99.0%, respectively, of first-year ex ante gross savings.

7.2 Recommendations

Eliminate or reduce fourth-year retention evaluations: The small or non-existent changes in both TDF and EUL argue for scaling down or eliminating future fourth-year retention evaluations. Requiring eighth-year and twelfth-year, rather than fourth-year and ninth-year, retention studies most likely would provide more useful information for estimating EUL. Regardless of the timing of the study, it may be worthwhile to reduce its scope, such as by targeting measures likely to fail.

Target specific measures: Tailor subsequent evaluations to target measures most likely to change, such as lighting measures. Certain measures, particularly costly ones such as efficient chillers or refrigeration systems, are unlikely to change in the span of a few years. Funds spent evaluating such measures might better be spent on measures more likely to change quickly.

8. References

The following references were important sources of information, techniques, and guidelines for this evaluation:

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11. Proctor Engineering Group, *Statewide Measure Performance Studies: Supplemental Technical Degradation Factors (Final Report)*. September 18, 1998.

12. RLW Analytics, Inc., *Impact Evaluation of Pacific Gas & Electric Company and Southern California Edison 1994 Nonresidential New Construction Programs*, prepared for the Pacific Gas & Electric Company, March 1, 1997.

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15. SAS Institute, Inc., *SAS/STAT User's Guide* (Version 6: Volume 2: Fourth Edition), 1990.

16. SBW Consulting, Inc., *Final Evaluation Research Plan--PG&E's 1994/96 Non-Residential New Construction Retention Study*, October 15, 1998.

17. SBW Consulting, Inc., *Handbook for PG&E's 1994/96 Non-Residential New Construction Retention Study*, October 15, 1998.

Appendix A

Listing of Key Terms

Following are definitions of key terms necessary for understanding this retention study. They are presented alphabetically.

- **As-built consumption.** An estimate of end use and/or whole building annual energy consumption that is based upon observations made during an on-site survey. As-built consumption was estimated for each sampled site during the first-year impact study. As-built consumption was re-estimated at sites where changes occurred since the first-year impact study on-site survey.
- **Baseline consumption.** An estimate of end use and/or whole building annual energy consumption under conditions that would have existed had the energy efficiency measures not been implemented. Building envelope and equipment characteristics correspond to Title 24/20 or to the baseline assumptions of the NRNC program, whichever is applicable.
- **Change.** A whole-building change occurs when original energy-saving equipment is modified or replaced. This change may affect: (1) the entire building, e.g., a demolition, (2) a specific portion of the building, e.g., conversion of a warehouse area into office spaces, (3) a building system, e.g., a complete lighting system change out, or (4) a portion of a system, e.g., replacing an efficient motor with another unit. These modifications, replacements, or removals can cause energy savings to increase, decrease, or stay the same.
- **Change in Savings**. When a change occurs to one or more measures at a site, then the whole-building savings associated with the site may or may not be affected. If, for instance, a change occurs to a motor measure so that it is replaced with a lower-efficiency model, then the change in savings would be negative. It is also possible, however, for a change to yield no change in savings, as when, for example, lighting ballasts are replaced with ones with the same make, model, and performance. Changes in savings can also be positive, for example, if a rebated refrigeration compressor is replaced with a higher-efficiency unit.
- **Effective Useful Life (EUL)**. The amount of time that elapses until half of the whole-building level savings achieved by the NRNC program have failed. A program-level EUL was be computed using the revised estimates of gross savings for measures that are found to be out of service.
- **End Use**. Categories of energy consumption that correspond to building energy systems. End uses of interest to this study included: building envelope, HVAC, lighting, motors, and refrigeration.
- **Failure**. Failure occurs when a change, as defined above, results in decreased savings, or a negative change in savings. For this evaluation, failure can occur at three levels: (1) kWh failure, (2) measure failure, and (3) whole-building failure.

- **Gross savings.** Difference between baseline consumption and the as-built consumption for a measure, end use or an entire building.
- **kWh failure**. Occurs when a change to one or more measures at a site reduces associated whole-building energy savings. kWh failure can occur in both removal and replacement situations, e.g., when lighting fixtures are removed, or where efficient compressors are replaced with less-efficient models. In both cases, the whole building energy savings would be reduced. In the extreme cases where all equipment related to a particular measure is removed, or all measures at a site are removed, then the kWh failure also constitutes measure failure and whole-building failure, respectively. All of the techniques for statistical analysis of effective useful life proposed for this study concern themselves only with kWh failure.
- **Measure.** Equipment or design features installed in a customer's facilities that are different from the baseline equipment required by Title 24/20 or the baseline assumptions of the PY94/96 NRNC programs. Installing the equipment or adopting the design feature changed energy consumption relative to the baseline. In some cases, PG&E provided rebates to the customer for the installation of such a measure. Each whole building in the first-year evaluations had one or more measures. The combined savings of all measures at the whole building yielded the whole-building-level savings.
- **Measure failure.** Occurs when a change to a particular measure at a site eliminates all associated energy savings. For example, if all rebated efficient motors at a site were removed and not replaced, measure failure would have occurred for the efficient motor measure.
- **On-site Survey.** An inspection and measurement of building envelope components or equipment affected by measures installed at a sampled site. An on-site survey was conducted for each site in this study as part of the first-year impact study. Subsequent on-site surveys were conducted as part of this evaluation at sites where changes occurred in building envelope components or equipment associated with measures evaluated in the first-year impact study. On-site surveys were also performed at several sites to verify telephone survey results indicating no changes had occurred.
- **Out of Service.** A measure is out of service if it has been removed or permanently disabled. A measure is removed if the equipment or building envelope component comprising the measure is no longer present, present but not operable, or has been replaced with equipment that is less efficient than the as-built conditions observed in the first-year impact study on-site survey. A measure is not considered to be out of service if changes in its performance are due to vacancy effects and differences in operating schedules not caused by the disabling of the measure. See the similar definition for "failure."
- **Persistence.** The degree to which the energy savings initially achieved by the installation of a measure lasts over time. There are two components of persistence: (a) retention and (b) performance. A measure is retained if the building envelope components or equipment that comprise the measure are still in-service (present and operable). Savings from certain types of in-service measures may decline over time due to changes in measure performance. These effects are accounted for by applying statewide technology degradation factors.
- **PG&E Customer Representative.** A member of PG&E's division or corporate staff who services one of the customers who received rebates from the program. In some cases this was the person who assisted the customer in applying to the program.
- **PG&E Project Manager.** The primary client contact who directed our work in this study,

Valerie Richardson (415) 973-6163.

- **Program:** PG&E's combined paid-year 1994 and 1996 Nonresidential New Construction (PY94/96 NRNC) programs. A total of 861 PG&E customer sites received incentives during these two program years.
- **Project File.** A file containing all paperwork associated with each site. This included a completed telephone survey, customer contact log, information from the first-year impact study, and other important documentation generated during this study.
- **Retention.** The fraction of the paid measures that are still in service after a specified period of time.
- **Sampled Site.** A site that was selected to satisfy the objectives of this study. Other sites were also selected to use as replacements if a customer refused to participate in the study or was eliminated for other reasons.
- **Survival Function**. A statistical model for estimating the EUL of NRNC program savings. The primary input to this model are estimates of the change in whole-building energy savings (kW and kWh) that occur at each point of significant change for the sites included in this study.
- **Technical Degradation Factor.** A scalar to account for time- and use-related changes in the energy savings of a high efficiency measure or practice relative to a standard efficiency measure or practice. Expressed as a decimal fraction between 0 and 1. A value of 1 indicates no degradation of savings has occurred relative to standard efficiency. A value of 0 indicates that none of the savings remain relative to standard efficiency.
- **Telephone Survey.** A telephone interview with PG&E's PY94/96 NRNC program participants to collect information necessary to determine if a substantial change has occurred in energy efficiency measures.
- **Whole Building.** A whole building (also referred to in some contexts as a "site") is defined as one or more contiguous structures operated by the same corporation within a ZIP code area. The first-year evaluation consultant assigned each whole building a unique site identification number.
- **Whole-building failure.** Occurs when there is measure failure for all measures at a site. For example, if an industrial facility is demolished, then all measures at the site have failed, and the whole building has failed from an energy savings perspective.

Appendix B

Telephone Survey Instrument

1. Introduce yourself and the purpose of this survey to the primary site contact. Indicate what building/facility is of interest, e.g., Seaside Office Complex, Building K, at 1005 Seaside Highway. Explain that you are conducting a follow-up evaluation of energy efficiency measures installed in the building. Determine which member of the building owner's staff would be best informed about changes that have occurred since the 1st year evaluation on-site. As needed, list a contact for each of the following building systems. Also obtain contact information for the person who can authorize an on-site visit, if one is needed, and the person we should contact to schedule the visit (you may do this after asking Question 2, at your discretion). If the customer refuses to participate in the survey, check the rejection box below and circle the applicable reason for rejection.

	Name	Position	Phone # / When to Call
Envelope	CNAME(N)	CNOTES(N)	CPHONE(N)
HVAC	CNAME(N)	CNOTES(N)	CPHONE(N)
Lighting	CNAME(N)	CNOTES(N)	CPHONE(N)
Motors	CNAME(N)	CNOTES(N)	CPHONE(N)
Refrigeration	CNAME(N)	CNOTES(N)	CPHONE(N)
Authorization Contact	CNAME(N)	CNOTES(N)	CPHONE(N)
On-Site Scheduling Contact	CNAME(N)	CNOTES(N)	CPHONE(N)

☐ Rejection - Circle Reason: No contact Language barrier Lack of time
TSRVDISP Business gone Lack of knowledge
Other (specify)____

Notes:

2. Ask respondent(s) if there have been any changes in equipment/envelope components since _______ (Approximate date of 1st year evaluation on-site). If yes, ask for a description of the changes.

	Yes	No	Don't Know	Description of Change
Envelope ENDUSE				MEASURE CHANGE
HVAC ENDUSE				MEASURE CHANGE
Lighting ENDUSE				MEASURE CHANGE
Motors ENDUSE				MEASURE CHANGE
Refrigeration ENDUSE				MEASURE CHANGE

Notes:

SITENOTE

3. Thank the respondents for their assistance and end the first portion of the survey. If there have been changes, review the DOE-2 BDL input specifications used to model gross savings from each efficiency measure. Match these to building system characteristics recorded in the 1st year evaluation on-site surveys and convert these inputs to equipment/building envelope component counts, by type. For each measure, record on the Measure Specification Form (for the appropriate building system) the count and the associated capacity (tons, hp, square feet of envelop), along with a description of where this equipment is located at the site, e.g., 4th through 6th floor in a high-rise office building. If it is clear that more than 10% of the capacity of any measure has become "out of service" based on the information obtained in Question 2, go to Question 5. If not continue to the next question.

4. If additional information is needed to determine if a site visit is required, contact the appropriate respondent(s) for each building system for which a measure may have changed. Using the Measure Specification Form, review the list of equipment/envelope components, by type and location that comprises each of the measures. Ask the respondent whether any of the equipment/envelope components has been removed, disabled, or replaced since its original installation at the site. If replaced determine whether the equipment was replaced with less efficient equipment. Record an approximate count of "out of service" equipment/envelope component of each type on the Measure Specifications Form. Determine whether more than 10% of any measure's capacity has become "out of service."
Notes:

5. If the 10% or more of any efficiency measure's capacity is "out of service," call the Authorizing Contact and ask if they will authorize an on-site inspection.	
Authorizing Contact	
Name: CNAME(N)	Title: CNOTES(N)
Phone #/ When to Contact: CPHONE(N)	
Willing to Allow On-Site: ___Yes ____No	
Notes:	

6. If an on-site has been authorized, call the scheduling contact and obtain the following information.	
Appointment Date/Time: OSRVDATE	Contact Name: CNAME(N)

Location at Site to Meet:
Directions to site, including parking instructions:
Access problems related to inspection of equipment:
Safety issues, e.g., safety glasses, hearing protection, hard hats:
Other issues:

Appendix C

Data Sources

This appendix describes the four existing data sources for this evaluation. Three of the four sources came from the PY94/96 NRNC first-year savings evaluations, listed below.

1. Pacific Gas & Electric Company, *Impact Evaluation of Pacific Gas & Electric Company and Southern California Edison 1994 Nonresidential New Construction Programs*, March 1, 1997.

2. Pacific Gas & Electric Company, *Pacific Gas & Electric Company 1996 Non-Residential New Construction Evaluation*, March 1, 1998.

Information from these evaluations provided valuable background information to support telephone surveys, on-site surveys, and the subsequent EUL and TDF analyses. These included a database of site characteristics and energy savings data, paper files with supporting documentation, and the evaluation DOE-2 models used to compute energy savings.

Statewide TDF studies provided important material, such as measure-specific TDFs, for performing the TDF analysis. Table C-1 summarizes the role of each data source.

Table C-1: Summary of Data Sources

Data Source	Status	EUL Analysis	TDF Analysis
First-year evaluation databases	Existing	X	X
First-year evaluation paper files	Existing	X	
First-year evaluation DOE-2 models	Existing	X	X
Statewide TDF studies	Existing		X

C.1 First-Year Evaluation Databases

Database information produced by the PY94/96 NRNC first-year evaluations included whole-building-level and end-use-level (lighting, HVAC, motors, refrigeration, and shell) kWh and kW savings, contact and company information, PG&E identification numbers, and detailed counts and descriptions of equipment. We used the whole-building ex post savings from these databases to develop the sample frame for this study. The first-year evaluation databases also provided background information for telephone surveyors to review prior to contacting customers and detailed information to help on-site surveyors identify changed measures.

C.2 First-Year Evaluation Paper Files

For the 1996 NRNC evaluation, these files contained copies of the original PG&E program applications plus PG&E supporting documentation. Only site map sketches were available for the 1994 NRNC evaluation. In both cases, files provided background information on rebated measures for telephone and on-site surveyors.

C.3 First-Year Evaluation DOE-2 Models

The DOE-2 models prepared for each site in the PY94/96 NRNC program evaluations were important to this evaluation. Models for each site contained key energy usage and equipment characteristic parameters for estimating savings for efficiency measures. In many cases, they also contained equipment descriptions gathered during on-site surveys. Based on this information, measures were identified for four situations relevant to the evaluation: (a) to discuss during the telephone survey, (b) to match against the changes mentioned by the telephone survey respondent, (c) to inspect during the on-site survey, and (d) to apply measure-level TDFs to calculate whole-building TDFs. We modified these models to compute revised energy savings when a change occurred to one or more measures.

C.4 Statewide TDF Studies

We obtained the 20-year stream of technical degradation factors (TDFs) for the four applicable measures from three CADMAC-sponsored assessments of relative technical degradation rates. These TDFs were used to calculate whole-building TDFs for each evaluated site with a TDF-affected measures. The three applicable reports were as follows:

1. Proctor Engineering Group, *Statewide Measure Performance Study: An Assessment of Relative Technical Degradation Rates (Final Report).* April 24, 1996.

2. Proctor Engineering Group, *Statewide Measure Performance Study #2: An Assessment of Relative Technical Degradation Rates (Final Report)*. May 14, 1998.

3. Proctor Engineering Group, *Statewide Measure Performance Studies: Supplemental Technical Degradation Factors (Final Report)*. September 18, 1998.

Appendix D

Measurement Specification Form and Contact Log

Measure Specification Form

The top portion of this form contains general customer information and gross savings estimates obtained from the first-year evaluation databases. The bottom portion consists of a blank table for recording information about measure changes gathered from the telephone survey, database and DOE-2 model search, and on-site survey.

1994 / 96 Measure Specification Form

Interviewier's Initials: ____________ Date:____________ Page ____ of ____

SITEID: 7 RLW Survey date: 9/17/97
EVALYEAR: 1996 DIVISIO SIERRA

RLW survey time frames
94: July-Sept 96 96: Aug-Oct 97

HVAC
Pkg Rooftop AC

EMS present?

Cooling Tower
No

Day Lighting
No

Spaces:
REATAIL 1408 sq ft

Company Floyd Smith Const.
Street 3941 Park Drive #10
City: El Dorado Hills 95762

Contact Name Sherry Smith
Contact Phone 9169334683
FacilityType Small Retail
Total floor area 1408 # floors: 1
New floor area: -99

LightsType	Control	Count
Fluor	None	14
Incand	None	1

Total KW:	1.04	LKWH:	5973.73	SKWH	-370.92	MKWH:	0
Total KWH	5397.99	LKW:	1.62	SKW:	-0.3	MKW:	0
% KW:	0.01	RKWH:	0	HKWH:	-204.82		
% KWH:	0.01	RKW:	0	HKW:	-0.27		

Other info Name of the retail store is Blessings

Key	Measure Description	Measure Location	Unit Capacity	Installed Count	Total Capacity	Out of Service Count	Out of Service Capacity	Reason Out of Service	Replacement Equipment	Confirmed Count

Reason for Out of Service Code:
1. Removed 2. Permanently Disabled 3. Replaced with baseline equipment 4. Replaced with less efficient equipment 5. Replaced with more efficient equipment

Contact Log

Objective

The objective of the Contact Log was to document the history of telephone contacts made to obtain various elements of information throughout the evaluation process. Contacts with the customer as well as the PG&E marketing representatives were included. This log was kept in the project file and submitted to PG&E at the end of the study.

Instructions

Site No. - Enter the appropriate site no. on each form.

Customer Name - Record the Company Name.

Contact Name - Each successful telephone contact with the PG&E marketing representative or the customer is recorded on the log form. Do not make an entry every time you leave a message. However, do make an entry if you have tried someone several times and are giving up to pursue another path.

PG&E/Cust. - Enter a P or C to identify whether the contact is a PG&E employee or a customer employee.

Purpose - In most cases, just record the appropriate code from the list at the bottom of the log. The "Note" column is for additional explanation as needed.

Date - Enter the date the contact is made.

By - Enter the initials of the caller.

KEEP THE CONTACT LOG IN THE PROJECT FILE AT ALL TIMES.

PG&E's 1994/96 Non-Residential New Construction Retention Study
Contact Log

Site No. ______________________

Customer Name ____

Contact Name	PG&E(P)/ Cust (C)	Purpose Code	Purpose Note	Date	By

Purpose Codes:

TS- Telephone Survey **OS- Schedule On-Site**

MI- Additionial informatio **OT- Other**

Appendix E

Site Evaluation Database

This appendix documents the final data products from this evaluation. These products consist of the final evaluation database, as well as the site zip files and corresponding paper files. In addition, we document the raw data sets we received from PG&E, the intermediate data sets we developed during the evaluation, and the SAS jobs we wrote to analyze and manipulate the data.

With the exception of the paper files, all of these data products are loaded on one 100-megabyte Iomega® Zip™ disk, with the following directory structure:

Table E-1: Contents of Data Products Diskette

SUBDIRECTORY	CONTENTS
CODE	SAS jobs used to create intermediate data sets.
DATA	Original databases and data sets created by RLW Analytics for the 1994 and 1996 NRNC first-year evaluations. Intermediate data sets created during the evaluation.
FINDATA	Final program evaluation database and data sets.
SITEZIPS	Site zip files, each containing spreadsheets and DOE-2 files used for TDF and/or EUL analyses, as applicable.

These subdirectories and their contents are discussed in greater detail below. A list of the files in each of these subdirectories can be found in Tables E-2A and E-2B.

E.1 SAS Jobs

The CODE directory contains the SAS jobs that manipulated the original 1994 and 1996 first-year evaluation databases to create the evaluation sample frame. The RLWDATAx series of jobs manipulated data from the first-year impact evaluations to create a combined sample frame. The SAMPLEx series of jobs defined strata and selected the sample.

E.2 Data Sets

The DATA directory contains key raw and intermediate data sets for this evaluation. Raw data can be found in the two zip files named RLW94 and RLW96. The RLWDATAx SAS jobs processed these data to create the data sets in the RLW zip file. The SAMPLEx SAS jobs subsequently created the sample frame data sets in the SAMPLE zip file.

Table E-2A: Detailed List of Electronic Data Products

Subdirectory	FILE NAME	TYPE OF FILE(S)	DESCRIPTION
\CODE	RLWDATA1.SAS	SAS 6.12 job	Converts original first-year evaluation data from RLW94.ZIP and RLW96.ZIP into SAS data sets.
	SAVE4D.SAS	SAS 6.12 job	Converts 1994 first-year evaluation raw end use savings into useable form.
	RLWDATA2.SAS	SAS 6.12 job	Combines all 1994 SAS data sets into ALL4.SD2.
	RLWDATA3.SAS	SAS 6.12 job	Combines all 1996 SAS data sets into ALL6.SD2.
	RLWDATA4.SAS	SAS 6.12 job	Combines 1994 and 1996 data sets, adds identifiers and weights to create ALLRLW.SD2.
	SAMPLE1.SAS	SAS 6.12 job	Draws sample from ALLRLW.SD2.
	NEYALLOC.XLS	Excel 97 workbook	Calculates strata population and sample sizes and creates sample frame data set FRAME1.SD2.
	SAM_RE.INC	SAS 6.12 include file	Calculates relative error for stratified random sample.
	SAMPLE2.SAS	SAS 6.12 job	Summarizes and checks various sample weights.
	SAMPLE2A.SAS	SAS 6.12 job	Creates revised sample frame FRAME1A, summarizes and checks various sample weights.

Table E-2B: Detailed List of Electronic Data Products (continued)

Subdirectory	FILE NAME*	TYPE OF FILE(S)	DESCRIPTION
\DATA	**RLW94.ZIP** contac4a.xls* contact4.xls* engdata.zip save4b.xls save4c.xls sitecnt4.xls	Excel 5.0 workbooks (zipped), text files (zipped)	Original 1994 first-year evaluation data (renamed and reformatted by SBW)
	RLW96.ZIP kw6.xls kwh6.xls mhkw6.xls mhkwh6.xls pgecon6.xls* rkw6.xls rkwh6.xls slkw6.xls slkwh6.xls weight6.xls	Excel 5.0 workbooks (zipped)	Original 1996 first-year evaluation data (renamed and reformatted by SBW)
	RLW.ZIP all4.sd2* all6.sd2* allrlw.sd2* contac4a.sd2* contact4.sd2* divcodes.sd2 kw6.sd2 kwh6.sd2 mhkw6.sd2 mhkwh6.sd2 pgecon6.sd2* rkw6.sd2 rkwh6.sd2 save4a.sd2 save4b.sd2 save4c.sd2 save4d.sd2 save4e.sd2 sitecnt4.sd2* slkw6.sd2 slkwh6.sd2 weight6.sd2	SAS 6.12 data sets (zipped)	1994 and 1996 first-year evaluation datasets (after SBW SAS processing)
	SAMPLE.ZIP frame1.sd2* frame1a.sd2*	SAS 6.12 data sets (zipped)	Sample frame (initial and actual--latter with "a" suffix)
\SITEZIPS	S<site id>.ZIP	Various files (in zip files)	DOE-2 models, TDF calculation workbooks, etc.
\FINDATA	NRNC9496.XLS*	Excel 97	Final retention study database
	NRNC9496.XPT*	SAS Version 5 transport	Final retention study database

* Files marked with asterisks contain confidential customer information

E.3 Site Zip Files and Supporting Documentation

The SITEZIPS subdirectory contains 80 self-extracting site zip files. Each of these site zip files corresponds to an evaluated site. The site zip files follow the naming convention S<site identification number>.ZIP. Each site zip file may contain any or all of the files listed in Table E-3. Note that of the 80 analyzed sites, 78 sites received TDF analysis, and 3 sites (Nos. 43, 7179, and 7323) received measure change analysis. Site No. 7179 was the only one subjected to both types of analysis.

Note that the site zip files do not contain information only available on hard copy, such as telephone surveys, contact logs, measurement specification forms, and on-site survey field notes. This hard copy supplemental information was shipped to PG&E separately. Both the electronic files in the SITEZIPS directory and the supporting documentation have been purged of any information that might reveal the identity, phone number, or location of a customer.

Table E-3: Contents of Site Zip Files

FILE NAME (**** = site ID number)	**DESCRIPTION**
S****BA.INP S****BA.INP	First-year impact evaluation DOE-2.1E input files, created by RLW Analytics (BA=baseline, AB=as-built).
S****BA.SIM S****BA.SIM	Output files from SBW runs of first-year input files (BA=baseline, AB=as-built).
PGE****.CAL, **.CAL, **B.CAL, PLNT.INC, PLNT_PAR.INC	DOE-2 auxiliary files created by RLW, called by input files.
S****TE.INP/.SIM S****TM.INP/.SIM S****TO.INP/.SIM	SBW-created DOE-2.1E input and output files, with TDF-affected measure removed (TE=EMS, TM=metal halide, TO=oversized evaporative condenser).
TDF****.XLS	Excel 97 workbook for calculating whole-building 20-year TDF stream.
S****SAV.XLS	Excel 97 workbook for calculating whole-building savings differences from measure changes.
S****CL.INP/.SIM	SBW-created DOE-2.1E input and output files, with changes to measures included.

E.4 Retention Study Database

The FINDATA subdirectory contains the final evaluation database. This database holds information gathered from the first-year impact evaluations, as well as from telephone surveys, on-site inspections, and engineering calculations performed as part of the retention study. The key variable for the 228 observations in the database is the site identification number (SITEID), which can be matched with the site zip files.

Note that the database contains confidential information about customer names, addresses, and phone number.

Table E-4 lists the data sets that comprise the database. We have supplied the database in two formats, described below:

NCRT9496.XPT: This version of the database is a SAS Version 5 transport file containing multiple data sets. The SAS Version 5 transport file can be read by any version of SAS on any currently supported platform, including SAS PC for Windows, and SAS under TSO. Each data set within the transport file contains labels for each variable, along with information on each variable's data type and format. This information can be accessed via the SAS PROC CONTENTS procedure.

NCRT9496.XLS: This version of the database is a Microsoft Excel 97 workbook containing multiple worksheets. Each worksheet contains a data set, and the worksheet entitled "LABELS" describes each variable in all data sets.

Table E-4: Contents of Retention Study Database

Data set name	Source	Description of contents
LABELS	--	Variable labels for all other data sets (for Excel version only)
F_SITE	First-year evaluations	Site building descriptions, whole-building-level gross savings estimates, and site contact information
F_SPACE	First-year evaluations	Zone descriptions for each site
R_MEAS	Retention study	Descriptions of measure changes and savings differences due to changes
R_SITE	Retention study	Sample, survey, and strata information; telephone survey data; whole-building-level technical degradation factors (TDFs)

Appendix F

Survival Analysis Methodology

This appendix contains the original survival analysis methodology, as presented in the final research plan for this evaluation. This methodology ultimately was not used, because of the insufficient number of kWh failures.

Effective Useful Life Analysis

Below we present our approach to the survival analysis and subsequent estimation of the effective useful life (EUL) of the PY94/96 NRNC programs. Note that this approach uses information about the effective date and magnitude of out-of-service savings at a measure level, and generates estimates of whole-building-level EULs. These building-level estimates can then be weighted up to the population.

The first part of this section describes the appropriate unit of analysis. The final part describes various issues surrounding survival analysis in the context of this study, including left vs. right censoring, the hazard function, precision, covariates, hypothesis testing, data structure, required sample sizes, and alternative approaches.

Unit of Analysis

The Retroactive Waiver states that the unit of analysis should be the whole building. Given current survival analysis methods, such a unit of analysis presents a problem. Survival analysis uses information on the survival of units such as patients or light bulbs. This is a binary outcome--survival versus failure or death. If the building is the unit of analysis, then partial or fractional failure are possible, i.e., 30 percent of the kWh savings in a given building can cease to exist at the end of two or three years. However, survival analysis requires binary outcomes. Thus, the unit of analysis needs to be some quantity of kWh savings. For example, one could track the survival of each kWh or each bundle of 100 kWh for a given building or the entire collection of buildings. Here, the number of observations is equal to the number of kWh saved or number of bundles of kWh saved. The level of aggregation for a bundle is designed to avoid the possibility of survival fractions thus allowing the appropriate survival analysis techniques to be applied. Hereafter, a kWh saved or a kWh savings bundle is simply referred to as kWh. Later we explain why the number of kWh failures in this context will very likely be sufficiently high to generate enough kWh failures to attain the desired level of precision. The EUL resulting from the survival analysis of kWh could then be applied to all of the kWh savings for the program.

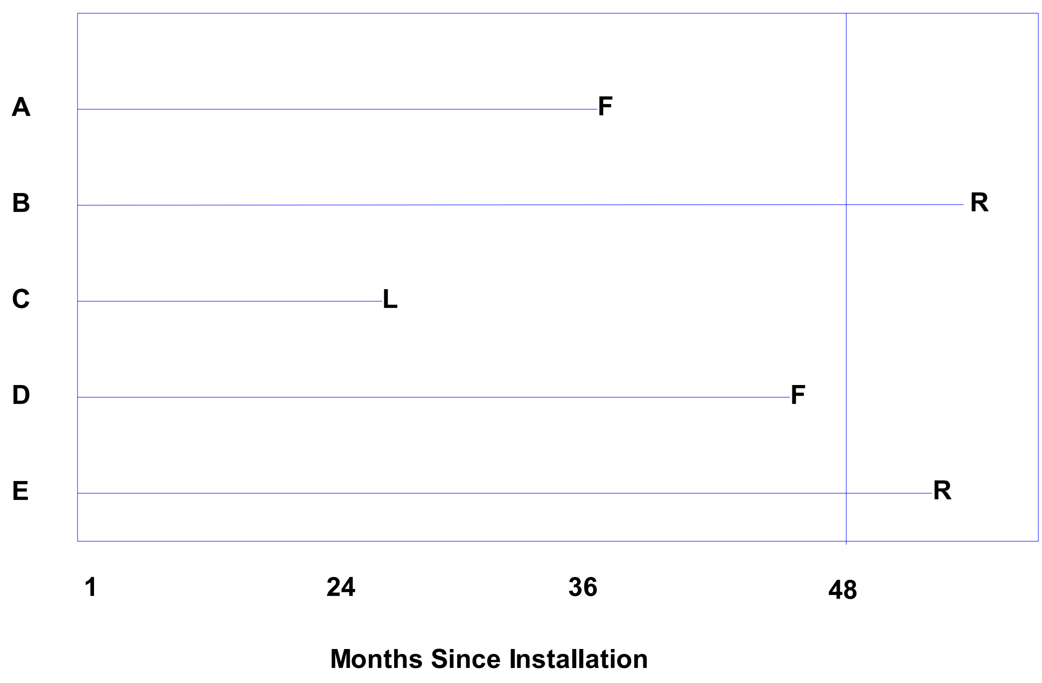
Left Censoring Versus Right Censoring

In this survival analysis, an event is defined as a point in time at which a particular kWh no longer exists, hereafter referred to as a "failure" of that particular kWh. This implies that we need to know not only that a given kWh has failed but we must also know when it failed.

Two concepts critical to our approach are the right censoring and the left censoring of the data. Right censoring of the data occurs when a kWh is observed before the failure event occurs, i.e., the kWh is still there. Left censoring occurs when the actual installation date for a piece of equipment is unknown. Figure 1 illustrates the distinction between right and left censoring. The observation followed by an "L" is a case in which the savings did not survive until the 48th month, the month of observation, but we do not know the time of failure. This is a case of "left" censoring. The observations by an 'F" represent those cases in which the savings did not survive until the 48th month but for which we *do* know the time of failure. These represent cases of "no" censoring. The observations marked by an "R" represent those cases in which savings survived until the 48th month and will not fail until some time beyond the 48th month. These represent cases of "right" censoring. Both right censoring and left censoring can have significant impacts on the precision of any survival analysis.

Right censoring is inevitable when one conducts a two- or four-year follow-up on kWh savings associated with measures that have expected useful lives of 15 to 18 years. For example, in a two- or four-year retention study, very few of the kWh savings associated with chillers or boilers in a small sample will have experienced failure. The problem with right censoring is that more kWh that have experienced failure must be brought into the sample in order to produce a robust estimate of the EUL. Of course, right censoring is expected to be somewhat less of a problem in the case of kWh associated with measures like lighting, which has a shorter EUL.

Figure 1: Right Versus Left Censoring



Asking participants to report the time of kWh failure can somewhat more easily mitigate the problem of left censoring. When a sampled site is inspected, we will ask the customer when the changes occurred which lead to failures in kWh savings. The reduction in kWh savings associated with these changes will be defined as kWh failures at that date. In using such an approach, we must guard against the threat of measurement error since customers may be wrong in stating the kWh failure date.

Hazard Function

For the time being, we will assume the following general form of the constant hazard function:

$$h(t) = \lambda \qquad (1)$$

The corresponding survivor function is:

$$S(t) = e^{-\lambda t} \qquad (2)$$

This, in turn, has the following implied probability density function for the well-know exponential distribution with parameter λ:

$$f(t) = \lambda e^{-\lambda t} \qquad (3)$$

This constant hazard implies an exponential distribution for the time until an event occurs. Other functional forms, such as the Gompertz and the Weibull, will also be explored during the analysis. However, we also realize that the probability of a kWh not surviving increases with time, i.e., the hazard is not constant over time. To handle such a situation, we will also explore non-proportional hazard functions. For this purpose, Cox's (1984) partial likelihood method will be explored.

$$S(t) = [S_o(t)]^{\exp(\beta x)} \qquad (4)$$

where

$S(t)$ =	The survival probability at time t with covariate x
S_o =	The survivor function for a building for which the covariate values are all 0.
x =	A vector of covariates
t =	Time.

Of course, it is possible that there are other probability distributions that might be adopted. Such a model is the log-logistic model, which has a rather simple survivor function,

$$S(t) = \frac{1}{1 + (\lambda t)^{\gamma}} \qquad (5)$$

where $\gamma = 1/\sigma$

$\lambda = \exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

Such a model is called the *accelerated failure time model*.

Precision

The precision that one can achieve is in large part a function of the number of kWh failures that one can expect to see in a second or fourth-year study. The number of kWh failures that one can expect to see is largely a function of the expected EULs. For example, for the hazard function (Equation 1), the median survival time is given by

$$\hat{t}(50) = \hat{\lambda}^{-1} \log 2 \qquad (6)$$

with a standard error of

$$\text{s.e.}\{\hat{t}(50)\} = \frac{\hat{t}(50)}{\sqrt{r}} \qquad (7)$$

where r is the number of kWh failures within a sample. The more kWh failures there are, the smaller the standard error and the greater the precision of the estimate. That is, the number of kWh failures is directly related to the power of any survival analysis to determine whether any differences between re-estimated EULs and the ex ante EULs are statistically different at some predetermined level of confidence. Of course, in a second or fourth-year retention study, the number of kWh failures associated with longer-EUL measures will be very small while the numbers of kWh failures associated with shorter-EUL measures will be more numerous. While the problem of right censoring may be somewhat serious for all kWh, it may be particularly acute for the kWh associated with longer-EUL measures.

Covariates

Other factors that may affect the life distribution should also be investigated. For example, do the kWh savings associated with a restaurant experience different rates of failure than kWh savings associated with an office? Such an analysis will allow us, to some extent, to control for the heterogeneity of the determinants of kWh survival. Also, note that the characteristics of each building that do not change over time will be controlled for by including a building specific intercept in the model, i.e., each kWh or kWh bundle associated with a given building will have a common intercept.

Software

The Statistical Analysis System (SAS) software will be used to estimate all survival functions. SAS has a wide range of procedures (LIFETEST, LIFEREG, and PHREG) that can handle right censoring and provide standard errors for each point on the survival curve (including the median) as well as the entire survival function itself. LIFETEST and PHREG also allow for the inclusion of covariates. This software also allows for the possibility of weighting each observation to reflect the sample weights when a non-proportional sample is drawn, as is the case in this study.

Hypothesis Testing

First, note that the Protocols consider useful life to be that year in which half of the units associated with a given measure (e.g., T-8 lamps) installed in a given program year are still in place and functioning. This is consistent with the definition of the median value. It turns out that in survival analysis, the median value is of greatest importance because the mean value is biased downward when there is right censoring, as is the case in this study. Thus, our hypothesis test will focus on the ex ante and ex post median values.

This raises an issue with respect to the ex ante median value. The Protocols currently contain EULs for measures, not whole buildings. One of the first steps in conducting this study will be to construct an ex ante EUL for the whole building. We propose to do this using the method described previously for computing building-level TDF. This can then be used as the point of comparison in our hypothesis test.

The null hypothesis established for this phase of the analysis is that the building-level EUL (a median value) estimated as a part of this research project is not statistically different from the ex ante EUL (a median value) at the 70% and 80% percent levels of confidence, i.e.,

$$EUL_{ex\ post} = EUL_{ex\ ante.} \qquad (8)$$

The hypothesis test is perhaps the most difficult task. This is the case since, in order to compare the *ex ante* median to the *ex post* median, we must first forecast the ex post median. That is, the model will be extrapolated to times that are far beyond those that are actually observed. The forecast error will be substantial.

Once the median is forecasted, a one-sample sign-test will be calculated. This test is a way to compare the EUL based on the sample to a predetermined point estimate, the ex ante EUL (that is, the median of all values, which we will designate M_0). First, a count is made of the number of values exceeding M_0. We will call this count n_1. The count of the number of values less than M_0 is designated as n_2. If the alternative hypothesis is that the population median $\neq M_0$ then the test statistic is the smaller of n_1 and n_2. The null hypothesis is rejected if the test statistic is less than the critical value contained in the appropriate statistical tables.

The critical value that will be used for this two-tailed sign test is 1.28 (80%).

Data Structure

From information gathered during the on-site surveys, we will modify first-year evaluation DOE-2 models to reflect any changes we discover that might result in kWh failures. We will rerun these models and calculate the reduction in savings resulting from each kWh failure. These savings losses, along with the dates of measure installation and kWh failure, will be placed in a database with the structure shown in Table 2.

The data can then be read into SAS where the data will be structured in the manner shown in Table 3. Each observation represents a bundle, with the duration denoting the number of months after installation that each bundle has survived to date. For bundles that have not survived, the status flag is equal to one, and the duration is the time from installation to kWh failure.

Table 2: Data Structure for EUL Analysis

Site	Total kWh	Treat_dt	Lost1_kWh	Lost1_dt	Lost2_kWh	Lost2_dt	Lost3_kWh	Lost3_dt
1	45,000	6/3/94	1,000	3/1/96	10,000	7/4/97	.	.
2	1,200,000	2/3/94	0	.	.	.	.	.
3	820,000	12/15/94	0	.	.	.	.	.
4	56,000	12/25/95	20,000	2/14/97	.	.	.	.
5	15,000,000	4/2/95	12,000	4/4/96	100,000	5/30/97	5,000	4/3/98
6	150,000	8/30/95	10,000	3/1/97	.	.	.	.
7	235,000	11/1/94	0	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
n	.	.	.	.	.	.	.	.

~~Note~~: The size of the standard bundle should be equal to the smallest bundle unless the smallest bundle is so small as to create an exceedingly high number of observations. In such a case, the smallest bundles may have to be dropped from the analysis.

Table 3: Data Structure

OBS	DURATION	STATUS
1	3	1
2	12	1
3	5	1
4	41	0
5	32	1
6	41	0
7	41	0
8	23	1
9	9	1
10	14	1
11	41	0
12	41	0
13	12	1
14	41	0
15	41	0
16	41	0
17	41	0
18	34	1
19	41	0
20	41	0
21	25	1
22	41	0

Required Samples Sizes

For this evaluation, one must attempt to estimate the number of kWh failures required to achieve the required level of precision. To perform this calculation, one must make a number of other assumptions in addition to the confidence level. For example, how big a difference between the *ex ante* and the *ex post* EULs (the so-called effect size) should the statistical test be able to detect as significant?[1] This is a particularly critical factor since the sample size is to a large extent a function of the effect size. As the expected size of the effect increases, the required size of the sample decreases. Because, the Protocols say nothing about effect size, there is a fair amount of latitude regarding the size of their retention samples. Simply setting the desired level of confidence at 80 percent, as the Protocols do, does not lead one to the desired sample size.

For this calculation the exponential functional form was assumed to produce a range of required sample sizes. The following assumptions were made:

- a power[2] of .8 or .7
- an alpha of .20 (i.e., 80 percent confidence level)
- an *ex ante* EUL of 16 years
- a range of possible effect sizes, Δ

The calculation of the effect size requires some further explanation. If one assumes that the survival curves have an exponential distribution, then we have:

$$\pi_{\mathrm{T}} = \mathrm{S}(\tau)\exp(-\lambda_{\mathrm{T}}\tau) \qquad (8)$$

where π_T is the proportion of kWh bundles surviving at some fixed time τ and λ_T is the constant hazard for a given kWh bundle. Equation 7 can be rewritten as

$$\lambda_{\mathrm{T}} = \frac{-\log\pi_{\mathrm{T}}}{\tau} \qquad (9)$$

In a similar way, we can obtain for the ex ante EUL at the same time τ

$$\lambda_{\mathrm{C}} = \frac{-\log\pi_{\mathrm{C}}}{\tau} \qquad (10)$$

Thus, the effect, Δ, is defined as

$$\frac{\lambda_T}{\lambda_C} \qquad (11)$$

Specifically for the median, the following equation holds

[1] The effect size, the size of the sample, and the confidence level can be used to determine the *power* of the test (Cohen, 1988). Alternatively, the desired power of the test, the expected effect size, and the confidence level can be used to determine the size of the sample.

[2] The power of a statistical test of a null hypothesis is defined as the probability that it will lead to a rejection of the null hypothesis when it is false.

$$\Delta = \frac{\lambda_T}{\lambda_C} = \frac{M_C}{M_T} \qquad (12)$$

where M_C is the estimated median survival time based on the sample in this study while M_T is the estimated median survival time for the ex ante EUL.

It can be shown that if an equal number subjects are allocated to each treatment, the total number of events, E, that need to be observed in a study comparing two treatment groups is given approximately by

$$E = [(Z_{1-\alpha} + Z_{1-\beta})(1+\Delta)/(1-\Delta)]^2 \qquad (13)$$

where $Z_{1-\alpha/2}$ is the upper point of the standard normal distribution and $Z_{1-\beta}$ is the power of the test. Using this equation and the assumptions listed earlier, the number of required kWh failures was calculated. However, an adjustment must be made to these numbers that account for the fact that we have only one group that has a known distribution, the sample of sites and their associated kWh bundles in this study. The *ex ante* EUL has no distribution; it is just an *a priori* engineering assumption. Such an adjustment must be done in order to account for the fact that we have only half of the sampling error. Using an adjustment factor of 0.50 (Cohen, 1988) produces a new range of required kWh failures from 30 to 113.

While we plan to survey 150 sites, we are assuming, for this calculation, that we will actually visit no more than 30 sites. Let us also assume that the kWh savings at each site can be divided into ten bundles bringing the total number of bundles to 300 (10 x 30). Thus at one range of the continuum, we must observe kWh failures in at least 30 or 10 percent of the 300 bundles. At the other end of the continuum, we must observe kWh failures in at least 113 or 38 percent of the 300 bundles.

Alternative Approaches

There are four basic approaches to estimating EULs. The approach we propose adopting is classic survival analysis (CSA) which involves the analysis of data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end-point (Collett, 1994). If the expected number of kWh bundle failures is not observed during the on-site surveys, we will adopt one or more of the three alternatives to classic survival analysis listed below:

1. Regression: Uses the familiar estimation of an ordinary least squares (OLS) regression that estimates the relationship between time and the percent of savings remaining at a site or the percent of equipment still present and operable (Maddala, 1992).

2. Functional Form: Involves assuming a functional form (AFF) such as the logistic or exponential, conducting a survey at a given point in time after the installation, and using the data in conjunction with the adopted functional form to estimate the EUL.

3. Time Series: Analyzes a single variable over time, using such methods as Box-Jenkins and exponential smoothing (Goodrich, 1992).

Program-Level EUL

We will calculate one EUL applicable to the PY94/96 NRNC programs. This program-level EUL will be computed as the sample-weighted mean of the corresponding whole-building-level EULs. The combined case weights for this evaluation (described in Section 5.2) will be used to extrapolate the results from the sample of 150 sites in this evaluation to the program population of 861 sites.

References

1. Cohen, Jacob, *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1988.

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4. Goodrich, Robert L. *Applied Statistical Forecasting*. Belmont, MA: Business Forecast Systems, 1992.

5. Maddala, G. S. *Introduction to Econometrics*. Englewood Cliffs, NJ: Prentice Hall, 1992.

6. Parmar, M. *Survival Analysis: A Practical Approach*. New York: John Wiley & Sons, 1995.

7. SAS Institute, Inc., *SAS/STAT User's Guide* (Version 6: Volume 2: Fourth Edition), 1990.

8. SBW Consulting, Inc., *Final Evaluation Research Plan--PG&E's 1994/96 Non-Residential New Construction Retention Study*, October 15, 1998.

Appendix G

M&E Protocol Information

This appendix provides a consolidated tabulation of results from this evaluation, which meet the reporting requirements defined by the California Public Utility Commission's Measurement and Evaluation (M&E) Protocols. It provides all information required by the following tables in the M&E Protocols:

Table 6	Protocols for Reporting Results of Required Studies Used to Support an Earnings Claim (Section B)
Table 7	Documentation Protocols for Data Quality and Processing (Section B)

The end of this appendix also contains the retroactive waiver that modifies nonresidential new construction retention study requirements. This waiver is titled “Southern California Edison and Pacific Gas & Electric Retroactive Waiver Nonresidential New Construction Program Persistence Studies” (Study ID Numbers 548/554 and 323-R1, approved March 18, 1998).

RESPONSE TO M&E PROTOCOL TABLE 6

Protocol Table 6.B
Results of Retention Study
PG&E PY1994 Nonresidential New Construction Sector

Study ID 323 R1

Item 1			Item 2		Item 3	Item 4	Item 5	Item 6		Item 7	Item 8	Item 9
PG&E Measure Code	Studied Measure Description	End Use	Ex Ante EUL	Source of Ex Ante EUL (ref. Ftnote)	Ex post EUL from Study	Ex Post EUL to be used in Claim	Ex Post EUL Standard Error	80% Conf. Interval Lower Bound	80% Conf. Interval Upper Bound	p-Value for Ex Post EUL	EUL Realizat'n Rate (ex post/ex ante)	"Like" Measures Associated with Studied Measure (by measure code)
N/A	Whole building[1]	--	16 years	1	16 years	16 years	N/A	N/A	N/A	N/A	1	Not applicable.

Ex Ante Source References: 1 PG&E Program Files

Notes
1. Per Deviation #1 in the retroactive waiver, this retention study treated the measures for the programs as the "whole building," rather than a collection of separate measures associated with specific end uses. Therefore, this study evaluated changes in savings for each whole building (also referred to as a "site").

RESPONSE TO M&E PROTOCOL TABLE 7

1. *Overview Information*

A. Study Title and ID Number: PY94 Nonresidential New Construction Retention Study, PG&E Study ID Number 323 R1.

B. Program, Program Year, and Program Description: This evaluation covers the 1994 and 1996 Non-Residential New Construction Programs. Sites covered by the first-year savings evaluations for these programs included all those with applications that were paid rebates in either 1994 or 1996.

C. End Uses and Measures Covered: Per Deviation #1 in the retroactive waiver, this retention study treated the measures for the programs as the "whole building," rather than a collection of separate measures associated with specific end uses. Therefore, this study evaluated changes in savings for each whole building (also referred to as a "site").

D. Methods and Models Used: We estimated changes in gross savings by running DOE-2.1E simulations and other engineering models. For sites with measures affected by technical degradation factors (TDF), these calculated changes formed the basis for determining program-level TDFs. Originally, we intended to use the calculated changes at sites with kWh failures to develop a statistical model to estimate effective useful life (EUL). The absence of any kWh failures made the estimation of any statistical models impossible. As a result, the ex ante EUL was adopted. The aforementioned analysis methods for estimating any changes in gross savings are described in detail in Section 6 (Analysis Methods). The originally planned statistical analysis is described in detail in Appendix F.

E. Analysis Sample Size: The table below outlines the evaluation population, sample frame, and final analysis sample. Additional details can be found in Section 4 (Sample Design).

	Number of Sites			Sample Weights*	% of Ex Post Savings**	
Retention Study Stratum	Program Population (estimate)	First-Year Impact Evaluation Sample	Retention Sample	Retention to First-year	kWh	kW
1	536	102	49	2.082	2.4	3.3
2	158	45	32	1.406	8.4	9.9
3	73	32	20	1.600	10.7	9.2
9	94	49	49	1.000	66.6	63.0
All	**861**	**228**	**150**	**--**	**88.1**	**85.4**

* For simplicity's sake, only the four sample weights to extrapolate retention sample results to the first-year evaluation sample are shown. The 10 weights used to extrapolate first-year evaluation sample results to the program population span the retention evaluation strata. Multiplying these 10 weights by the 4 other weights on a site-by-site basis yields a total of 32 combined case weights that extrapolate the retention sample to the program population.

2. Database Management

A. Data Sources: The two new data sources developed for this evaluation, the telephone survey and on-site survey, are described in detail in Section 5 (Data Collection). Existing data sources that were used in this evaluation are listed and described in Appendix C (Data Sources). Section 2 (Overview of Research Design) contains a flowchart depicting the interrelationships between the data sources.

B. Data Attrition: All 228 sites that participated in the 1994 and 1996 first-year evaluations were included in the sample frame. Of these, we selected 150 sites (plus a number of replacement sites) via a stratified random sample. Among potential telephone survey respondents, 150 of the 151 (99.3%) agreed to participate. All nine of the on-site survey respondents agreed to participate. Sample selection processes, recruitment, response rates, and attrition are described in more detail in Section 4 (Sample Design).

C. Data Quality Checks and Procedures: To verify the quality of the evaluation data we produced, we used a two-pronged approach, described as follows: (1) Reproduce First-Year Evaluation Results. We worked with PG&E and past evaluation consultants to develop a sample frame that contained whole-building-level ex ante and ex post savings estimates and case weights that yielded the program population totals documented in the final PY94/96 NRNC program evaluation reports. (2) Check DOE-2 Results. For sites that required DOE-2-based analysis, we first reran the first-year evaluation DOE-2 models, compared the results with the original database savings, and in two cases, resolved resulting discrepancies. After modifying the models to adjust for TDF effects, we calculated the relative change in savings. For sites with non-trivial changes, we double-checked model inputs and associated calculations.

D. Unused Data: All data collected were used.

3. Sampling

A. Sampling Procedures and Protocols: A complete description of the sample design and implementation can be found in Section 4 (Sample Design).

B. Survey Information: The telephone survey instrument is provided in Appendix B. Among potential telephone survey respondents, 150 of the 151 (99.3%) agreed to participate. All nine of the on-site survey respondents agreed to participate. Further information on survey response rates can be found in Section 4 (Sample Design).

C. Statistical Descriptions: Not applicable.

4. Data Screening and Analysis

A. Outliers and Missing Data: Not applicable.

B. Background Variables: Not applicable.

C. Data Screening: No screening of cases was done beyond the initial sampling.

D. Model Statistics: Not applicable.

E. Specification: Not applicable.

F. Measurement Error: We checked the accuracy of telephone survey self-reporting by visiting four sites that reported no changes to energy efficiency equipment. In all four cases, the on-site surveys confirmed the validity of the telephone survey.

G. Influential Data Points: Not applicable.

H. Missing Data: Not applicable.

I. Precision: Not applicable.

SCE and PG&E Retroactive Waiver

SOUTHERN CALIFORNIA EDISON AND PACIFIC GAS & ELECTRIC RETROACTIVE WAIVER
NONRESIDENTIAL NEW CONSTRUCTION PROGRAM
PERSISTENCE STUDIES
(Study ID Numbers 548/554 and 323-R1)
Date Approved: April 15, 1998

Summary of Request

This waiver requests adjustments by Southern California Edison (Edison) and Pacific Gas & Electric (PG&E) to the Protocols for the Persistence Study requirements for their Nonresidential New Construction Programs. Edison and PG&E seek approval to use the sampling plan and whole building modeling from the 1994 and 1996 impact evaluations as the basis of the persistence study sample and models. This requires the following Protocol deviations:

1. Treat the "measure" for these programs as the "whole building", rather than as a collection of separate measures.
2. Calculate a program-wide "effective useful life (EUL)" on the basis of program participant buildings and rebated components which are no longer in service (partially or fully).
3. Calculate a program-wide "technical degradation factor" on the basis of a ratio between current whole building energy savings calculated using degraded equipment efficiency and the whole building energy savings calculated in the original impact study.
4. Combine the persistence studies for program years 1994 and 1996 into a single study to be filed in March, 1999. The sample for this study will be drawn from a pooled sample from the PY94 and PY96 impact studies.

In the remainder of this waiver, items (1) to (4) above are referenced by their item number.

PROGRAM SUMMARY Nonresidential New Construction Program

Southern California Edison

	1996	1994
Number of Participants (coupons)	130	295
Administrative Costs	$919K	$3,940K
Incentive Costs	$2,834K	$5,518K
Total Program Costs	$3,753K	$9,480K
Net Resource Benefits	$12,081K	$22,715K
Earnings	$1,297K	$2,017K

Pacific Gas & Electric

	1996	1994
Number of Participants (coupons)	407	454
Administrative Costs	$5,099K	$3,724K
Incentive Costs	$6,283K	$6,673K

Total Program Costs	$11,382K	$10,397K
Net Resource Benefits	$61,603K	$36,935K
Earnings	$2,364K	$7,655K

Proposed Approach

Edison and PG&E propose to use the methodology from their 1994 and 1996 nonresidential new construction first year impact studies as the foundation for their persistence methodology. This proposed methodology will build on the sampling, data collection and analysis methods of the impact studies, and the rich database generated in these studies. This approach will provide the most accurate and cost-effective approach to evaluating persistence.

The methodology which is being proposed for this study is summarized below:

- A sample frame will be created from the pooled participant samples from the PY94 and PY96 NRNC impact evaluations. A persistence study sample will be drawn from this pooled sample.
- A telephone survey will be performed on the sample selected. Respondents will be asked about changes to their facilities (or portions thereof) which had participated in the NRNC program. Changes in these participating facilities will trigger an on-site survey to examine the status of equipment installed under the NRNC program. Changes triggering an on-site survey will include: a) the facility being removed from service, b) change of tenant, or c) removal or modification of equipment installed under the NRNC program.
- A DOE-2 simulation will be performed for all sampled sites as follows. The original DOE-2 runs for each facility will be modified to reflect the results of the statewide performance study[1]. The efficiencies of installed equipment will be adjusted based on the performance study and the DOE-2 run re-simulated to determine whole building impacts resulting from the performance change.
  In addition, for sites where significant facility alterations have occurred (as determined through the telephone survey and subsequent on-site survey), these changes will be reflected through appropriate modification and re-simulation of the original DOE-2 model. Energy simulations will be based on the original footprint of the participant buildings except as follows: a) additions to the buildings will not be included in calculations of energy savings, and b) spaces removed from service will be subtracted from calculated energy savings
- The results of the modified DOE-2 simulations will be statistically expanded to the participant population. Statistical expansion of savings estimates will be based on the original footprint of participant buildings except as follows: a) additions to buildings will not be used in expanding energy savings estimates, and b) spaces removed from service will be reflected in the expansion of energy savings estimates. Program gross and net results will be then be factored up or down to reflect persistence effects.

Rationale

The first year impact studies for their nonresidential new construction programs conducted by Edison and PG&E included a carefully drawn sample of the participant buildings, and statistical expansions that relate this sample to the full program population. Detailed on-site surveys were conducted, and DOE-2 models were constructed, for each of the sampled buildings. The companies have retained these data in a form which can be re-used for the proposed persistence study.

The proposed approach will seek to identify changes to the buildings which may have eliminated some or all of the original buildings' energy systems, or which could degrade their energy performance. These effects will be quantified through use of the original DOE-2 models. The results, determined from the original sample of buildings, will be expanded to the program population using the same expansion factors developed from the impact study sampling methodology.

[1] Treatment of technical degradation is subject to further revision and clarification for all persistence studies. An issue which remains to be determined is the functional form of technical degradation, i.e., linear function, cumulative percentage, step function, etc.

This approach to determining persistence will pose a minimum of inconvenience to customer facilities, and will make good use of the expensive and highly detailed information that was previously gathered. We believe it is the most efficient method for arriving at accurate persistence information for new buildings.

Proposed Waiver

In following this proposed approach, Edison and PG&E seek CADMAC approval to deviate from the Protocols in the following specific ways:

(1) Treat the "measure" for these programs as the "whole building", rather than as a collection of separate measures

Parameter

Table 9A for Nonresidential New Construction, Measures Included in Retention and Performance Studies.

Protocol Requirement

The Protocols specify that the "Top 10 Measures" be included.

Waiver Alternative

For Nonresidential New Construction programs, the Impact Measurement Protocols specify, in Table C-8, that the End Use Element is the Whole Building, and that the measures are "all lighting hardware efficiency improvements combined, and all HVAC combined". The designated unit of measurement is the load impact per building. Table 9A should be modified to specify "Whole Building Performance", rather than "Top 10 Measures", to be consistent with the previously adopted revisions which are reflected in Table C-8.

Rationale

The Nonresidential New Construction program sought to improve the overall energy efficiency of the building, not simply to install a few specified measures. In this respect, it was different from a retrofit program, which necessarily focused on changing one or more discrete systems within an existing structure. In earlier modifications to the Protocols, changes were made to the requirements for conducting impact measurements which reflected this characteristic of the new construction program. This change merely extends this logic to the follow-on persistence studies.

The current protocols for persistence studies treat the new construction program like a retrofit program, requiring a measure-by-measure treatment. This approach would not provide meaningful information about whether or how much the whole building performance had degraded over time.

As will be discussed below, the completed impact studies provide a foundation for conducting the persistence studies in an efficient and consistent manner. Furthermore, by studying the persistence of energy efficiency improvements on the whole building, we will be able to answer the more relevant question about how overall new building efficiency changes over time.

(2) Calculate a program-wide "effective useful life (EUL)" on the basis of program participant buildings which are no longer in service (partially or fully)

Parameter

The Net Resource Benefits are to be calculated as the product of :

1st year net impacts x effective useful life x technical degradation factor

according to Table 10, Note 3b. The effective useful life (EUL) parameter in this calculation is addressed here for nonresidential new construction programs.

Protocol Requirement

The Protocols' definition in Appendix A of Effective Useful Life speaks of the median number of years that the measures installed under the program are still in place and operable. In the case of the Edison and PG&E nonresidential new construction programs, where the whole building is the measure, an appropriate interpretation of this definition is needed.

Waiver Alternative

Edison and PG&E propose to interpret the definition of Effective Useful Life, in the case of this program, to mean the effective useful life of the new buildings (or portions thereof) which participated in its program, and to translate reductions in the program participant building stock into reductions in program savings over time.

Rationale

For nonresidential new construction, there are generally two kinds of changes to buildings which affect their useful life: the original space is taken out of service, or it is remodeled and the original energy systems are no longer present. In either case, the original program effects are no longer operative, and so would be removed from subsequent earnings claims. Since we are concerned here with the whole building, these changes may apply to the entire space, to a portion of the space, or even to one of the systems in the space (e.g. a lighting system change-out). The challenge is to quantify the energy effects of these changes.

The proposed approach would be taken in two steps. First, a telephone survey would be conducted to determine which of the buildings in the sample had undergone significant changes or remodeling since they were first built under the program. Second, for those sites which appear to be changed, a follow-up on-site survey would be conducted to determine the nature of the changes. If the space or its systems are found to be substantially different from their state at the time of the impact evaluation, then the lost energy savings associated with the original space or systems would be calculated. These "lost savings" would be statistically expanded to the entire program population and a reduction factor for the 1st year net impacts would be calculated.

The technical details of this process would be carried out using the same methods and procedures as were used in the original impact study in order to retain consistency. The only changes that would enter into the calculations would be those discussed in the previous paragraph. Other kinds of changes, such as different operating hours or even different tenants, would not be included. This is because the intent of the persistence studies is to focus on the physical characteristics of the program's effects, not the operational characteristics of the buildings which could change frequently over the life of the building.

(3) Calculate a program-wide "technical degradation factor" on the basis of a ratio between current whole building energy savings and the whole building energy savings calculated in the original impact study

Parameter

The Net Resource Benefits are to be calculated as the product of :

1st year net impacts x effective useful life x technical degradation factor

according to Table 10, Note 3b. The technical degradation factor (TDF) in this calculation is addressed here for nonresidential new construction programs.

Protocol Requirement

The Protocols definition in Appendix A of Technical Degradation Factor is: A scalar to account for time and use related change in the energy savings of a high efficiency measure or practice relative to a standard efficiency measure or practice. In the case of the Edison and PG&E nonresidential new construction programs, where the whole building is the measure, an appropriate interpretation of this definition is needed.

Waiver Alternative

Edison and PG&E propose to interpret the definition of Technical Degradation Factor, in the case of this program, to mean the degradation in energy savings of the new buildings which participated in its program over time.

Rationale

The rationale here is similar to that for Waiver Alternative #3 discussed above.

For nonresidential new construction, there are many measures which could be reduced in their technical performance over time. When this happens, the original program savings are reduced and so would be subtracted from subsequent earnings claims. Since we are concerned here with the whole building, these changes need to be determined in the context of the whole building energy savings. The challenge is to quantify the energy effects of these changes.

The proposed approach would apply the results of the statewide performance degradation studies to the equipment installed in the sample buildings. The original DOE-2 models for these buildings would be re-run with revised equipment efficiencies, and the difference in whole-building energy savings calculated. These "lost savings" would be statistically expanded to the entire program population and a reduction factor for the 1st year net impacts would be calculated.

The technical details of this process would be done using the same methods and procedures as were used in the original impact study in order to retain consistency. The only changes that would enter into the calculations would be those discussed in the previous paragraph. Other kinds of changes, such as different operating hours or even different tenants, would not be included. This is because the intent of the persistence studies is to focus on the physical characteristics of the program's effects, not the operational characteristics of the buildings which could change frequently over the life of the building.

(4) Combine the persistence studies for program years 1994 and 1996 into a single study to be filed in March, 1999. The sample for this study will be drawn from a pooled sample from the PY94 and PY96 impact studies

Protocol Requirement

Table 9A specifies that retention studies for program years 1994 and 1995 should be combined and submitted in March, 1999. Similarly, retention studies for program years 1996 and 1997 should be combined and submitted in March, 2001.

Waiver Alternative

Edison and PG&E propose to do a combined persistence study of program years 1994 and 1996 (the two years for which impact evaluations were completed), and to submit the results in March, 1999. The sample for this study will be drawn from a pooled sample from the PY94 and PY96 impact studies

Rationale

It would be impossible to do persistence studies for program years 1995 and 1997, because the proposed approach to conducting these persistence studies relies on the existing impact evaluation data, and these data do not exist for those years.

Combining the studies for PYs 1994 and 1996 allows for a more robust sample of new construction participants. Over the study period this approach will lead to a larger number of observations in years two to four of new building use. It will also provide age-specific persistence data from two different building age cohorts (as sought by the Protocols in Table 9A, #2). Both of these study design characteristics should lead to more accurate estimation of a NRNC survival function that can be applied to both program years. Because the DOE-2 based methodology being proposed is extremely costly, combining program years will also help to keep evaluation costs under control.

Table A
Summary of Retroactive Waiver for Studies 548/554 and 323-R1

Impact Measurement Requirements - Table 9A and Table 10

Parameters	Protocol Requirements	Waiver Alternative	Rationale
Measures to be included in retention study	Table 9A: include top 10 measures or 50 percent of resource value	Make persistence studies consistent with the designated unit of measurement for the first year impact study as specified in Table C-8 by using whole building analysis instead of top 10 measures. Use whole building analysis methodology developed for PY94 and PY96 impact evaluations.	New construction program addressed whole building performance. Impact studies measured whole building performance. Measure-by-measure approach is not appropriate here.
Effective useful life	Table 9A, Section 3: data should be collected (using telephone, on-site, or mail surveys) and used to estimate a survival function for each measure. Effective useful life (EUL) is determined from the survival function.	Interpret to mean effective useful life of the whole-building energy efficiency level in new buildings which participated. A building's energy savings survival function is determined from data on its removal from service and changes in its energy using equipment. Effective useful life (EUL) is determined from the survival function.	Approach would quantify loss of program savings due to buildings taken out of service or remodels that affect the overall energy efficiency of the building. Lost savings can be expanded to program population using statistical methods developed for impact studies.
Technical degradation factor	Table 9A, Section 4: technical degradation factor is to be determined at a measure level by the statewide performance study.	Interpret to mean degradation in energy and demand savings over time of new buildings which participated. Savings losses will be calculated for whole buildings, using existing DOE-2 models with individual equipment degradation included in model.	Approach would quantify loss of program savings due to performance degradations of equipment, as identified by the statewide performance study. This methodology will provide a more accurate estimate of technical degradation at a whole building level.
Combined persistence studies	Table 9A, Section 2: retention studies for PY94 and PY95 to be done by 1999; retention studies for PY96 and PY97 to be done by 2001.	Combine PY94 and PY96 studies. Sample will be drawn from a pooled sample from PY94 and PY96 impact studies.	Under proposed methodology, needed data and models are not available for PY95 and PY97. Combining PY94 and PY96 studies allows for more robust sample, more accurate estimation of survival function, and reduced costs.