PG&E's PY 1994-1996 Ninth Year Non Residential New Construction Retention Study

PG&E Study ID numbers: 323 R2 and 424 R1

March 1, 2004

Prepared for:

Pacific Gas and Electric Company

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Measurement and Evaluation
Customer Energy Management Policy, Planning &
Support Section
Pacific Gas and Electric Company
San Francisco, California

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As part of its Customer Energy Management Programs, Pacific Gas and Electric Company (PG&E) has engaged consultants to conduct a series of studies designed to increase the certainty of and confidence in the energy savings delivered by the programs. This report describes one of those studies. It represents the findings and views of the consultant employed to conduct the study and not of PG&E itself.

Furthermore, the results of the study may be applicable only to the unique geographic, meteorological, cultural, and social circumstances existing within PG&E's service area during the time frame of the study. PG&E and its employees expressly disclaim any responsibility or liability for any use of the report or any information, method, process, results or similar item contained in the report for any circumstances other than the unique circumstances existing in PG&E's service area and any other circumstances described within the parameters of the study.

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Summary

The goal of the study was to estimate the persistence of whole-building savings among the participating facilities of the 1994 and 1996 Non-Residential New Construction (NRNC) programs offered by Pacific Gas and Electric and Southern California Edison. This report provides the PG&E results. A companion report is available for SCE's programs. This report also provides results for fifteen Pre 1998 Carryover projects (called Performance Adder projects). These were program year 1996 projects but were not paid until 1999.

This study has been conducted under a waiver given to Southern California Edison and Pacific Gas and Electric. Following the waiver, the report emphasizes the persistence of savings at the whole building level rather than the retention of specific measures. The key issues explored in this study were:

- **Technical Degradation**, the reduction in the whole-building savings from technical degradation of the installed measures due to age and wear,
- **Persistence of Whole-Building Savings** due to the continued use of the building with either the originally installed measures or replacement measures of equal or better efficiency,
- **Survival Function of Savings**, the mathematical model used to characterize the persistence of the whole-building savings as a function of time, and
- **Effective Useful Life (EUL),** the number of years from the initial program year when one half of the whole-building savings would be expected to persist.

The three programs addressed in this study had a total of 876 participating facilities, with a total ex-post first year savings of about 191,478,000 kWh of energy and 45,750 kW of demand. We collected information on a sample of 165 of these facilities, about 20% of all facilities. The sites in the sample had almost half of the total energy and demand savings of all 876 projects. We used a telephone survey to identify changes in any sample project that might reduce its energy efficiency. On-site surveys were conducted for all projects where the telephone survey indicated changes that may have impacted the whole-building saving. Onsite surveys were done at 64 of the 165 sample sites.

DOE-2 models were constructed for all sample buildings for which the onsite audits revealed changes that would affect the whole-building savings. A total of seven sites were found to have lost savings. Table 1 summarizes the current program persistence determined from these data. Results are given for the1994 and 1996 NRNC programs as well as the Performance Adder projects.

Year	Ex Post Savings		Lost Savings		Persistence
	kWh	**kW**	**kWh**	**kW**	
1994	81,350,000		1,297,375		98.4%
		19,680		429	97.8%
1996	83,970,000		833,506		99.0%
		20,000		130	99.3%
Performance Adder	26,158,256		0		100.0%
		6,060		0	100.0%
Total	191,478,256		2,130,881		98.9%
		45,740		559	98.8%

Table 1: Persistence Results

Across the three program segments, almost 99% of the ex-post first-year savings has persisted to the current time.

Four different survival models were estimated from the persistence results of the fourth-year and ninth-year persistence studies for each of the three program segments. Each of the estimated survival models was used to calculate the estimated EUL. Table 2 shows the median value as well as the upper and lower bounds for the EUL at the 80% level of confidence.

Model	Median EUL	Upper Bound	Lower Bound
Exponential	630	1,176	84
Log Normal	36	95	0
Weibull	22	43	1
Logistic	16	21	10

Table 2: Effective Useful Life for Annual Energy

The exponential model was rejected since it did not fit the data as well as the other models. The remaining three models fit the available data equally well but provided widely varying estimates of the EUL. For example, under the logistic model, the 80% confidence for the EUL is from 10 years to 21 years. The ex-ante value of the EUL, which was 16 years, is within the lower and upper bounds given by each of these three models. Therefore we have concluded that the ex-ante value of the EUL cannot be rejected, and that the ex- post estimate should be taken to be equal to the ex-ante estimate of 16 years.

In the technical degradation analysis, DOE-2 models were constructed for almost all of the sample buildings. The results, shown below in Table 3, indicate that there is virtually no technical degradation of either the energy or demand savings of these programs on a whole-building basis.

FINAL RESULTS

All End Uses Combined
Program Years 1994 and 1996

Measure	Ex Post Savings[1]		EUL	
Description	kWh	kW	Ex Ante	Ex Post
Whole Building[2] kW	--	45,740	16 Years	16 Years
Whole Building[2] kWh	191,478,256	--	16 Years	16 Years
Totals	191,478,256	45,740	16 Years	16 Years

Year	kW	kWh
1	1.000	1.000
2	0.996	0.996
3	0.996	0.996
4	0.997	0.997
18	0.997	0.997
19	1.000	0.998
20	1.001	0.998

Table 3: Technical Degradation Results

[1, 2]: See Notes in Appendix A

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Executive Summary

Goals

The goal of the study was to estimate the persistence of whole-building savings among the participating facilities of the 1994 and 1996 Non-Residential New Construction (NRNC) programs offered by Pacific Gas and Electric and Southern California Edison. This report provides the PG&E results. A companion report is available for SCE's programs.

This report also provides results for fifteen Pre 1998 Carryover projects (called Performance Adder projects). These were program year 1996 projects but were not paid until 1999.

Throughout the report the term ***persistence*** refers to the current whole-building savings as compared to the whole building first year savings, e.g., the savings after a specified number of years. The term ***retention*** refers to the continued operation of a participant facility or portion thereof, or an incented measure serving the facility. This study has been conducted under a waiver given to Southern California Edison and Pacific Gas and Electric. Following the waiver, the report emphasizes the persistence of savings at the whole building level rather than the retention of specific measures.

The key issues explored in this study were:

- **Technical Degradation**, the reduction in the whole-building savings from technical degradation of the installed measures due to age and wear,
- **Persistence of Whole-Building Savings** due to the continued use of the building with either the originally installed measures or replacement measures of equal or better efficiency,
- **Survival Function of Savings**, the mathematical model used to characterize the persistence of whole-building savings as a function of time, and
- **Effective Useful Life (EUL),** the number of years from the initial program year when one half of the whole-building savings would be expected to persist.

Methodology

As shown in Table 4, the three programs addressed in this study had a total of 876 participating facilities, with a total ex-post first year savings of about 191,478,000 kWh of energy and 45,750 kW of demand. We collected information on a sample of 165 of these facilities, about 20% of all facilities. The sample was stratified to over-represent the sites with the greatest savings. The sites in the sample had almost half of the total energy and demand savings of all 876 projects.

	Population	Sample	Percent
Sites	876	165	19%
kWh	191,478,256	90,407,322	47%
kW	45,740	20,507	45%

Table 4: Program Population and Sample Summary

The 876 projects addressed in this study fell across the three program segments that are shown in Table 5. Four hundred and sixty-nine (469) of the sites were from the 1994 NRNC program, and 392 from the 1996 NRNC program. There were another 15 sites that were program year 1996 projects but were not paid until 1999. These sites are referred to as the "Performance Adder" projects. Our samples of the 1994 and 1996 NRNC program participants were identical to the fourth-year persistence samples, which in turn were a subset of the samples of buildings that were included in the first-year impact evaluations. These samples were stratified by the tracking estimate of savings so that larger projects were included with higher probability. We sampled 56 of the 469 sites in the 1994 program and 94 of the 392 sites in the 1996 program. We sampled all of the 15 Performance Adder sites. All results were weighted to extrapolate back to the population of program participants in each of the three program segments.

	Program Population			**Persistence Sample**		
Year	**Sites**	**kWh**	**kW**	**Sites**	**kWh**	**kW**
1994	469	81,350,000	19,680	56	14,847,763	3,404
1996	392	83,970,000	20,000	94	49,401,303	11,043
Performance Adder	15	26,158,256	6,060	15	26,158,256	6,060
Total	876	191,478,256	45,740	165	90,407,322	20,507

Table 5: More Detailed Description of the Sample

In the technical degradation analysis, DOE-2 models were constructed for virtually all of the sample buildings.[1] In each building-specific model, a technical degradation factor was applied to each category of equipment based on the degradation estimates developed by the Statewide Technical Degradation study.[2] We recalculated the kWh and kW savings of the building for each of twenty years to reflect the technical degradation.

We used stratified ratio estimation to extrapolate the technical degradation sample results up to the population of all program participants. We estimated the technical degradation factors in the population for years one through twenty as the ratio between (a) the kWh and kW savings in the specified year after adjusting for technical degradation, and (b) first-year ex-post kWh and kW savings. By definition, the first-year technical degradation factors were one.

To provide the information required for the persistence analysis, we used a combination of telephone and on-site surveys to identify changes in the sample sites that might reduce their energy efficiency. We used the resulting sample information to estimate the proportion of the whole-building savings that is persisting and to estimate the effective useful life of the whole-building savings. Our approach was designed to satisfy the requirements of the M&E Protocols issued by CADMAC and has been reviewed by the appropriate CADMAC subcommittee. The whole-building approach used in this evaluation was consistent with the 1994 and 1996 first-year impact evaluations, fourth-year persistence evaluation, and the waiver filed by the two utilities.

We used the telephone survey to identify changes in the sample that might reduce their energy efficiency. Follow-up on-site surveys were conducted for all sites where the telephone survey indicated changes that may have impacted the whole-building savings, such as turnover of occupants, renovation of space, removal of the original equipment, or replacement by less efficient equipment. An onsite visit was not required for equipment repairs, replacement with

[1] Technical degradation models were not constructed for seven refrigerated warehouses since they had no measures that were subject to technical degradation as specified in the Statewide Technical Degradation study.

[2] "Summary Report of Persistence Studies: Assessments of Technical Degradation Factors, Final Report," CADMAC Report #2030P, Proctor Engineering Group, February 23, 1999.

equally or more efficient equipment, and changes in operating schedules. Altogether we did onsite surveys at 64 of the 165 sample sites.

The on-site survey consisted of a walk-through of the building by a surveyor. During the on-site, the surveyor compared the data collected during the original survey to the observed equipment. Particular attention was given to the systems that had received incentives in the NRNC program.

In the persistence analysis, DOE-2 models were constructed for all sample buildings for which the onsite audits revealed changes that would affect the whole-building savings. Using our current DOE-2 model generator, we recalculated the ex-post first year savings and the current savings reflecting the current installed equipment and utilization of the building. From the difference in the two estimates of savings we calculated the lost savings to be used in calculating the persistence and EUL of savings. A total of seven sites were found to have changes that resulted in lost savings.

The first step in the statistical analysis of persistence was to estimate the current persistence of the savings for each of the three program segments. We did this by using stratified ratio estimation to estimate 1 minus the ratio between (a) the lost savings in the population of all program participants, and (b) the first-year ex-post kWh and kW savings. All measures of savings were calculated from the DOE-2 models constructed for the sample sites.

Next, four different survival models were estimated from the persistence results of the fourth-year and ninth-year persistence studies for each of the three program segments. Each of the estimated survival models was used to calculate the expected survival proportions for years one through twenty, and to calculate the estimated EUL. The EUL is defined to be the number of years after which the survival proportion for savings would equal to 50%. For example, suppose that after four years, the survival proportion is equal to 85%, i.e., the savings have declined by 15% in four years. Then, under the exponential survival model, under which the probability of failure is assumed to be constant over time, the EUL would be about 17 years[3].

The final objective of the present study was to compare the ex-post estimate of the EUL (i.e., the estimate obtained in this study) to the ex-ante estimate of the EUL that is currently assumed in the program. Because of the whole-building approach, a jackknife methodology[4] was used to calculate the standard errors of the estimated parameters and the EUL. These results were used to carry out a statistical hypothesis test to determine whether the ex-post estimate was significantly different than the ex-ante assumed value.

Results

All building models were projected to their respective original program populations to obtain the total program results presented here. Table 6 shows the estimated technical degradation factors for the energy and demand savings for the total program population. For example, in year ten, the whole-building demand savings of the program is expected to be 0.994 times the first-year whole-building demand savings due to technical degradation of the measures installed in the buildings. These results indicate that there is virtually no technical degradation of either the energy or demand savings on a whole-building basis.

[3] Survival proportion (s) = e^{at}, where s=0.85 and t=4. ln(s)=at or ln(0.85)= -0.1625 =a*4. a=(-0.0406)*17= -0.6902. $e^{-0.6902} = 0.50$

[4] The jackknife methodology looks at the variation in the results as individual projects are excluded, one at a time, from the sample. The methodology is described in Appendix B.

Year	kW	kWh
1	1.000	1.000
2	0.996	0.996
3	0.996	0.996
4	0.997	0.997
18	0.997	0.997
19	1.000	0.998
20	1.001	0.998

Table 6: Technical Degradation Results

Table 7 summarizes the current persistence for the total program savings in annual energy savings in kWh and peak period demand savings in kW. The table shows the persistence results for the 1994 and 1996 programs and the Performance Adder sites. The ex-post savings are the first-year savings shown in Table 5. The lost savings are the total lost savings in the program estimated from the sample. Across the entire set of participating facilities, almost 99% of the ex-post first-year savings has persisted to the current time.

	Ex Post Savings		Lost Savings		
Year	kWh	kW	kWh	kW	Persistence
1994	81,350,000		1,297,375		98.4%
		19,680		429	97.8%
1996	83,970,000		833,506		99.0%
		20,000		130	99.3%
Performance Adder	26,158,256		0		100.0%
		6,060		0	100.0%
Total	191,478,256		2,130,881		98.9%
		45,740		559	98.8%

Table 7: Persistence Results

Table 8 summarizes the persistence information used in the survival analysis. The third through fifth columns summarize the persistence results from the fourth year persistence study. The fieldwork for this study was conducted in 1998, approximately four years after the completion of the 1994 projects and approximately two years after the completion of the 1996 projects. The Performance Adder projects were not included in that study. The fourth year persistence found no lost savings so all of the savings was assumed to have survived.

	MWh	4th Year Persistence			9th Year Persistence		
Year	Savings	Years	Survived	Lost	Years	Survived	Lost
1994	81,350	4	81,350	0	9	80,053	1,297
1996	83,970	2	83,970	0	7	83,136	834
Performance Adder	26,158	na	na	na	5	26,158	0

Table 8: Data for the Energy-Savings Survival Analysis

The final three columns of Table 8 summarize the persistence results from the present, ninth-year persistence study. Our fieldwork for this study was conducted in 2003, approximately nine years after the completion of the 1994 projects, approximately seven years after the completion of the 1996 projects, and approximately five years after the completion of the Performance Adder projects. We have taken the lost energy savings from Table 7, expressed in MWh.

The information summarized in Table 8 was used to estimate the survival function assuming four standard survival models, using the SAS procedure Proc LifeReg[5]. The observed survival and failure observations were assumed to be censured, meaning that we do not know exactly when the failures occurred. For example, the 1,297 MWh of failed savings found in the present study was assumed to have occurred after the fourth year but prior to the ninth year of building life. This reflects the fact that it was not possible to determine the actual age of each sample building when the changes occurred that caused the failed savings.

Table 9 shows the estimated parameters of each of the four estimated survival functions: exponential, log normal, Weibull and logistic. A single parameter, denoted alpha, characterizes the exponential survival function, whereas two parameters (alpha and beta) characterize the remaining three survival functions. The table shows each of the estimated parameters for each of the four models. The functional form of each of these survival functions can be found in the SAS documentation.

Model	alpha	beta
Exponential	908	na
Log Normal	3.58	0.66
Weibull	23.68	4.13
Logistic	15.58	1.66

Table 9: Estimated Parameters of the Survival Equations

The estimated survival functions were used to calculate the persistence factors for twenty years, as shown in Figure 1. Note that the persistence factors are essentially identical in the first nine years but diverge dramatically thereafter.

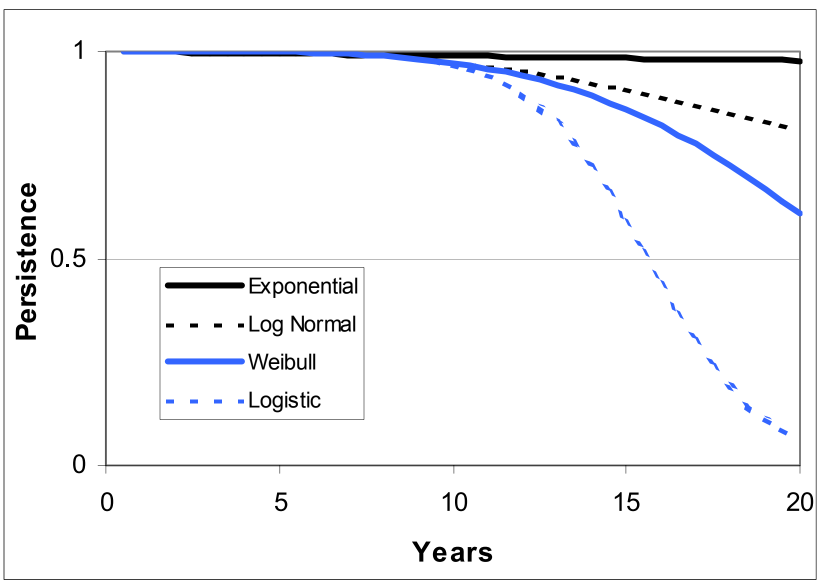

Figure 1: Estimated Survival Functions

[5] The LIFEREG procedure fits parametric accelerated failure time models to survival data.

The estimated survival functions were also used to calculate the equivalent useful life (EUL) of the whole-building savings of these programs. The EUL was determined by calculating the number of years at which the estimated persistence would equal 50%. Table 9 summarizes the results. Under the exponential model, the median EUL was 630 years. Given that this result is implausible, we have rejected the exponential model.

The remaining three models give a range of median EUL from a low of 16 years to a high of 36 years. This wide range of results shows that the available information is too weak to estimate the EUL reliably, but these results do show that the ex-ante value of 16 years is conservative.

Table 9 also shows the upper and lower bounds for the EUL at the 80% level of confidence. For example, under the logistic model, the 80% confidence for the EUL is from 10 years to 21 years. The ex-ante value of the EUL, which was 16 years, is within the 80% confidence interval given by each of the three models, log normal, Weibull, and logistic. Therefore we have concluded that the ex-ante value of the EUL cannot be rejected, and that the ex-post estimate should be taken to be equal to the ex-ante estimate of 16 years.

Model	Median EUL	Upper Bound	Lower Bound
Exponential	630	1,176	84
Log Normal	36	95	0
Weibull	22	43	1
Logistic	16	21	10

Table 10: Effective Useful Life for Annual Energy

The main report also reports results for peak demand. They were very similar to the results for annual energy that have been described.

FINAL RESULTS

All End Uses Combined
Program Years 1994 and 1996

Measure	Ex Post Savings[1]		EUL	
Description	**kWh**	**kW**	**Ex Ante**	**Ex Post**
Whole Building[2] kW	--	45,740	16 Years	16 Years
Whole Building[2] kWh	191,478,256	--	16 Years	16 Years
Totals	191,478,256	45,740	16 Years	16 Years

Discussion of the Results

In this ninth year persistence study, we found that almost 99% of the savings have persisted. The exponential survival model assumes that the failure rate is constant from year to year over the life of the savings. Under the exponential survival function, the savings would persist almost indefinitely since the failure rate has been very small in the first nine years. Of course it is unlikely that the 876 buildings in these programs will last indefinitely. Therefore we have rejected the exponential model.

The remaining three estimated survival functions all have decreasing persistence rates as displayed in Figure 1, i.e., these models have increasing failure rates. Under these survival functions, the rate of failure is predicted to increase at varying rates after ten years of service from the low rate observed in the first nine years. Therefore these three models yield substantially different estimates of the EUL, ranging from 16 years to 36 years.

But during the first nine years, these models yield practically identical predicted persistence rates, as shown in Figure 2. At the present time each of these three models fits the available data equally well. In other words the observed data are insufficient to identify which of these three models is best.

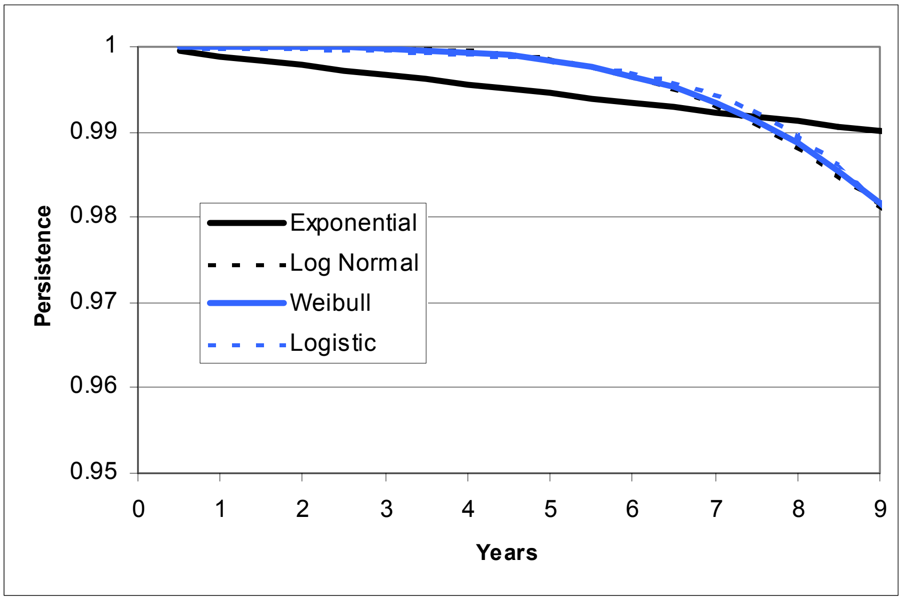

Figure 2: Predicted Survival Rates for the first Nine Years

Lessons Learned

The principle conclusions of this study are:

- The degradation and persistence of whole-building savings can be measured cost-effectively by utilizing the detailed engineering models and excellent customer relationships from the first-year evaluation studies.
- The statistical methodology of the present study seems to work well.
- The persistence of savings is high in these programs.
- Different survival models yielded median estimates of the EUL ranging from 16 to 36 years for energy and from 14 to 23 years for demand. Under the logistic survival model, for example, the 80% confidence for the median EUL of energy was from 10 to 21 years. Therefore the ex-ante estimate of savings of 16 years was not rejected, and the ex-post estimate has been retained at 16 years.

Introduction and Overview

This is the final report for Pacific Gas and Electric's 1994 and 1996 Non-Residential New Construction Ninth-Year Program Persistence evaluation. This document summarizes the key issues in this study, presents the study methodology, and details the findings of the study. A companion report is available for Southern California Edison Company.

This report also provides results for fifteen Pre 1998 Carryover projects (called Performance Adder projects). These were program year 1996 projects but were not paid until 1999.

This study can be thought of as having four phases:

1. Study design
2. Data collection
3. Analysis
4. Reporting

Each phase of the project presented unique challenges.

The figure below shows the overall flow of the project from study design to final reporting. It also summarizes the key issues at each stage of the project. The discussion below briefly describes how we addressed these issues. More complete discussion can be found throughout this report.

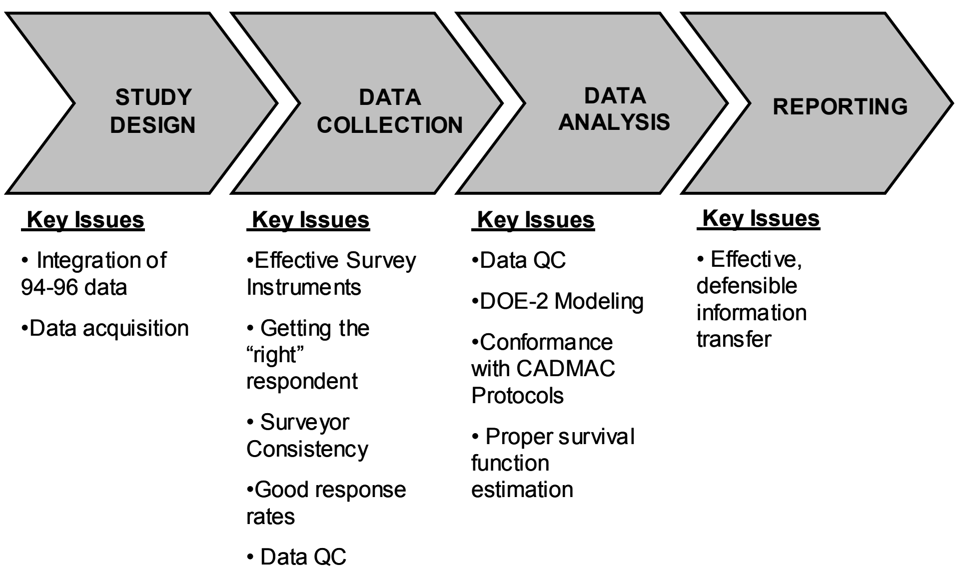

Figure 3: Overall Project Flow and Key Issues

Study Design

Quality control steps that were taken in the early stages of the work profoundly affected the ultimate success of the project. To ensure that a solid foundation was set for the project, the senior staff at RLW Analytics and AEC personally performed the study design tasks.

The first issue that had to be addressed was the integration of the 1994 and 1996 program data. Data collection was slightly different for the 94 and 96 first-year studies and the data resided in databases with different formats. Moreover a different contractor did the PG&E fourth-year persistence study for these programs. This had the potential to introduce errors into the study from the outset. Because we developed these databases for the original impact evaluations, we had an intimate understanding of the structures and the key differences. The same staff that originally developed each of the databases was responsible for merging the data. This use of the original database designers minimized the chances for data errors that could have propagated through the remainder of the analysis.

There were some slight differences in the data collected and engineering modeling algorithms between the 94 and 96 studies. We updated the PY94 database to the PY96 database format and reran the PY94 models with the latest DOE-2 algorithms. The new models were used to re-estimate the ex-post first-year and current savings of each site that had significant changes.

Under the waiver filed by the two utilities, the sample for the ninth-year persistence analysis was to be identical to the sample used in the fourth-year studies of these programs. The fourth-year sample was comprised of 165 sites. So a new sample design was not required, but as described above, effective coordination with the fourth-year contractor was required.

Data Collection

We used a telephone survey to identify changes in the buildings that might reduce their energy efficiency. Perhaps the most critical data collection issue was ensuring that the proper respondent was contacted for the telephone survey. The proper respondent is the one who is most knowledgeable about construction and maintenance activity at the sample site. We started with the decision-maker survey respondent from the first year impact studies. We recognized that the appropriate decision-maker during the construction process was not necessarily the proper contact for maintenance issues. Therefore, we qualified the respondent and asked for a referral in the event that someone else was a more appropriate contact.

Follow-up on-site surveys were conducted for all sites where the telephone survey indicated changes that may have impacted the whole-building savings, such as turnover of occupants, renovation of space, removal of the original equipment, or replacement by less efficient equipment. An onsite visit was not required for equipment repairs, replacement with equally or more efficient equipment, and changes in operating schedules. Altogether we did onsite surveys at 64 of the 165 sample sites.

When possible, the same on-site staff used in the first-year impact evaluations was used to conduct the onsite surveys. The project manager discussed the project objectives and data collection procedures with the on-site staff. Each surveyor was an experienced DOE-2 engineer, and was well-qualified to understand the data collection and modeling issues key to answering the research questions posed by this project.

The on-site survey consisted of a walk-through of the building by the surveyor. During the on-site, the surveyor compared the data collected during the original survey to the observed equipment. Particular attention was given to the building systems that had received incentives in the NRNC program.

Analysis

Our analysis approach was designed to satisfy the requirements of the M&E Protocols issued by CADMAC. The methodology has been reviewed by the appropriate CADMAC subcommittee. The whole-building approach used in this evaluation was consistent with the 1994 and 1996 first-year impact evaluations, fourth-year persistence evaluation, and the waiver filed by the two utilities.

The key issues explored in this study were:

- **Technical Degradation**, the reduction in the whole-building savings due to the technical degradation of the installed measures from age and wear,
- **Persistence of Whole-Building Savings** due to the continued use of the building with either the originally installed measures or replacement measures of equal or better efficiency,
- **Survival Function of Savings**, the mathematical model used to characterize the persistence of whole-building savings as a function of time, and
- **Effective Useful Life (EUL),** the number of years from the initial program year when one half of the whole-building savings would be expected to persist.

In the technical degradation analysis, DOE-2 models were constructed for almost all of the 165 sample buildings. In each building-specific model, a technical degradation factor was applied to each category of equipment based on the degradation estimates developed by the Statewide Technical Degradation study. We recalculated the kWh and kW savings of the building for each of twenty years to reflect the technical degradation. The application of the technical degradation factors to the simulation models was facilitated using Model-IT, our automated DOE-2 modeling software.

In the persistence analysis, DOE-2 models were constructed for all sample buildings for which the onsite audits revealed changes that would affect the whole-building savings. Using our current DOE-2 model generator, we recalculated the ex-post first year savings and the current savings reflecting the current installed equipment and utilization of the building. From the difference in the two estimates of savings we calculated the lost savings to be used in calculating the persistence and EUL of savings. A total of seven sites were found to have changes that resulted in lost savings.

The key to obtaining meaningful measure retention and persistence results from the on-site survey and simulation exercise is to insure that the models respond only to observed building changes. Thus, once the on-site survey was completed, data entry and modeling needed to focus on these changes, while leaving other building attributes energy-neutral. This required knowledge of both the original modeling process and new modeling techniques necessary to calculate the impact of the building changes. Because we were using the same on-site survey team that completed the first-year NRNC evaluations, the group was intimately familiar with the process that created the original models.

The central issue of analysis was to carry out the survival analysis at the whole-building level, using a methodology that would yield unbiased estimates of program-level survival functions and effective useful life. The whole-building approach meant that standard statistical survival analysis was not applicable for the individual sample buildings since it was uncertain how the analysis would reflect the stratified selection of the sample, the variation in savings from building to building within the sample and the fact that often only a fraction of the initial savings would be lost. Fortunately, the same stratified ratio estimation methods used in the original evaluation studies could be used to estimate aggregate program-level survival rates. These in turn could be used to estimate survival functions under alternative survival models as well as the effective useful life of the aggregate program-wide whole-building savings. A jackknife technique was used to calculate the standard error of the estimated EUL and to test the hypothesis that the true EUL is equal to the ex-ante value assumed in the program.

Reporting

The most important reporting issue is to ensure that the data and knowledge is effectively transferred to PG&E at the conclusion of the project. The final report has been written by senior staff. There have been multiple iterations of review and revision before delivery of the draft to PG&E.

The datasets to be delivered were assembled by senior database developers at RLW and AEC. The database structure conforms to common standards and has been documented such that anyone reasonably proficient with databases will easily understand the structure and be able to use the databases to perform additional analysis or reporting.

Detailed Methodology

Sample Design

Under the waiver filed by the two utilities, the sample for the ninth-year persistence analysis was to be identical to the sample used in the fourth-year studies of these programs. The fourth-year sample was comprised of 165 sites. So a new sample design was not required. However care was required to determine proper weights to extrapolate the sample back to the full population of program participants.

As shown in Table 4, the three programs addressed in this study had a total of 876 participating facilities, with a total ex-post first year savings of about 191,478,000 kWh of energy and 45,750 kW of demand. We collected information on a sample of 165 of these facilities, about 20% of all facilities. The sample was stratified to over-represent the sites with the greatest savings. The sites in the sample had almost half of the total energy and demand savings of all 876 projects.

	Population	Sample	Percent
Sites	876	165	19%
kWh	191,478,256	90,407,322	47%
kW	45,740	20,507	45%

Table 11: Program Population and Sample

The 876 projects addressed in this study fell across the three program segments that are shown in Table 12. 469 of the sites were from the 1994 NRNC program, and 392 from the 1996 NRNC program. There were another 15 sites that were program-year 1996 projects but were not paid until 1999. We refer to these as the "Performance Adder" projects.

	Program Population			Persistence Sample		
Year	**Sites**	**kWh**	**kW**	**Sites**	**kWh**	**kW**
1994	469	81,350,000	19,680	56	14,847,763	3,404
1996	392	83,970,000	20,000	94	49,401,303	11,043
Performance Adder	15	26,158,256	6,060	15	26,158,256	6,060
Total	876	191,478,256	45,740	165	90,407,322	20,507

Table 12: More Detailed Description of the Sample

Our sample of the 1994 and 1996 NRNC program participants was identical to the fourth-year persistence samples, which in turn were a subset the samples of buildings that were included in the first-year impact evaluations. These samples were stratified by the tracking estimate of savings so that larger projects were included with higher probability. We sampled 56 of the 469 sites in the 1994 program and 94 of the 392 sites in the 1996 program. We sampled all of the 15 Performance Adder sites. All results were weighted to extrapolate back to the populations of program participants.

Telephone Survey Instrument

The goal of the telephone survey was to determine if the participating buildings are still in service and if there have been any significant changes to those buildings. The survey instrument addressed the following topics:

- Is the building, or portion of the building, which participated in the NRNC program still in service?
  - If no longer in service, when was it removed and why?
  - Is the building permanently out of service, or is it just temporarily vacant?
- Obtain information about any changes to the energy-consuming equipment in the building.
  - Is the incented equipment still in place and operable?
  - If not, was it removed, disconnected, broken, or damaged? Why / how?
  - When was the equipment removed or disconnected?
  - Was this part of a larger modification? What else happened?
  - What replaced the incented equipment?
  - Have other energy-consuming systems been removed or modified? Which systems?
- Determine if there is a new tenant in the building, and if so, determine if the type of business has changed.
  - Have there been any remodeling changes?
  - Were there any changes when the new occupant moved in?

The telephone survey instrument was written to function as a recruiting instrument for the onsite survey if the interviewer discovers any of the following:

- The facility has been removed from service
- A new tenant has moved into the facility, and changes have been made
- Any of the incented equipment has been removed or modified

The telephone survey contained a total of 14 questions. A draft instrument was pre-tested on ten customers and some refinements were made. The total time necessary to administer the survey was approximately 10 minutes. The draft of the survey instrument is contained in Appendix C of this report.

Telephone Surveys

The telephone surveys were conducted from RLW Analytics' Sonoma, CA office by two technically qualified surveyors. The flowchart below outlines the telephone survey process.

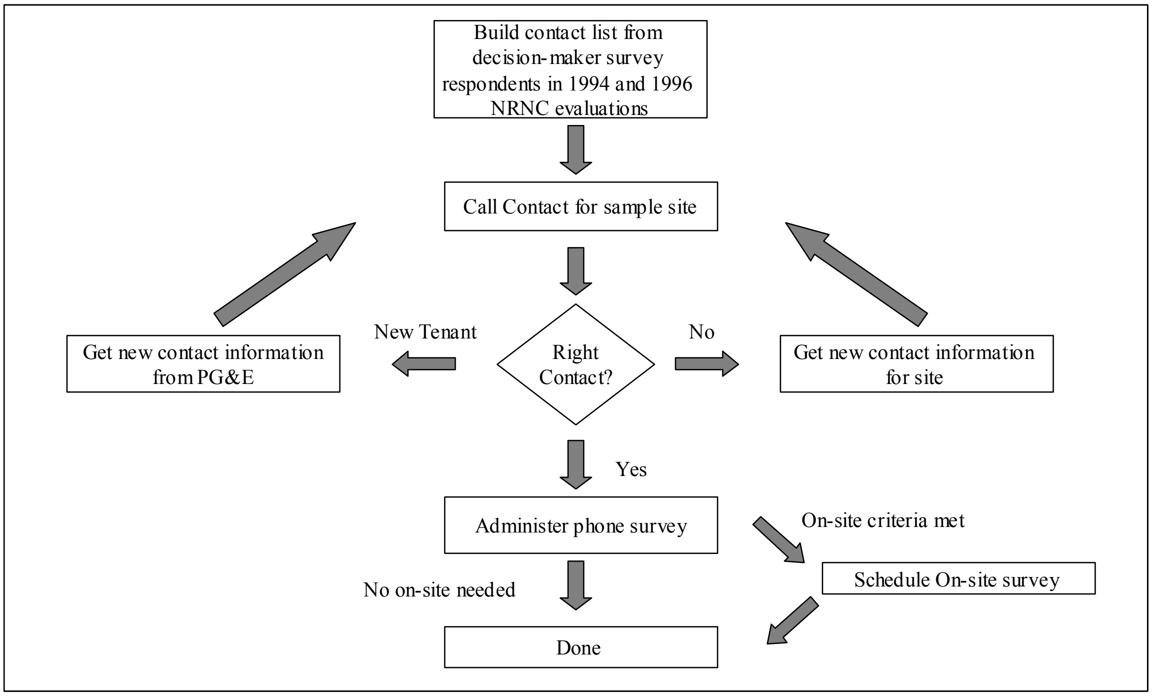

Figure 4: Flowchart of Telephone Survey Process

We began the telephone survey process by extracting the name and phone number of the primary respondent for the decision-maker (DM) survey for the 1994 or 1996 NRNC impact evaluation database. We were already in possession of these databases. They are part of our project records from the impact evaluations. The contact information was appended to the sample frame data for this study.

In order to ensure the highest possible level of accuracy from the survey data, each respondent was screened to ensure that they were knowledgeable about the operation of the sample building. The first contact was with the first year impact study decision-maker survey respondent. The telephone surveyors first verified that the DM survey respondent was still involved and knowledgeable about the building. If not, the surveyors asked for a referral to the appropriate contact. The referral information was entered into the tracking database and the surveyors attempted to reach the new contact. If it was found that a new tenant has moved into a site, location information was provided to PG&E so that the PG&E project manager could provide the surveyors with contact information for the new customer.

RLW Analytics adopted a policy of a minimum of 7 attempts to contact each sample point before that point was deemed unreachable and replaced in the sample. In this study, there were no replacements of sample points due to non-response or any other reason.

Once the appropriate person was reached, the survey was administered and, if appropriate, an on-site survey was scheduled. All contact and survey data were stored in a database for later analysis and delivery to PG&E.

An on-site survey was triggered based on the telephone survey questions if:

1. the facility had been removed from service,
2. there had been a tenant change that included a tenant improvement, or

3. there had been a removal or modification of equipment installed through the NRNC Program

An on-site survey was not required if any of the following apply:

- The building was only temporarily vacant
- Only lamps, task lighting, or other process or plug loads were changed
- The measure was removed and replaced by a similar measure with the same or greater efficiency

The phone surveyors attempted, on average, 3.4 times to contact a site. The maximum number of attempts made to contact a site was 12. They spoke with an average of 1.7 contact persons per site. The phone surveyors were instructed to contact those individuals in charge of influencing or making the decisions on the installation choice and usage of the energy equipment at the site. The contact was the same as the primary contact from previous years 46% of the time in PY 94 sites. PY 96 sites proved to have more of the same contact people at 52% of the sites. The contact was the same as the original primary contact for all of the PY 99 sites.

Recruiting

Sites identified during the phone interview as potential survey sites were recruited at that time. The phone surveyor scheduled the site visit and confirmed the contact and building location information. Utility account representatives had access to the survey schedule and could easily arrange to accompany the surveyor during the on-site survey.

On-Site Survey Training

In preparation for the original NRNC evaluation studies, a detailed training course was developed and delivered to all surveyors. The course covered a range of issues, including program design and operation, targeted measures, customer relations and etiquette, measure identification, and surveying techniques. Since the surveyor used in this project was also involved in the original NRNC evaluations, further detailed training on the program and modeling was unnecessary. The specifics of the persistence study goals were discussed with the surveyor before any on-site visits were made. The on-site survey conducted during the original evaluation was reviewed, and issues relative to the specific building surveyed were reviewed.

On-Site Surveys

The original survey data that was collected in the first-year impact evaluations was the primary basis for the analysis. As explained in the prior section, new onsite surveys were only required if the telephone survey had indicated that the facility had been removed from service, and new tenant had moved in and made changes, or any of the incented equipment had been removed or modified.

Under the preceding guidelines, onsite visits were carried out for 64 of the 165 sample sites. The on-site visit at the surveyed site took from 1 to 4 hours to complete. Areas of the building associated with changes identified during the phone survey and subsequent interviews with site personnel were surveyed. The surveyor also looked for evidence of other remodeling activity not reported by the site contact, but did not find any.

Before going into the field, the surveyor examined the original data and made changes only to data elements that are related to changes in the building or equipment affecting this study. The Survey-IT database containing all 94/96 first year evaluation sites was used as a baseline. The

Survey-IT database contains the building information collected during the original on-site survey. During the persistence on-site survey, changes to the building description data that relate to this study were identified and entered into the Survey-IT database.

An important role of the on-site surveyor was to verify first hand the information given to the phone surveyor. Thus, phone survey responses relating to physical changes to the building were verified. The on-site survey began with an interview of the site contact, consisting of the following questions:

- Has the use of the participant building (or portion thereof) changed since the energy consuming systems were installed? If so, how?
- Have any of the rebated systems been removed? If so, why? What was installed in their place?
- Is energy-consuming equipment being used differently than it was originally? Has it been modified?
- Were any changes made since the building was occupied as a result of a PG&E energy-efficiency retrofit program? If so, what equipment was affected? Was any equipment that was installed under the original program changed during a later retrofit program?
- Is there a maintenance schedule for the energy-efficient equipment?
- Are energy-consuming systems in a good state of repair?

An interview guide was developed to guide the surveyor through the interview process. The interview guide and the original on-site data were used as the data collection instruments for this study.

The overall process was:

1. If the phone survey indicated that an on-site visit was necessary, the site was recruited and scheduled.
2. Program records and previous on-site data forms and data were reviewed by the surveyor prior to the site visit.
3. The engineer responsible for the model collected the on-site data. As discussed above, data collection focused on changes to the building since the original survey.
4. The on-site surveyor entered the changes to the on-site survey data directly into the Survey-IT database.
5. As soon as the data were keyed into the program, the automated model building software created the DOE-2 model ***and*** calculated changes in energy savings for the surveyed site. The models were checked for reasonableness by the surveyor and by the AEC senior engineer.

QC

After the data were collected, the changes were entered into the Survey-IT database. A revised DOE-2 model was automatically generated using the Model-IT software. Range checks implemented at the data entry and the model output level were used to screen model inputs and results for data quality and accuracy. The DOE-2 output reports were thoroughly reviewed by the surveyor/modeler, and also by senior RLW and AEC engineers.

The original data from the PY94 and PY96 evaluations were subject to a series of QC checks during the course of those studies. The original building description data were considered to be adequately validated for the purposes of this study.

DOE-2 Simulations

DOE-2 models were developed using our automated modeling tool and the on-site survey database containing a merged set of the PY94 and PY96 buildings. Our latest modeling algorithms and engineering assumptions were used in this study. Revised models incorporating the Technical Degradation Factors developed from the CADMAC Statewide Technical Degradation study were created for virtually all sampled sites. Additional model changes relating to measure retention were implemented for surveyed sites.

The key to obtaining meaningful results from the simulation exercise was to ensure that the models respond only to observed changes in equipment performance or operation. Thus, once the survey was completed, data entry and modeling focused on these changes, while leaving other building attributes energy-neutral. Any reduction in energy savings identified by the simulations was applied to the original savings estimates for consistency with prior studies.

Technical Degradation

In the technical degradation analysis, a site-specific DOE-2 model was constructed for each individual sample building. In each building-specific model, a technical degradation factor was applied to each category of equipment based on the degradation estimates developed by the Statewide Technical Degradation Study.[6] Building attributes associated with measures experiencing technical degradation were modified using an automated approach, allowing efficient generation of new DOE-2 models. We recalculated the kWh and kW savings of the building for each of twenty years to reflect the technical degradation.

The sample of 1996 projects contained seven refrigerated warehouses. These projects were not subject to any of the technical degradation factors reported in the Statewide Technical Degradation Study. We attributed a whole-building technical degradation factor of one to the first-year savings of these sites so that they could be retained in the program-wide analysis.

The CADMAC Statewide Technical Degradation study covered a number of measures applicable to the NRNC program. The full list of measures considered by the CADMAC study, and their applicability to this study is shown in Table 13. Based on the results from the CADMAC study, the only measures that were applicable to the 1994 and 1996 NRNC programs and shown to have technical degradation were M02 Commercial Air Conditioning, M08 metal halide lighting and M19 dimmable daylighting controls.[7]

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[6] "Summary Report of Persistence Studies: Assessments of Technical Degradation Factors, Final Report," CADMAC Report #2030P, Proctor Engineering Group, February 23, 1999.

[7] The report did provide a TDF for Oversized Evaporative Cooled Condenser measures (M03) but it assumed an air cooled condenser as a baseline as typical of a retrofit measure. The relative degradation was assumed to be caused by mineral scale buildup on the wetted condenser surfaces, which can occur in evaporative condensers but does not occur in air-cooled condensers. In NRNC, the baseline was a standard-sized water-cooled condenser rather than an air cooled condenser. Oversized evaporative condensers are designed to reduce the refrigerant condensing temperature relative to a standard sized unit. Since scale deposition increases with increasing water temperature, the relative degradation of an oversized condenser should be less than a standard unit, and the TDF should be greater than 1.0. We conservatively assumed a TDF of 1.0 for this measure.

Measure		Applies to NRNC	Has a TDF
M01	Residential Packaged Air-Conditioners		✓
M02	Commercial Packaged Air Conditioners	✓	✓
M03	Oversized evaporative condensers for grocery stores		✓
M04	High-efficiency residential refrigerators		✓
M05	Electronic ballasts	✓	
M06	T-8 lamps and electronic ballasts	✓	
M07	Reflector installation with de-lamping		
M08	Metal halide lighting, 250-400 Watt	✓	✓
M09	Occupancy sensors	✓	
M10	High-efficiency motors	✓	
M11	Adjustable speed drives for HVAC fans	✓	
M12	Infra-red gas fryers		
M13	Residential ceiling insulation		
M14	LED exit signs	✓	
M15	Adjustable speed drives for process pumping		
M16	Adjustable speed drives for injection molding equipment		✓
M17	Residential wall insulation		
M18	Switched or stepped daylighting controls	✓	
M19	Dimmable daylighting controls	✓	✓
M20	Agricultural irrigation pumps		✓
M21	VAV systems	✓	
M22	Energy management systems	✓	
M23	High-efficiency air compressors		
M24	High-efficiency compressed air distribution		
M25	Compact fluorescent downlights	✓	

Table 13: Measures where Technical Degradation Applies

The TDFs defined in the CADMAC study were derived primarily from engineering studies on the physical causes of measure degradation. The TDF was defined as “a scalar amount to account for the time and use related change in the energy savings of a high efficiency measure or practice relative to a standard efficiency measure or practice.” The TDFs are a series of yearly numbers which, when multiplied by the first year savings yield an estimate of the energy savings in years subsequent to the first year. The TDFs associated with the measures addressed in this study are shown in Table 14.

Year	M02 Comm DX AC	M08 HID fixtures	M19 Dimmable DLighting
1*	1.00	1.00	1.00
2	1.00	0.96	0.73
3	1.00	0.96	0.61
4	1.01	0.96	0.54
5	1.01	0.96	0.48
6	1.01	0.96	0.43
7	1.01	0.96	0.39
8	1.01	0.96	0.36
9	1.01	0.96	0.33
10	1.02	0.96	0.31
11	1.02	0.96	0.29
12	1.02	0.96	0.27
13	1.02	0.96	0.26
14	1.02	0.96	0.24
15	1.02	0.96	0.23
16	1.02	0.96	0.23
17	1.02	0.96	0.22
18	1.02	0.96	0.21
19	1.06	0.96	0.21
20	1.08	0.96	0.20

Table 14: Technical Degradation Factors by Measure

The savings reported for each participant were estimated on a whole-building level. Since the whole-building savings were made up of the net contributions of all conservation actions above Title 24, it was necessary to disaggregate the savings associated with the three affected measures, and apply the correct TDF to the savings from each of these measures. The process is further complicated by the interactions between measures, since savings of all affected measures taken together is likely to be different from the sum of the individual measure savings.

Due to the complexities of applying the TDFs to simulation results, TDFs were applied to the simulation inputs for some measures as described below. From an engineering perspective, this approach was more consistent with the engineering basis of the TDFs, and more straightforward to implement in the simulation model. The approach taken for each affected measure is outlined below:

Commercial AC. The CADMAC study gave M02 commercial direct-expansion air conditioners a *negative* TDF, which increased to 1.08 by year 20. The relative technical degradation of commercial air conditioners was investigated by Peterson, et al. (1999)[8]. The study focused on coil fouling as the dominant mechanism for relative efficiency loss between standard and high efficiency air conditioners. A laboratory study was conducted, where standard and high-efficiency air conditioners were subject to controlled fouling conditions using an aerosol injection

[8] Peterson, G. and J. Proctor. 2/22/1999. *Persistence 3A: An Assessment of Technical Degradation Factors for Commercial Air Conditioners and Energy Management Systems, Final Report.* San Francisco, CA: Persistence Subcommittee, California DSM Measurement Advisory Committee (CADMAC Report #2028P).

process. The efficiency of the standard and high efficiency units were monitored throughout the test. The study concluded that under severe fouling conditions, the high efficiency air conditioner displayed less efficiency degradation than the standard efficiency unit. Secondary research indicated that under average conditions the fouling equivalent to the test conditions will occur toward the end of the life of the unit, so that the TDF increases in years 19 and 20. We used these factors as given in the report to adjust the cooling energy consumption in packaged air-cooled air conditioners and heat pumps in each of the sampled buildings.

Metal Halide Lighting. The TDFs for metal halide lighting fixtures were based on an engineering study of the stability of the fixture input power relative to a baseline mercury vapor fixture. The CADMAC study concluded that the input power to a metal halide fixture will increase at a rate of about 0.4% per 1,000 hours over the 10,000 hour life of the lamp, while the input power to the baseline fixture will be stable. Based on this conclusion, the input power to a metal halide lamp increases an average of 2% for a lamp with an average age of 5,000 hours.

The CADMAC study reported TDFs in terms of savings rather than input power. The TDFs in the CADMAC report were developed for a specific set of conditions, where a 250 W metal halide fixture replaced a 400 W mercury vapor fixture. In this specific example, the savings degraded an average of 4% over the life of the lamp, thus a TDF of 0.96 was calculated for this technology. Note that the degradation in savings is a function both of the increase in lamp watts and the original savings percentage.

In the first-year evaluation of the programs, savings were calculated against the Title 24 allowed lighting power density. The allowed LPD varied as a function of space occupancy type. The savings calculations didn't consider the baseline fixture type, only the difference between the installed and allowed lighting power densities. In the present study, we applied the CADMAC findings for the expected increase in input power rather than the degradation of saving. For both PY94 and PY96, we increased the input wattage of all metal halide fixtures by 2%, and recalculated the savings using the same baseline assumptions as those used in the original evaluation.

Dimmable Daylighting Controls. In the CADMAC study, the TDFs for daylighting controls were calculated based on an engineering study of failure mechanisms for switched, stepped, and dimming controls. Switched and stepped controls (M18) were judged to have no technical degradation. TDFs were established for dimming controls (M19) to account for a portion of the controllers failing over time. The failure mechanisms identified for dimming controls were expected to cause uneven operation of the system, resulting in bypass of the controls by building occupants, and a reduction in the lighting connected load subject to daylight control.

Our simulation of energy savings from daylighting utilized a DOE-2 "function" to calculate the ratio of the exterior illuminance to the illuminance "seen" by the daylighting sensor. Standard DOE-2 algorithms were used to simulate the action of the control system in response to the interior illuminance levels calculated by the "function." The fraction of the total lighting load in the daylit space connected to the control system was calculated directly from the onsite survey data.

Persistence Analysis

In the persistence analysis, DOE-2 models were constructed for all sample buildings for which the onsite audits revealed changes that would affect the whole-building savings. Using our current DOE-2 model generator, we recalculated the ex-post first year savings and the current savings reflecting the current installed equipment and utilization of the building. From the difference in the two estimates of savings we calculated the lost savings to be used in calculating the persistence and EUL of savings. A total of seven sites were found to have changes that resulted in lost savings.

Statistical Analysis

The statistical analysis was carried out in the following steps:

(a) Estimate the technical degradation factors for each of the twenty years.

(b) Estimate the current program-wide survival rate of the whole-building savings for each of the program segments based on the DOE-2 simulation of the sites with lost savings.

(c) Use the survival results from both the fourth-year and ninth-year persistence studies to estimate survival functions under four different statistical survival models.

(d) Use the survival functions to calculate and graph the predicted survival rates for each of twenty years.

(e) Use the survival functions to calculate the equivalent useful life (EUL) implied by the assumed survival model.

(f) Use a Jackknife technique to assess the standard errors for the estimated parameters and EUL associated with each survival model.

(g) Compare the ex-post estimate of the EUL (i.e., the estimates obtained in this study) to the ex-ante estimate of the EUL that is currently assumed in the program.

Each of these steps is discussed briefly below.

We used stratified ratio estimation to extrapolate the technical degradation sample results up to the population of all program participants. We estimated the technical degradation factors in the population for years one through twenty as the ratio between (a) the kWh and kW savings in the specified year after adjusting for technical degradation, and (b) first-year ex-post kWh and kW savings. By definition, the year-one technical degradation factor was taken to be one.

The first step in the statistical analysis of persistence was to estimate the current persistence of the savings for each of the three program segments. We did this by using stratified ratio estimation to estimate one minus the ratio between (a) the lost savings in the population of all program participants, and (b) the first-year ex-post kWh and kW savings. All measures of savings were calculated from the DOE-2 models constructed for the sample sites.

Next, four different survival models were estimated from the persistence results of the fourth-year and ninth-year persistence studies for each of the three program segments. Each of the estimated survival models was used to calculate the expected survival proportions for years one through twenty, and to calculate the estimated EUL. The EUL is defined to be the number of years after which the survival proportion for savings would equal 50%. For example, suppose that after four years, the survival proportion is equal to 85%, i.e., the savings have declined by 15% in four years. Then, under the exponential survival model, under which the probability of failure is assumed to be constant over time, the EUL would be about 17 years.

The final objective of the present study was to compare the ex-post estimate of the EUL (i.e., the estimate obtained in this study) to the ex-ante estimate of the EUL that is currently assumed in the program. If permitted by the data, a statistical hypothesis test was to be carried out to determine whether the ex-post estimate was significantly different than the ex-ante assumed value. Due the whole-building approach taken in this study, the standard errors and confidence intervals given by standard statistical survival analysis were not appropriate. Instead, we used a jackknife methodology which looks at the variation in the results as individual projects are excluded, one at a time, from the sample. The methodology is described in Appendix B.

Findings

Technical Degradation

The results from the building-specific DOE-2 simulation models were projected to the original program populations to obtain the total program results presented here. To avoid double counting, technical degradation was estimated separately from the persistence and EUL of savings. Table 15 shows the results of this analysis.

The second column of Table 15 shows the estimated technical degradation factors for the demand savings the 876 sites in the program population. For example, in year ten, the whole-building demand savings of the program is expected to be 0.997 times the first-year whole-building demand savings due to technical degradation of the measures installed in the buildings. In other words, the first-year demand savings are only reduced by 0.3% due to the application of the technical degradation factors identified in the CADMAC California study. In years 19 and 20, the whole-building the whole-building demand savings of the program is expected to increase to slightly larger than one, to 100% and 100.1% of the first-year savings. This result is due to the effect of the negative TDF for commercial AC, as discussed in the preceding section.

Year	kW	kWh
1	1.000	1.000
2	0.996	0.996
3	0.996	0.996
4	0.997	0.997
5	0.997	0.997
6	0.997	0.997
7	0.997	0.997
8	0.997	0.997
9	0.997	0.997
10	0.997	0.997
11	0.997	0.997
12	0.997	0.997
13	0.997	0.997
14	0.997	0.997
15	0.997	0.997
16	0.997	0.997
17	0.997	0.997
18	0.997	0.997
19	1.000	0.998
20	1.001	0.998

Table 15: Technical Degradation Results

The third column of Table 15 shows the estimated technical degradation factors for the energy savings of the program population. In the case of energy, the whole building, program wide TDFs are only slightly less than one for all years.

Current Persistence

Onsite surveys were done at 64 of the 165 sample sites. A total of seven sites were found to have changes that resulted in lost savings. Table 16 shows the first-year and current energy and demand savings of these seven sites. These results are based on our current DOE-2 model generator and the combined information from the initial and current onsite surveys of these sites. In the Appendix is a description of the on-site findings and modeling decisions made for each of the sites listed in Table 16. Site ID 7391 is the only site where the failed savings is greater than the first year impact savings. In the case of Site ID 7391 the customer installed 100 fixtures in addition to the fixtures that were already there. This caused the lighting power density (LPD) to exceed the Title 24 baseline. Since the baseline at this site is now worse than code allows, more savings have failed than were originally saved.

Site ID	Year	Whole-Building Savings from the DOE2 Simulations					
		kWh			kW		
		1st Year	Current	Failed	1st Year	Current	Failed
7304	1994	277,041	269,814	7,227	83	81	2
7337	1994	106,264	15,514	90,750	42	14	28
7392	1994	46,401	-349	46,749	12	-3	15
204	1996	649,535	204,138	445,397	107	34	73
277	1996	1,169,709	1,048,113	121,596	168	151	17
281	1996	582,630	488,309	94,321	182	173	9
331	1996	190,748	186,626	4,122	42	41	1

Table 16: Failed Whole-Building Savings

The results shown in Table 16 were combined with the ex-post first-year savings for the remaining sample sites, and extrapolated to the program populations. Table 17 summarizes the results. The ex-post savings are the first-year results taken from Table 12. The lost savings is developed from Table 16. The table shows the current persistence for the total program savings in annual energy savings in kWh and peak demand savings in kW, for the 1994 and 1996 programs and the Performance Adder sites. Across the entire set of participating facilities, almost 99% of the ex-post first-year savings has persisted to the current time.

Year	Ex Post Savings		Lost Savings		Persistence
	kWh	kW	kWh	kW	
1994	81,350,000		1,297,375		98.4%
		19,680		429	97.8%
1996	83,970,000		833,506		99.0%
		20,000		130	99.3%
Performance Adder	26,158,256		0		100.0%
		6,060		0	100.0%
Total	191,478,256		2,130,881		98.9%
		45,740		559	98.8%

Table 17: Persistence Results

Survival Analysis for Annual Energy Savings

Table 18 summarizes the persistence information used in the survival analysis for annual energy savings. The second column of the table shows the ex-post energy savings of the three program segments, in MWh. The next three columns summarize the persistence results from the fourth year persistence study. The fieldwork for this study was conducted in 1998, approximately four years after the completion of the 1994 projects and approximately two years after the completion of the 1996 projects. The Performance Adder projects were not included in that study. The fourth year persistence found no lost savings so all of the savings was assumed to have survived.

The final three columns of Table 18 summarize the persistence results from the present, ninth year persistence study. Our fieldwork for this study was conducted in 2003, approximately nine years after the completion of the 1994 projects, approximately seven years after the completion of the 1996 projects, and approximately five years after the completion of the Performance Adder projects. We have taken the lost energy savings from Table 17, expressed in MWh.

	MWh	4th Year Persistence			9th Year Persistence		
Year	Savings	Years	Survived	Lost	Years	Survived	Lost
1994	81,350	4	81,350	0	9	80,053	1,297
1996	83,970	2	83,970	0	7	83,136	834
Performance Adder	26,158	na	na	na	5	26,158	0

Table 18: Data for the Energy-Savings Survival Analysis

The information summarized in Table 18 was used to estimate the survival function assuming four standard survival models, using the SAS procedure Proc LifeReg. The observed survival and failure observations were assumed to be censured. For example, the 1,315 MWh of failed savings found in the present study was assumed to have occurred after the fourth year but prior to the ninth year of building life. This reflects the fact that it was not possible to determine the actual age of each sample building when the changes occurred that caused the failed savings.

Table 19 shows the estimated parameters of each of the four estimated survival functions: exponential, log normal, Weibull and logistic. A single parameter, denoted alpha, characterizes the exponential survival function, whereas two parameters (alpha and beta) characterize the remaining three survival functions. The table shows each of the estimated parameters for each of the four models. The functional form of each of these survival functions can be found in the SAS documentation.

Model	alpha	beta
Exponential	908	na
Log Normal	3.58	0.66
Weibull	23.68	4.13
Logistic	15.58	1.66

Table 19: Estimated Parameters of the Energy Savings Survival Equations

The jackknife procedure was used to calculate standard errors for the parameters of each of the survival functions. Table 20 shows the results. These results show that there is substantial uncertainty in the estimated parameters.

Model	Alpha		Beta	
	Estimate	St. Err.	Estimate	St. Err.
Exponential	908	614	na	na
Log Normal	3.58	1.01	0.66	0.40
Weibull	23.68	19.25	4.13	3.04
Logistic	15.58	4.47	1.66	0.87

Table 20: Standard Errors for the Estimated Parameters

The estimated survival functions were used to calculate the persistence factors for twenty years, as shown in Figure 5. Note that the persistence factors are essentially identical in the first nine years but diverge dramatically thereafter.

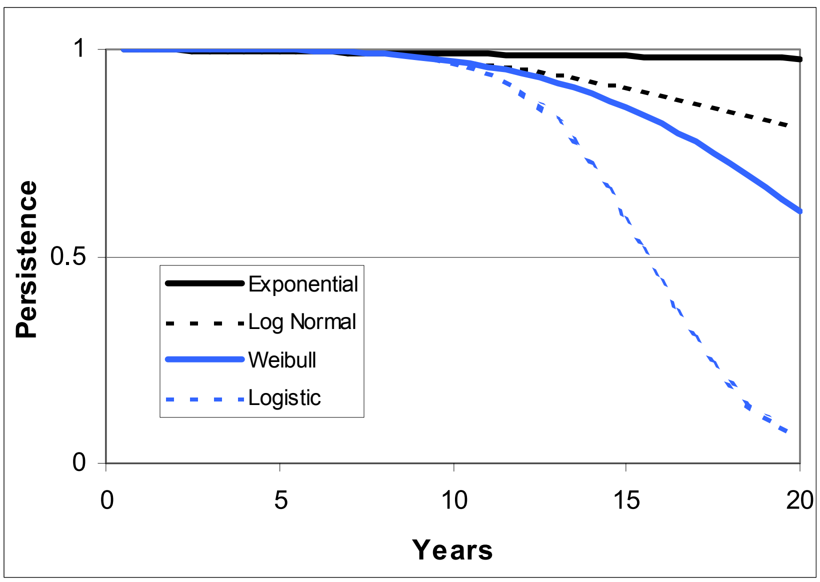

Figure 5: Estimated Survival Functions for Energy Savings

The estimated survival functions were also used to calculate the equivalent useful life (EUL) of the whole-building energy savings of these programs. The EUL was determined by calculating the number of years at which the estimated persistence would equal 50%. Table 21 summarizes the results. Under the exponential model, the calculated EUL was 625 years. Given that this result is implausible, we can reject the exponential model.

The remaining three models give a range of EUL from a low of 16 years to a high of 36 years. Table 21 also shows the standard errors for the EUL under each of the survival models. These results show that the available information is too weak to estimate the EUL reliably.

Model	EUL	
	Estimate	St. Err.
Exponential	630	426
Log Normal	36	46
Weibull	22	16
Logistic	16	4

Table 21: Effective Useful Life for Annual Energy Savings

Table 22 shows the 80% confidence intervals for the EUL under the various survival models. For example, under the logistic model, the median EUL is 16 years and the 80% confidence interval is 10 to 21 years. Since the ex-ante value of 16 years is within this interval, we cannot reject the ex-ante value. Based on this analysis, we have concluded that the ex-post value of the EUL should be taken to be 16 years, equal to the ex-ante value.

Model	Median EUL	Upper Bound	Lower Bound
Exponential	630	1,176	84
Log Normal	36	95	0
Weibull	22	43	1
Logistic	16	21	10

Table 22: 80% Confidence Intervals for EUL

Survival Analysis for Peak Demand Savings

Table 23 summarizes the persistence information used in the survival analysis for peak demand savings. The second column of the table shows the ex-post peak demand savings of the three program segments, as shown in Table 17. The next three columns summarize the persistence results from the fourth year persistence study. The fourth year persistence study found no lost demand savings so all of the savings were considered to have survived. The final three columns of Table 23 summarize the persistence results from the present, ninth year persistence study. We have taken the lost peak demand savings from Table 17.

Year	kW Savings	4th Year Persistence			9th Year Persistence		
		Years	Survived	Lost	Years	Survived	Lost
1994	19,680	4	19,680	0	9	19,251	429
1996	20,000	2	20,000	0	7	19,870	130
Performance Adder	6,060	na	na	na	5	6,060	0

Table 23: Data for the Peak Demand Savings Survival Analysis

As with energy, the information summarized in Table 23 was used to estimate the survival function assuming four standard survival models, using the SAS procedure Proc LifeReg. Table 24 shows the estimated parameters of each of the four estimated survival functions: exponential, log normal, Weibull and logistic.

Model	alpha	beta
Exponential	830	na
Log Normal	3.14	0.47
Weibull	17.26	5.81
Logistic	13.64	1.24

Table 24: Estimated Parameters of the Demand Savings Survival Equations

The estimated survival functions were used to calculate the persistence factors for twenty years, as shown in Figure 6. Note that Figure 6 is very similar to Figure 5

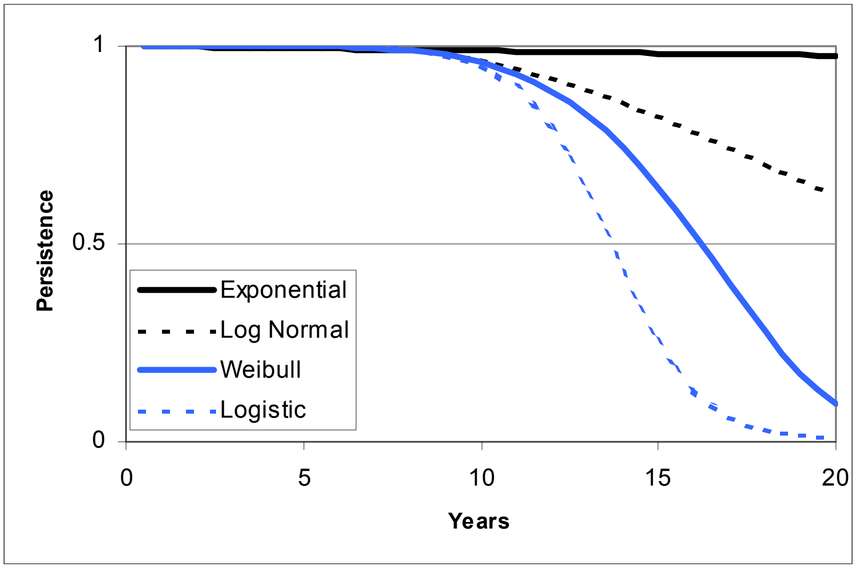

Figure 6: Estimated Survival Functions for Peak Demand Savings

The estimated survival functions were also used to calculate the equivalent useful life (EUL) of the whole-building demand savings of these programs. The EUL was determined by calculating the number of years at which the estimated persistence would equal 50%. Table 25 summarizes the results. Under the exponential model, the calculated EUL was 627 years. As with the energy savings, we reject the exponential model.

The remaining three models give a range of EUL from a low of 15 years to a high of 30 years. Since these results are so close to the energy EULs, we have not calculated their standard errors.

Model	EUL
Exponential	575
Log Normal	23
Weibull	16
Logistic	14

Table 25: Effective Useful Life for Peak Demand Savings

Discussion of the Results

In this ninth year persistence study, we found that almost 99% of the savings of these programs have persisted. One of the survival models that we considered was the exponential model. The exponential survival model assumes that the failure rate is constant from year to year over the life of the savings. Under this model, our analysis indicates that the savings would persist almost indefinitely. This is consistent with the observed data since the failure rate has been very small in the first nine years. Of course it is unlikely that the buildings that participated in the 1994 and 1996 NRNC programs will last indefinitely. Therefore we have rejected the exponential model.

The remaining three estimated survival functions all have increasing failure rates, as displayed in Figure 5 and Figure 6. Under these survival functions, the rate of failure is predicted to increase at varying rates after ten years of service from the low rate observed in the first nine years. Therefore these three models yield substantially different estimates of the EUL, ranging from 16 to 36 years in the case of energy, and from 14 to 23 years for demand.

But during the first nine years, these models yield practically identical predicted persistence rates, as shown in Figure 7. While Figure 7 shows the survival functions for energy, those for demand are almost identical. Therefore at the present time each of these three models fits the available data equally well. In other words the observed data are insufficient to identify which of these three models is best. Therefore we do not have enough information to estimate the EUL reliably, although we can say that the ex-ante assumed valued of 16 years is probably conservative.

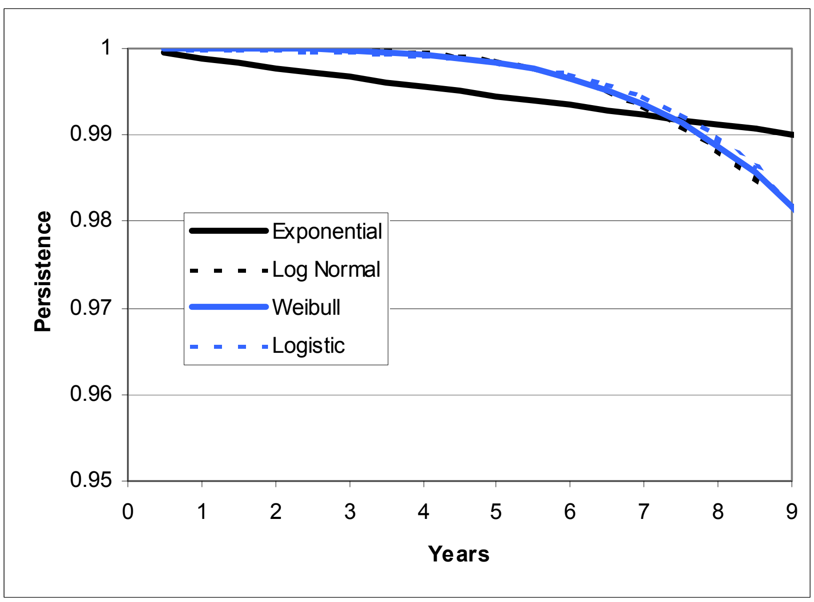

Figure 7: Predicted Energy Survival Rates for the first Nine Years

FINAL RESULTS

All End Uses Combined
Program Years 1994 and 1996

Measure Code	Measure Description	Ex Post Savings[1]			EUL	
		kWh	kW	Therms	Ex Ante	Ex Post
N/A	Whole Building[2] kW	--	45,740	--	16 Years	16 Years
N/A	Whole Building[2] kWh	191,478,256	--	--	16 Years	16 Years
Totals		191,478,256	45,740	--	16 Years	16 Years

Conclusions and Methodological Lessons Learned

The principle substantive and methodological conclusions of this study are:

- There is little or no technical degradation of the whole-building energy and savings.
- At the current time, virtually all of the first-year energy and demand savings persist. In the buildings in the 1994 program, over 98% of the original energy and almost 98% of the original demand savings persist to the time of our study. In the buildings in the 1996 program, over 99% of the original energy and demand savings persist
- The degradation and persistence of whole-building savings can be measured cost-effectively by utilizing the detailed engineering models and excellent customer relationships from the first-year evaluation studies.
- The whole-building approach and the statistical methodology of the present study seem to be appropriate for these programs.
- The persistence of savings is high in these programs.
- Different, survival models yielded median estimates of the EUL ranging from 16 to 36 years for energy and from 14 to 23 years for demand. Under the logistic survival model, for example, the 80% confidence for the median EUL of energy was from 10 to 21 years. Therefore the ex-ante estimate of savings of 16 years was not rejected, and the ex-post estimate has been retained at 16 years.

Appendix A Protocols for Reporting Savings

Table 6B. Protocols for Reporting of Results of Required Studies

Measure Information for the Nonresidential New Construction Sector

All End Uses Combined
Program Years 1994 and 1996

Measure Code	Measure Description	Ex Post Savings[1]			EUL	
		kWh	kW	Therms	Ex Ante	Ex Post
N/A	Whole Building[2] kW	--	45,740	--	16 Years	16 Years
N/A	Whole Building[2] kWh	191,478,256	--	--	16 Years	16 Years
Totals		191,478,256	45,740	--	16 Years	16 Years

Measure Code	Measure Description	Ex Post Technical Degradation Factors[3]																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
N/A	Whole Building[2] kW	1.000	0.996	0.996	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	1.000	1.001
N/A	Whole Building[2] kWh	1.000	0.996	0.996	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.998
Totals		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes

1. Net savings, per the 1994 and 1996 first-year impact evaluations.

2. Per Deviation #1 in the SCE/PG&E retroactive waiver for nonresidential new construction dated April 15, 1998, Retention Study No. 323-R1 treated the measures for the programs as the "whole building," rather than a collection of separate measures associated with specific end uses. Therefore, the study evaluated changes in savings for each whole building (also referred to as a "site").

3. The twenty technical degradation factors correspond to the TDFs given in the CADMAC study, shown here in Table 14. TDF 1 corresponds to the first year. It is one by definition.

Table 7B. Documentation Protocols for Data Quality and Processing in Retention Studies

1. OVERALL INFORMATION

A. Study Title and Study ID Number

Study Title: PG&E's PY 1994-1996 Ninth Year Non Residential New Construction Retention Study

Study ID Number: 323 R2 and 424 R1

B. Program, Program Year and Program Description

Program: PG&E Nonresidential New Construction Programs

Program Years: 1994 and 1996

Program Description:

The Nonresidential New Construction Program provides design assistance and rebates to nonresidential customers who adopt efficiency measures and design features that reduce electric consumption and demand in new construction projects. PG&E paid out incentives to 861 projects under the NRNC Programs during 1994 and 1996.

C. End Uses and/or Measures Covered

All measures that received rebates through the program were studied. The impact of the measures was studied on a whole-building basis.

D. Methods and Models Used

All projects included in the fourth-year persistence study were included in this study. Telephone surveys and onsite audits were used to identify changes in the facility that could affect the whole-building energy efficiency of the project. DOE-2 models were used to estimate the impact on energy and demand savings of the changes that were found. Added DOE-2 models were used to determine the effect of the technical degradation factors identified in a prior statewide study. Stratified ratio estimation was used to extrapolate the results to the program population. Four different statistical survival analysis models were used to estimate the EUL. The jackknife technique described in Appendix B was used to assess the standard error of the estimated EUL under each of the models.

E. Analysis Sample Sizes

All 165 projects included in the fourth-year persistence study were included in the telephone survey. Onsite surveys were done at all sites that indicated a change - 64 of the 165 sample sites.

2. DATABASE MANAGEMENT

A. Key Data Elements and Sources

Persistence information was collected in a telephone survey. If the respondent indicated that installed measures had been removed or disabled, an onsite audit was carried out. The estimates of technical degradation were determined by the technical degradation factors identified in the CADMAC statewide study, and were applied to the engineering models developed in the first-year impact evaluation studies.

B. Data Attrition Process

No sample data points were excluded for any reason.

C. Internal Data Quality Procedures

The files from the first-year evaluation studies and the fourth-year persistence studies were used to identify the sites and respondents for the survey. Extensive data quality control was used to ensure accurate telephone survey data. The detailed onsite audit procedures and Survey-IT database management system used in the first-year impact evaluation were used in all onsite audits carried out in this study. The DOE-2 simulation models were given extensive quality control review by our engineering staff.

D. Unused Data Elements

All data collected in this study were used in the analysis.

3. SAMPLING

A. Sampling Procedures and Protocols

All projects included in the fourth-year persistence study were included in the telephone survey implemented in this study so no new sample design was required. All 15 Performance Adder projects were included in the sample. If the survey revealed any change that might diminish the energy or demand savings, an onsite audit was carried out. Onsite surveys were done at 64 of the 165 sample sites. A total of seven sites were found to have changes that resulted in lost savings.

B. Survey Information

The telephone survey instrument is given in Appendix C. The response rate was 100% so non-response bias was not an issue.

C. Statistical Descriptions

The technical degradation factors used in the analysis are given in Table 14 of the report. Table 16 provides the failed-savings data used in the persistence analysis. Table 18 summarizes the data used in the survival models.

4. DATA SCREENING AND ANALYSIS

A. Procedures for Treating Outliers and Missing Data

Outlier analysis was not required since there was no conventional statistical modeling. No sample sites were excluded from any of the analysis..

B. Background Variables

The engineering models held weather, hours of occupancy and operating schedules fixed to the levels assumed in the first-year impact evaluations.

C. Data Screen Process

There was no screening.

D. Model Statistics

As displayed in Figure 7, the three survival models other than the exponential model provided virtually identical predicted survival rates for the first nine years. All three of these models provided an excellent fit to the persistence rates observed in the fourth-year and ninth-year persistence studies for these two programs. The exponential model fit the observed data more poorly and was rejected because of the implausible large EUL resulting from this model.

E. Model Specification

Four different survival models were considered. The exponential model was rejected. Since the three remaining models fit the data very well, the data did not provide any definitive basis for choosing between these three models. However the logistic model had the smallest standard error for the EUL.

F. Measurement Errors

Considerable care was taken to make the engineering simulations as accurate as possible and to reflect the technical degradation following appropriate engineering principles and the results of the Statewide Technical Degradation study.

G. Influential Data Points

The EUL results were affected by the seven sites that had lost savings that were listed in Table 16. All sites except four in one-site strata were reflected in the jackknife procedure used to assess the standard error of the survival-analysis results.

H. Missing Data

In the survival-analysis methodology, we used a technique called censored data to handle the fact that failure dates were generally unknown. .

I. Precision

The standard errors for the model parameters and EUL estimates were calculated using the jackknife procedure described in Appendix B.

Appendix B Jackknife Methodology

Introduction

The results of this study were developed by first collecting data for a sample of projects selected from the program population following a stratified sample design, then using stratified ratio estimation to estimate the persistence of the whole-building savings of the program, and finally, using statistical survival analysis to estimate the EUL under various survival models. If the data had been collected following a simple random sampling plan, if the analysis of retention had been carried out at the measure level, and if there was the same savings for each measure of a given type, then standard statistical survival analysis could have been used to calculate the standard error of the estimated EUL. But if a stratified sample design has been used with varying sampling fractions from stratum to stratum, and if the savings are considered at the whole-building level so that failure is not a binary phenomenon, then the standard survival analysis is not appropriate. Two related questions arise – whether the case weights that reflect the sample design should be included in the statistical modeling, and how to assess the statistical precision of the results.

Using Weights

The case weight is defined to be the reciprocal of the inclusion probability, i.e., the probability that each project is included in the sample. For a stratified sample design the case weight assigned to each sample point in a given stratum is equal to the number of population units in the stratum divided by the number of sample units in the stratum. In this study, the sample used in the fourth-year persistence study was selected from the sample used in the first-year persistence study so the overall inclusion probability is the product of the inclusion probabilities in each of the two stages of sampling. The use of these weights with stratified ratio estimation provides unbiased and consistent estimators of the current persistence of savings.

The persistence of savings is of interest in its own right and is the determinant of other more complex statistics such as the equivalent useful life (EUL). The persistence statistics reported in Table 18 and Table 23, were used to estimate the EUL under various survival models using the LifeReg procedure found in SAS.

Statistical Precision

Any complex statistic such as the EUL that we can calculate by applying statistical modeling to sample data can be regarded as having a sampling distribution. In other words, the value of the statistic can be expected to vary from sample to sample across all possible samples. We often assume that in large samples the expected value of the estimator is approximately equal to the value of the population parameter that would be obtained in theory if it were possible to apply the statistical modeling to the data for entire population. Under this assumption, we assess the statistical precision of the estimator by estimating the standard deviation precision of the estimator in repeated sampling.

Sarndal[9] and others have described a method called the Jackknife. The Jackknife technique is a computationally intensive but well-regarded method for evaluating the statistical precision of a complex modeling procedure. In the context of the present study, the basic idea is to drop one project at a time from the sample, adjust the case weights accordingly, apply the stratified ratio estimation to

[9] C. E. Sarndal, B. Swensson, and J. Wretman, *Model Assisted Survey Sampling*, Springer-Verlag, 1992. See Section 11.7, pp. 437-442.

estimate the persistence of the program using the remaining data, and use the survival modeling technique to analyze the resulting persistence. The variance of the resulting estimates of the model parameters and EUL is used to calculate their standard errors.

In his equation (11.5.7), Sarndal suggests that the estimator of the variance can be calculated using the equation:

$$\hat{V} = \sum_{h=1}^{H} \left[(A_h - 1)/A_h \right] \sum_{a=1}^{A_h} \left[\hat{\theta}_{(ha)} - \hat{\theta} \right]^2$$

In our application, H is the number of strata, $A_h = n_h$, the sample size from each stratum h, $\hat{\theta}$ is the value of the estimator using the full sample, and $\hat{\theta}_{(ha)}$ is the value of the estimator when observation a is deleted from stratum h. In our application the case weights themselves were used to define the unique strata. Fourteen strata were defined in each of the two program years. Four strata had only one sample project per stratum. These projects were retained in each of the Jackknife samples. Altogether, 150 separate Jackknife samples were analyzed to estimate the variance of the model parameters and the EUL.

An approximate 80% confidence interval was calculated as $\hat{\theta} \pm 1.282\sqrt{\hat{V}}$. If the ex-ante value of the EUL was outside of the resulting confidence interval, we rejected the ex-ante value. If the confidence interval included the ex-ante value, then the hypothesis was accepted that the true value was equal to the ex-ante value.

Appendix C Telephone Survey Instrument

Site ID : {**RLW ID**}
Site Name: {**SITE NAME**}
Contact Name: {**CONTACT**}
Title: {**TITLE**}
Role/Responsibility: {**ROLE**}
Phone Number: {**PHONE**}
Program Year: **{PY}**
Strata: **{STRATA}**

Call Log:

	Date	Time	By	Who	Result	Comment
1						
2						
3						
4						
5						
6						
7						

*Hello {**contact name**} my name is {**surveyor**}. I am calling from RLW Analytics, Inc. We are an independent contractor hired by **{utility}** to evaluate their Commercial New Construction programs. Neither I nor anyone else connected with this study will attempt to sell you anything. Your name and responses will not be used for any purpose other than this study. We understand that you previously participated in a study in {**program year**} to determine the energy savings that resulted from the program measures that were installed in your building at {**address**}. You also participated in a second study a few years later that determined if the energy efficiency measures were still in place. My call today is a follow up to the second study, which the California Public Utilities Commission has mandated {**utility**} to conduct.*

Q1. Are you the owner or the owner's representative of {**name of building**} at {**address**}?
01 Yes
02 No **(Get referral info)** **Name:**________________________________
98 Don't Know **(Get referral info)** **Phone:**________________________________
99 Refused **(Thank, attempt to get referral, and terminate)**

The survey is very short, and normally takes less than 5 minutes. Upon completion of the survey we will mail you a gift card or e-mail you a $20 gift certificate from any of the following retailers.

REI	**Barnes and Noble**	**Amazon**	**Best Buy***
Hollywood Video*	**Macy's**	**Target**	**Sportmart**

** Gift card, requires accurate mailing address.*

Q2. Is this a good time for you to answer a few questions?
01 Yes
02 No → Call back **(Get time/date)** **Date/Time**:____________________
Call someone else **(Get referral)** **Name/Phone**:____________________
Refused participation

Q3. Is the space at {**address**} currently vacant or occupied?

01 Occupied **Go to 4**
02 Vacant **Go to 3A**
98 Don't Know **(Get referral information, start survey over with referral)**
99 Refused **(Attempt to get referral)**

Q3A. When did the most recent tenant move out?

Month______ Year______

Q3B. Why did the most recent tenant move out?

01 Lease Expired
02 Evicted
03 Tenant Broke Lease
04 Building Unusable
05 Other______________________________
98 DK
99 REFUSED

Q3C. Are you actively attempting to lease the space?

01 Yes - Temporary Vacancy **Schedule On-Site at end, Continue at Q5.**
02 No - Permanent Vacancy **Not likely On-site is Necessary.**
98 Don't know **(Get Referral)** **Name**______________________________
99 Refused **(Get Referral)** **Phone**______________________________

IF NO, GET DETAILS

____
____
____

Q4. Has the tenant in the building changed since 1998?

01 Yes **Continue**, **Schedule On-Site After Survey**
02 No **Go to 5**
98 DK **(Get referral, and continue survey) Name**____________________________
99 Refused **(Get referral, and continue)** **Phone**____________________________

Q4A. When did the tenant surveyed in 1998 move out*? (OK to approximate)*

Month________ Year________

According to our records, the space at {**address**} *received incentives in {**Program Year**} for* {**types of equipment**}

Q5. Would you describe the {**type of equipment**} incented in the program as in place and working, in place, working, but not in use, in place but not working, or as removed or partially removed? **(Read for each incented measure)**

(Enter a check for the corresponding responses in the table below)

Q#	Measure	CODE	Don't Know (get contact info)
Q5A	**{Lighting}**		
Q5B	**{Shell}**		
Q5C	**{HVAC}**		
Q5D	**{Other}**		

CODES:

1=IN PLACE AND WORKING (SKIP TO Q14)
2=IN PLACE WORKING, BUT NOT IN USE (SKIP TO Q14)
3=IN PLACE AND PARTIALLY WORKING (SKIP TO Q11)
4=REMOVED/PARTIALLY REMOVED (SKIP TO Q6)
5=IN PLACE NOT WORKING (SKIP TO Q11)
6=NOT APPLICABLE

Q6. Why was the equipment (removed or disconnected)?

Q#	Measure Description	CODE	Other
Q6A	**{Lighting}**		
Q6B	**{Shell}**		
Q6C	**{HVAC}**		
Q6D	**{Other}**		

CODES:

1 = NOT USED
2 = DAMAGED
3 = REMODEL
4 = TENANT IMPROVEMENT (TI)
4 = OTHER (DESCRIBE)
5 = NA

Q7. When was the equipment (removed or disconnected)? *(OK to approximate, best estimate)*

Q#	Measure Description	Date (Month/Year)
Q7A	**{Lighting}**	
Q7B	**{Shell}**	
Q7C	**{HVAC}**	
Q7D	**{Other}**	

Q9. Was this part of a larger modification to the building?

01 Yes
02 No **Go to END, OR Q11 if applicable for other measures**
98 Don't know
99 Refused

Q10. Please list, to the best of your recollection, the modifications that were made.

(Circle all that apply)

01	Lighting Systems	06	Cosmetic Changes
02	Shell	07	Building Additions
03	HVAC Systems	08	Demolition
04	Other Energy (verbatim):	09	Other_____________________
05	____________________________		
	____________________________		
	______________________		

Go to end, or 11 if applicable

Q11. Please explain why the measure is no longer functional?

Q#	MEASURE DESCRIPTION	CODE	Description of Failure
Q11A	**{Lighting}**		
Q11B	**{Shell}**		
Q11C	**{HVAC}**		
Q11D	**{Other}**		

CODES:

1 = MECHANICAL/TECHNICAL FAILURE 2 = OTHER (DESCRIBE) 3 = DON'T KNOW

Q12. Approximately when did the equipment stop working?

Q#	MEASURE DESCRIPTION	DATE (Month/Year)
Q12A	**{Lighting}**	
Q12B	**{Shell}**	
Q12C	**{HVAC}**	
Q12D	**{Other}**	

Q13. Are there plans to replace the non-functioning equipment?

Q#	MEASURE DESCRIPTION	CODE	Other
Q13A	**{Lighting}**		
Q13B	**{Shell}**		
Q13C	**{HVAC}**		
Q13D	**{Other}**		

CODES:

1 = YES, AS SOON AS POSSIBLE
2 = YES, IN THE NEXT FEW MONTHS
3 = YES, WITHIN IN A YEAR
4 = YES, BUT NOT SURE WHEN
5 = NO PLANS TO REPLACE
6 = OTHER (DESCRIBE)
7 = DON'T KNOW

Q14. Have any other modifications been made to the building?

01 Yes
02 No **Go to end**
98 Don't know
99 Refused

Q14A. Please list, to the best of your recollection, the modifications that were made.
(Circle all that apply)

01 Lighting Systems
02 Shell
03 HVAC Systems
04 Other Energy (verbatim)
____

05 Cosmetic Changes
06 Building Additions
07 Demolition
08 Other______________________

END - - - - Schedule On-Site if Necessary
At this time would like to schedule an on-site survey of this facility because the energy efficiency measures that were rebated have changed. As part of the on-site survey, the engineer assigned to your project will collect information on the affected measures so that we may understand the full extent of the changes that were made. This will in no way affect the rebate you were given, the utility simply needs to understand the average life expectancy of the energy efficiency measures they help pay for. The information we collect is in turn used to aid in future energy efficiency program design.

Are you the right person to talk to about scheduling an on-site visit. We anticipate the site visit will take between 1 and 2 hours, or less. The time depends upon the complexity and number of measures that require inspection. For agreeing to participate in the on-site survey we would like to thank you by providing a $50 gift certificate from any of our qualified retailers.

REI	Barnes and Noble	Amazon	Best Buy*
Hollywood Video*	Macy's	Target	Sportmart

Address:____

Date:	Time:	By:	

End
That completes the survey. We appreciate the time you have taken to participate in this study.

Contact Log:

Decision Maker Name: ____________________ Phone: ________ Email: ______________
Building Measures Name: ____________________ Phone: ________ Email: ______________

Site Contact Name: ____________________ Phone: ________ Email: ______________

Other Name: ____________________ Phone: ________ Email: ______________

Misc. Notes
____
____
____
____
____

On-site Details
____
____
____
____
____

Appendix D On-site Write-ups

In this section we provide write-ups for the seven sites listed in Table 16, i.e., the sites with failed savings. Similar write-ups are available for all sites that had an onsite survey.

RLW ID: 94P7304

Bldg Type: General C&I Work

Original Measure Description: Energy Efficient Lighting.

Reason for RLW follow-up On-site: Change in lighting.

On-site Findings: There has been an office built out in the interior of the warehouse. The new office totals 1820 square feet. It is conditioned and has the following lighting:

F43EE	6
F42EE	9
F43LL	26
FU2EE	1

3 of the original 400-watt HPS lamps were removed to make space for the office. In addition all of the HPS on the factory floor are being replaced with MH as they go out. None of the people I spoke with were able to confirm whether or not the new office received incentives.

Necessary Actions: Change the model to reflect the new space. The 1820 square foot office will be added to the model. It is a two-story office measuring 28 feet wide by 65 feet deep. 3 400-watt HPS lamps were removed to make space for the office. On the first floor there are (9) F42EE and (6) F43EE. On the second floor there are (26) F43LL and (1) FU2EE.

The model changes resulted in reduced savings since office LPD, 1.02 was greater than the warehouse LPD, 1.02.

RLW ID: 94P7337

Bldg Type: Office

Original Measure Description: Interior lighting

Reason for RLW follow-up On-site: Multiple Changes in Tenancy

On-site Findings: The original building has been divided into two addresses (remodel began in early 2001). The 2891 address is currently un-occupied. The second level was removed and there is a subsequent loss of square footage from the original space. Address 2883 currently has 15,928 square feet (6020sf is lab) and 2891 currently has 15,072 square feet. The combined two spaces are 31000 square feet compared to the original 40,896 square feet. The lighting fixtures consist of some energy efficient magnetic-ballast fixtures with T8 lamps and some electronic ballast fixtures with T8 lamps. The current lighting for each space is as follows:

94P7337 (a)		
Location	Fixture	Qty
Offices	F43LL T8	4
	F43LE T8	103
	F42LL T8	15
	FU2LL T8	8
	F41EE T12	2
Lab (6020sf)	F43LL T8	60
Exits	EDLED/1	9
94P7337 (b)		
Location	Fixture	Qty
Offices	F43LL T8	64
	F43EE T8	52
	F42LL T8	63
	FU2LL T8	1
Exits	EDLED/1	7

The LPD for (a) was changed from an average of 0.61 to 1.22

The LPD for (b) was changed from an average of 0.61 to 1.04

Necessary Actions: The rebated lighting was for the fixtures. The current lighting is a hybrid of T8 lamps and Magnetic Ballast fixtures and the space is different. The model in Survey-it should be changed.

The models changes resulted in decreased savings due to increased LPD.

RLW ID: 94P7392

Bldg Type: Office

Original Measure Description: Whole Building.

Reason for RLW on-site: Change in Ownership

On-site Findings: This site has a large discrepancy from what was originally incented. As a result two separate trips were made by RLW auditors to this site to confirm the findings. It was confirmed with the site contact that the auditors were indeed at the correct site. The building at address 3351 was incented in 1994 according to the contact. The square footage of 16,000 was confirmed to match the original on-site.

The on-site visit found T-8 lighting prevalent through the building. Some tenants had modified the lighting and T-12 lamps were found in one suite. The lighting has been increased by nearly 100 fixtures. It is possible the original auditor took lighting specs from plans and did not verify the lighting at the site. It is common for lighting to be added to a building after it has been built out. Several of the offices are medical practices that often require increased lighting. The overall building LPD increased from 0.92 to 1.62, resulting in significant savings decreases after model changes. An LPD of 1.62 is greater than the baseline allowance, therefore savings for this site are now negative, as shown in the persistence analysis.

There are now twenty units installed at the site. There are split DX, split heat pumps, and packaged gas/electric units. It appears the discrepancy is due to the fact that the original auditor did not have complete information. The general contractor provided information on the units to the auditor per documentation in the project file. It is possible that the individual provided the mechanical specifications from the plans and did not verify the HVAC units by direct observation. This lack of direct verification may have been prompted by the limited roof access requiring an extension ladder. The use of plans to verify equipment installed is not reliable because it is common for substitutions to be made during construction. The new units were calculated to total 72.5 tons of cooling which equates to 220 square feet per ton. This is a significant but not unreasonable increase over the original value.

Necessary Actions: The model should be changed to reflect the tenant changes in lighting, and the different rooftop units should be changed in the model. Two suites on the second floor were under construction and one was locked so the lighting counts for the second floor are approximate.

The roof top units are as follows:

Suite #	Manufacturer	Model #	Serial #	Notes
110	Rheem	RPMC-048CAZ	0272M190308593	2 HP fan. Mfd. Date 5/03
110	Rheem	RPKA-048CAS	4971M47955908	2 HP fan. Mfd. Date 11/95
240	BDP	588APW048080AAAG	4793GO4774	80 kBtu input / 64.8 kBtu output
220	BDP	588APW060100AAAG	3893GO5287	100 kBtu input / 81 kBtu output
210	BDP	588APW060100AAAG	5693GO4134	100 kBtu input / 81 kBtu output
200	BDP	588APW060100AAAG	4793GO4728	100 kBtu input / 81 kBtu output
Unknown	Unknown	661BP060-A	3093EO1083	¼ HP fan
Unknown	Rheem	RPKA-060CAZ	5767M149815485	1/3 HP fan. Mfd. date 4/98
Unknown	Carrier	48GS-03606051	3800G14284	60 kBtu input / 48 kBtu output
Unknown	Unknown	Unknown	Unknown	No info on name plate
105	BDP	563AN036-A	4793E07470	1/8 HP fan
105	BDP	563AN036-A	4793E07402	1/8 HP fan
Unknown	Ruud	URGG-07E48CKR	AYA4497	½ HP fan, 1/3 HP fan, 75in/58.7out
Unknown	Carrier	48GS-060090501	0599G10020	90 kBtu input / 72.1 kBtu output
Unknown	Rheem	Unknown	Unknown	No info on name plate
115	Ruud	UPKA-048JAZ	4966M14947893	1/3 HP fan. Mfd. Date 4/94.
115	Ruud	UPKA-048JAZ	4966M14947890	1/3 HP fan. Mfd. Date 4/94.
Unknown	BDP	661BJ042-A	1494E19071	¼ HP fan
Unknown	BDP	561AJ036-C	0894E08106	¼ HP fan
Unknown	BDP	561AJ036-C	0894E08119	¼ HP fan

The lighting count is as follows:

First floor (space 1?)	Count	Second floor (space 2?)	Count
F44LL	6	F43LL	90
F43LL	137	F42LL	10
F43EE	16		
F42LL	11		
FU2EE	27		

The new packaged units had equal or better efficiency than the model that had been removed no HVAC model changes were required. The overall building LPD increased from 0.92 to 1.62, resulting in significant savings decreases after model changes.

RLW ID: 96P204

Building Type: C&I Storage

Original Measure Description: Energy efficient lighting.

Reason for RLW follow-up On-site: Change in ownership.

On-site Findings: There are now three tenant spaces on site. The total square footage for the building is 319,800. The first suite has added a significant amount of fluorescent lighting. The total count for MH for the site is greater than the original survey. It seems the lighting was added because the warehouses have racks stacked almost to ceiling height. This made the rows very dark. In addition the first suite had a very brightly lit work area in one portion of the warehouse.

Necessary Actions: The first suite is approximately 47,064 square feet, there is a 4,905 square foot office in the space. They have added a significant amount of fluorescent lighting. There are now 165 F82LL, 2 F42LL, and 75 MH 400. The office has 66 F42LL.

The second space is 145,986 square feet. This space has 71 MH 400.

The third space is 126,750 square feet, with a 2,835 square foot office. This space has 142 MH 400, and the office has 31 F43LL.

Building LPD changed from 0.24 to 0.49 resulting in significantly decreased savings after model changes.

RLW ID: 96P277

Building Type: General C&I Work

Original Measure Description: Indoor Lighting & Motor efficiency of HVAC units.

Reason for RLW follow-up On-site: Change in Tenancy and ownership.

On-site Findings: Seven HVAC packaged roof top units were removed, and two were replaced (presumably by previous tenant). The removed and replaced units were not rebated. Both rebated VSD's are still in place although the model numbers are recorded differently, the units are still the same.

The current units are as follows:

Nuvelo HVAC Models			
	Current	Original	Rebated?
1	Trane: #SXHFC4040E56D7AD2001GKLRT8	Trane: #SXHC4040456C7CD201GT	YES
2	Trane: #SXHFC5540E67D8AD2001GKLRT8	Trane: #SXHC5540A67C9CD201GT	YES
3	Trane: #YCD300B4	Trane: #YCD300B4	
4	Trane: #YCD300B4	Trane: #YCD300B4	
5		Trane: #YCD300B4	
6		Trane: #YCD300B4	
7		Trane: #YCD300B4	
8	Trane: #YCD240B4	Trane: #YCD240B4	
9	Trane: #YCD240B4	Trane: #YCD240B4	
10	Trane: #YCD240B4	Trane: #YCD240B4	
11	Trane: #YCD240B4	Trane: #YCD240B4	
12	Trane: #TCO180B4	Trane: #TCO180B4	
13	Trane: #TCO180B4	Trane: #TCO180B4	
14	Trane: #TCO300B4	Trane: #TCO300B4	
15	Trane: #TCO300B4	Trane: #TCO300B4	
16		Trane: #TC036C4	
17		Trane: #TCD060C4	
18	Trane: #TCH420A4	Trane: #TCH420A4	
19	Trane: #TCH420A4	Trane: #TCH420A4	
20	Trane: #TTA048C4	Trane: #TTA042C3	
21	Trane: #TWA036C4	Trane: #TTA042C3	
22		Trane: #TTA042C3	
23	Mitsubishi: #PU24EK2	Mitsubishi: #PU24EK2	
24		Mitsubishi: #PU24EK2	
25	Mitsubishi: #PU24EK	Mitsubishi: #PU24EK	
26	Mitsubishi: #PU24EK	Mitsubishi: #PU24EK	
27	Mitsubishi: #PU24EK	Mitsubishi: #PU24EK	
28	Mitsubishi: #PU24EK	Mitsubishi: #PU24EK	
29	Mitsubishi: #PU24EK	Mitsubishi: #PU24EK	

The current owners are in the process of remodeling the building. The contact indicated that they would be adding more HVAC units within the next 2 years before the remodel is completed.

The lighting is in the process of being changed and much of the production area is being converted into computer labs and R&D labs.

The current lighting count is as follows:

Manufacturing Space			
Location	Fixture	Qty	Lamps
Delivery	F43LL	78	3
	F42LL	51	0
Main Floor	MH400/1	198	1
Restroom	CFQ26/1	6	1
	F42LL	10	2
Machine room	F42LL	1	2
	F21LL	8	1
1st Floor Offices			
Lunchroom	F43LL	53	3
Accent Lights	F11LL	28	1
Recessed	CFQ26/1	13	1
Main Floor	F42LL	11	2
Electrical room	F43LL	10	3
Main Offices	FU2LL	7	2
	F43LL	108	3
2nd Floor Offices			
Stairs	F43LL	2	3
	CFQ26/1	14	1
Main Offices	F43LL	49	3
	FU2LL	2	2
	F43LL	198	3
Restroom	F42LL	10	2
Hot Water	F42LL	2	2

The LPD in the combined first and second level office space was increased from 0.74 to 1.08 and is expected to change further in the next 2 years.

The LPD in the manufacturing space was decreased from 1.15 to 0.93 and is expected to change further in the next 2 years.

Necessary Actions: The HVAC model changes or removals do not affect the Survey-it model. The lighting in the combined office space increased the LPD and does affect the Survey-it model.

RLW ID: 96P281

Building Type: Office

Original Measure Description: Lighting & HVAC

Reason for RLW follow-up On-site: Change in tenancy.

On-site Findings: The building is vacant and not in use at this time. There are changes to the lighting fixtures, and some occupancy sensors were installed. There are no changes to the roof packaged A/C units.

The original lighting rebates for the following:

Original lighting rebates	
122	F44LL fixtures
181	FU2LL fixtures
88	F42LL fixtures
73	CQ26/2 fixtures
55	I150/1 fixtures
30	MH175/1 fixtures
28	EFL7/2 fixtures
23	BX18/1 fixtures
18	F83LL fixtures
12	H50/1 fixtures
Current lighting is as follows	
486	F43LL fixtures (284 are delamped to 2 lamps)
105	FU2LL fixtures
29	CQ26/2 fixtures
23	F82LL fixtures

Necessary Actions: Lighting changes to the model are necessary.

Increased LPD in computer lab space to above baseline resulted in decreased savings after model changes.

RLW ID: 96P331

Building Type: General C&I Work

Original Measure Description: Indoor Lighting.

Reason for RLW follow-up On-site: Added a few lights in Machine Shop.

On-site Findings: Carroll Smith indicated that some lights were added in the Machine shop due to insufficient lighting in the work areas and lathes. Seven F82EE fixtures were added and four more will be added in the next few weeks. No other changes have occurred. The LPD for the machine shop was changed from 1.07 to 1.09 and will be 1.11 in a few weeks.

Necessary Actions: The added lighting did change the LPD from 1.07 to 1.09 and will be 1.11 by January 2004 a modification of the model is required.

Model changes resulted in slightly decreased savings.