RETENTION STUDY OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 AND 1997 RESIDENTIAL NEW CONSTRUCTION ENERGY EFFICIENCY PROGRAMS

1996-1997 RESIDENTIAL NEW CONSTRUCTION NINTH YEAR RETENTION

PG&E Study ID number:
386R2

CALMAC Study ID number:
PGE0247.01

March 1, 2006

Measurement and Evaluation
Customer Energy Efficiency
Policy, Evaluation & Regulatory Requirements Section
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As part of its Customer Energy Efficiency 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.

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Ninth-year Retention Study of Pacific Gas & Electric Company's 1996 and 1997 Residential New Construction Energy Efficiency Programs

PG&E Study ID Number: 386R2

CALMAC Study ID Number: PGE0247.01

Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs," as adopted by California Public Utilities Commission Decision 93-05-063, revised June 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

This study analyzes the effective useful life (EUL) of selected measures for which rebates were paid through Pacific Gas & Electric Company's 1996 and 1997 Residential New Construction Energy Efficiency Programs. A measure's EUL is the age at which half the units of the measure rebated and installed under the program are no longer in place and operable. More specifically, a measure's EUL is the age at which half the savings accounted for by units of the measure installed under the program are no longer achieved.

Methodology

The data necessary for this study were obtained from the sample of 414 participating homes included in the fourth-year retention study of the program. The results are based on the available data for all 414 homes. For the 253 sample homes with updated survey data from this current retention study, 74 completed an on-site survey and 179 completed a telephone survey. For the remaining 161 sample homes, we had telephone survey data from the fourth-year retention study.

To estimate a measure's EUL, this study used a method commonly referred to as survival analysis. The set of techniques referred to as survival analysis is widely used to analyze data representing a period of time. Survival analysis was conducted separately for three of the four measures studied: CAC, ducts, and cooking. This analysis was not conducted for stubs because all stubs were assessed as retained in the data collected.

To estimate a measure's EUL, this study assumed the age at which a unit of a measure is not retained follows some general path. Technically, this path is referred to as a distribution. Therefore, the general method was to collect data on the ages at which units were not retained and use those data to estimate the specific path or parameters of the distribution. The estimated path or parameters of the distribution of the age at which a unit of a measure is not retained were then used to estimate the measure's EUL.

This study considered a variety of distributional assumptions: gamma, Weibull, exponential, log-normal, and log-logistic. The selection of the most appropriate distribution was based on several criteria: implications for the non-retention rate over time; likelihood ratio test; analysis of residuals; and maximum of the log-likelihood function.

Study Results

This study analyzes the EULs of four measures installed under the 1996 and 1997 Residential New Construction Programs: high-efficiency central air conditioning (CAC), high-efficiency duct work (ducts), natural gas cooking (cooking), and natural gas dryer stub (stubs). For CAC and ducts, this study recommends the measure's ex ante EUL continue to be used in future earnings claims. For both cooking and stubs, this study recommends the estimated EUL of 28 years be used in future earnings claims. The table below provides a summary of the results.

1996 and 1997 Residential New Construction Energy Efficiency Programs
Summary of Effective Useful Life Estimates

Program Year	Measure	End Use	EUL (years)						P-value (H_0: ex post = ex ante)	EUL Realization Rate (adopted ex post /ex ante)
			ex ante	Estimated ex post (from study)	Adopted ex post (to be used in claim)	ex post Standard Error	80% Confidence Interval			
							Lower Bound	Upper Bound		
1996, 1997	High-efficiency central air conditioning	Cooling	18	28	18	2.24	25	31	<0.01	1.00
	High-efficiency duct work	Cooling, Heating	25	73	25	3.74	68	78	<0.01	1.00
	Natural gas cooking	Miscellaneous	20	28	28	2.46	25	31	<0.01	1.39
	Natural gas dryer stub	Miscellaneous	18	·	28	-	-	-	-	1.56

For CAC and ducts, although each measure's ex ante EUL is outside the 80 percent confidence interval for its EUL, there is not sufficient basis for replacing the measure's ex ante EUL with its estimated EUL. Namely, for these two measures, it seems reasonable to expect the non-retention rate to increase over time. Unfortunately, none of the distributions for which it was possible to obtain results for these two measures allow the non-retention rate to be increasing over time. Therefore, the estimated EULs for CAC and ducts may be too high.

On the other hand, for cooking and stubs, there is sufficient basis for replacing the ex ante EUL (20 and 18 years, respectively) with the smallest estimated cooking EUL of 28 years:

1. Both cooking and stubs are fuel-switching measures. The savings associated with each of them by the first-year impact evaluations depends on the saturation of a natural gas appliance in the participant population.
2. Based on the survey data collected for this study, 52 percent of homes that installed a stub under the program have a natural gas dryer, compared with the 55 percent at the time of the first-year impact evaluations. Therefore, almost all the savings accounted for stubs installed under the program continue to be achieved.
3. Estimated EULs for cooking were obtained assuming all but the gamma distribution, which provided us four sets of results to compare and contrast. For all of the distributional assumptions, the cooking ex ante EUL is outside the 80 percent confidence interval for its EUL and smaller than the estimated EUL.
4. We have no particular expectations regarding how the proportion of participating homes that cook with natural gas or that use a natural gas dryer will change over time.

Regulatory Waivers and Filing Variances

None.

NINTH-YEAR RETENTION STUDY OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 AND 1997 RESIDENTIAL NEW CONSTRUCTION ENERGY EFFICIENCY PROGRAMS

FINAL REPORT

PG&E Study ID Number: 386R2

CALMAC Study ID Number: PGE0247.01

Prepared for

Pacific Gas and Electric Company
San Francisco, California

Prepared by

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Oakland, California
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March 1, 2006

ES

EXECUTIVE SUMMARY

This report provides the results of a ninth-year retention study of Pacific Gas & Electric Company's (PG&E) 1996 and 1997 Residential New Construction Programs. This study was conducted in accordance with the Measurement and Evaluation Protocols (M&E Protocols) of the California DSM Measurement Advisory Committee (CADMAC).[1]

As given in the M&E Protocols, the purpose of a retention study "…is to collect data on the fraction of measures or practice remaining in a given year that will be used to produce a revised estimate of its effective useful life" (p. 23). The M&E Protocols go on to define effective useful life (EUL) as "[a]n estimate of the median number of years that the measures installed under the program are still in place and operable" (p. A-1). That is, a measure's EUL is the age at which half the units of the measure installed under the program are no longer in place and operable. More specifically, a measure's EUL is the age at which half the savings accounted for by units of the measure installed under the program are no longer achieved.

Each measure installed under the 1996 and 1997 Residential New Construction Programs has an EUL value that was used in the last earnings claim, which is referred to as the ex ante EUL. The value of a measure's EUL used in future earnings claims will be either its EUL estimated by a retention study or its ex ante EUL. If a measure's ex ante EUL is outside the 80 percent confidence interval for the measure's EUL based on a retention study, then the EUL estimated by the retention study may be used in future earnings claims. On the other hand, if a measure's ex ante EUL is inside the 80 percent confidence interval, then its ex ante EUL will be used in future earnings claims.

E.1 SUMMARY OF THE RESULTS

This study analyzes the EULs of four measures installed under the 1996 and 1997 Residential New Construction Programs: high-efficiency central air conditioning (CAC), high-efficiency duct work (ducts), natural gas cooking (cooking), and natural gas dryer stub (stubs). For CAC and ducts, this study recommends the measure's ex ante EUL continue to be used in future earnings claims. For both cooking and stubs, this study recommends the estimated EUL of 28 years be used in future earnings claims. The estimated EUL of 28 years will replace the cooking ex ante EUL of 20 years and the stub ex ante EUL of 18 years. Table ES-1 provides a summary of the results.

[1] California Public Utilities Commission, *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, Decision 93-05-063. Revised June 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

Table ES-1
1996 and 1997 Residential New Construction Programs
Summary of Effective Useful Life Estimates

Program Year	Measure	End Use	EUL (years)						P-value (H_0: ex post = ex ante)	EUL Realization Rate (adopted ex post /ex ante)
			ex ante	Estimated ex post (from study)	Adopted ex post (to be used in claim)	ex post Standard Error	80% Confidence Interval			
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1996, 1997	High-efficiency central air conditioning	Cooling	18	28	18	2.24	25	31	<0.01	1.00
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	Natural gas dryer stub	Miscellaneous	18	-	28	-	-	-	-	1.56

For each measure, Table ES-1 presents the ex ante and adopted ex post EULs and the EUL realization rate. Also, for CAC, ducts, and cooking, this table presents the selected results of the survival analysis. Survival analysis results are not presented for stubs because all stubs were assessed as retained in the data collected.

For CAC and ducts, although each measure's ex ante EUL is outside the 80 percent confidence interval for its EUL, there is not sufficient basis for replacing the measure's ex ante EUL with its estimated EUL. Namely, for these two measures, it seems reasonable to expect the non-retention rate to increase over time. Unfortunately, none of the distributions for which it was possible to obtain results for these two measures allow the non-retention rate to be increasing over time. Therefore, the estimated EULs for CAC and ducts may be too high.

On the other hand, for cooking and stubs, there is sufficient basis for replacing the ex ante EUL (20 and 18 years, respectively) with the smallest estimated cooking EUL of 28 years:

1. Both cooking and stubs are fuel-switching measures. The savings associated with each of them by the first-year impact evaluations depends on the saturation of a natural gas appliance in the participant population.
2. Based on the survey data collected for this study, 52 percent of homes that installed a stub under the program have a natural gas dryer, compared with the 55 percent at the time of the first-year impact evaluations. Therefore, almost all the savings accounted for stubs installed under the program continue to be achieved.
3. Estimated EULs for cooking were obtained assuming all but the gamma distribution, which provided us four sets of results to compare and contrast. For all of the distributional assumptions, the cooking ex ante EUL is outside the 80 percent confidence interval for its EUL and smaller than the estimated EUL.
4. We have no particular expectations regarding how the proportion of participating homes that cook with natural gas or that use a natural gas dryer will change over time.

E.2 STUDY DATA

In each of the program years, the measures included in this study accounted for at least 98 percent of the ex post net savings. This clearly meets the M&E Protocols measure requirements.

This study attempted to complete a survey with the current occupants of the 414 participating homes included in the fourth-year retention study of PG&E's 1996 and 1997 Residential New Construction Programs. We successfully completed surveys with the current occupants of 253, or 61 percent, of these homes. The results are based on the available data for all 414 sample homes. For the 253 sample homes with updated survey data from this current retention study, 74 completed an on-site survey and 179 completed a telephone survey. For the remaining 161 sample homes, we had telephone survey data from the fourth-year retention study.

The purpose of each survey was to collect the data necessary from a sample of participating homes to determine the retention status of the measures installed under the program. Furthermore, if a measure appeared not to be retained, the surveys collected any available data on when the measure was not retained.

E.3 METHODS

This retention study, like most, was conducted when more than half the units of the measures installed under the program year were still in place and operable. Therefore, it was necessary to employ statistical methods to estimate the EULs of measures installed under the 1996 and 1997 Residential Construction Programs. To estimate a measure's EUL, this study used a method commonly referred to as survival analysis. The set of techniques referred to as survival analysis is widely used to analyze data representing a period of time. Survival analysis was conducted separately for three of the four measures studied: CAC, ducts, and cooking. This analysis was not conducted for stubs because all stubs were assessed as retained in the data collected.

E.3.1 Estimating an EUL

To estimate a measure's EUL, this study assumed the age at which a unit of a measure is not retained follows some general path. Technically, this path is referred to as a distribution. Therefore, the general method was to collect data on the ages at which units were not retained and use those data to estimate the specific path or parameters of the distribution. The estimated path or parameters of the distribution of the age at which a unit of a measure is not retained were then used to estimate the measure's EUL.

This study considered a variety of distributional assumptions: gamma, Weibull, exponential, log-normal, and log-logistic. These are common distributional assumptions when conducting survival analysis. Even when there are a priori expectations about the path (distribution) followed by the age at which a unit of a measure is not retained, it can be informative to consider alternative paths. The selection of the most appropriate distribution was based on several criteria:

- implications for the non-retention rate over time;
- likelihood ratio test;
- analysis of residuals; and
- maximum of the log-likelihood function.

E.3.2 Confidence Interval for a Measure's EUL

The log of a measure's EUL estimate and the standard error of the log of a measure's EUL estimate are obtained directly. A measure's EUL estimate was then obtained by calculating the exponential of the log value ($e^{log(EUL\ estimate)}$). A confidence interval for a measure's EUL was obtained in a similar manner.

In general, the bounds of a confidence interval for a parameter are calculated as the parameter estimate ± the standard error of the parameter estimate times the critical value from the appropriate distribution for the desired level of confidence. Using the standard error of the log of a measure's EUL estimate, we calculated the 80 percent confidence interval for the log of a measure's EUL. The lower and upper bounds of the 80 percent confidence interval for a measure's EUL were then obtained by calculating the exponential of the lower and upper bound values of the 80 percent confidence interval for the log of the measure's EUL, respectively.

1 INTRODUCTION

This report provides the results of a ninth-year retention study of Pacific Gas & Electric Company's (PG&E) 1996 and 1997 Residential New Construction Programs. This study was conducted in accordance with the Measurement and Evaluation Protocols (M&E Protocols) of the California DSM Measurement Advisory Committee (CADMAC) at the request of the California Public Utilities Commission.[1] The study was managed by PG&E. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org.

In this section of the report, we introduce the M&E Protocol requirements and describe the structure of the remainder of the report.

1.1 PROTOCOL REQUIREMENTS

The M&E Protocols require that the retention studies of PG&E's 1996 and 1997 Residential New Construction Programs be combined and conducted on the schedule for program year 1996. Furthermore, for this program and these program years, the M&E Protocols require two retention studies, a fourth-year and a ninth-year. This report provides the results of a ninth-year retention study.

As given in the M&E Protocols, the purpose of a retention study "…is to collect data on the fraction of measures or practice remaining in a given year that will be used to produce a revised estimate of its effective useful life" (p. 23). The M&E Protocols go on to define effective useful life (EUL) as "[a]n estimate of the median number of years that the measures installed under the program are still in place and operable" (p. A-1). That is, a measure's EUL is the age at which half the units of the measure installed under the program are no longer in place and operable. More specifically, a measure's EUL is the age at which half the savings accounted for by units of the measure installed under the program are no longer achieved.

Each measure installed under the 1996 and 1997 Residential New Construction Programs has an EUL value that was used in the last earnings claim, which is referred to as the ex ante EUL. The value of a measure's EUL used in future earnings claims will be either its EUL estimated by a retention study or its ex ante EUL. If a measure's ex ante EUL is outside the 80 percent confidence interval for the measure's EUL based on a retention study, then the EUL estimated by the retention study may be used in future earnings claims. On the other hand, if a measure's ex ante EUL is inside the 80 percent confidence interval, then its ex ante EUL will be used in future earnings claims.

[1] California Public Utilities Commission, *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, Decision 93-05-063. Revised June 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

1.2 ORGANIZATION OF THE REPORT

The next section of the report describes the data used by this study. Section 3 discusses the methods used to estimate a measure's EUL. The construction of the confidence interval for a measure's EUL as well as the companion hypothesis test about the value of a measure's EUL, are also discussed in that section. Section 4 presents the study results. The report concludes with six appendices:

- Appendix A: Advance letter sent to a sample of homes that participated in the program informing them of an upcoming telephone survey and possible on-site survey.
- Appendix B: On-site data collection materials.
- Appendix C: Telephone questionnaire.
- Appendix D: Examples of duct non-retention and retention.
- Appendix E: As required by the M&E Protocols, Table 6B.
- Appendix F: As required by the M&E Protocols, Table 7B.

2 STUDY DATA

This section of the report describes the data used by this study to estimate the EULs of measures installed under PG&E's 1996 and 1997 Residential New Construction Programs. It discusses the measures and the participating homes included in the study, the data sources used, and how the data were prepared for the analysis.

2.1 MEASURES INCLUDED IN THE STUDY

According to the M&E Protocols, the following measures should be included in a retention study:

> …the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less (p. 24).

In each of the program years, the measures included in this study accounted for at least 98 percent of the ex post net savings. This clearly meets the M&E Protocols measure requirements.

This study analyzes the EULs of the following four measures installed under PG&E's 1996 and 1997 Residential New Construction Programs:

- high-efficiency central air conditioning (11.5 or better seasonal energy efficiency ratio),
- high-efficiency duct work (installation per PG&E program standards),
- natural gas cooking, and
- natural gas dryer stub.

These same measures were included in the fourth-year retention study.

2.2 PARTICIPATING HOMES INCLUDED IN THE STUDY

This study attempted to complete a survey with the current occupants of the 414 participating homes included in the fourth-year retention study of PG&E's 1996 and 1997 Residential New Construction Programs. We successfully completed surveys with the current occupants of 253, or 61 percent, of these homes. The results presented in Section 4 are based on the available data for all 414 sample homes. For 253 sample homes, we had updated survey data from this current retention study, and for the remaining 161 sample homes, we had survey data from the fourth-year retention study.

Typically, retention studies of a program are based on the program participants included in the first-year impact evaluation. For these participants, the measures installed and in what quantity

as well as any participant-specific savings estimates are known. The fourth-year retention study, however, was not based on the participating homes included in the first-year impact evaluation.

The fourth-year retention study drew a new sample of participating homes using the sample design given in Table 2-1. The sampling frame was limited to participants in California Energy Commission (CEC) climate zones 11, 12, and 13 who received rebates for all four measures (high-efficiency central air conditioning, high-efficiency duct work, gas cooking, gas dryer stub). The sample was stratified by program year and climate zone. Each program year was allocated the same number of completes (200), which were then allocated across climate zones proportional to program participation that year.

Table 2-1
Fourth-Year Retention Study Sample Design

CEC Climate Zone	# Participants All 4 Measures Installed	4th-year # Completes		9th-year # Completes			
					Obtained		
		Target	Obtained	Target	Onsite	Telephone	Total
1996							
11	545	43	45	45	11	22	33
12	1,459	116	119	119	24	51	75
13	515	41	43	43	6	20	26
Total	2,519	200	207	207	41	93	134
1997							
11	611	35	37	37	4	17	21
12	2,099	120	122	122	14	51	65
13	791	45	48	48	15	18	33
Total	3,501	200	207	207	33	86	119
Total							
11	1,156	78	82	82	15	39	54
12	3,558	236	241	241	38	102	140
13	1,306	86	91	91	21	38	59
Total	6,020	400	414	414	74	179	253

Limiting the sampling frame to participants in climate zones 11, 12, and 13 who received rebates for four measures excludes relatively few participants with one exception. In each program year, less than 2 percent of participants were outside climate zones 11, 12, or 13. In addition, in 1997, only 3 percent of participants received rebates for a subset of the four measures. However, in 1996, 32 percent of participants received rebates for only a subset of the four measures.

2.3 DATA SOURCES

This study used data from five sources:

1. The tracking databases for the 1996 and 1997 Residential New Construction Programs.
2. PG&E's customer information system.

3. The telephone survey conducted for the fourth-year retention study.
4. The on-site visits conducted for this study.
5. The telephone surveys conducted for this study.

2.3.1 Program-tracking Database

This study attempted to complete surveys with the current occupants of the 414 participating homes included in the fourth-year retention study of the 1996 and 1997 Residential New Construction Programs. The fourth-year retention study drew this sample of homes from a sampling frame developed from the 1996 and 1997 program-tracking databases. For each participating home, the program-tracking databases provided:

- PG&E control number from the customer information system, which facilitated the process of obtaining updated customer information for the participating home.
- Complete service address.
- Measures installed under the program.
- Dates the program rebates were paid. The fourth-year retention study based a participating home's program year assignment on these date. (If the rebates were paid in 1996, the home was assigned to program year 1996 and if the rebates were paid in 1997, the home was assigned to program year 1997.)

2.3.2 PG&E Customer Information System

PG&E's control number was essentially a unique premise ID. Although PG&E no longer assigns control numbers, it was still possible to use it to obtain updated customer information (name and telephone number) for all but nine of the 414 sample homes. We searched PG&E's customer information system for the remaining nine sample homes using the service address.

2.3.3 Surveys

As described above, this study used data from three surveys conducted at two points in time: at the time of the fourth-year retention study and at the time of this current (ninth-year) retention study. The purpose of each survey was to collect the data necessary from a sample of participating homes to determine the retention status of the measures installed under the program. Furthermore, if a measure appeared not to be retained, the surveys collected any available data on when the measure was not retained.

The fourth-year retention study completed telephone surveys with 414 participating homes. This study attempted to complete surveys with the current occupants of these 414 participating homes. We successfully completed surveys with the current occupants of 253, or 61 percent, of the sample homes.

On-site Survey

Over a period of about three and a half weeks (January 16 through February 8, 2006), we completed on-site surveys with 74 sample homes. The on-site data collection materials, which include a scheduling form, the on-site data collection protocols, and the on-site data collection instrument are provided in Appendix B.

We targeted new occupants of the 414 sample homes for on-site surveys, where an occupant was classified as "new" if the account name was different from the account name at the time of the fourth-year retention study. Of the 414 sample homes, 174 (42 percent) had new occupants. To ensure the randomness of the homes at which we completed an on-site survey, quotas were set by city. The target number of completes was 75 on-site surveys. So, we set the target number of completes (quota) in each city at (75/174) times the number of new occupants in the city.

To encourage participation in the on-site survey as well as the telephone survey, we sent a letter in advance of the surveys to all 414 sample homes informing them of the upcoming surveys (see Appendix A). In addition, to encourage participation in the on-site survey, a $50 incentive was offered. We offered a higher incentive ($75) if it seemed that it might persuade a reluctant new occupant to permit an on-site survey. The field auditors also dropped off letters at homes where they were having trouble reaching the occupant to schedule an on-site survey (see Appendix B). Lastly, the field auditors had access to Spanish-speaking KEMA staff to facilitate completing on-site surveys with Spanish-speaking occupants.

A summary of the final status of the 174 sample homes with new occupants is given in Table 2-2. As this table shows, at the conclusion of the fieldwork, we attempted to complete telephone surveys with 72 sample homes with new occupants. Also, when the telephone number we got from the PG&E customer information system was incorrect, we attempted to obtain the correct telephone number using various directories available on the Internet that allow telephone numbers to be looked up by address.

Table 2-2
On-site Survey Final Status

Status	Homes	
	#	%
On-site survey completed[a]	74	42%
Refusal, don't attempt telephone survey	17	10%
Incorrect telephone number	12	7%
Attempt to complete telephone survey	72	41%
Total[a]	175	100%

[a] One on-site survey was completed with an original occupant. Hence, the total of 175 reflects 174 new occupants and one original occupant.

Telephone Survey Conducted for the Current Study

We attempted to complete a telephone survey with 311 sample homes. (The remaining 103 of the 414 sample homes are accounted for by the on-site survey—complete, incorrect telephone number, or refusal.) Over a period of about 2 weeks (February 2 through February 16, 2006), we completed telephone surveys with 179, or 58 percent, of these homes. The telephone questionnaire is given in Appendix C.

As already discussed, to encourage participation in the telephone survey, we sent a letter in advance of the survey to all the sample homes informing them of the upcoming survey (see Appendix A). Also, the telephone survey was offered in both English and Spanish. A summary of the final status of the 311 sample homes sent to the telephone survey house is provided in Table 2-3. When the telephone number we got from the PG&E customer information system was incorrect, we attempted to obtain the correct telephone number using various directories available on the Internet that allow telephone numbers to be looked up by address. Telephone numbers with a final status of "live" were called repeatedly over the two-week period we were in the field, on different days and different times of the day.

Table 2-3
Telephone Survey Final Status

	Homes	
Status	**#**	**%**
Telephone survey completed	179	58%
Refusal	16	5%
Language problems	2	1%
Incorrect telephone number	44	14%
Live	70	23%
Total	311	100%

2.4 DATA PREPARATION

Here, we describe how the data were prepared for the analysis, which is discussed in the next section. It is not until Section 4 that we present the results of the analysis. Section 4 presents both the EUL estimates as well as some basic information available from the data collected. (For example, for each measure, the number of units not retained based on the fourth-year retention study and the number of units not retained based on this current retention study.)

For each measure (high-efficiency central air conditioning, high-efficiency duct work, natural gas cooking, and natural gas dryer stub), the analysis data set consisted of 414 observations, one for each of the 414 participating homes included in the fourth-year retention study. The observation on each sample home consisted of a minimum age and a maximum age at which the measure was not retained, based on all available data. If a survey was completed for a sample home, then the available data included the updated survey data. If a survey was not completed

for a sample home, then the latest survey data available were from the fourth-year retention study.

For each sample home, we reviewed the available data to determine the retention status of each measure. If a measure was not retained, the minimum and maximum ages at which the measure was not retained are relatively straightforward. If the exact age at which a measure was not retained was known, then the minimum and maximum ages used in the analysis were both this exact age. Sometimes it was only known that a measure was not retained between age x and age y (where age x is less than age y). In this case, the minimum age used in the analysis was age x and the maximum age used in the analysis was age y.

If a measure was retained, typically the minimum age used in the analysis was the age of the measure the last time a survey was completed with the sample home. We know the measure was retained at least up until this age, but it may be not retained the day following the survey. If a measure was retained, the maximum age used in the analysis was set to missing.

In general, to calculate the age of a measure, its installation date is needed. For the installation date, we used PG&E's date on premises for the original occupant in the sample home. If we did not have the date on premises for the original occupant in the sample home, we used the average date on premises for the original occupants in the same program year as the sample home.

3 METHODS

This section of the report discusses the methods used to estimate the EULs of measures installed under PG&E's 1996 and 1997 Residential New Construction Programs. The construction of a confidence interval for a measure's EUL and the companion hypothesis test about the value of a measure's EUL are also discussed. The study results for each measure are presented in the next section.

The analysis discussed here was conducted separately for three of the measures studied: high-efficiency central air conditioning, high-efficiency duct work, and natural gas cooking. This analysis was not conducted for natural gas dryer stubs because all stubs were assessed as retained in the data collected.

3.1 SURVIVAL ANALYSIS

The purpose of a retention study is to estimate a measure's EUL, which is the age at which half the units of the measure installed under the program are no longer in place and operable. More specifically, a measure's EUL is the age at which the savings accounted for by units of the measure installed under the program are no longer achieved. This retention study, like most, was conducted when more than half the units of the measures installed under the program year were still in place and operable. Therefore, it was necessary to employ statistical methods to estimate the EULs of measures installed under the 1996 and 1997 Residential Construction Programs.

To estimate a measure's EUL, this study used a method commonly referred to as survival analysis. The set of techniques referred to as survival analysis is widely used to analyze data representing a period of time. The method has several names, depending on the area of application, but was first referred to as survival analysis because it was initially used to analyze death rates. For example, in engineering "survival analysis" is reliability analysis and in economics it is duration analysis. The terminology used in the analysis may also vary depending on the area of application. In this report, we use the survival analysis terminology, but modify it when appropriate for the application of survival analysis to retention.

3.1.1 The Basics

To estimate a measure's EUL, this study assumed the age at which a unit of a measure is not retained follows some general path. Technically, this path is referred to as a distribution. Therefore, the general method was to collect data on the ages at which units were not retained and use those data to estimate the specific path or parameters of the distribution. The estimated path or parameters of the distribution of the age at which a unit of a measure is not retained were then used to estimate the measure's EUL.

The parameters of the distribution of the age at which a unit of a measure is not retained were estimated by fitting a general linear regression model to the log (natural) of the ages at which units were not retained observed in the data. This model can be written as:

$$\log(T_j) = \mu + \sigma\varepsilon_j,$$

where

T_j = observed age at which unit j was not retained,

μ = location parameter or intercept,

σ = scale parameter, and

ε_j = random error term.

The exponential of the error term of this model (e^{ε_j}) was assumed to follow the standardized form of the distribution of the age at which a unit is not retained. The general linear regression model was fitted by maximizing the log-likelihood function for the assumed distribution.

To estimate a measure's EUL, the estimated parameters of the distribution of the age at which a unit of the measure is not retained were then used in the survival function. This function is simply one minus the cumulative distribution function of the age at which a unit is not retained. The survival function $S(t;\theta)$ gives the probability of retaining a unit of a measure until at least age t, given the parameter vector θ. Therefore, the estimate of a measure's EUL is the age t^* such that the survival probability $S(t^*;\hat{\theta}) = 0.50$, where $\hat{\theta}$ is the vector of parameter estimates.[1]

3.1.2 Weights

In the retention analysis of a measure, the relative importance of a unit depends on the energy costs avoided by its installation. If the energy costs avoided per unit of a measure varies across units, it is necessary to use weights that reflect the different levels of energy costs avoided when fitting the general linear regression model.

[1] The general linear regression model was fitted to the log of the ages at which units of a measure were not retained. Therefore, the estimated parameters used in the survival function directly produced the log of a measure's EUL estimate such that the survival probability is 0.50. A measure's EUL estimate was then obtained by calculating the exponential of this log value ($e^{log(EUL\ estimate)}$).

For each of the measures analyzed by this study, the energy costs avoided per unit of the measure are expected to be similar across units. Therefore, it was not necessary to use weights in the analysis. However, we used the standard sampling weights anyway. The standard sampling weights were calculated by stratum as:

(total number of participating homes in a stratum)
/(number of sample homes included in the analysis in a stratum).

3.1.3 Distribution Options

This study considered a variety of distributional assumptions:

- Gamma,
- Weibull,
- Exponential,
- Log-normal, and
- Log-logistic.

These are common distributional assumptions when conducting survival analysis. Even when there are a priori expectations about the path (distribution) followed by the age at which a unit of a measure is not retained, it can be informative to consider alternative paths.

The gamma distribution is the most general of the distributions listed above. It has three free parameters, location (μ), scale (σ), and shape, whereas the other distributions have only one or two free parameters. The gamma distribution includes the Weibull, exponential, and log-normal distributions as special cases. The Weibull distribution includes the exponential distribution as a special case.

The Weibull, log-normal, and log-logistic distributions have two free parameters, location and scale; and the exponential distribution has one free parameter, location. The Weibull and log-normal distributions result as special cases of the gamma distribution when the shape parameter equals one and zero, respectively. The exponential distribution results as a special case of the gamma distribution when both the shape and scale parameters equal one or as a special case of the Weibull distribution when the scale parameter equals one.

The gamma distribution has more parameters than the other distributions and places fewer constraints on the parameters than the Weibull, exponential, and log-normal distributions. Therefore, the EUL estimates obtained assuming a gamma distribution will most closely reflect the data. On the other hand, because the gamma distribution has the most parameters and places the fewest constraints on them, the gamma distribution requires more not retained units in the analysis data set than the other distributions in order to fit a general linear regression model. Furthermore, if the analysis dataset contains a sufficient number not retained units, all of the distributions tend to produce similar EUL estimates.

3.1.4 Distribution Adopted

The selection of the most appropriate distribution was based on several criteria:

- implications for the non-retention rate over time;
- likelihood ratio test;
- analysis of residuals; and
- maximum of the log-likelihood function.

Non-Retention Rate Over Time

The distributional assumption has implications for the non-retention rate over time. These implications are seen via the hazard function $h(t;\theta)$. Roughly, the hazard function can be thought of as the probability a unit of a measure is not retained at age t, given the unit has been retained up to that age. Formally, it is the negative ratio of the survival probability density function dS/dt to the survival function,

$$h(t;\theta) = -\frac{dS/dt}{S(t;\theta)}.$$

An increasing hazard function means the non-retention rate increases as a unit of a measure ages, whereas a decreasing hazard function means the non-retention rate decreases as a unit of a measure ages. If the hazard function is constant, the non-retention rate remains constant as a unit of a measure ages. The hazard function of the gamma distribution may have a variety of shapes. However, it is often difficult to determine which possible shape the hazard function of the gamma distribution actually takes on.

The hazard function of the Weibull distribution may have one of three shapes: always decreasing, always increasing, or constant. If the scale parameter is greater than one, then the hazard function is decreasing, whereas if the scale parameter is less than one, then the hazard function is increasing. Recall, a Weibull distribution with scale parameter equal to one corresponds to the exponential distribution. The exponential distribution has a constant hazard function.

If the hazard function of the Weibull distribution is increasing (the scale parameter is less than one), the rate of increase depends on the value of the scale parameter. If the scale parameter is between 0.5 and 1, the hazard function is increasing at a decreasing rate; if the scale parameter equals 0.5, the hazard function is increasing at a constant rate; and if the scale parameter is between 0 and 0.5, the hazard function is increasing at an increasing rate.

The hazard function of the log-logistic distribution may increase to a peak and then decrease or it may be always decreasing. If the scale parameter is less than one, then the hazard function is increasing then decreasing, whereas if the scale parameter is greater than or equal to one, then the hazard function is always decreasing.

The log-normal distribution has a hazard function that increases to a peak and then decreases. The larger the scale parameter, the sooner the hazard function reaches its peak and begins to decrease. A hazard function that is increasing then decreasing means that for some period of time after a unit of a measure is installed, the non-retention rate increases as the unit of the measure ages then, after some point, the non-retention rate decreases as the unit of the measure ages.

Likelihood Ratio Test

If a distribution is a special case of another distribution, the appropriateness of the former versus the latter can be formally tested using the likelihood ratio test. Therefore, likelihood ratio tests comparing the appropriateness of the Weibull, exponential, and log-normal distributions versus the gamma distribution were conducted. A likelihood ratio test comparing the appropriateness of the exponential distribution versus the Weibull distribution was also conducted.

Analysis of Residuals

According to Allison (1995), Cox-Snell residuals are commonly used in survival analysis and are defined as:

$$e_j = -\log(S(t_j;\hat{\theta}))\,,$$

where

e_j = the residual associated with the observed age t_j at which unit j is not retained and

$S(t_j;\hat{\theta})$ = the estimated survival function at t_j.

A Cox-Snell residual is right-censored, interval-censored, left-censored, or uncensored if the observed age at which the unit was not retained that it is associated with is right-censored, interval-censored, left-censored, or uncensored, respectively. The definitions of these various terms for the age at which a unit was not retained are as follows:

Right-censored: If a unit is still retained, the age it will be when it is not retained is right-censored, the upper bound is unknown (infinity).

Interval-censored: If a unit was not retained sometime between age x and age y (where age x is less than age y).

Left-censored: Left-censoring is a special case of interval-censoring, where age x is zero years (i.e., soon after installation).

Uncensored: The age at which a unit was not retained is known exactly.

If a distributional assumption is appropriate, the Cox-Snell residuals have an approximate exponential distribution with a location parameter of zero. For each distributional assumption a general linear regression model was fitted, this was tested. This test involved fitting a second

general linear regression model to the log of the Cox-Snell residuals assuming an exponential distribution. If the estimated location parameter was not statistically different from zero at the 10 percent level of significance or better, then the distribution assumed for the age at which a unit of measure is not retained may be appropriate.

Maximum of the Log-likelihood Function

Recall, under each assumed distribution, the general linear regression model is fitted by maximizing the log-likelihood function. A larger maximum value of the log-likelihood function suggests a better model fit.

3.2 CONFIDENCE INTERVAL FOR A MEASURE'S EUL

The general linear regression model was fitted to the log of the ages at which units of a measure were not retained. Therefore, the log of a measure's EUL estimate and the standard error of the log of a measure's EUL estimate were provided directly. A measure's EUL estimate was then obtained by calculating the exponential of the log value ($e^{log(EUL\ estimate)}$). A confidence interval for a measure's EUL was obtained in a similar manner.

In general, the bounds of a confidence interval for a parameter are calculated as the parameter estimate ± the standard error of the parameter estimate times the critical value from the appropriate distribution for the desired level of confidence. Using the standard error of the log of a measure's EUL estimate, we calculated the 80 percent confidence interval for the log of a measure's EUL. The lower and upper bounds of the 80 percent confidence interval for a measure's EUL were then obtained by calculating the exponential of the lower and upper bound values of the 80 percent confidence interval for the log of the measure's EUL, respectively.

The log of a measure's EUL estimate is assumed approximately normally distributed. Therefore, the critical value employed in the calculation of a confidence interval for the log of a measure's EUL was approximated using the value from the t distribution for the appropriate degrees of freedom and desired level of confidence (80 percent). The degrees of freedom were the number of units of the measure employed in the analysis minus one.

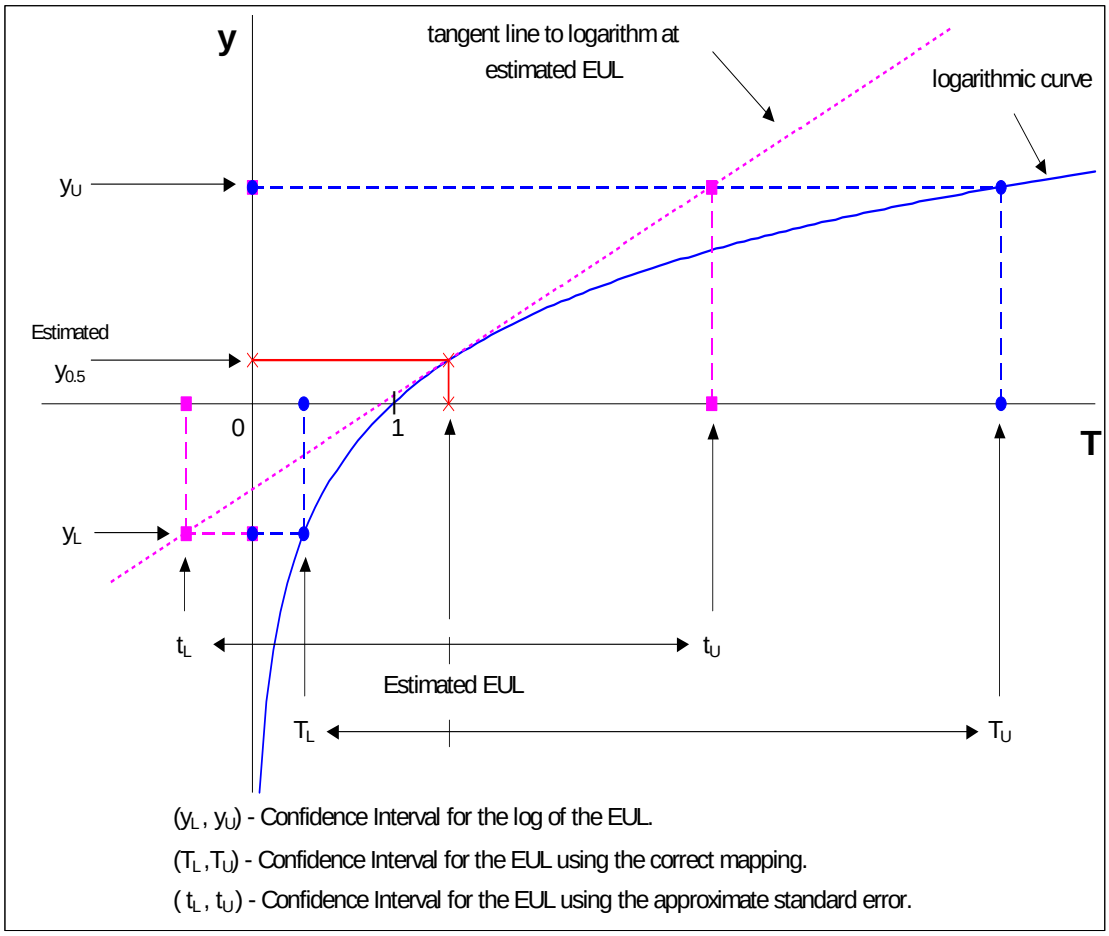
3.2.1 Alternative Confidence Interval

This study calculates and reports a confidence interval for a measure's EUL based on a confidence interval for the log of the measure's EUL as discussed above. Alternatively, a confidence interval for a measure's EUL may be calculated using the standard error of the measure's EUL estimate. This standard error may be approximated by the exponential of the standard error of the log of the measure's EUL estimate. A confidence interval for a measure's EUL based on the standard error of the measure's EUL estimate is symmetric about the measure's EUL estimate. That is, the lower and upper bounds of this confidence interval are the same distance from the measure's EUL estimate.

A confidence interval for the log of a measure's EUL is similarly symmetric about the log of the measure's EUL estimate. However, a confidence interval for a measure's EUL based on a confidence interval for the log of the measure's EUL is not symmetric about the measure's EUL estimate. This is because the logarithmic transformation is non-linear. Consequently, a confidence interval for a measure's EUL based on the standard error of the measure's EUL estimate is less accurate than a confidence interval for the measure's EUL based on a confidence interval for the log of the measure's EUL. The two methods of calculating a confidence interval for a measure's EUL are illustrated in Figure 3-1.

The larger the standard error of a measure's EUL estimate, the greater the consequences of the non-linearity of the logarithmic transformation and the less accurate a confidence interval for the measure's EUL based on the standard error of the measure's EUL estimate. The non-linearity of the logarithmic transformation also explains why a confidence interval for a measure's EUL based on the standard error of the measure's EUL estimate may contain negative values, which are clearly impossible. A confidence interval for a measure's EUL based on a confidence interval for the log of the measure's EUL will never contain negative values.

Figure 3-1
Two Methods of Calculating a Confidence Interval for the EUL



3.3 HYPOTHESIS TEST ABOUT THE VALUE OF A MEASURE'S EUL

Results are reported for the test of whether a measure's EUL is significantly different (at the 20 percent level) from its ex ante EUL. Formally, results are reported for the null hypothesis: a measure's EUL equals its ex ante EUL, and the alternative hypothesis: a measure's EUL does not equal its ex ante EUL.

The statistic on which this test was based is:

$$\frac{\left|\log\left(\hat{EUL}\right) - \log\left(ex\ ante\ EUL\right)\right|}{standard\ error\ of\ the\ \log\left(\hat{EUL}\right)},$$

where

$\log\left(\hat{EUL}\right)$ = the log of a measure's EUL estimate.

The log of a measure's EUL estimate is assumed to have an approximate normal distribution with mean log (EUL) and unknown variance. Therefore, this test statistic has an approximate t distribution with degrees of freedom equal to the number of units of the measure employed in the analysis minus one.

The p-value is the probability of obtaining a value of the test statistic greater than or equal to the value calculated if a measure's EUL equals its ex ante EUL (the null hypothesis is true). The larger the p-value, the more likely a measure's EUL equals its ex ante EUL. In this study, if the p-value was less than or equal 0.20, a measure's EUL was determined not to equal its ex ante EUL (the null hypothesis was rejected).

3.4 REFERENCES

Allison, Paul D. 1995. *Survival analysis using the SAS® system: A practical guide*. Cary, NC: SAS Institute Inc.

4 RESULTS

This section of the report presents the results of the retention analysis for the following measures installed under PG&E's 1996 and 1997 Residential New Construction Programs:

- high-efficiency central air conditioning (CAC),
- high-efficiency duct work (ducts),
- natural gas cooking (cooking), and
- natural gas dryer stub (stub).

Before presenting the results of the survival analysis discussed in the previous section, we describe the analysis data, examine non-retention based on some simple tabulations of the data collected, and define non-retention for the measures studied.

4.1 ANALYSIS DATA

Table 4-1 shows the number of participating homes included in the retention analysis as compared with the number in the population of participants by measure.[1] Depending on the measure, we were unable to complete a survey with the current occupants of between 156 and 161 sample homes. For these sample homes, the retention status of each measure was based on the fourth-year survey data and, therefore, the age of a retained measure was in the neighborhood of four years. For the remaining 248 to 253 sample homes, the retention status of each measure was based on the survey data collected for this current (ninth-year) retention study, which was either an on-site or a telephone survey. For these sample homes, the age of a retained measure was in the neighborhood of nine years.

Table 4-1
Retention Analysis Data

Measure	ex ante EUL (years)	Total # Participating Homes (Population)	# Homes Included in Retention Analysis				Excluded From Analysis
			Total	4th-year Survey Only	9th-year Survey		
					On-site	Phone	
CAC	18	7,300	414	161	74	179	0
Cooking	20	6,746	404	156	72	176	10
Ducts	25	6,969	414	161	74	179	0
Stub	18	6,704	408	159	71	178	6

[1] The program installed two CAC units at about 5 percent of participating homes. For the remaining measures, the program installed one unit. Given the small number of homes with two CAC units and the fact that for sample homes the retention status of both units was the same, the analysis was conducted at the home rather than the CAC unit level.

Table 4-1 also shows the number of sample homes that were excluded from the analysis. A sample home was only excluded from the analysis if it was determined that the measure in fact had never been installed under the program. Such instances of non-installation have already been accounted for by the first-year impact evaluations. If an original occupant indicated that they had never had a natural gas cooking appliance, then the sample home was excluded from the cooking analysis.

A total of six sample homes were determined not ever to have had a stub installed, three based on the telephone surveys (fourth- or ninth-year), and three based on the on-sites conducted for the current retention study. One telephone survey respondent would not pay the $200 to have the builder install the stub and two other respondents wanted to install a gas clothes dryer but there was no stub. One of the homes at which an on-site was conducted did not have natural gas service and, at the other two, the auditor found no evidence that a stub had ever been installed or removed.

4.2 NON-RETENTION OVER TIME

The fourth- and ninth-year survey data provide a limited opportunity to examine at a descriptive level the path that the age at which a unit of a measure is not retained follows. The non-retention rate of units of a measure over time determines the measure's EUL, the age at which half the units installed under the program are no longer in place and operable. By measure, Table 4-2 presents the retention status at the end of two periods: the first four years after installation and the next five years. Note this table includes only sample homes for which a survey was completed at the time of both the fourth-year retention study and the current retention study.

Table 4-2
Retention Status Over Time

Measure	ex ante EUL (years)	# Homes Surveyed Both 4th- and 9th-years	Installation thru 4th-yr		4th-yr thru 9th-yr	
			% Homes w/Measure Not Retained	# Homes w/Measure Retained	% Homes w/Measure Not Retained	# Homes w/Measure Retained
CAC	18	253	0.4%	252	4.4%	241
Cooking	20	248	0.4%	247	4.0%	237
Ducts	25	253	2.0%	248	6.9%	231
Stub	18	249	0.0%	249	0.0%	249

For CAC, cooking, and ducts, the pattern of non-retention is similar: the proportion of sample homes with a unit of the measure not retained appears to be larger over the last five years than it was during the preceding four years following installation. For CAC and ducts, in particular, it seems reasonable to expect the non-retention rate to increase over time. That is, as these measures age, they are more likely to fail. Furthermore, failure is likely to be the primary reason a CAC unit in a home is not retained or ducts in a home are not retained.

Considering the 161 sample homes with survey data only from the fourth-year retention study:

- All CAC units were retained.
- Two of the 161 sample homes did not retain their cooking measure.
- Three of the 161 sample homes did not retain their ducts.
- All stubs were retained.

After combining these results with the 253 sample homes for which updated survey data were obtained, it is still the case that the most non-retention has been observed for ducts. This result is somewhat surprising. It is also still the case that in the data collected all stubs were retained.

4.3 NON-RETENTION DEFINED

4.3.1 High-efficiency Central Air Conditioning

We considered three reasons a high-efficiency central air conditioning unit may be not retained: removed, replaced, or not working. With one exception, all of the CAC units not retained had been replaced because they had failed or were in the process of failing. The one exception was a CAC unit that was replaced because the occupant wanted to upgrade to a higher quality, higher efficiency model.

4.3.2 High-efficiency Duct Work

If a respondent to a telephone survey gave any indication that their ducts may have changed, we considered that non-retention. In part, this approach was based on the fact that it is very difficult to determine over the telephone the extent to which an event affected the savings associated with the ducts. Also, based on the on-sites, we discovered occupants were often not aware of changes that affected the savings associated with the ducts. So, on the one hand, there are probably some changes telephone survey respondents identified that we assessed as duct non-retention that in fact did not affect the savings associated with the ducts. On the other hand, however, we are fairly confident telephone survey respondents were not aware of all the changes to their ducts. Consequently, we think our approach probably produced a reasonable estimate of duct non-retention overall.

At 16 of the 74 homes (22 percent) where we conducted an on-site survey, we determined there were changes that affected the savings associated with the ducts. (See Appendix D for examples of ducts assessed as not retained and ducts assessed as retained.) The changes were of the following nature:

- Leaks and tears
- Ducts moved or replaced
- Blockages and collapses
- Disconnected ducts

- Rodent damage.

Although we observed duct non-retention at quite a few homes, usually we thought that only some of the savings associated with the ducts had been lost.

For example, in the stratum covering program year 1996 and CEC climate zone 12, six homes each had partial duct non-retention of 10 percent.[2] Instead of designing the analysis so that each of these homes would have one-tenth of their ducts not retained and nine-tenths retained, we selected one home in the stratum to represent the ducts not retained by all six homes. We only allowed a home to represent the partial duct non-retention of homes in the same strata and homes for which the age at which the ducts were not retained was similar. This approach both retained the data relevant for the analysis and a sample of independent observations.

If instead we had given each sample home 10 units of ducts and identified each unit as either retained or not retained, the sample would no longer consist of 414 independent observations but 4,140 observations, not all of which would be independent of each other. We would expect duct units at the same home to be more similar than duct units at different homes. The standard errors of the EUL estimates provided directly would assume the 4,140 observations were independent of each other. Consequently, it would be necessary to adjust the standard errors of the EUL estimates provided directly. While in theory this poses no particular problem, in practice it does, because the data on which the adjustment are based, the ages at which ducts are not retained, are not very good. Hence, we did not use this approach, but allowed a home to represent its own partial duct non-retention as well as the partial duct non-retention of other homes.

4.3.3 Natural Gas Cooking

Natural gas cooking is a fuel-switching measure. The savings associated with cooking by the first-year impact evaluations depend on the proportion of participating homes that cook with natural gas. We considered natural gas cooking to be not retained if, the last time a sample home completed a survey, the cook top was not natural gas. Participating homes may have installed either a range (cook top and oven in the same appliance) or a cook top.

Ideally, if a participating home had installed a range, we would have considered cooking to be not retained (or at least partially not retained) if the cook top and oven were not both natural gas. However, our on-site survey experience suggests that the description of the cooking measure in the program-tracking database is sometimes incorrect. Specifically, for some participating homes, the program-tracking database indicates that a natural gas range was installed, when it appears that in fact only a natural gas cook top was installed. Of the 74 homes where we conducted an onsite survey, 37 had installed a range according to the program-tracking database.

[2] Making the simplifying assumption that the savings associated with ducts can be distributed equally across all the ducts in a home, replacement of 10 percent of total duct length would be 10 percent non-retention. This is a relatively simple assessment of partial non-retention. In the case of leaking, blocked, or disconnected ducts, the auditors made a best guess of the percentage of savings lost.

We determined for at least four of these sample homes (11 percent) that in fact only a natural gas cook top was installed.[3]

4.3.4 Natural Gas Dryer Stub

All natural gas dryer stubs were assessed as retained in the data collected. Perhaps more importantly, based on the survey data collected for this study, 52 percent of homes that installed a stub under the program have a natural gas dryer. The savings associated with stubs by the first-year impact evaluations are based on 55 percent of participating homes having a natural gas dryer.

4.4 SURVIVAL ANALYSIS RESULTS

For CAC, cooking, and ducts (the measures with some observed non-retention in the data collected), Table 4-3 presents the results of the survival analysis. Results are presented for each distribution for which it was possible to fit a general linear regression model. The more parameters a distribution has, the more non-retained units there must be in order to fit the general linear regression model. Therefore, it is easiest to fit a model assuming the age at which a unit of a measure is not retained follows an exponential distribution, with only one free parameter; and it is hardest to fit a model assuming a gamma distribution, with its three free parameters. The remaining distributions each have two free parameters. None of the measures had enough non-retained units to fit a model assuming a gamma distribution.

Table 4-3
Survival Analysis Results

Measure	ex ante EUL (years)	Distribution	Maximum of Log-Likelihood	Selected Parameter Estimate Scale	Estimated EUL (years)	80% Confidence Interval (EUL, in years)		Standard Error (years)
						Lower Bound	Upper Bound	
CAC (n=414)	18	Exponential	-1271.7	1.00 [a]	163	148	180	12.3
		Log-logistic	-1190.1	0.37	28	25	31	2.2
		Log-normal	-1211.2	1.07	57	49	66	6.9
Cooking (n=404)	20	Exponential	-891.7	1.00 [a]	170	154	188	13.2
		Log-logistic	-829.5	0.40	31	28	35	3.0
		Log-normal	-821.4	0.96	47	40	54	5.7
		Weibull	-830.2	0.41	28	25	31	2.5
Ducts (n=414)	25	Exponential	-2167.1	1.00 [a]	73	68	78	3.7
		Log-logistic	-2167.6	0.89	76	65	89	9.4
		Log-normal	-2200.7	2.35	251	200	315	44.2

[a] The value of the scale parameter for the exponential distribution is always 1, it is not estimated.

[3] When analyzing the onsite survey data, we came across five sample homes that had installed a range according to the program-tracking database, but their cook top and oven currently use different fuels. The cook top uses natural gas, but the oven does not. For four of these five sample homes, the cook top and oven also used different fuels at the time the current occupant moved-in. At the time these homes were built, it was rare for a cook top and oven in the same appliance to use different fuels. It is still not all that common. When we investigated these five sample homes further, for four of the homes, we were able to determine that the cook top and oven were in fact separate appliances.

For each measure—CAC, cooking, and ducts—it was possible to estimate the measure's EUL under three or four distributional assumptions about the age at which a unit of the measure is not retained. For all of the distributional assumptions, each measure's ex ante EUL is outside the 80 percent confidence interval for the measure's EUL and smaller than the estimated EUL. Therefore, for each measure, the choice of a distributional assumption does not affect whether or not the measure's ex ante EUL may be replaced by the estimated EUL. However, the different distributional assumptions do produce different EUL estimates.

For a given measure, which distributional assumption is most appropriate, was based on several criteria:

- analysis of residuals;
- likelihood ratio test;
- implications for the non-retention rate over time; and
- maximum of the log-likelihood function.

For all three measures—CAC, cooking, and ducts—the residual analysis did not suggest any distribution was more appropriate than another.

In addition, for cooking, based on a likelihood ratio test, the Weibull distribution is more appropriate than the exponential distribution at better than the 1 percent significance level. All the likelihood ratio tests involve either the Weibull or gamma distributions, distributions for which it was not possible to obtain results for CAC or ducts.

Next, for each measure in turn, we discuss which distributional assumption is most appropriate based on the remaining criteria: These criteria: are the implications for the non-retention rate over time and the maximum of the log-likelihood function.

4.4.1 High-efficiency Central Air Conditioning

The estimated EULs for high-efficiency central air conditioning range between 28 and 163 years, compared with an ex ante EUL of 18 years. The low and high of this range correspond to the log-logistic and exponential distributions, respectively. Although the CAC ex ante EUL is always outside the 80 percent confidence interval for the CAC EUL, we recommend the ex ante EUL continue to be used in future earnings claims.

We make this recommendation because the distribution selection criteria do not strongly point to any one distribution. First, the distributions differ with respect to only two of the four criteria: the implications for the non-retention rate over time and the maximum of the log-likelihood function. Second, none of the distributions for which it was possible to obtain results for CAC allow the non-retention rate to be increasing over time.

The exponential distribution always results in a constant non-retention rate over time and the log-normal distribution always results in a non-retention rate over time that is initially increasing then decreasing. The estimated scale parameter of the log-logistic distribution is less than one, which suggests the non-retention rate over time of CAC is initially increasing and then decreasing. As discussed earlier, for CAC in homes, it seems reasonable to expect the non-retention rate to increase over time. Consequently, the estimated EULs for CAC may be too high.

Still, it is necessary to select a distribution from among the available results. Based on the maximum of the log-likelihood function, the log-logistic distribution was selected. However, we do not recommend replacing the CAC ex ante EUL of 18 years with the estimated EUL of 28 years because the estimate may be too high.

4.4.2 Natural Gas Cooking

The estimated EULs for natural gas cooking range between 28 and 170 years, compared with an ex ante EUL of 20 years. The low and high of this range correspond to the Weibull and exponential distributions, respectively. We recommend the smallest estimated EUL of 28 years be used in future earnings claims.

We make this recommendation primarily because cooking is a fuel-switching measure and we have no particular expectations regarding how the proportion of participating homes that cook with natural gas will change over time. Therefore, it makes sense to be conservative and go with the smallest estimated EUL. In addition:

1. The likelihood ratio test ruled out the exponential distribution, which produced the largest EUL estimate (170 years).
2. None of the remaining distributions—log-logistic, log-normal, and Weibull— seems more appropriate than another based on the residual analysis.
3. The log-normal distribution has the largest maximum value of the log-likelihood function. However, the estimated EUL assuming a log-normal distribution is substantially larger than the estimated EUL assuming either a Weibull or log-logistic distribution, 47 years compared with 28 or 31 years.

Based on the available data, it appears that the proportion of participating homes that do NOT cook with natural gas (i.e., non-retention) is initially increasing and then decreasing or always increasing. The estimated scale parameter for both the log-logistic and Weibull distributions is less than one. For the log-logistic distribution, this means the non-retention rate over time increases and then decreases. For the Weibull distribution, a scale parameter less than one means the non-retention rate over time is always increasing. Furthermore, the Weibull distribution has an estimated scale parameter between 0 and 0.5, which means the non-retention rate is increasing at an increasing rate. The log-normal distribution always results in a non-retention rate over time that increases and then decreases.

4.4.3 High-efficiency Duct Work

The estimated EULs for high-efficiency duct work range between 73 and 251 years, compared with an ex ante EUL of 25 years. The low and high of this range correspond to the exponential and log-normal distributions, respectively. Although the duct ex ante EUL is always outside the 80 percent confidence interval for the duct EUL, we recommend the ex ante EUL continue to be used in future earnings claims. The situation for ducts is similar to that of CAC.

We make this recommendation because the distribution selection criteria do not strongly point to any one distribution. First, the distributions differ with respect to only two of the four criteria: the implications for the non-retention rate over time and the maximum of the log-likelihood function. Second, none of the distributions for which it was possible to obtain results for ducts allow the non-retention rate to be increasing over time.

The exponential distribution always results in a constant non-retention rate over time, and the log-normal distribution always results in a non-retention rate over time that is initially increasing then decreasing. The estimated scale parameter of the log-logistic distribution is less than one, which suggests the non-retention rate over time of ducts is initially increasing then decreasing. As discussed earlier, for ducts in homes, it seems reasonable to expect the non-retention rate to increase over time. Consequently, the estimated EULs for ducts may be too high.

Still, it is necessary to select a distribution from among the available results. Based on the maximum of the log-likelihood function, the exponential distribution was selected. However, we do not recommend replacing the duct ex ante EUL of 25 years with the estimated EUL of 73 years because the estimate may be too high.

It is interesting that ducts, the measure with the most non-retention, has the highest estimated EULs. This is most likely because the ages at which ducts were not retained are less exact than the ages at which CAC units and cooking were not retained. So, the duct EUL may be higher than its ex ante EUL of 25 years, but the available data are not rich enough to provide a reasonable replacement.

4.5 SUMMARY

For CAC, cooking, and ducts, Table 4-4 summarizes the results for the selected distribution. This table also includes each measure's adopted ex post EUL and its EUL realization rate, which is its adopted ex post EUL divided by its ex ante EUL.

Table 4-4
Summary of Results

Measure	ex ante EUL (years)	Results Selected						Adopted ex post EUL (years)	EUL Realizatn Rate
		Distributn	Non-ret Rate Over T	Estimated EUL (years)	80% Conf Interval (EUL in years) Lower Bound	80% Conf Interval (EUL in years) Upper Bound	P-value		
CAC	18	Log-logistic	Increases, then decreases	28	25	31	<0.01	18	1.00
Cooking	20	Weibull	Increases	28	25	31	<0.01	28	1.39
Ducts	25	Exponential	Constant	73	68	78	<0.01	25	1.00

A few points should be emphasized regarding these results:

- For each measure, for all of the distributions for which it was possible to obtain results, the measure's ex ante EUL is outside the 80 percent confidence interval for the measure's EUL and smaller than the estimated EUL. Therefore, the choice of a distributional assumption does not affect whether or not the measure's ex ante EUL may be replaced by the estimated EUL.
- There is not sufficient basis for replacing the CAC ex ante EUL (18 years) or the ducts ex ante EUL (25 years) with their estimated EULs of 28 years and 73 years, respectively. Namely, for these two measures, it seems reasonable to expect the non-retention rate to increase over time. Unfortunately, none of the distributions for which it was possible to obtain results for these two measures allow the non-retention rate to be increasing over time. Therefore, the estimated EULs for CAC and ducts may be too high.
- Cooking is a fuel-switching measure and we have no particular expectations regarding how the proportion of participating homes that cook with natural gas will change over time. Therefore, we recommend replacing the cooking ex ante EUL of 20 years with the smallest estimated EUL of 28 years.

4.5.1 Natural Gas Dryer Stubs

All natural gas dryer stubs were assessed as retained in the data collected. In addition, a stub is a fuel-switching measure. Based on the survey data collected for this study, 52 percent of homes that installed a stub under the program have a natural gas dryer. The savings associated with stubs by the first-year impact evaluations are based on 55 percent of participating homes having a natural gas dryer. Therefore, when the proportion of participating homes with natural gas dryers drops below 28 percent, half the savings accounted for by stubs installed under the program will no longer be achieved.

We recommend replacing the stub ex ante EUL of 18 years with the selected cooking estimated EUL of 28 years. Both stubs and cooking are fuel-switching measures. The savings associated with each of them by the first-year impact evaluations depends on the saturation of a natural gas appliance in the participant population. For cooking, it was possible to use survival analysis

techniques to estimate its EUL because all homes that installed cooking under the program installed a natural gas cooking appliance. Therefore, when half the homes that installed cooking under the program no longer have a natural gas cooking appliance, half the savings accounted for by cooking installed under the program will no longer be achieved.

For stubs, on the other hand, only a subset of the homes that installed a stub under the program also installed a natural gas dryer (55 percent). Suppose there were a total of 100 participating homes and participating homes 1 through 55 also installed a natural gas dryer. It would be possible to use survival analysis techniques to estimate when half of the participating homes 1 through 55 no longer had a natural gas dryer. However, the savings accounted for by stubs installed under the program do not depend on whether or not participating homes 1 through 55 continue to have a natural gas dryer, but on the proportion of natural gas dryers in the participant population as a whole. Participating homes 1 through 25 may no longer have a natural gas dryer, but participating homes 75 through 100 may now have a natural gas dryer. In which case, the savings accounted for by stubs installed under the program continue to be achieved. Fortunately, the cooking measure gives us an opportunity to estimate an EUL that depends on the proportion of participating homes with a natural gas appliance.

A

ADVANCE LETTER

January 13, 2006

«al_name_valu»
«al_mladdr_valu» «al_mladdr2_valu»
«al_mlcity_valu», «al_mlstate_valu» «al_mlzip_valu»

Dear «al_name_valu»:

This letter is to inform you that Pacific Gas & Electric Company (PG&E) has hired KEMA, Inc. to evaluate PG&E's Residential New Construction Program. Your home at «address_all_valu» in «CITY» participated in this program in «Program_Year». The purpose of the evaluation is to confirm the energy savings obtained by the program and to assist in statewide energy planning.

Soon, you will be contacted by telephone to complete a brief survey about the measures installed in your home through the program. The survey will focus on four measures:

- central air conditioning unit,
- cook top and oven,
- ducts, and
- natural gas dryer stub.

Also, a KEMA auditor may contact you to schedule a visit. The auditor would like to examine the four measures listed above in-person. (The auditor will have a badge that identifies PG&E and KEMA.)

If you have any questions about the telephone survey or KEMA's visit, please call PG&E's Smarter Energy Line 1-800-933-9555. Thank you in advance for your help with this study.

Sincerely,

Beatrice Mayo BM

Beatrice Mayo
Project Manager
Customer Energy Efficiency
Pacific Gas & Electric Company

492 Ninth Street, Suite 220 ■ Oakland, CA 94607-4048 U.S.A. ■ Tel: +1 510-891-0446 ■ Fax: + 1 510-891-0440
www.kema-xenergy.com

B ON-SITE DATA COLLECTION MATERIALS

This appendix contains the following on-site data collection materials used in this study:

- Scheduling form
- Letter auditors dropped off at homes where they were having trouble reaching the occupant to schedule an on-site survey
- On-site data collection protocols
- EPA (U.S. Environmental Protection Agency) Duct Sealing brochure referred to in the protocols
- On-site data collection instrument (main form)
- On-site data collection instrument supplement (used when the program tracking indicates two central air conditioning units were installed)

Ninth-year Retention Study of PG&E's 1996 and 1997 Residential New Construction Program

Schedule On-site

1 Unique IDs

kemaid	«kemaid»
cntl	«cntl»
prem_id	«PREM_ID»
acct_id	«ACCT_ID»
sa_id	«SA_ID»

2 Updated or old contact information?

Updated contact information.

3 Contact information

City, Call order	«CITY», «ctyorderfnl»
Status 06Jan21 a.m.	«status_kate»
Sample 2 vs. 1	«newcontactinfo_valu»
Phone number	«thephone_valu»
Name	«thename_valu»
Street address	«address_all_valu»
Zip	«ZIP»

4 Survey

S1. Hello, my I speak with «thename_valu»? [IF CONTACT IS UNAVAILABLE, SPEAK WITH ANY ADULT. "Perhaps you can help me."]

Contact available.....1
Another adult available.....2
No adult available ..... [**RECORD BELOW BEST DAY/TIME TO CALL BACK**] 3

_____

Refused .....["Thank you. Good-bye."] -98

kemaid=«kemaid»

[S1=Contact available (1) or Another adult available (2)]

S2. My name is _____ and I'm calling on behalf of your utility Pacific Gas & Electric Company. Let me assure you this is not a sales or marketing call. Rather, your utility PG&E is in the process of evaluating its Residential New Construction Program. Your home at «address_all_valu» in «CITY» participated in this program in «Program_Year». Do I have it correct that you currently live at this address?

Yes 1
No.....["Thank you for your time. Good-bye."] 2
Don't know .....["Thank you for your time. Good-bye."] -98
Refused .....["Thank you for your time. Good-bye."] –99

[S2=Yes (1)]

S3. The purpose of the evaluation is to confirm the energy savings obtained by the program and to assist in statewide energy planning. As part of this effort, I would like to schedule a time to visit your home to examine four measures installed through the program. The four measures I will examine are:

- the central air conditioning unit,
- the cook top and oven,
- the ducts, and
- the natural gas dryer stub.

The data I collect will be kept entirely confidential. PG&E is offering $50 as a token of its appreciation to customers whose homes I visit. May I schedule a visit?

Yes 1
No.....["Thank you for your time. Good-bye."] 2
Don't know .....["Thank you for your time. Good-bye."] -98
Refused .....["Thank you for your time. Good-bye."] –99

[S3=Yes (1)]

S4. [SCHEDULE VISIT] Great!

(a) [RECORD RESPONDENT NAME]: _____

(b) Visit date: _____

(c) Visit time: _____

(d) Whom should I ask for when I arrive? _____

kemaid=«kemaid»

S5. Do I have your address exactly correct?

(a) «address_all_valu»

[RECORD "Y" [yes] or correct street address]: _____

_____

(b) «CITY»

[RECORD "Y" [yes] or correct city]: _____

(c) «ZIP»

[RECORD "Y" [yes] or correct zip]: _____

S6. After I've visited your home, to whom should we make the $50 incentive check payable to and where should we send it?

(a) Name: _____

(b) Street Address: _____

(c) City: _____

(d) State: _____

(e) Zip: _____

Thank you in advance for your help with this study. Again, my name is _____. I work for KEMA. PG&E hired us to conduct the study. When I visit your home I will have a badge that identifies PG&E and KEMA. I look forward to seeing you on the [VISIT DATE AND TIME]. If you need to contact me before then, you can reach me at [JOE: *1-800 number and extension*, KATE: *cell phone number*]. Good-bye.

Date:

«thename_valu»
or Current Pacific Gas & Electric Company (PG&E) Customer
«address_all_valu»
«CITY», CA «ZIP»

Dear «thename_valu» or Current PG&E Customer:

Your home participated in Pacific Gas & Electric Company's Residential New Construction Program in «Program_Year». PG&E has hired KEMA, Inc. to evaluate this program. The purpose of the evaluation is to confirm the energy savings obtained by the program and to assist in statewide energy planning.

As part of the study, I would like to schedule a time to visit your home to examine four measures installed through the program. The four measures I will examine are:

- central air conditioning unit,
- cook top and oven,
- ducts, and
- natural gas dryer stub.

The data I collect will be kept entirely confidential. PG&E is offering $50 as a token of its appreciation to customers whose homes I visit.

My recent efforts to contact you to schedule a visit have been unsuccessful. If you are interested in scheduling a visit, you can reach me on my cell phone at *xxx-xxx-xxx*. I hope we are able to schedule a visit before I leave your area.

Sincerely,

Katherine Dresher
Energy Specialist

492 Ninth Street, Suite 220 ■ Oakland, CA 94607-4048 U.S.A. ■ Tel: +1 510-891-0446 ■ Fax: + 1 510-891-0440
www.kema-xenergy.com

Ninth-year Retention Study of PG&E's 1996 and 1997 Residential New Construction Program

On-site Data Collection Protocols

This brief document accompanies the on-site data collection instrument. Please review it along with the instrument prior to beginning the on-site visits.

1 Objective of the On-site Visit

The objective of the on-site visit is to determine:

- Whether or not the central air conditioner is the same unit that was installed when the house was built.
- Whether or not the central air conditioner works.
- Whether or not the customer cooks with natural gas.
- Whether or not the condition of the ducts has changed since they were installed.
- Whether or not there is a natural gas dryer stub.

If a measure listed above has **changed since the house was built**, the next step is to determine about when the event occurred. Measure issues that existed at the time the house was built were addressed in the impact evaluation.

2 Attire and Supplies

Dress neatly (no jeans or shorts). Wear long sleeves (and pants) to protect skin from scrapes and cuts. If possible, wear clothing that has "KEMA" on it.

Bring the following supplies with you to the on-site visit:

- Clipboard
- Pen
- KEMA/PG&E ID badge
- Flashlight
- Ladder
- Leather work gloves
- Hard hat
- Protective dust mask
- Wasp spray
- Screwdriver (all purpose--with both a Phillips and a flat head, a couple of sizes of each)
- Camera

3 Safety First

Be careful!

- Use proper lifting techniques. In general, be careful moving items (e.g., pulling items away from the wall).
- Outside central air conditioning unit: There is the potential for poisonous animals (e.g., snakes) and insects (e.g., spiders, bees, hornets). Use caution.
- Use proper ladder safety.
- When moving around ducts, wear leather work gloves (long sleeves and pants) to avoid sheet metal cuts.
- When working in cramped spaces, wear a hard hat to avoid head knockers.
- When working in attics, step only on planking to avoid falling through ceilings. (You break it you buy it.)
- When working in attics or crawlspaces, anticipate encounters with rodents, wasps, spiders, skunks etc.
- When working around fiberglass insulation (e.g., in attics and crawlspaces), wear a protective dust mask.
- DO NOT ENTER SPACES WITH EXPOSED ASBSETOS INSULATION. Without specific training and certification, proper personal protective equipment, decontamination procedures and equipment, and hazardous waste disposal training and certification, no asbestos exposure or work of any kind is allowed.

4 Upon Arrival

- Be sure your KEMA/PG&E ID badge is visible.
- Introduce yourself and remind the customer about your appointment. Provide them another copy of the advance letter.

5 Conduct the On-site Visit

The on-site data collection form was designed to be largely self-contained. Here, we include only a brief description of a split versus packaged unit. We also provide some additional notes for the duct inspection.

5.1 Split Versus Packaged Unit

In a split unit, the condenser and compressor are together outdoors, and the evaporator is indoors. In a packaged unit, the condenser, compressor, and evaporator are all together outdoors. In typical residential applications, split units are most common.

5.2 Duct Inspection Notes

- Likely **locations** of ducts you will be able to view: attics, basements, garages, and maybe crawlspaces.

  Ducts are also often in walls and ceilings, but it is unlikely you will be able to view these ducts.

- We are only trying **to identify changes to the ducts since they were installed**. The actual specifications of the ducts at the time they were installed vs. the Residential New Construction Program's specifications, has already been addressed by the impact evaluation.
- Consequently, we are looking for:

(1) Indications that ducts have been removed

(2) Disconnected ducts. (It seems reasonable to assume all ducts were originally connected.)

(3) Damaged ducts. (It seems reasonable to assume all ducts were originally undamaged.)

(4) Flexible ducts that have become tangled, kinked, or crushed AFTER they were installed

(5) Clear deterioration of seals

- **Examine seals at**
  - Duct connections (A in EPA Duct Sealing brochure)
  - Joints between ducts
  - Returns (B in EPA Duct Sealing brochure)
  - Furnace and filter slot (D in EPA Duct Sealing brochure, SEE detail blow-up in middle panel)
  - Supply (F in EPA Duct Sealing brochure)
- FYI: All leaks and connections should be sealed with mastic, metal tape, or an aerosol-based sealant. (ENERGY STAR lists mastic, metal-backed tape, "AEROSEAL.") "Duct tape should never be used because it will not last" (EPA Duct Sealing Brochure). Duct tape has vinyl backing with fiber reinforcement and a rubber-based adhesive.

  Recall, however, improper sealing at the time the home was built has already been addressed by the impact evaluation. We are only trying to identify changes to the ducts since they were installed.

(6) Clear deterioration of insulation

- **Condition of insulation on ducts in unconditioned spaces**
  - It appears in all climates, ducts in the attic should be insulated
  - In warm climates (e.g., coastal CA), it appears insulation on ducts in the basement or crawlspaces is unnecessary. In contrast, in mixed climates (e.g., inland CA) and cold climates (e.g., northern Midwest), ducts in the basement or crawlspaces should be insulated.

- FYI, per ENERGY STAR (January 2006): Ducts in conditioned spaces do not need to be insulated. Ducts in unconditioned spaces should be insulated equal or greater than R-4.
  - Flexible ducts come with insulation
  - Again, insulation not there originally and should have been, has already been addressed by the impact evaluation.

(7) Any duct, seal, insulation repairs

- For background information you may want to peruse: the CEE's Duct Installation and Sealing Standards, which is a supplementary document to its Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems.

Sources:
EPA Duct Sealing brochure
ENERGY STAR Duct Specifications
EPA Duct Sealing customer fact sheet
EPA Duct Insulation customer fact sheet

HIGH UTILITY BILLS?
STUFFY ROOMS? DUSTY HOUSE?
IT COULD BE YOUR DUCTS.

A duct system that is well-designed and properly sealed can make your home more comfortable, more energy efficient, and safer. Here are some reasons why duct improvements are a wise investment:

Comfort

Sealing and insulating ducts can help with common comfort problems, such as rooms that are too hot in the summer or too cold in the winter.

Health

Sealing ducts can help improve indoor air quality by reducing the risks of pollutants entering ducts and circulating through your home. Fumes from household and garden chemicals, insulation particles, and dust can enter your duct system through leaks and can aggravate existing asthma and allergy problems.

Safety

During normal operation, gas appliances such as water heaters, clothes dryers, and furnaces release combustion gases, like carbon monoxide, through their ventilation systems. Leaking ductwork in your heating and cooling system may cause "backdrafting," where these gases are drawn into the living space, rather than expelled to the outdoors. Sealing leaks can minimize this risk.

Save Money

Leaky ducts can reduce heating and cooling system efficiency by as much as 20 percent. Duct sealing and insulating increases efficiency, lowers your energy bills, and can often pay for itself in energy savings. Plus, if you're planning to install new heating and cooling equipment, know that a well designed and sealed duct system may allow you to downsize to a smaller, less costly heating and cooling system.

Protect the Environment

Energy generation is one of the largest contributors to greenhouse gases. By sealing your ducts and reducing the amount of energy necessary to comfortably heat or cool your home, you can reduce the amount of air pollution generated.

EPA

United States
Environmental
Protection Agency
6202J
Washington DC 20460

Official Business
Penalty for Private Use $300

Recycled/Recyclable—Printed with vegetable oil based inks on recycled paper (Minimum 50% post-consumer content)

CHANGE FOR THE BETTER WITH ENERGY STAR

U.S. Environmental Protection Agency

Duct Sealing

EPA 430-F-04-048 October 2004

WHAT IS
ENERGY STAR®?

ENERGY STAR is the government-backed symbol for energy efficiency. It identifies homes and more than 40 types of products and services that meet strict guidelines set by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). With ENERGY STAR, consumers can save energy and money without sacrificing performance.

EPA also provides important recommendations on products and installations to get the most in comfort and energy savings. Saving energy will also help protect the environment by reducing air pollution and global warming associated with energy production.

HELP PROTECT
THE ENVIRONMENT

Did you know that the average home produces twice the greenhouse gases as the average car? In fact, 15 percent of all greenhouse gases are generated from the energy used in houses nationwide.

Energy used in our homes often comes from the burning of fossil fuels at power plants, which contributes to smog, acid rain, and global warming. Simply put, the less energy we use in our homes, the less air pollution we generate.

For more information visit www.energystar.gov and click on home improvement or call 1-888-STAR-YES (1-888-782-7937).

CHANGE FOR THE BETTER WITH ENERGY STAR

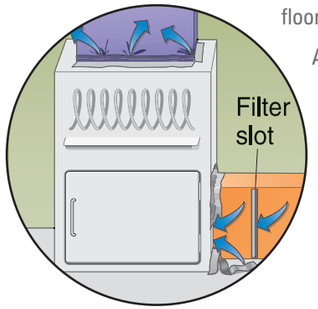
HOW DUCTS WORK

Ducts are an integral part of a forced-air system, such as a furnace, heat pump, or central air conditioner. The job of ducts is to circulate heated or cooled air evenly to every room in a house. Ducts are commonly concealed in walls, ceilings, attics, basements, or crawl spaces. This can make them difficult to access and repair.

Poorly performing ducts often leak the air that you paid to heat and cool. Poorly performing ducts can cause your heating and cooling system to work harder to keep your home at a comfortable temperature.

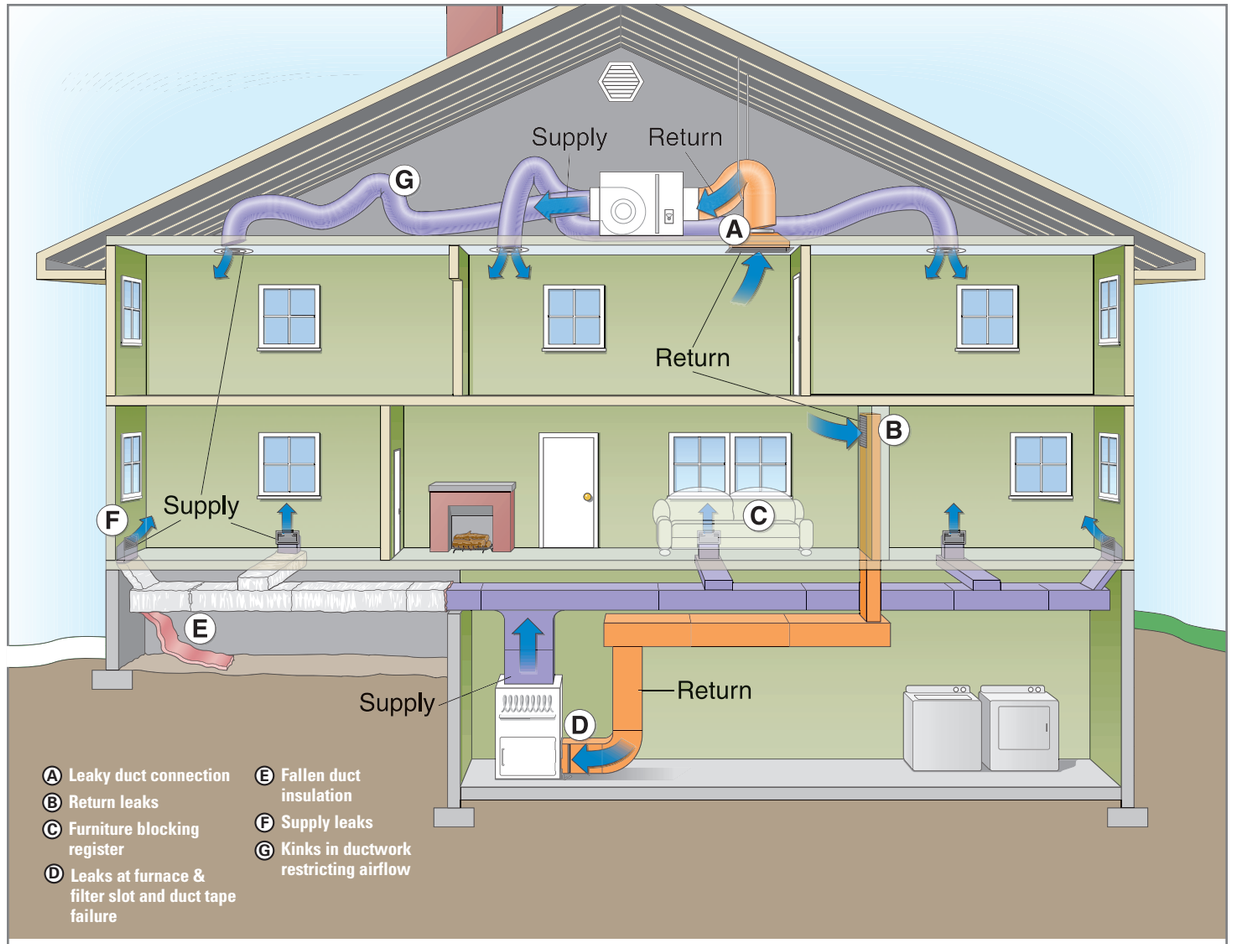
These conditions can be a sign of poorly performing ducts.

- High summer and winter utility bills.
- Your system's filters get dirty quickly.
- Dirt streaks showing at the corners and connections of ducts.
- Rooms are stuffy and never seem to feel comfortable.
- Your ducts are located in the attic or crawl space and they are not insulated or have damaged insulation.
- Flexible ducts are tangled or kinked.
- The spaces between the floor joists and wall studs have been enclosed and are being used to move air. When these cavities are used as ductwork, they are usually very leaky. You can detect this in the basement if sheet metal is nailed to the ceiling between the floor joists.



LEAKS AT FURNACE & FILTER SLOT AND DUCT TAPE FAILURE

A well-designed, sealed, and insulated duct system will improve your system's ability to consistently cool and heat every room in your home.



REPAIRING AND MAINTAINING YOUR DUCTS

If you suspect you have poorly performing ducts, EPA recommends using a professional contractor for duct improvements. Usually, contractors who install heating and cooling systems also repair ductwork. Typically, when making improvements to your duct system, a contractor will:

- Inspect the whole duct system, including attic and crawl spaces. The contractor will measure air flow and duct leakage with diagnostic equipment and remove registers and grills to ensure that ducts are properly connected.
- Evaluate how well the system's supply air and return air is balanced for better air flow. Many systems have air return ducts that are too small. Re-evaluate airflow after repairs are completed.
- Seal all leaks and connections with mastic, metal tape, or an aerosol-based sealant. Duct tape should never be used because it will not last.
- Seal all registers and grills tightly to the ducts.
- Insulate ducts in unconditioned areas, like attics and crawl spaces, with duct insulation that carries an R value of 6 or higher.
- Repair damaged and disconnected ducts and straighten out flexible ducts that are tangled or crushed.
- Include a new filter as part of any duct system improvements.
- To make sure there is no backdrafting of gas or oil-burning appliances, conduct a combustion safety test after ducts are sealed.

kemaid=«kemaid»

Ninth-year Retention Study of PG&E's 1996 and 1997 Residential New Construction Program

On-site Data Collection Instrument

1 Unique IDs

kemaid: «kemaid»	acct_id: «ACCT_ID»
cntl: «cntl»	sa_id: «SA_ID»
prem_id:«PREM_ID»	

2 Customer information

Phone number	«thephone_valu»
Name	«thename_valu»
Street address	SEE On-site Scheduling Instrument (S5a)
City	SEE On-site Scheduling Instrument (S5b)
Zip	SEE On-site Scheduling Instrument (S5c)
Built	Measures installed through program sometime during the period 1993 thru 1996
On-site contact	SEE On-site Scheduling Instrument (S4d)

3 Collect Data

General instructions

- Circle numbers (as opposed to text)
- Print legibly

4.1 Visit Information (on-site surveyor answer)

V1. On-site surveyor: _____

V2. Date and time of on-site

V2a. [RECORD DATE] (mm/dd/2006)	__ __/__ __/2006
V2b. [RECORD TIME]	a.m. / p.m. [CIRCLE ONE]

kemaid=«kemaid»

4.2 Move-in Date

M1. [ASK] According to our records you moved to this address in «pge_dtonprem_mchar» «pge_dtonprem_yr_valu». Is this correct?

1 Yes	2 No	-98 Don't know	-99 Refused

[IF SKIP M1 or M1=No (2)]
M2. When did you move to this address? [-98 Don't know, -99 Refused]

M2a. [RECORD MONTH 1-12]	__ __
M2b. [RECORD YEAR yyyy]	__ __ __ __

4.3 Central Air Conditioner

Description from program-tracking data: «_1»

4.3.1 Only 1 Central Air Conditioner (according to program-tracking data)

A1. At the time you moved into your home, was there a central air conditioning unit in place?

1 Yes	[PROCEED TO NEXT CAC QUESTION]
2 No -98 Don't know -99 Refused	[SKIP TO 4.4 DUCTS]

[A1=Yes (1), ALL OTHER RESPONSES SKIP TO 4.4 DUCTS]
A2. At the time you moved into your home, was the central air conditioner the original unit or had it been replaced? [**PERHAPS THE CUSTOMER RECEIVED PAPERWORK ON THE UNIT WHEN THEY PURCHASED THEIR HOME.**]

1 Original	2 Replacement	-98 Don't know	-99 Refused

[IF A2=Replacement (2)]
A3. About when was it replaced?

A3a. [CIRCLE ONE]	1 Range / 2 Before / 3 After / 4 Exact
A3b. Start date (mm/yyyy)	__ __/__ __ __ __
A3c. Range only: end date	__ __/__ __ __ __

[IF "Don't know" or "Refused," CIRCLE "2" AND ENTER MOVE DATE.]

A4. At the time you moved into your home, did the central air conditioning work?

1 Yes	2 No	-98 Don't know	-99 Refused

kemaid=«kemaid»

A5. Since living here, have you replaced the central air conditioning unit?

1 Yes	2 No	-98 Don't know	-99 Refused

[IF A5=Yes (1)]
A6. About when did you replace it?

A6a. [CIRCLE ONE]	1 Range / 2 Before / 3 After / 4 Exact
A6b. Start date (mm/yyyy)	__ __/__ __ __ __
A6c. Range only: end date	__ __/__ __ __ __

[IF "Don't know" or "Refused," CIRCLE "1" AND ENTER START DATE=MOVE DATE, END DATE=ON-SITE DATE.]

[IF A5=Yes (1)]
A7. Why did you replace it?

A8. Currently, does the central air conditioner work?

1 Yes	2 No	-98 Don't know	-99 Refused

[IF A8=No (2)]
A9. About when did it stop working?

A9a. [CIRCLE ONE]	1 Range / 2 Before / 3 After / 4 Exact -98 Don't know / -99 Refused
A9b. Start date (mm/yyyy)	__ __/__ __ __ __
A9c. Range only: end date	__ __/__ __ __ __

4.4 Ducts

Description from program-tracking data (seems almost to repeat cac measure): «_4»

D1. Are you aware of any remodeling or other events either before or after you moved here, that resulted in any changes to the ducts? Perhaps ducts were removed, replaced, repaired, or added.

1 Yes	2 No	-98 Don't know	-99 Refused

kemaid=«kemaid»

[IF D1=Yes (1)]
D2. Briefly describe for me the remodel or other event.

4.5 Natural Gas Measures

Description of cooking measure from program-tracking data: «_2»

G1.When you first moved into your home, which of the following appliances used natural gas?

G1a. Cook top	1 Yes / 2 No / -98 Don't know / -99 Refused
G1b. Oven	1 Yes / 2 No / -98 Don't know / -99 Refused
G1c. Clothes dryer	1 Yes / 2 No / 3 No clothes dryer / -98 Don't know / -99 Refused

G2.Currently, which of the following appliances uses natural gas? [CONFIRM BEFORE RECORDING]

G2a. Cook top	Auditor confirmed: 1 Yes / 2 No
G2b. Oven	Auditor confirmed: 1 Yes / 2 No
G2c. Clothes dryer	Auditor confirmed: 1 Yes / 2 No / 3 No clothes dryer

[FOR A GIVEN APPLIANCE, IF G1=Yes (1) AND G2=No (2)]
G3. About when did you stop using the natural gas appliance?

Data Item	G3a. Cook top	G3b. Oven	G3c. Clothes dryer
G3x_1. [SPECIFY ONE] 1 Range / 2 Before / 3 After / 4 Exact			
G3x_2. Start date (mm/yyyy)	__ __/ __ __ __ __	__ __/ __ __ __ __	__ __/ __ __ __ __
G3x_3. Range only: end date	__ __/ __ __ __ __	__ __/ __ __ __ __	__ __/ __ __ __ __

[IF "Don't know" or "Refused," ENTER "1" AND ENTER START DATE=MOVE DATE, END DATE=ON-SITE DATE.]

kemaid=«kemaid»

[FOR A GIVEN APPLIANCE, IF G1=Yes (1) AND G2=No (2)]
G4. Why did you stop using the natural gas appliance?

G4a. Cook top	
G4b. Oven	
G4c. Clothes dryer	

4.6 Follow-up (on-site surveyor answer)

4.6.1 Natural Gas Dyer Stub

FG1. [IF CLOTHES DRYER IS NOT CURRENTLY GAS, LOOK FOR NATURAL GAS DRYER STUB]

1 Found dryer stub	2 Dryer stub not found

[IF FG1=Dryer stub not found (2)]
FG2. [CHECK WITH THE CUSTOMER. DID THEY KNOW THE DRYER STUB WAS REMOVED? IF SO, DO THEY KNOW WHY? DO THEY HAVE SOME REASON TO THINK THE DRYER STUB WAS NEVER THERE? IF SO, HAVE THEM EXPLAIN.]

1 Removed	FG2a. Why?
2 Never there	FG2b. Basis?
3 No -99 Refused	[PROCEED WITH EXAMINATION OF CENTRAL AIR CONDITIONTER]

[IF FG2=Removed (1)]
FG3. [DOES THE CUSTOMER HAVE ANY IDEA WHEN THE DRYER STUB WAS REMOVED?]

FG3a. [CIRCLE ONE]	1 Range / 2 Before / 3 After / 4 Exact -98 Don't know / -99 Refused
FG3b. Start date (mm/yyyy)	__ __/__ __ __ __
FG3c. Range only: end date	__ __/__ __ __ __

kemaid=«kemaid»

4.6.2 Central Air Conditioner

- Although we are prepared to collect information on both the outdoor and indoor units for a split-system, the information on the outdoor unit should be sufficient
- If a nameplate is not visible on the outside of a unit or it is not legible, remove the back cover. There may be a nameplate inside.
- If not found, enter "NF"
- To distinguish zeros from the letter O, put brackets around the letter [O].

FC1. Unit A

FC1a. Location of outdoor unit (describe from position of facing front door)	
FC1b. Split-system or packaged?	1 Split / 2 Packaged / 3 Other [SPECIFY BELOW] FC1b_o. _____
FC1c. Outdoor unit manufacturer	
FC1d. Other names on outdoor unit	
FC1e. Outdoor unit model #	
FC1f. Outdoor unit serial #	
FC1g. Outdoor unit date of manufacture	[COMPLETE LATER (POST ON-SITE)]
FC1h. Indoor unit manufacturer	
FC1i. Indoor unit model #	
FC1j. Indoor unit serial #	
FC1k. Indoor unit date of manufacture	[COMPLETE LATER (POST ON-SITE)]
FC1L. ENERGY STAR label?	1 Yes / 2 Not found
FC1m. Based on customer responses	1 Original / 2 Replacement / 3 Unknown

kemaid=«kemaid»

FC1n. [IF FC1m=Unknown (3)] Auditor's best guess	FC1n_a. 1 Original / 2 Replacemnt / 3 Unknwn FC1n_b. Basis:

FC2. Unit B [SEE SEPARATE SHEET]

4.6.3 Ducts

- See duct inspection sheet
- Use FD1_9 and FD1_10 either to specify a different problem or the same problem again, but with a different date—which you may not know until you collect the date information
- For each possible problem:
  - (a) Estimate proportion-- **in 10 percentage point increments**--of ducts with that problem. **If no ducts have that problem, enter "0."**
    - **If a section of duct has multiple problems, record the proportion in FD1_9 or FD1_10 and describe the multiple problems.** That is, assign a section of duct to one and only one of the 10 options (FD1_1-FD1_10). e.g., if a section of duct is both damaged (FD1_3) and there is clear deterioration of the insulation (FD1_6), record the proportion in FD1_9 or FD1_10 and describe the multiple problems. DO NOT record the proportion in both FD1_3 and FD1_6.
    - Consider any added ducts along with the rest of the ducts (including any removed). That is, the added ducts along with the rest of the ducts are the duct system, totaling 100 percent.
    - If, e.g., the seals are covered by insulation so you can't see the seals to determine if there has been any deterioration, record "CS" (Can't See).

    If the proportion of ducts is greater than 0, continue to complete the remainder of the row:
  - (b) Briefly explain the basis for your assignment of ducts to that category
    - For "FD1_4 Tangled, kinked, crushed POST installation," be sure the explanation includes why you think it happened post installation
    - For FD1_9 and FD1_10, include in the explanation a description of the problem
  - (c) If helpful, take a photograph

FD1. Ducts for central air conditioning unit A or if two units and share ducts

Problem	FD1_xa. % Ducts	FD1_xb. Explain	FD1_xc. Photo #
FD1_1. Removed			

kemaid=«kemaid»

Problem	FD1_xa. % Ducts	FD1_xb. Explain	FD1_xc. Photo #
FD1_2. Disconnected			
FD1_3. Damaged			
FD1_4. Tangled, kinked, crushed POST		Basis for determining POST:	
FD1_5. Deterioration of seals		[WHERE TO LOOK: connections, joints, returns, furnace and filter slot, supply]	
FD1_6. Deterioration of insulation			
FD1_7. Duct, seal, insulation repairs			
FD1_8. Replaced			
FD1_9.		Problem:	
FD1_10.		Problem:	

FD1_xy. Ducts for central air conditioning unit A or if two units and share ducts CONTINUED
[CHECK WITH THE CUSTOMER. DID THEY NOTICE ANY OF THESE PROBLEMS? IF SO, ABOUT WHEN DID THEY NOTICE THEM? IN PARTICULAR, 1 REMOVED, THEY MAY HAVE SOME IDEA WHEN.]

Data Item	Problem [SPECIFY BELOW x=1-10]		
FD1_xt. [SPECIFY ONE] 1 Range / 2 Before / 3 After / 4 Exact -98 Don't know / -99 Refused			
FD1_xs. Start date (mm/yyyy)	__ __/ __ __ __ __	__ __/ __ __ __ __	__ __/ __ __ __ __
FD1_xe. Range only: end date	__ __/ __ __ __ __	__ __/ __ __ __ __	__ __/ __ __ __ __

[FINISHED. THANK.]

Ninth-year Retention Study of PG&E's 1996 and 1997 Residential New Construction Program

On-site Data Collection Instrument Supplement

- 2 Central Air Conditioning Units

4.3 Central Air Conditioner

4.3.2 Two Central Air Conditioning Units (according to the program-tracking data)

kemaid=[RECORD kemaid] _____

A1_2. At the time you moved into your home, how many central air conditioning units were in place—one, two, or none?

1 One	[RETURN TO THE MAIN INSTRUMENT AND PROCEED WITH QUESTION A2]
2 Two	[PROCEED WITH THIS SUPPLEMENTAL INSTRUMENT]
3 None -98 Don't know -99 Refused	[RETURN TO THE MAIN INSTRUMENT AND PROCEED WITH SECTION 4.4 DUCTS]

[A1_2=Two (2)]

A2. At the time you moved into your home, were these central air conditioners the original units or had one or both of them been replaced? [**PERHAPS THE CUSTOMER RECEIVED PAPERWORK ON THE UNIT WHEN THEY PURCHASED THEIR HOME.**]

Unit A	Unit B
A2. 1 Original / 2 Replacement -98 Don't know / -99 Refused	A2_2. 1 Original / 2 Replacement -98 Don't know / -99 Refused

[IF A2 or A2_2=Replacement (2)]

A3. About when [WAS IT/WERE THEY] replaced?

	[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Data Item	Unit A	Unit B
[CIRCLE ONE]	A3a. 1 Range / 2 Before 3 After / 4 Exact	A3a_2. 1 Range / 2 Before 3 After / 4 Exact
Start date (mm/yyyy)	A3b. __ __/__ __ __ __	A3b_2. __ __/__ __ __ __
Range only: end date	A3c. __ __/__ __ __ __	A3c_2. __ __/__ __ __ __

[IF "Don't know" or "Refused," CIRCLE "2" AND ENTER MOVE DATE.]

A4. At the time you moved into your home, did both of the central air conditioning units work? [IF "no," DETERMINE IF BOTH DIDN'T WORK OR IF ONLY ONE, WHICH ONE.]

[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Unit A	Unit B
A4. 1 Yes / 2 No -98 Don't know / -99 Refused	A4_2. 1 Yes / 2 No -98 Don't know / -99 Refused

A5. Since living here, have you replaced either of the central air conditioning units? [IF "yes," DETERMINE IF REPLACED BOTH OR IF ONLY ONE, WHICH ONE.]

[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Unit A	Unit B
A5. 1 Yes / 2 No -98 Don't know / -99 Refused	A5_2. 1 Yes / 2 No -98 Don't know / -99 Refused

[IF A5 or A5_2=Yes (1)]
A6. About when did you replace [IT/THEM]?

	[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Data Item	Unit A	Unit B
[CIRCLE ONE]	A6a. 1 Range / 2 Before 3 After / 4 Exact	A6a_2. 1 Range / 2 Before 3 After / 4 Exact
Start date (mm/yyyy)	A6b. __ __/__ __ __ __	A6b_2. __ __/__ __ __ __
Range only: end date	A6c. __ __/__ __ __ __	A6c_2. __ __/__ __ __ __

[IF "Don't know" or "Refused," CIRCLE 1 AND ENTER START DATE=MOVE DATE, END DATE=ON-SITE DATE.]

[IF A5 or A5_2=Yes (1)]
A7. Why did you replace [IT/THEM]?

[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Unit A	Unit B
A7.	A7_2.

A8.Currently, do both central air conditioners work? [IF "no," DETERMINE IF BOTH DON'T WORK OR IF ONLY ONE, WHICH ONE.]

[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
Unit A	Unit B
A8. 1 Yes / 2 No -98 Don't know / -99 Refused	A8_2. 1 Yes / 2 No -98 Don't know / -99 Refused

[IF A8 or A8_2=No (2)]
A9. About when did [IT/THEY] stop working?

Data Item	[CAREFUL. IF RESPONSE VARIES BY UNIT, CONSISTENTLY RECORD RESPONSES FOR THE SAME UNIT IN THE SAME COLUMN.]	
	Unit A	Unit B
[CIRCLE ONE]	A9a. 1 Range / 2 Before 3 After / 4 Exact -98 Don't know / -99 Refused	A9a_2. 1 Range / 2 Before 3 After / 4 Exact -98 Don't know / -99 Refsd
Start date (mm/yyyy)	A9b. __ __/__ __ __ __	A9b_2. __ __/__ __ __ __
Range only: end date	A9c. __ __/__ __ __ __	A9c_2. __ __/__ __ __ __

[RETURN TO THE MAIN INSTRUMENT AND PROCEED WITH SECTION 4.4 DUCTS.]

4.6 Follow-up (on-site surveyor answer)

4.6.2 Central Air Conditioner

FC2. Unit B

FC2a. Location of outdoor unit (describe from position of facing front door)	
FC2b. Split-system or packaged?	1 Split / 2 Packaged / 3 Other [SPECIFY BELOW] FC2b_o. _____
FC2c. Outdoor unit manufacturer	
FC2d. Other names on outdoor unit	
FC2e. Outdoor unit model #	

FC2f. Outdoor unit serial #	
FC2g. Outdoor unit date of manufacture	[COMPLETE LATER (POST ON-SITE)]
FC2h. Indoor unit manufacturer	
FC2i. Indoor unit model #	
FC2j. Indoor unit serial #	
FC2k. Indoor unit date of manufacture	[COMPLETE LATER (POST ON-SITE)]
FC2L. ENERGY STAR label?	1 Yes / 2 Not found
FC2m. Based on customer responses	1 Original / 2 Replacement / 3 Unknown
FC2n. [IF FC2m=Unknown (3)] Auditor's best guess	FC2n_a. 1 Original / 2 Replacemnt / 3 Unknwn FC2n_b. Basis:

C

TELEPHONE QUESTIONNAIRE

Ninth-year Retention Study of PG&E's 1996 and 1997 Residential New Construction Program

Telephone Survey

1 Sample Data

Data useful to include with with survey data	
kemaid	KEMA unique participating home ID
cntl	Last known PG&E legacy control number
prem_id	PG&E premise ID
acct_id	PG&E account ID
sa_id	PG&E service agreement ID
zip	zip (from 4th-year study sample database)
Phone number	
shphone	Phone number
Fields used in survey	
shname	Contact name
shaddrss	Street address (from 4th-year study sample database)
city	City (from 4th-year study sample database)
progyr	Program participation year (from 4th-year study sample database)
origoccp	Original occupant=1, else=0 year (based on 4th-year study survey data Q5)
myonprem	Month (e.g., JANUARY) and year current occupant first served
cacnotxt	Number of central air conditioners installed thru program: "1 central air conditioner was" or "2 central air conditioners were"

2 Survey

2.1 Survey information

srvydate	Date survey completed

2.2 Introduction

- The survey starts with question I1. Text highlighted in blue is for organizational purposes and can be ignored by the survey house.

I1. Hello, may I speak with<shname>? [IF CONTACT IS UNAVAILABLE, SPEAK WITH ANY ADULT. "Perhaps you can help me." IF RESPONDENT ASKS WHO'S CALLING: My name is _____ and I'm calling on behalf of your utility Pacific Gas & Electric Company.]

Contact available.....1
Another adult available.....2
No adult available ..... [RECORD BEST DAY/TIME TO CALL BACK] 3
Refused ..... ["Thank you. Good-bye."] 98

[IF I1=Contact available (1) or Another adult available (2)]

I2. My name is _____ and I'm calling on behalf of your utility Pacific Gas & Electric Company. Let me assure you this is not a sales or marketing call. Rather, your utility PG&E is in the process of evaluating its Residential New Construction Program. Your home at <shaddrss> in <city> participated in this program in<progyr>. Do I have it correct that you currently live at this address?

Yes 1
No..... ["Thank you for your time. Good-bye."] 2
Don't know ..... ["Thank you for your time. Good-bye."] 98
Refused ..... ["Thank you for your time. Good-bye."] 99

[IF I2=Yes (1)]

I3. The purpose of the study is to confirm the energy savings obtained by the program and to assist in statewide energy planning. As part of this effort, I would like to ask you a few questions about items installed in your home through the program. The data I collect will be kept entirely confidential. Shall I proceed?

Yes 1
No..... ["Thank you for your time. Good-bye."] 2
Don't know ..... ["Thank you for your time. Good-bye."] 98
Refused ..... ["Thank you for your time. Good-bye."] 99

[IF I3=Yes (1) AND I1=Another adult available (2)]

I4. [RECORD NEW CONTACT NAME]

2.3 Original Versus Subsequent Occupant

[IF origoccp=1]

O1. According to our records, you were the first to live in this home. Is that correct?

Yes ..... [SKIP TO A1] 1
No..... [SKIP TO O3a] 2
Don't know ..... [SKIP TO A1] 98
Refused ..... [SKIP TO A1] 99

[IF origoccp=0]
O2. According to our records, you moved to this address in<myonprem>. Is this correct?

Yes	[SKIP TO A1] 1
No	2
Don't know	[SKIP TO A1] 98
Refused	[SKIP TO A1] 99

[IF O1 OR O2=No (2)]
O3a. What month and year did you move to this address? [RECORD MONTH]

January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	10
November	11
December	12
Don't know	98
Refused	99

[IF O1 OR O2=No (2)]
O3b. [RECORD YEAR]

[RECORD YEAR 1993-2006]	
Don't know	98
Refused	99

2.4 Central Air Conditioner

There are two sets of essentially the same questions: at move in (AM) and since living there or currently (AS). Only new occupants are asked the AM set of questions, all are asked the AS set.

A1. According to our records, <cacnotxt> installed in your home through the program. At the time you moved into your home, how many central air conditioning units were there?

[RECORD NUMBER 0, 1, 2, …]	
Don't know	98
Refused	99

2.4.1 One Central Air Conditioner

[SKIPS BASED ON A1:
IF A1=2 SKIP TO AM1_1
IF A1=0, >2, 98, 99 SKIP TO D1]

[IF A1=1 AND O1=1, 98, or 99 (original occupant) SKIP TO AS1]

AM1. At the time you moved into your home, was the central air conditioner the original unit or had it been replaced?

Original 1
Replacement.....2
Don't know ..... [SKIP TO AM3] 98
Refused ..... [SKIP TO AM3] 99

[IF AM1=Original (1) or Replacement (2)]
AM1a. Why do you say that?

[IF AM1=Replacement (2)]
AM2. About when was it replaced? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AM3. At the time you moved into your home, did the central air conditioning work?

Yes 1
No.....2
Don't know 98
Refused 99

AS1. Since living here, have you replaced the central air conditioner?

Yes 1
No.....[SKIP TO AS3] 2
Don't know .....[SKIP TO AS3] 98
Refused .....[SKIP TO AS3] 99

[IF AS1=Yes (1)]
AS1a. Why did you replace it?

[IF AS1=Yes (1)]
AS1b. How energy efficiency is the new central air conditioner compared with the unit it replaced? Is the new central air conditioner less energy efficient, more energy efficient, or as energy efficient?

Less 1
More.....2
Same.....3
Don't know .....[SKIP TO AS2] 98
Refused .....[SKIP TO AS2] 99

[IF AS1b=Less (1), More (2), or Same (3)]
AS1c. Why do you say that?

[IF AS1=Yes (1)]
AS2. About when did you replaced it? Anything you can tell me would be helpful; whether it is

the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AS3. Currently, does the central air conditioner work?

Yes	[SKIP TO D1N] 1
No	2
Don't know	[SKIP TO D1N] 98
Refused	[SKIP TO D1N] 99

[IF AS3=No (2)]

AS4. About when did it stop working? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

2.4.2 Two Central Air Conditioners

Same set of questions asked for one central air conditioner are asked here twice, once for unit A and once for unit B. (Changed question numbers—including skips as needed, indicated unit A or B.)

[IF A1=1 SKIP TO D1N]

AM0_1. Please answer my next few questions for one of these central air conditioning units, which I'll refer to as unit A.

[IF A1=2 AND O1=1, 98, or 99 (original occupant) SKIP TO AS1_1]

AM1_1. At the time you moved into your home, was central air conditioning unit A the original unit or had it been replaced?

Original	1
Replacement	2
Don't know	[SKIP TO AM3_1] 98
Refused	[SKIP TO AM3_1] 99

[IF AM1_1=Original (1) or Replacement (2)]

AM1a_1. Why do you say that?

[IF AM1_1=Replacement (2)]

AM2_1. About when was it replaced? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AM3_1. At the time you moved into your home, did central air conditioning unit A work?

Yes 1
No.....2
Don't know 98
Refused 99

AS1_1. Since living here, have you replaced central air conditioning unit A?

Yes 1
No.....[SKIP TO AS3_1] 2
Don't know .....[SKIP TO AS3_1] 98
Refused .....[SKIP TO AS3_1] 99

[IF AS1_1=Yes (1)]
AS1a_1. Why did you replace it?

[IF AS1_1=Yes (1)]
AS1b_1. How energy efficiency is the new central air conditioner compared with the unit it replaced? Is the new central air conditioner less energy efficient, more energy efficient, or as energy efficient?

Less 1
More.....2
Same.....3
Don't know .....[SKIP TO AS2_1] 98
Refused .....[SKIP TO AS2_1] 99

[IF AS1b_1=Less (1), More (2), or Same (3)]
AS1c_1. Why do you say that?

[IF AS1_1=Yes (1)]
AS2_1. About when did you replaced it? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AS3_1. Currently, does central air conditioning unit A work?

Yes ..... [SKIP TO AM0_2] 1
No.....2
Don't know ..... [SKIP TO AM0_2] 98
Refused ..... [SKIP TO AM0_2] 99

[IF AS3_1=No (2)]

AS4_1. About when did it stop working? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AM0_2. I have a similar set of questions for the other central air conditioning unit, which I'll refer to as unit B.

[IF A1=2 AND O1=1, 98, or 99 (original occupant) SKIP TO AS1_2]

AM1_2. At the time you moved into your home, was central air conditioning unit B the original unit or had it been replaced?

Original 1
Replacement.....2
Don't know ..... [SKIP TO AM3_2] 98
Refused ..... [SKIP TO AM3_2] 99

[IF AM1_2=Original (1) or Replacement (2)]
AM1a_2. Why do you say that?

[IF AM1_2=Replacement (2)]

AM2_2. About when was it replaced? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AM3_2. At the time you moved into your home, did central air conditioning unit B work?

Yes 1
No.....2
Don't know 98
Refused 99

AS1_2. Since living here, have you replaced central air conditioning unit B?

Yes 1
No.....[SKIP TO AS3_2] 2
Don't know .....[SKIP TO AS3_2] 98
Refused .....[SKIP TO AS3_2] 99

[IF AS1_2=Yes (1)]
AS1a_2. Why did you replace it?

[IF AS1_2=Yes (1)]

AS1b_2. How energy efficiency is the new central air conditioner compared with the unit it replaced? Is the new central air conditioner less energy efficient, more energy efficient, or as energy efficient?

Less 1
More 2
Same 3
Don't know .....[SKIP TO AS2_2] 98
Refused .....[SKIP TO AS2_2] 99

[IF AS1b_2=Less (1), More (2), or Same (3)]

AS1c_2. Why do you say that?

[IF AS1_2=Yes (1)]

AS2_2. About when did you replaced it? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

AS3_2. Currently, does central air conditioning unit B work?

Yes ..... [SKIP TO AM0_2] 1
No.....2
Don't know ..... [SKIP TO AM0_2] 98
Refused ..... [SKIP TO AM0_2] 99

[IF AS3_2=No (2)]

AS4_2. About when did it stop working? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

2.5 Ducts

The first question is phrased a little differently for new versus original occupants.

D0. My next questions are about the duct-work in your house. Ducts carry warm and cool air throughout your home. They are usually located in the attic, and bring the warm and cool air to the registers in your walls and/or ceilings.

[IF O1=1, 98, or 99 (original occupant) SKIP TO D1O]

D1N. Are you aware of any remodeling or other events that occurred either before or after you moved here that resulted in any changes to the ducts? Perhaps they were removed, replaced, repaired, or added.

Yes ..... [SKIP TO D2_1] 1
No..... [SKIP TO C1a] 2
Don't know ..... [SKIP TO C1a] 98
Refused ..... [SKIP TO C1a] 99

D1O. Are you aware of any remodeling or other events that have occurred since you've lived here that resulted in any changes to the ducts? Perhaps they were removed, replaced, repaired, or added.

Yes 1
No..... [SKIP TO C1a] 2
Don't know ..... [SKIP TO C1a] 98
Refused ..... [SKIP TO C1a] 99

[IF D1N or D1O=Yes (1)]

D2_1. Briefly describe for me the first of these events.

D3_1. About when did this event occur? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

D2a_2. Are you aware of another event that resulted in changes to the ducts?

Yes 1
No..... [SKIP TO C1a] 2
Don't know ..... [SKIP TO C1a] 98
Refused ..... [SKIP TO C1a] 99

[IF D2a_2=Yes (1)]

D2b_2. Briefly describe for me the second of these events.

[IF D2a_2=Yes (1)]

D3_2. About when did this event occur? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

[IF D2a_2=Yes (1)]

D2a_3. Are you aware of another event that resulted in changes to the ducts?

Yes 1
No..... [SKIP TO C1a] 2
Don't know ..... [SKIP TO C1a] 98
Refused ..... [SKIP TO C1a] 99

[IF D2a_3=Yes (1)]
D2b_3. Briefly describe for me the third of these events.

[IF D2a_3=Yes (1)]
D3_3. About when did this event occur? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

[IF D2a_3=Yes (1)]
D2a_4. Are you aware of another event that resulted in changes to the ducts?
Yes 1
No..... [SKIP TO C1a] 2
Don't know ..... [SKIP TO C1a] 98
Refused ..... [SKIP TO C1a] 99

2.6 Natural Gas Measures

The cook top and oven set of questions are the same. The dryer set of questions is different because we're trying to determine whether or not the natural gas dryer stub is still there.

2.6.1 Cook top

C1a. Is your current cook top natural gas?
Yes ..... [SKIP TO C1b] 1
No.....2
Don't know 98
Refused 99

[IF C1a=No (2), Don't know (98), or Refused (99)]
C2a. Have you ever had a natural gas cook top in this home?
Yes 1
No..... [SKIP TO C1b] 2
Don't know ..... [SKIP TO C1b] 98
Refused ..... [SKIP TO C1b] 99

[IF C2a=Yes (1)]
C3a. About when did you last use a natural gas cook top? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.
[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

[IF C2a=Yes (1)]
C4a. Why did you stop using a natural gas cook top?

2.6.2 Oven

C1b. Is your current oven natural gas?

Yes	[SKIP TO S1] 1
No	2
Don't know	98
Refused	99

[IF C1b=No (2), Don't know (98), or Refused (99)]
C2b. Have you ever had a natural gas oven in this home?

Yes	1
No	[SKIP TO S1] 2
Don't know	[SKIP TO S1] 98
Refused	[SKIP TO S1] 99

[IF C2b=Yes (1)]
C3b. About when did you last use a natural gas oven? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

[IF C2b=Yes (1)]
C4b. Why did you stop using a natural gas oven?

2.6.3 Clothes dryer stub

S0. My next questions are about 2 items: your clothes dryer and a natural gas dryer stub.

A natural gas dryer stub is a small pipe that sticks out of the wall next to or behind your clothes washer and dryer. The pipe allows a natural gas clothes dryer to be hooked up. It looks like a short, rigid tube that is capped off or has a valve on the end of it.

S1. Have you ever had a natural gas clothes dryer in this home?

Yes	[SKIP TO S4] 1
No	2
Don't know	98
Refused	99

[IF S1=No (2), Don't know (98), or Refused (99)]
S2. According to our records, when this house was built a natural gas dryer stub was put in. Do you have any reason to think this stub was not put in?

Yes	1
No	[SKIP TO S5] 2
Don't know	[SKIP TO S5] 98

Refused .....[SKIP TO S5] 99

[IF S2=Yes (1)]
S3. Please explain why you think a stub was never put in.

[IF S1=Yes (1)]
S4. Currently, do you have a natural gas clothes dryer?

Yes .....[SKIP TO END] 1
No.....2
Don't know 98
Refused 99

[IF S2 OR S4 =No (1), Don't know (98), or Refused (99)]
S5. Do you have any reason to think the natural gas dryer stub was removed?

Yes 1
No.....[SKIP TO END] 2
Don't know .....[SKIP TO END] 98
Refused .....[SKIP TO END] 99

[S5=Yes (1)]
S6. Please explain why you think the stub was removed.

[S5=Yes (1)]
S7. About when was the stub removed? Anything you can tell me would be helpful; whether it is the exact month and year, before or after some date, or sometime between two dates.

[RECORD DATE INFORMATION: WRITE OUT MONTHS, E.G., "JANUARY" AND USE 4 DIGITS TO SPECIFY YEAR, E.G., 2006.]

END: Those are all the questions I have for you. Thank you very much for your help with this study.

D

EXAMPLES OF DUCT RETENTION AND NON-RETENTION

In the process of conducting the on-site surveys for this study, the auditors took almost 175 photographs. Included in this appendix are some examples of duct retention and non-retention they observed.

Figure D-1
Disconnected Duct, Non-retention

Figure D-2
Nicely Installed Ducts, Retained

Figure D-3
Nicely Installed Ducts, Retained

Figure D-4
Kink Consistent with Installation, Retained

E

TABLE 6B

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Protocol Table 6B
Results of Ninth-year Retention Study
Pacific Gas & Electric Company's 1997 and 1997 Residential New Construction Energy Efficiency Programs

PG&E Study ID Number: 386R2

CALMAC Study ID Number: PGE0247.01

Item 1			Item 2		Item 3	Item 4	Item 5	Item 6		Item 7	Item 8	Item 9
			EUL (years)									
Measure	End Use	Measure Description	ex ante	Source of ex ante	Estimated ex post (from study)	Adopted ex post (to be used in claim)	ex post Standard Error	80% Confidence Interval Lower Bound	80% Confidence Interval Upper Bound	P-value (H_0: ex post = ex ante)	EUL Realization Rate (adopted ex post /ex ante)	"Like" Measures Associated with Studied Measures
High-efficiency central air conditioning	Cooling	See table on next page	18	a	28	18	2.24	25	31	<0.01	1.00	None
High-efficiency duct work	Cooling, Heating		25	a	73	25	3.74	68	78	<0.01	1.00	None
Natural gas cooking	Miscellaneous		20	a	28	28	2.46	25	31	<0.01	1.39	None
Natural gas dryer stub	Miscellaneous		18	a	-	28	-	-	-	-	1.56	None

[a] Program Year 1996: PG&E Advice Filing 1921-G/1540-E October 1995. Program Year 1997: PG&E Advice Filing 1978-G/1608-E October 1, 1996. In addition, for each of the measures listed in this table, the 4th-year retention study recommended the ex ante EULs continue to be used in future earnings claims.

Measure	Measure Description
High-efficiency central air condtioning	AC 1 UNIT - 10.2 TO 12.2 M/F
	AC 1 UNIT - 10.2 TO 12.2 S/F
	AC 1 UNIT - 10.2 TO 13.5 S/F
	AC 1 UNIT - 10.2 W/1.5 SEER INCREASE
	AC 1 UNIT - 10.2 W/2.0 SEER INCREASE
	AC 1 UNIT - 10.2 W/3.0 SEER INCREASE
	AC 1 UNIT - 10.7 TO 12.2 S/F
	AC 1 UNIT - 10.7 W/1.5 SEER INCREASE
	AC 1 UNIT - 10.7 W/2.0 SEER INCREASE
	AC 1 UNIT - 11.2 W/1.5 SEER INCREASE
	AC 1 UNIT - 11.2 W/2.0 SEER INCREASE
	AC 1 UNIT - 11.2 W/3.0 SEER INCREASE
	AC 2 UNIT - 10.2 TO 12.2 S/F
	AC 2 UNIT - 10.2 W/1.5 SEER INCREASE
	AC 2 UNIT - 10.2 W/2.0 SEER INCREASE
	AC 2 UNIT - 10.2 W/3.0 SEER INCREASE
	AC 2 UNIT - 10.7 TO 12.2 S/F
	AC 2 UNIT - 10.7 W/1.5 SEER INCREASE
	AC 2 UNIT - 10.7 W/2.0 SEER INCREASE
	AC 2 UNIT - 10.7 W/3.0 SEER INCREASE
	AC 2 UNIT - 11.2 W/1.5 SEER INCREASE
	AC 2 UNIT - 11.2 W/2.0 SEER INCREASE
	AC 2 UNIT - 11.2 W/3.0 SEER INCREASE
	DOWNSIZE A/C BY 1/2 TON
	HIGH EFFICIENCY A/C - MULTI-FAMILY
	HIGH EFFICIENCY A/C - SINGLE FAMILY DETACHED
	SUPER EFFICIENT A/C - 15+ SEER
	SUPER EFFICIENT A/C - 16+ SEER
	SUPEREFFICIENT AC
High-efficiency duct work	DUCTS 1 UNIT - 10.2 W/1.5 SEER INCREASE
	DUCTS 1 UNIT - 10.2 W/2.0 SEER INCREASE
	DUCTS 1 UNIT - 10.2 W/3.0 SEER INCREASE
	DUCTS 1 UNIT - 10.7 W/1.5 SEER INCREASE
	DUCTS 1 UNIT - 10.7 W/2.0 SEER INCREASE
	DUCTS 1 UNIT - 11.2 W/1.5 SEER INCREASE
	DUCTS 1 UNIT - 11.2 W/2.0 SEER INCREASE
	DUCTS 1 UNIT - 11.2 W/3.0 SEER INCREASE
	DUCTS 2 UNIT - 10.2 W/1.5 SEER INCREASE
	DUCTS 2 UNIT - 10.2 W/2.0 SEER INCREASE
	DUCTS 2 UNIT - 10.2 W/3.0 SEER INCREASE
	DUCTS 2 UNIT - 10.7 W/1.5 SEER INCREASE
	DUCTS 2 UNIT - 10.7 W/2.0 SEER INCREASE
	DUCTS 2 UNIT - 10.7 W/3.0 SEER INCREASE
	DUCTS 2 UNIT - 11.2 W/1.5 SEER INCREASE
	DUCTS 2 UNIT - 11.2 W/2.0 SEER INCREASE
	DUCTS 2 UNIT - 11.2 W/3.0 SEER INCREASE
	DUCTS-AC - 1 UNIT - 12.2 S/F
	DUCTS-AC - 1 UNIT - 13.5 S/F
	DUCTS-AC - 12.2 M/F
	DUCTS-AC - 2 UNIT - 12.2 S/F
	HIGH EFFICIENCY DUCTS
Natural gas cooking	COOKTOP
	GAS COOKTOP/RANGE
	RANGE
Natural gas dryer stub	DRYER STUB

F.1 OVERVIEW INFORMATION

a. Study Title and Study ID Number

Study Title: Retention Study of Pacific Gas & Electric Company's 1996 and 1997 Residential New Construction Energy Efficiency Programs.

Study ID Numbers:

- Pacific Gas & Electric Company (PG&E): 386R2
- CALMAC: PGE0247.01

b. Program, Program Years, and Program Description

Program: PG&E Comfort Home Program.

Program years: 1996 and 1997.

Program description: Provided financial incentives to builders who constructed energy-efficient homes that exceeded Title 24 standards.

c. End Uses and Measures Covered

Table F-1 lists the end uses and measures covered by this study.

Table F-1
End Uses and Measures Covered

End Use	Measure
Cooling	High-efficiency central air conditioning (CAC)
Cooling, Heating	High-efficiency duct work (ducts)
Miscellaneous	Natural gas cooking (cooking)
	Natural gas dryer stub (stub)

d. Methods and Models Used

This study estimated EULs for three measures: CAC, ducts, and cooking. An EUL was not estimated directly for stubs because all stubs were assessed as retained in the data collected. To estimate a measure's EUL, this study assumed the age at which a unit of a measure is not retained follows some general distribution. Therefore, the general method was to collect data on

the ages at which units were not retained and use those data to estimate the specific path or parameters of the distribution. The estimated path or parameters of the distribution of the age at which a unit of a measure is not retained were then used to estimate the measure's EUL.

This study considered a variety of distributional assumptions: gamma, Weibull, exponential, log-normal, and log-logistic. The selection of the most appropriate distribution was based on several criteria:

- implications for the non-retention rate over time;
- likelihood ratio test;
- analysis of residuals; and
- maximum of the log-likelihood function.

Based on the selection criteria listed above, Table F-2 identifies the distribution selected for each measure. In Section 4, the table titled Survival Analysis Results presents the results for each distribution for which it was possible to fit the model.

Table F-2
Distribution Selected by Measure

Measure	Distribution Selected
CAC	Log-logistic
Cooking	Weibull
Ducts	Exponential

e. Analysis Sample Size

Table F-3 summarizes the data used in the analysis.[1]

Table F-3
Retention Analysis Data

	# Homes				
	Included in Retention Analysis				Excluded From Analysis
Measure	Total	4th-year Survey Only	9th-year Survey On-site	9th-year Survey Phone	
CAC	414	161	74	179	0
Cooking	404	156	72	176	10
Ducts	414	161	74	179	0
Stub	408	159	71	178	6

[1] The program installed two CAC units at about 5 percent of participating homes. For the remaining measures, the program installed one unit. Given the small number of homes with two CAC units and the fact that for sample homes the retention status of both units was the same, the analysis was conducted at the home rather than the CAC unit level.

F.2 DATABASE MANAGEMENT

a. Data Sources and Elements

This study used data from five sources:

1. The tracking databases for the 1996 and 1997 Residential New Construction Programs:
   SAS dataset: measures.sas7bdat. For the 414 sample homes, this SAS dataset contains all of the data from the Access database "9697 res nc retention study db – NEW.mdb," tables "1996 Comfort Homes Tracking" and "1997 Comfort Homes Tracking." The Access database is from the fourth-year retention study.
2. PG&E's customer information system:
   SAS dataset: recap00.dmrcne.xpt.
3. The telephone survey conducted for the fourth-year retention study:
   Excel file "Survey_for_EUL 2006 02 22.xls", the sheet "RLWSurvey." These data are from the Access database "9697 res nc retention study db – NEW.mdb," table "Sampling Frame & Survey Data."
4. The on-site visits conducted for this study:
   The Excel file "onsitedatcollctd_v2.xls" contains two sheets: data from the scheduling form was entered into sheet "schedule onsite" and data from the onsite data collection instrument was entered into sheet "onsite data collectn instrumnt."
5. The telephone surveys conducted for this study:
   The responses to the closed-ended questions are in the Excel file "t15902_20060217.xls" and the responses to the open-ended questions are in the Excel file "t15902_opens_20060217.xls."

Program-tracking Database

For each participating home, the program-tracking databases provided:

- PG&E control number from the customer information system, which facilitated the process of obtaining updated customer information for the participating home.
- Complete service address.
- Measures installed under the program.
- Dates the program rebates were paid. The fourth-year retention study based a participating home's program year assignment on these date. (If the rebates were paid in 1996, the home was assigned to program year 1996 and if the rebates were paid in 1997, the home was assigned to program year 1997.)

PG&E Customer Information System

PG&E's control number was essentially a unique premise ID. Although PG&E no longer assigns control numbers, it was still possible to use it to obtain updated customer information (name and

telephone number) for all but nine of the 414 sample homes. We searched PG&E's customer information system for the remaining nine sample homes using the service address.

Surveys

This study used data from three surveys conducted at two points in time: at the time of the fourth-year retention study and at the time of this current (ninth-year) retention study. The purpose of each survey was to collect the data necessary from a sample of participating homes to determine the retention status of the measures installed under the program. Furthermore, if a measure appeared not to be retained, the surveys collected any available data on when the measure was not retained.

b. Data Attrition

This study attempted to complete surveys with the current occupants of the 414 participating homes included in the fourth-year retention study of the 1996 and 1997 Residential New Construction Programs. The fourth-year retention study drew this sample of homes from a sampling frame developed from the 1996 and 1997 program-tracking databases. The results are based on the available data for all 414 sample homes. For the 253 sample homes with updated survey data from this current retention study, 74 completed an on-site survey and 179 completed a telephone survey. For the remaining 161 sample homes, we had telephone survey data from the fourth-year retention study.

c. Data Used to Merge Datasets

As discussed above, we used PG&E control number to obtain updated customer information. Also, we assigned an internal unique ID to each of the 414 sample homes ("kemaid").

d. Data Collected Specifically for the Analysis but Not Used

None.

F.3 SAMPLING

a. Sampling Procedures and Protocols

This study attempted to complete a survey with the current occupants of the 414 participating homes included in the fourth-year retention study of PG&E's 1996 and 1997 Residential New Construction Programs. Typically, retention studies of a program are based on the program participants included in the first-year impact evaluation. For these participants, the measures installed and in what quantity as well as any participant-specific savings estimates are known. The fourth-year retention study, however, was not based on the participating homes included in the first-year impact evaluation.

The fourth-year retention study drew a new sample of participating homes using the sample design given in Table F-4. The sampling frame was limited to participants in California Energy Commission (CEC) climate zones 11, 12, and 13 who received rebates for all four measures (high-efficiency central air conditioning, high-efficiency duct work, gas cooking, gas dryer stub). The sample was stratified by program year and climate zone. Each program year was allocated the same number of completes (200), which were then allocated across climate zones proportional to program participation that year.

Table F-4
Fourth-Year Retention Study Sample Design

CEC Climate Zone	# Participants All 4 Measures Installed	4th-year # Completes		9th-year # Completes			
					Obtained		
		Target	Obtained	Target	Onsite	Telephone	Total
1996							
11	545	43	45	45	11	22	33
12	1,459	116	119	119	24	51	75
13	515	41	43	43	6	20	26
Total	2,519	200	207	207	41	93	134
1997							
11	611	35	37	37	4	17	21
12	2,099	120	122	122	14	51	65
13	791	45	48	48	15	18	33
Total	3,501	200	207	207	33	86	119
Total							
11	1,156	78	82	82	15	39	54
12	3,558	236	241	241	38	102	140
13	1,306	86	91	91	21	38	59
Total	6,020	400	414	414	74	179	253

Limiting the sampling frame to participants in climate zones 11, 12, and 13 who received rebates for four measures excludes relatively few participants with one exception. In each program year, less than 2 percent of participants were outside climate zones 11, 12, or 13. In addition, in 1997, only 3 percent of participants received rebates for a subset of the four measures. However, in 1996, 32 percent of participants received rebates for only a subset of the four measures.

b. Survey Information

The on-site data collection instrument and telephone questionnaire are provided in Appendices B and C, respectively. We targeted new occupants of the 414 sample homes for on-site surveys. A summary of the final status of the 174 sample homes with new occupants is given in Table F-5. As this table shows, at the conclusion of the fieldwork, we attempted to complete telephone surveys with 72 sample homes with new occupants.

Table F-5
On-site Survey Final Status

Status	Homes	
	#	%
On-site survey completed[a]	74	42%
Refusal, don't attempt telephone survey	17	10%
Incorrect telephone number	12	7%
Attempt to complete telephone survey	72	41%
Total[a]	175	100%

[a] One on-site survey was completed with an original occupant. Hence, the total of 175 reflects 174 new occupants and one original occupant.

A summary of the final status of the 311 sample homes sent to the telephone survey house is provided in Table F-6. (The remaining 103 of the 414 sample homes are accounted for by the on-site survey—complete, incorrect telephone number, or refusal.)

Table F-6
Telephone Survey Final Status

Status	Homes	
	#	%
Telephone survey completed	179	58%
Refusal	16	5%
Language problems	2	1%
Incorrect telephone number	44	14%
Live	70	23%
Total	311	100%

The sample homes for which we were able to obtain updated survey data may be different from the sample homes for which we were unable to obtain updated survey data. However, it is unlikely they are different in ways that would affect the study results in any measurable way. Also: (1) The available data for all 414 sample homes were included in the analysis. (2) As a result of targeting new occupants for on-site surveys, we very aggressively attempted to complete surveys with this group of sample homes. This minimized any potential bias from an under-representation of new versus original occupants.

c. Statistical Descriptions

By measure, Table F-7 presents the retention status at the end of two periods: the first four years after installation and the next five years. Note this table includes only sample homes for which a survey was completed at the time of both the fourth-year retention study and the current retention study.

Table F-7
Retention Status Over Time

Measure	ex ante EUL (years)	# Homes Surveyed Both 4th- and 9th-years	Installation thru 4th-yr		4th-yr thru 9th-yr	
			% Homes w/Measure Not Retained	# Homes w/Measure Retained	% Homes w/Measure Not Retained	# Homes w/Measure Retained
CAC	18	253	0.4%	252	4.4%	241
Cooking	20	248	0.4%	247	4.0%	237
Ducts	25	253	2.0%	248	6.9%	231
Stub	18	249	0.0%	249	0.0%	249

F.4 DATA SCREENING AND ANALYSIS

a. Treatment of Outliers and Missing Data Points

In this type of analysis, units not retained soon after installation may be considered "outliers." However, as this analysis takes place nine years following installation, any effect of such "outliers" should be negligible.

See the discussion of missing data in Section h below.

b. Background Variables

See the discussion of omitted factors in Section e below.

c. Data Screens

Each of the 414 sample homes was included in the analysis of a measure unless it was clear that the measure in fact had never been installed under the program. For CAC and ducts, all 414 sample homes were included in the analysis. For cooking and stubs, 10 and 6 sample homes, respectively, were excluded from the analysis.

d. Model Statistics

The standard model statistics for the selected final models are provided in Table F-8. The p-value for the intercept corresponds to a test of the hypothesis that the intercept equals 0. SAS does not provide p-value for the scale parameter.

Table F-8
Selected General Linear Regression Model Statistics

Measure	Distribution	Intercept			Scale[a]	
		Estimate (ln(years))	Standard Error (ln(years))	P-value	Estimate	Standard Error
CAC	Log-logistic	3.32	0.0810	<0.0001	0.37	0.0238
Cooking	Weibull	3.47	0.0984	<0.0001	32.18	3.1674
Ducts	Exponential	4.66	0.0512	<0.0001	1.00	-

[a] The value of the scale parameter for the exponential distribution is always 1, it is not estimated.

The parameter estimates in Table F-8 produce the EUL estimates in Table F-9.

Table F-9
Summary of EUL Estimates

Measure	EUL (years)					P-value (H_0: ex post = ex ante)
	ex ante	Estimated ex post (from study)	ex post Standard Error	80% Confidence Interval		
				Lower Bound	Upper Bound	
High-efficiency central air conditioning	18	28	2.24	25	31	<0.01
High-efficiency duct work	25	73	3.74	68	78	<0.01
Natural gas cooking	20	28	2.46	25	31	<0.01

e. Specification

To estimate a measure's EUL, this study assumed the age at which a unit of a measure is not retained follows some general distribution. Therefore, the general method was to collect data on the ages at which units were not retained and use those data to estimate the specific path or parameters of the distribution. The estimated path or parameters of the distribution of the age at which a unit of a measure is not retained were then used to estimate the measure's EUL.

This study considered a variety of distributional assumptions: gamma, Weibull, exponential, log-normal, and log-logistic. These are common distributional assumptions when conducting survival analysis. Even when there are a priori expectations about the path (distribution) followed by the age at which a unit of a measure is not retained, it can be informative to consider alternative paths. The selection of the most appropriate distribution was based on several criteria:

- implications for the non-retention rate over time;
- likelihood ratio test;
- analysis of residuals; and

- maximum of the log-likelihood function.

Based on the selection criteria listed above, Table F-2 identifies the distribution selected for each measure. In Section 4, the table titled Survival Analysis Results presents the results for each distribution for which it was possible to fit the model.

1. Heterogeneity

The model specification and estimation procedures recognize and address heterogeneity of the sample homes by using standard sampling weights in the analysis. The weights vary by program year and climate zone combinations.

2. Omitted Factors

It is possible to include in the model of the age at which a unit of a measure is not retained the parameters of the assumed distribution as well as other independent variables. The additional independent variables may be background variables such as economic and political activity and/or variables that vary by sample home. For example, whether the original or a new occupant resides at a sample home

Modeling the age at which a unit of a measure is not retained as a function of the parameters of the assumed distribution as well as other independent variables will provide insight into the effect of these other independent variables on the age at which a unit is not retained. However, it is unclear whether additional independent variables will result in a better estimate of a measure's EUL.

The value of modeling the age at which a unit is not retained as a function of background variables and/or variables that vary by project depends on at least three factors:

1. The magnitude of their effect on the age at which a unit is not retained.
2. How accurately their future values can be estimated.
3. If the result is more than one estimate of the EUL (e.g., if a variable is categorical), whether or not the various EUL estimates and their standard errors can be meaningfully combined.

The future values of background variables and/or variables that vary by sample home may not be able to accurately estimated. In addition, the ultimate objective of this study is to estimate a single EUL for the population of a measure, not to estimate different EULs for different subpopulations of a measure. Therefore, we model the age at which a unit of a measure is not retained as a function of only the parameters of the assumed distribution.

f. Error in Measuring Variables

There are no particular concerns regarding error in measuring variables. The methods used are well suited to handle imprecise measurement of the age at which a unit of a measure is not retained.

g. Influential Data Points

See the discussion of outliers in Section a above.

h. Missing Data

There are no particular concerns regarding missing data. Again, the methods used are well suited to handle imprecise measurement of the age at which a unit of a measure is not retained.

i. Precision

The log of a measure's EUL estimate and the standard error of the log of a measure's EUL estimate are obtained directly. A measure's EUL estimate was then obtained by calculating the exponential of the log value ($e^{log(EUL\ estimate)}$). A confidence interval for a measure's EUL was obtained in a similar manner.

In general, the bounds of a confidence interval for a parameter are calculated as the parameter estimate ± the standard error of the parameter estimate times the critical value from the appropriate distribution for the desired level of confidence. Using the standard error of the log of a measure's EUL estimate, we calculated the 80 percent confidence interval for the log of a measure's EUL. The lower and upper bounds of the 80 percent confidence interval for a measure's EUL were then obtained by calculating the exponential of the lower and upper bound values of the 80 percent confidence interval for the log of the measure's EUL, respectively.